CLARK FORK RIVER AQUATIC AND RIPARIAN RESTORATION ACTIONS AND PRIORITIZATION ANALYSIS

Prepared By

Geum Environmental Consulting, Inc.
307 State Street
Hamilton, Montana 59840

Applied Geomorphology, Inc.
211 North Grand, Suite C
Bozeman, Montana 59715

TetraTech
825 West Custer Avenue
Helena, MT 59602

July, 2019

TABLE OF CONTENT

Introduction

The purpose of this document is to evaluate restoration priorities for the mainstem Clark Fork River (CFR) within the Upper Clark Fork Clark River Basin (UCFRB) to assist in the development of the State of Montana's 2019 Revised Restoration Plan for the Clark Fork River Aquatic and Riparian Resources (NRDP 2019). To support evaluating restoration priorities, restoration actions associated with the integrative remediation/restoration actions are evaluated. These restoration actions include major removal, re-vegetation, stabilization, and/or treatment actions, which should jump start recovery of vegetation conditions, with further natural recovery to occur over time. The basis for restoration is described in *State of Montana's Revised Restoration Plan for the Clark Fork River Aquatic and Riparian Resources* (NRDP 2007):

> *Upper Clark Fork River: The State's natural resource damage assessment completed in 1995 (Lipton et al. 1995) and the 2004 Record of Decision for the Upper Clark Fork River indicated that approximately 215 to 250 acres of floodplain along the 17 miles of the Upper Clark Fork River between Warm Springs Ponds and Deer Lodge contained phytotoxic concentrations of hazardous substances so that they were entirely or largely devoid of vegetation, having no or little capacity to support viable wildlife populations. It also indicated populations of otter, mink, and raccoon have been significantly reduced relative to baseline conditions.*
>
> *The 2008 settlement/consent decree provided the State with $95 million, plus interest, for the remediation of the Upper Clark Fork River and $26.7 million, plus interest, for the restoration of the Upper Clark Fork River. The DEQ will conduct the remediation activities that involve removal of contaminated tailings from areas mostly devoid of vegetation, treatment of other contaminated soils, with lime and deep tilling, and stream bank reconstruction. The NRDP will conduct restoration activities that will be integrated with remediation activities, and enhance riparian wildlife habitat by removing additional tailings and completing more vegetation activities (addition of organic matter, grasses, trees, and shrubs) to augment remediation work. The State's Restoration Plan also provides for acquisitions/easements in the upper Clark Fork River riparian zone, when feasible, based on landowner agreements. The State anticipates remediation and restoration work of the Upper Clark Fork River to be completed in the next 10 to 12 years.*

Current mainstem restoration actions are described in the *State of Montana's Revised Restoration Plan for the Clark Fork River Aquatic and Riparian Resources* (NRDP 2007). These actions were developed according to remedial actions in the 2004 Record of Decision (ROD) (EAP 2004). Remedial actions have been modified since the ROD, as described in the *Explanation of Significant Differences* (DEQ and EPA 2015) and now include actions originally described in the 2007 Restoration Plan. Therefore, there is a need to update restoration actions and priorities for the CFR mainstem where remedial actions are taking place.

Remedy Actions

This document assumes that remedial actions will continue as described in the *Explanation of Significant Differences* (DEQ and EPA 2015) (Attachment A) and the *Clark Fork River Reach A Design Approach* (CDM et al. 2016) (see Attachment B). The main components of the Remedial Action include:

Removal of tailings/impacted soils that meet the following conditions:

1. Arsenic levels exceed the human health standard in the surface interval (620 ppm).
2. The sum of Contaminants of Concern (COCs) (As, Cd, Cu, Pb, Zn) exceeds 1,400 mg/kg (parts per million) and any of the following:
    - The deepest contaminated interval of metals is deeper than 24 inches,
    - The contamination lies within the Channel Migration Zone (CMZ) regardless of depth (CMZ is defined by applying pre-project 90th percentile reach scale migration rate to allow 100 years of movement and high risk avulsion hazard zones),
    - Arsenic exceeds the human health standard at the surface (620 ppm) and the sum of COCs exceeds 1,400 mg/kg at an interval shallower than 24 inches, or
    - In areas where floodplain connectivity is desired, removal may occur below the depth of contamination to a depth that would result in the surface being connected (0.5 feet above the 2-year water surface elevation or lower.
3. Limited areas outside the CMZ where contaminated material is present and removing it will result in a more constructible remedial project.
4. Areas of uncommon native vegetation may be preserved and contamination left in place.

In addition, the following criteria are generally applied to floodplain grading and revegetation of remediated areas. This analysis assumes these criteria will be applied at a level similar to phases that have either been completed or are in progress:

- The floodplain is re-built to the approximately Q2 return flow elevation at the streambanks and gradually slopes to existing ground.
- Between 0.5 and 1.5 feet of vegetative growth media are placed on the floodplain surface depending on location.
- Floodplain features including point bars, side channels, wetlands, secondary channels, oxbow wetlands, etc. are incorporated into the grading. Where these features occur naturally they are typically re-built.
- The surface of the floodplain is treated with roughness (non-uniform topography) and woody debris.
- The surface of the floodplain is revegetated using native seed and native woody riparian plant species.

Where uncontaminated floodplain surfaces form channel banks, they are left unmodified, regardless of height or erosion potential.

Limiting Factors

Limiting factors to river and floodplain ecosystem health in the Clark Fork River mainstem include:

- Metals contaminated floodplain, streambanks, and channel bed
- Regulated flows at Warm Springs Pond
- Low base stream flow (including dewatering due to irrigation)
- Water temperature (elevated summer temperatures)
- Water quality, including elevated nutrients (resulting in algae blooms) from unknown sources and Warm Springs Ponds (low pH, metals, and arsenic)
- Lack of floodplain connectivity
- lack of woody vegetation cover on streambanks increasing streambank erosion

- Fish passage (diversion structures)
- Lack of aquatic habitat (limited pools, wood, woody vegetation)

These are the factors that need to be addressed in order to restore the mainstem Clark Fork River to baseline conditions. Factors that cannot be addressed through restoration actions are constraints on restoration.

Restoration Constraints

Several factors will influence the effectiveness of restoration actions implemented in the Clark Fork River mainstem area. These factors cannot be remedied by restoration actions evaluated in this document but are key constraints to effective restoration along the mainstem Clark Fork River:

- The effects of Warm Springs Ponds including discharge water with low pH, elevated temperatures in late summer, and elevated arsenic discharges from early summer through fall, dampening of the hydrograph above the Q10 flow, and causing periodic spikes in metals concentrations in the aquatic system.
- Nutrient sources that are contributing to elevated nitrogen and phosphorous and leading to *Cladophora* algae blooms.
- Aerial deposition of arsenic in upland areas.
- Uncertain future land management of remediated/restored areas.
- Infrastructure such as bridges, railroad, roads, and associated hard armoring.
- Recognition that all metals contamination within the Clark Fork River floodplain and streambed will not be removed or remediated, resulting in continued impact to water quality, river sediments, riparian and aquatic health.
- Over allocation of water rights resulting in low stream flow and increased stream temperature during critical periods.

Restoration Actions Included in Prioritization Effort

Restoration actions were developed by compiling actions for the Clark Fork River mainstem included in other restoration documents, and actions that have been identified during implementation of the integrated remediation/restoration actions in Phase 1, Phase 2, Phase 5 and Phase 6. The list of draft restoration actions was then vetted by NRDP, the consultant team, and biologists from Montana Fish, Wildlife, and Parks in February 2019.

Restoration Priorities

Restoration actions fall into three priority tiers, including:

- Tier I: Actions directly integrated with remediation actions in the Clark Fork River Operable Unit (i.e. remediation/restoration actions).
- Tier II: Actions occur within the Clark Fork River Operable Unit, but do not directly contribute to remediation of contamination in the Clark Fork River Operable Unit. Actions may benefit or enhance the remedial actions.
- Tier III: Actions do not occur in the Clark Fork River Operable Unit, but have been previously determined as high priorities for restoration.

Table 1 lists the restoration actions identified for the UCFRB and identify which priority tier each action falls into. Maintenance and Monitoring and Evaluation were originally included as Restoration Actions but were removed from the evaluation and prioritization because they are required actions under the 2007 Restoration Plan.

Table 1. Upper Clark Fork River restoration actions and priority tier for each action.

		Priority Tier		
Restoration Action #	**Restoration Action Description**	**I**	**II**	**III**
1	Additional Contamination Removal			
2	Additional Revegetation (within Remedy or Contamination Removal Areas)			
3	Floodplain Diversity Enhancement (within Remedy or Contamination Removal Areas)			
4	Restore Streambanks Ahead of Remediation			
5	Remove High-risk Contaminated Sediments Ahead of Remediation			
6	Land Acquisition			
7	Conservation Easements (on private land)			
8	Riparian Vegetation Expansion (outside of Remedy or Contamination Removal Areas)			
9	Floodplain Diversity Enhancement (outside of Remedy or Contamination Removal Areas)			
10	Channel Relocation			
11	Reach A Aquatic Habitat Enhancement			
12	Modification of Mainstem Clark Fork River Diversion Structures			
13	Clark Fork River Reaches B and C Aquatic Habitat Restoration			
14	Upper Blackfoot Mining Complex Restoration			
15	Upper Blackfoot River Native Trout Restoration			
16	Short and Long Term Management/Stewardship			

Description of Restoration Actions

The following restoration actions were identified for the Clark Fork River.

1. <u>Additional Contamination Removal</u>

This action includes removing contamination that would not be removed under Remedy. The most common reason for additional contamination removals is to increase floodplain connectivity by lowering the ground surface relative to the river stage. Downstream of Deer Lodge there could be areas outside of the Removal Boundary with high concentrations, but shallow depths, of contamination due to historic contaminant delivery and depositional patterns being different further downstream from the contaminated sediment sources. Removing additional contamination in these areas (outside of the CMZ) may be beneficial even if contamination where COC exceeds 1,400 mg/kg is less than 2 feet in depth.

2. <u>Additional Revegetation (within Remedy or Contamination Removal Areas)</u>

This action includes additional revegetation activities that are beyond what Remedy actions are expected to complete as Appropriate Vegetation defined in the 2008 settlement/consent decree. Additional revegetation would be implemented in areas where contamination removal is occurring, whether that is associated with Remedy or areas of additional removal completed by Restoration. Revegetating clean areas is covered separately under Restoration Action #8. Additional revegetation actions associated with Remedy or contamination removal areas could include:

- Planting more plants, additional species, or larger size plants;
- Adding additional species to seed mixes to increase diversity; and
- Installing other vegetation enhancement treatments such as pre-vegetated wetland sod mats.

3. <u>Floodplain Diversity Enhancement (within Remedy or Contamination Removal Areas)</u>

This action includes increasing or enhancing the diversity of reconstructed floodplains within or immediately adjacent to areas where Remedy is completed. Floodplain diversity enhancement would be completed in areas where contamination removal is occurring, whether that is associated with Remedy or areas of additional removal completed by Restoration. Specific examples of floodplain diversity enhancement include:

- Restore existing floodplain features such as wetlands, side channels, oxbows, etc.
- Create additional floodplain features such as wetlands, side channels, distributary flow channels, oxbows, etc.
- Diversify floodplain topography
- Lower floodplain surfaces to increase connectivity

4. <u>Restore Streambanks Ahead of Remediation</u>

This action includes re-building streambanks prior to remediating the adjacent floodplain. The purpose of this action is to reduce the amount of contaminated sediment entering the river due to bank erosion, and allow bank vegetation to begin to establish and expand earlier than would happen with the remediation schedule. Restoring streambanks ahead of remediation could also reduce the need for qualified streambank contractors to complete the work as part of remediation, and allow for some remedial infrastructure to be established ahead of remedy. This action only includes areas that would already be treated as part of Remedy. The action would include removing contamination from a buffer along the entire river channel, and installing streambank treatments currently being used for integrated remediation/restoration in the UCFRB.

5. Remove High Risk Contaminated Sediments Ahead of Remediation

This action includes removing high risk contaminated sediments prior to remedial actions. High risk areas include those where contaminated sediment is likely to enter the river system in the near future, such as outside meander bends with no vegetation and streambanks that intercept bare slickens.

6. Land Acquisition

This action includes acquiring land that will remain in state ownership.

7. Conservation Easements (private land easements)

This action includes placing conservation easements on lands that will remain in private ownership. There are numerous types of easements and organizations that hold and manage easements. For purposes of UCFRB restoration, easements would not allow development, would require grazing management, and would require the adoption of a riparian protection or buffer zone. Another potential type of easement that could apply to the UCFRB are channel migration easements (CMEs) that include a channel migration zone (CMZ) allowing for natural river migration over time.

8. Riparian Vegetation Expansion (outside of Remedy or Contamination Removal Areas or in phases where Remedy or Contamination Removal is complete)

This action includes expanding the riparian buffer within the Clark Fork River floodplain. These actions would apply to areas outside of those treated by Remedy actions, or any areas outside of contamination removal boundaries, where woody vegetation cover or native vegetation diversity could be increased. This action includes numerous revegetation activities, some examples include:

- Revegetation (planting, seeding, etc.)
- Planted riparian vegetation protection
- Restore and revegetate eroding, clean streambanks

9. Floodplain Diversity Enhancement (outside of Remedy or Contamination Removal Areas)

This action includes increasing or enhancing the diversity of floodplains in areas where contamination removal does not occur. Floodplain diversity enhancement includes creation of new features through surface excavation. It does not include active revegetation of these newly constructed features; those actions are covered under Restoration Action 12. Specific examples of floodplain diversity enhancement include:

- Diversify floodplain topography
- Create wetlands, side channels, distributary flow channels, oxbows, etc.
- Restore degraded or drained wetlands (i.e. in irrigated areas)

- Lower floodplain surfaces to restore connectivity and increase the potential for natural riparian vegetation expansion

10. Channel Relocation

This action includes relocating the channel from its current location where current channel conditions do not support river and ecological function. An example of a channel relocation action is in Phase 7 where the current channel is eroding into a steep terrace on the west side of the valley bottom. While channel relocation also occurs as part of remediation actions where channel instability would jeopardize remediation, those types of channel relocation are not considered part of this action. In some cases, however, channel relocations considered for restoration could provide numerous benefits to remediation, including increasing the efficiency of contamination removal.

11. Reach A Aquatic Habitat Enhancement

This action includes enhancement of aquatic habitat in Reach A. Specific aquatic habitat enhancement treatments could include:

- Increase overhanging woody cover along banks using woody debris of varying sizes and morphological character
- Increase woody debris in channel to promote scour and cover elements (i.e. mimic large willow clump recruitment to channel
- Enhance or construct side channels
- Modify channel geometry (e.g. narrowing the channel)
- Enhance and/or reconnect tributaries within the 100-year floodplain to the mainstem
- Create or enhance backwater habitat
- Enhance split flow channel features (i.e. bifurcation treatments at the head of islands)

12. Modification of Mainstem Diversions

This action includes modifying mainstem diversions that pose a risk to aquatic species movement or river function. Any structure that is a passage barrier, entrainment risk, or alters river function is included in this action. These actions would occur on diversions in Reach A with one diversion at Beavertail identified in Reach B. Actions may include:

- Removal of structure
- Retro-fitting of structure to allow passage of fish and increased floater safety
- Installation of fish screens in ditches
- Installation of stream gauges

13. Clark Fork River Reaches B/C Aquatic Habitat Restoration

This action includes addressing limiting factors in Reaches B and C of the UCFRB. Within Reaches B and C, the Flint Creek to Rock Creek reach, and Turah to the confluence with the Blackfoot River are priority areas. Additional study of the Flint Creek to Rock Creek Reach of the UCFRB is covered under the Restoration Plans (NRDP, 2018). This analysis includes actions that may improve aquatic habitat in these sections of the mainstem Clark Fork River. Additional actions may be identified. Actions needed to improve aquatic habitat in these sections of Reaches B and C include:

- Rip-rap removal/replacement/revegetation
- Riparian vegetation protection
- Riparian vegetation enhancement
- In-stream habitat enhancement (pool formation + cover)
- Channel Migration Zone (CMZ) recovery
- Remove floodplain constrictions (i.e. old railroad berms

14. Upper Blackfoot Mining Complex Restoration

This action includes completing restoration related to the Upper Blackfoot Mining Complex. $2 million is allocated to this action which is being implemented by the Montana Natural Resource Damage Program.

15. Upper Blackfoot River Bull Trout and Westslope Cutthroat Trout Restoration

This action includes restoring native trout species to the North Fork Blackfoot River. $500,000 are allocated to this action being implemented by Montana Fish, Wildlife and Parks and the U.S. Forest Service.

16. Short and Long Term Management/Stewardship

This action includes implementing either short or long term management actions in completed phases to establish and protect a riparian buffer along the mainstem Clark Fork River. These actions could also protect existing high functioning wetlands. The ROD calls for developing Landowner Best Management Plans for remediated areas. This action includes developing management and stewardship actions to prolong the protection of the remediated areas or for areas outside of remediation. Specific management and stewardship actions could include:

- Prepare land management plans for areas outside of Remedy
- Implement land management plans for areas outside of Remedy
- Establish lease agreements for areas outside of Remedy where restoration actions are completed or extend remediation lease agreements to prevent undesirable land uses within restoration areas for a specified length of time, or establish other incentive programs
- Install riparian fencing to protect a riparian buffer or CMZ in grazed areas
- Conduct weed control beyond remedy's obligation
- Implement grazing management (off-stream water sources, grazing management strategies)
- Develop and support partnerships with organizations that can work directly with landowners to promote stewardship of restored lands

Evaluation Criteria and Restoration Action Ranking

Each restoration action was evaluated to determine its priority for supporting restoration activities in the UCFRB mainstem Clark Fork River over the next 10 to 15 years. Restoration actions were evaluated at two levels. The first level includes the three tiers described above (Level One). The second level includes several criteria, and each Restoration Action is assigned a rating of high, medium, or low for each criteria. Criteria are applied for all of Reach A (where applicable), rather than on a phase by phase basis. This two level prioritization framework can be applied as restoration opportunities arise ahead of remediation actions or within a phase where remediation activities are being pursued.

Level One

There are three tiers for Level One Restoration Action ranking:

- Tier I: Priority weighting – 1 point (demonstrable contribution to achieving remediation goals)
- Tier II: No weighting – 0 points (no apparent contribution to achieving remediation goals)
- Tier III: Not ranked or prioritized as restoration money is already allocated to these projects

Level Two

Several categories were selected to evaluate restoration actions. Within each of these categories, criterion were developed for ranking each category as either High (1 point), Medium (0.5 points), or Low (0 points). Points are applied to each Restoration Action depending on the category it falls into. Each criteria and ranking category are described below:

Level Two Evaluation Categories and Ranking Criteria

1. *Technical Feasibility*

Technical feasibility is evaluated based on the degree of certainty or uncertainty related to the technical feasibility of implementing the action in the Upper Clark Fork River watershed, including extent each element has a reasonable chance of successful completion in an acceptable period of time.

Criterion	Score	Description
High	1	Action has been proven to be technically feasible within the Upper Clark Fork River Basin.
Medium	0.5	Technical feasibility of action is known for other projects but unknown within the Upper Clark Fork River Basin.
Low	0	Action is experimental or has not been proven to be technically feasible.

2. *Ecological Benefit (Floodplain Processes)*

This category evaluates the ecological benefit of the Restoration Action. The ecological benefit focuses on restoring natural floodplain processes. A checklist is used to determine the extent of ecological benefits. This category focuses on physical features and ecological processes, assuming that these components influence floodplain functions such as: flood attenuation, short and long term surface water storage, sediment/nutrient/ toxicant retention and removal, aquatic and terrestrial food web support, and groundwater discharge and recharge.

Criterion	Score	Description
High (More than 3 benefits checked)	1	Action provides many ecological benefits.
Medium (1-3 benefits checked)	0.5	Action provides some ecological benefits
Low (0 benefits checked)	0	Action provides no ecological benefits.

Ecological Benefit Checklist:

- Improves floodplain connectivity
- Increases natural recruitment potential for woody riparian vegetation
- Increases topographic diversity
- Reduces metals, sediment, or nutrient input to the ecosystem
- Increases floodplain substrate diversity

3. Biological Benefit (Aquatic)

This category evaluates the aquatic biological benefit of the Restoration Action. The biological benefit focuses on restoring natural function and conditions of the aquatic ecosystem and connected floodplain habitats. A checklist is used to determine the extent of aquatic biological benefits. If the Restoration Action does not directly touch the river channel or streambanks the score is Low.

Criterion	Score	Description
High (more than 3 benefits checked)	1	Action provides many aquatic biological benefits.
Medium (1 to 3 benefits checked	0.5	Action provides some aquatic biological benefits.
Low (0 benefits checked)	0	Action provides no aquatic biological benefits.

Aquatic Biological Benefit Checklist:

- Reduces water temperatures
- Improves water quantity
- Reduces instream fine sediment
- Reduces risk of metals inputs into aquatic system
- Reduces risk of nutrients inputs into aquatic system
- Increases overhanging woody riparian vegetation cover
- Has immediate benefit to aquatic biota
- Supports and increases aquatic habitat complexity

4. Biological Benefit (Terrestrial)

This category evaluates the terrestrial biological benefit of the Restoration Action. The terrestrial biological benefit focuses on restoring habitat diversity to the floodplain. A checklist is used to determine the extent of terrestrial biological benefits. If the Restoration Action does not occur within the Clark Fork River mainstem floodplain the score is Low. This category focuses on the structural components that translate to terrestrial functions such as forage, cover, movement, etc.

Criterion	Score	Description
High (more than 3 benefits checked)	1	Action provides many terrestrial biological benefits.
Medium (1 to 3 benefits cheeked	0.5	Action provides some terrestrial biological benefits.
Low (0 benefits checked)	0	Action provides no terrestrial biological benefits.

Terrestrial Biological Benefit Checklist:

- Improves woody riparian vegetation cover
- Improves structural diversity of riparian vegetation

- Improves patch diversity (i.e. creates multiple habitats)
- Does not impede movement of wildlife except for very short period of time
- Creates high quality vegetation communities (cottonwood stands, high quality wetlands)
- Creates contiguous floodplain corridors
- Reduces risk of metals uptake in vegetation (i.e. vegetation diversity, ingestion)

5. Adverse Environmental Impacts

This category evaluates potential for additional injury to the environment that may occur as a result of the Restoration Action. Adverse environmental impacts may include: short or long term fine sediment delivery to the river, loss of streambank vegetation and cover, etc.

Criterion	**Score**	**Description**
High (0 impacts checked)	1	Action has no adverse environmental impacts.
Medium (1 to 3 impacts checked)	0.5	Action has some short-term adverse environmental impacts.
Low (greater than 3 impacts checked)	0	Action has many short-term adverse or any long-term adverse environmental impacts.

Adverse Environmental Impact Considerations:

- Does action result in land disturbance that removes desirable/stabilizing vegetation?
- Does action create risk of fine sediment entering river?
    - Does action impact streambanks?
    - Is action within 50 feet of river?
    - Can BMPS control sediment delivery to river?
    - Does action change location or dimensions of river?
- Does action increase metal entrainment to river?
- Does action reduce floodplain connectivity?
- Does action impact long-term channel migration?
- Does action affect water temperature?
- Does action directly impact aquatic habitat?
    - Is loss short-term or long-term?
    - Does loss of habitat affect biological population, and if so, will the population rebound in the short-term or long-term?

6. Recovery Period and Potential for Natural Recovery

This category evaluates the recovery period for each Restoration Action compared to natural recovery or natural recovery based on ongoing or planned response action. Recovery period is defined as the length of time expected for an area to recover (meets specific objectives) after a Restoration Action is complete. A recovered area would support the services performed by the resource at its baseline condition, had the release not occurred.

Criterion	Score	Description
High	1	Recovery period is less than 5 years.
Medium	0.5	Recovery period is between 5 and 10 years.
Low	0	Recovery period is greater than 10 years.

Recovery Period Considerations:

- Does action increase area connected to the river (i.e. can natural recruitment of native vegetation be expected)?
- Does action increase the hydroperiod or reduce the depth to groundwater (i.e. more rapid recovery of wet areas)?
- Will the action create a small footprint of disturbance?
- Will minimal maintenance be required to aid recovery?
- Is the restoration action self-sustaining?

7. Consistency and Compliance with Federal, State, Tribal Policies, Rules, and Laws

This category evaluates whether the proposed alternative is consistent with relevant policies and compliant with applicable laws. The cumulative effect of coordination and costs for compliance with many policies, rules, and laws may affect restoration priority. For example, beaver reintroduction may have positive ecological benefits but may also have many constraints related to state and federal policies and laws.

Criterion	Score	Description
High	1	Action has no policies, rules and laws other than those required under CERCLA/Superfund.
Medium (1 to 3 checked)	0.5	Action has few policies, rules and laws other than those required under CERCLA/Superfund.
Low (greater than 3 checked)	0	Action has many policies, rules and laws other than those required under CERCLA/Superfund.

Policies, Rules, and Laws Checklist:

- NEPA/MEPA – EA or EIS required?
- BA/BO – biological assessment and opinion required?
- Floodplain permit required?
- 404 permit required?
- 124/310 permit required?
- SHPO - Cultural survey required?
- Water rights present?
- DEQ water quality permit required?

8. Adverse Socioeconomic Impacts

This category evaluates the social impacts of the Restoration Action. These are impacts beyond what remedial actions would already be having.

Criterion	Score	Description
High (0 checked)	1	Action has no social impacts.
Medium (1 to 3 checked)	0.5	Action has few social impacts.
Low (greater than 3 checked)	0	Action has many social impacts.

Social Impact Checklist:

- Affects commercial activities (haying, irrigation, river access for guides, etc.) that can't be compensated for
- Results in a loss of use for greater than 1 year
- Action affects visual aesthetics for greater than 5 years
- Action limits recreation activities (hunting, fishing, birding, etc.)
- Action prevents access to existing roads
- Action restricts public access to an area with current unrestricted public access
- Action affects public safety
- Action affects infrastructure

9. Data Gaps

This category evaluates how much data is needed to evaluate the Restoration Action. This includes data gaps related to understanding the feasibility and cost of the action.

Criterion	Score	Description
High	1	Action has no significant data gaps.
Medium	0.5	Data are available but need to be analyzed.
Low	0	New data are needed.

10. Proximity to Other Restoration or Remediation Actions

This category evaluates how close the Restoration Action is to other completed or planned restoration or remediation actions. This criteria assumes that multiple actions completed in close proximity will provide a greater restoration benefit than actions done in isolation. Benefits may include functional or cost savings benefits.

Criterion	Score	Description
High	1	Action is contiguous with or adjacent to a completed or planned restoration or remediation action.
Medium	0.5	Action is not adjacent but geomorphically/ecologically contiguous to other completed or planned restoration or remediation actions.
Low	0	Action is isolated from other completed or planned restoration or remediation actions.

11. Benefit to Completed Restoration or Remediation Actions

This category documents if the Restoration Action provides benefits to completed restoration or remediation actions.

Criterion	Score	Description
High	1	Action improves condition or increases protection of a completed restoration or remediation action.
Medium	0.5	Action improves condition or increases protection of an area that buffers a completed restoration or remediation action.
Low	0	Action has no benefit completed restoration or remediation action.

Benefit to Completed Actions Considerations:

- Does the action improve the condition or function (i.e. land use change) of a previously remediated or restored area?
- Does the action increase short or long term protection of the completed restoration or remediation?
- Does the action increase short or long term protection of an area?

12. Results of Response Actions

This category documents what is necessary in the way of Restoration Actions in light of ongoing or planned response actions. Also, consideration of the degree of consistency between a restoration action and the response action. For example, if the Restoration Action poses a risk of recontaminating an area where Remedy has been completed. Risks to completed actions may include: increased streambank erosion, increased flooding potential, etc.

Criterion	Score	Description
High (0 risks checked)	1	Action has no risk to completed restoration or remediation actions.
Medium (1 to 3 risks identified)	0.5	Action has a moderate risk to completed restoration or remediation actions.
Low (more than 3 risks checked)	0	Action has many risks to completed restoration or remediation actions.

Risks to Completed Actions Considerations:

- Is the action immediately downstream of an unremediated area?
- Will the action increase erosion or flooding of a downstream unremediated area?
- Does the action require re-entering an area (that would result in disturbance) that was previously remediated or restored?
- Is the outcome of the action uncertain?

13. Benefits Multiple Resources(Ecosystem Considerations)

This category documents if the Restoration Action benefits multiple resources. This is evaluated using results from criteria 2, 3, 4 and 8 above.

Criterion	Score	Description
High (more than 3 benefits checked)	1	Action benefits many resources.
Medium (1 to 3 benefits checked)	0.5	Action benefits some resources.
Low (0 benefits checked)	0	Action benefits no resources.

Multiple Benefit Checklist:

- Ecological Benefit (Floodplain Processes)—check if High above
- Biological Benefit (Aquatic) —check if High above
- Biological Benefit (Terrestrial) —check if High above
- Adverse Socioeconomic Impacts—check if High above

14. Cost-Effectiveness

This category is evaluated based on the estimated cost of the action. To apply this criteria in a meaningful fashion benefits must also be considered, otherwise the focus is to narrow. For example, one restoration action may achieve its goal in a short period of time and another project that would restore the same resource at less cost but over a longer period of time. Costs are broken into sub-categories for this purpose. While many actions could be implemented at a smaller scale, all actions were assumed to be implemented at the scale of Reach A (or full implementation if outside of Reach A) as a maximum scenario for purposes of this ranking exercise. The maximum scenario translates to the scale that would be most beneficial and provides maximum restoration benefit.

Criterion	Score	Description
High	1	Cost is < $1 million dollars.
Medium	0.5	Action has moderate costs and/or costs are justified for the overall expected benefit of the action. Cost is estimated to be between $1 and $5 million dollars.
Low	0	Action has high costs or costs are not justified for the overall expected benefit of the action. Cost is estimated to be >$5 million dollars.

15. Benefit:Cost

This category examines the relationship of the expected costs of the proposed action to the expected benefits from the restoration. In other words, whether the Restoration Action's costs are commensurate with the benefits the action provides. Application of this criteria is not a straight forward cost/benefit analysis or ratio. Benefits are evaluated based on ecological, biological, and social benefits. Costs are based on a total cost that can be broken down by phase, acre, unit, etc. as high net benefit (1), commensurate (0.5), or low net benefit (0). This category was evaluated by assigning a high, medium, low score based on the average value of 'high priority' benefit categories ('Technical Feasibility' 'Ecological Benefit' 'Biological Benefit-Aquatic' 'Biological Benefit-Riparian' and 'Recovery Period') and 'Cost' category. The following table was used to determine the score for each category.

Benefit:Cost Scoring Table			
Average Score High Priority Categories (Technical Feasibility, Ecological Benefit, Biological Benefit – Aquatic, Biological Benefit – Riparian, and Recovery Period	Cost Category Score		
	High (1)	Medium (0.5)	Low (0)
Low 0-0.4 (0)	0.5	0	0
Medium 0.5 to 0.7 (.5)	1	0.5	0
High 0.8-1.0 (1)	1	1	0.5

Ranking of Restoration Actions

This section documents the information and process used to rank each of the actions for each category. The ranking of each criterion for each category is based on the assumption that remedial action designs will be similar to phases completed to date (see Appendix A and Appendix B).

Each category was evaluated within the spatial context of Reach A except for Category 13 'Clark Fork River Reaches B & C Aquatic Habitat Enhancement', which includes two reaches of the CFROU downstream of Reach A. To further refine boundaries of evaluation, an Estimated Removal Boundary was developed for all of Reach A (Attachment C). For phases where integrated remediation and restoration actions are complete, or in progress, the design removal boundary was used (Phase 1, 2, 5, 6, 15, and 16). For reaches where preliminary design analyses are complete, the preliminary design boundary was used (Phase 3, 4, and 7). For phases and areas where contamination investigations are complete, a brief review of pit data was used to estimate removal boundary (portions of Phase 8, portions of Phase 9 and Phases 13-14). For other phases, the removal boundary was estimated based on the Channel Migration Zone (CMZ) boundary identified by CDM and AGI (2013), slickens visible on aerial imagery, and known contamination patterns in nearby phases. The Estimated Removal Boundary allowed calculation of approximate removal volumes and acreages of treatment inside and outside of likely remediation extents within each phase. Estimated costs were developed for each evaluation category. Table 2 summarizes the data used to quantify and evaluate each Action. The details of the quantification analysis are provided as a separate document (*Clark Fork River Aquatic and Riparian Restoration Actions and Prioritization Analysis_Quantification, Geum et al. 2019*).

Table 3 provides a summary of criterion scores for each Restoration Action by ranking category. Figure 1 shows each Restoration Action in order from highest ranking to lowest ranking. The ranking of each Restoration Action is further described in the rest of this section.

Table 2. Summary of how each evaluation category was quantified and assessed to determine valuation criterion scores.

Restoration Action	Quantification and Evaluation Criteria
1: Additional Contamination Removal	• Used data on additional contaminated sediment removals done in completed/remediated phases and average cost of contaminated sediment removals in completed phases • 5% of area within Estimated Removal Boundary in unremediated phases assumed to be additional removal to a depth of 2 feet
2: Additional Revegetation (within Remedy Area)	• Used data on additional revegetation implemented in completed/remediated phases, average costs of revegetation in completed phases, and Estimated Removal Boundary • 2% of area within Estimated Removal Boundary in unremediated phases assumed to be additional revegetation
3: Floodplain Diversity Enhancement (within Remedy Area)	• Used data on average number of floodplain features such as side channels, backwater features and wetlands in completed/remediated phases, average cost of constructing floodplain features, and Estimated Removal Boundary area • Wetlands quantified by average area in acres and depth of excavation; side channels and backwater features quantified by average length in linear feet • Applies to areas within Estimated Removal Boundary in unremediated phases • *Note: this action does not include revegetation included in Action 2*
4: Restore Streambanks Ahead of Remediation	• Used data on average length of channel in completed/remediated phases, average streambank construction costs, estimated quantity of contaminated sediment removal associated with streambank reconstruction and construction costs associated with access to streambanks • Streambank restoration quantified in linear feet of streambank, using a restoration width of 50 feet of contaminated sediment removal behind bank to a depth of 2 feet, back-filled with 1 foot of clean material • Applied only to unremediated phases upstream of Deer Lodge/Phase 15
5: Remove High-risk Contaminated Sediments Ahead of Remediation	• Used data on quantities of contaminated sediment removals done in completed/remediated phases and average cost of contaminated sediment removals • High risk contaminated sediments were defined as slickens (contaminated sediment) that intercept the existing channel; these areas were quantified by their aerial extent (acres) and an assumed removal depth of 2 feet
6: Land Acquisition	• Used data on recent land purchase costs and land ownership • Potential land acquisitions included land parcels that met the following criteria: 1) intersect the 100-year floodplain; 2) include some portion of the Clark Fork River channel; and 3) > 30 acres
7: Conservation Easements	• Used data on recent easement costs and land ownership • Potential conservation easements included land parcels that met the following criteria: 1) intersect a 100 foot buffer on both sides of the Clark Fork River channel; 2) does not currently have an easement; and 3) includes public land but not National Park Service land
8: Riparian Vegetation Expansion (outside of Remedy Area)	• Used data on revegetation costs for completed phases, restoration opportunities observed on aerial imagery in unremediated phases, and area within 100-year Floodplain but outside of Estimated Removal Boundary • 15% of the area outside of the Estimated Removal Boundary but within the 100-year floodplain assumed to be available for conversion to riparian vegetation in all phases, both remediated and unremediated

9: Floodplain Diversity Enhancement (outside of Remedy Area)	• Used data on average cost of constructing floodplain features and restoration opportunities identified via aerial imagery in unremediated phases • Developed a per phase cost for constructing wetlands, floodplain woody debris and roughness, side channel construction, and wetland protection and applied that cost to all phases, complete and incomplete
10: Channel Relocation	• Used data on recent channel construction costs and channel relocation opportunities identified using aerial imagery in unremediated phases • Channel relocation quantified by linear feet of opportunity identified using aerial imagery
11: Reach A Aquatic Habitat Enhancement	• Estimated costs of potential aquatic habitat enhancement activities (i.e. mid-channel woody debris habitat structures, island bifurcation treatments, backwater enhancement, tributary confluence restoration, channel narrowing) to develop a per mile cost for aquatic habitat enhancement • Applied per mile cost to 20% of total river miles in Reach A
12: Modification of Mainstem Clark Fork River Diversion Structures	• Used data on irrigation infrastructure in need of improvements in Reach A, and average costs of recent diversion upgrades or fish screen installation • Assumes all problematic diversions would be treated
13: Clark Fork River Reaches B and C Aquatic Habitat Restoration	• Used data on Reach B and C Clark Fork River length, CMZ widths, and rip rap locations; estimated costs of identified restoration treatments (identified restoration treatments include: riprap removal, riprap revegetation, floodplain planting, floodplain/riparian fencing, habitat structures, and streambank construction) • Quantified restoration treatments by acreage or linear feet as applicable and applied estimated costs per treatment • Restoration treatments were limited to priority areas within Reaches B and C (Flint Creek to Rock Creek and Turah to Blackfoot River confluence)
16: Short and Long Term Management & Stewardship	• Used data on average cost of construction of completed phases and known costs of grazing leases, fencing, water gaps, and water stations for livestock • Determined cost to be 2% of average cost of construction for completed phases and applied that cost to all phases, complete and incomplete; compared this cost to estimated costs for activities listed above

Table 3. Ranking of restoration actions by fifteen criteria. Values in table are point values and not category values. Category 1= 1 point; Category 2 = 0.5 points; Category 3= 0 points. Restoration actions colored green are Tier I and restoration actions colored orange are Tier II. Tier III actions are ranked for prioritization.

Restoration Action		Level One (Priority Ranking)	Level Two Ranking Categories and Criterion Values															Total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
			Technical Feasibility	Ecological Benefit	Biological Benefit (Aquatic)	Biological Benefit (Terrestrial)	Adverse Environ-mental Impacts	Recovery Period	Rules and Laws	Adverse Socio-Economic Impacts	Data Gaps	Proximity to Other Actions	Benefit to Completed Actions	Risks to Completed Actions	Benefits Multiple Resources	Cost	Benefit: Cost	
1	Additional Contamination Removal	1	1	1	0	1	0.5	0.5	1	1	1	1	1	1	1	0	0	**12**
2	Additional Revegetation (within Remedy)	1	1	0.5	0.5	0.5	1	1	1	1	1	1	1	1	1	0.5	0.5	**13.5**
3	Floodplain Diversity Enhancement (within Remedy)	1	1	1	1	1	0.5	1	1	1	1	1	1	1	1	1	1	**15.5**
4	Restore Streambanks Ahead of Remediation	1	0.5	1	1	1	0.5	1	1	0.5	0	1	1	0.5	0.5	0	0.5	**11**
5	Remove High Risk Contaminated Sediments Ahead of Remediation	1	0.5	0.5	0.5	0	0.5	1	1	0	0	1	0.5	0.5	0	1	0	**8**
6	Land Acquisition	1	1	1	1	1	1	0.5	1	0.5	0	1	1	1	0	0	0	**11**
7	Conservation Easements	1	1	0.5	0.5	0.5	1	0.5	0.5	1	0	1	1	1	0	1	1	**11.5**
8	Riparian Vegetation Expansion (outside of Remedy)	0	0.5	0.5	0	0.5	1	0.5	1	1	0.5	0.5	0.5	1	0.5	0	0	**8**
9	Floodplain Diversity Enhancement (outside of Remedy)	0	1	1	0.5	1	1	0.5	0	0.5	0	0.5	0.5	0.5	0.5	0.5	1	**9**
10	Channel Relocation	0	1	1	1	0.5	0.5	1	0	0.5	0	1	1	0.5	0.5	0.5	1	**10**
11	Reach A Aquatic Habitat Enhancement	0	0.5	0.5	1	0.5	0.5	1	0	0.5	0	1	0.5	0.5	0.5	0.5	0.5	**8**
12	Modification of Mainstem Clark Fork River Diversion Structures	0	0.5	0	0.5	0	0.5	0.5	0	0.5	0	0.5	0.5	0.5	0	0.5	0	**4.5**
13	Clark Fork River Reaches B&C Aquatic Habitat Enhancement	0	0.5	1	1	1	0.5	0.5	0	0.5	0	0	0	1	1	0.5	1	**8.5**
16	Short and Long Term Management/Stewardship	1	1	0.5	0.5	0.5	1	0.5	1	0.5	1	1	1	1	0	0.5	0.5	**11.5**

Figure 1. Restoration actions total ranking and prioritization scores. Restoration actions colored green are Tier I and restoration actions colored orange are Tier II.

Restoration Action #1: Additional Contamination Removal

Evaluation Category	Description	Criterion	Score	Notes
Tier	Contribution to Achieving Remediation Goals	I	1	Action directly helps achieve remediation goals
1	Technical Feasibility	High	1	Action has been completed in the UCFRB
2	Ecological Benefit	High	1	3 or more benefits checked on Ecological Benefit Checklist
3	Biological Benefit (Aquatic)	Low	0	Assumed additional removals will occur outside of CMZ so minimal direct influence on aquatic biological resources
4	Biological Benefit (Terrestrial)	High	1	3 or more benefits checked on Terrestrial Biological Benefit Checklist
5	Adverse Environmental Impacts	Medium	0.5	Outside of CMZ so not directly along river but action would disturb a large area of ground therefore it poses some Environmental Impact risk
6	Recovery Period	Medium	0.5	Due to large area of disturbance Recovery Period is estimated to be between 5 and 10 years
7	Federal, State, Tribal Policies, Rules, and Laws	High	1	Any additional contamination removal would be integrated with Remedial Actions and therefore covered by CERCLA/Superfund
8	Adverse Socioeconomic Impacts	High	1	Action does not add to any Social Impact outside of what Remedial Actions will impose
9	Data Gaps	High	1	Very few Data Gaps expected (assumed that test pit data will be available through Remedial Action investigations)
10	Proximity to Other Restoration or Remediation Actions	High	1	Action will occur immediately adjacent to Remedial Actions
11	Benefit to Completed Restoration or Remediation Actions	High	1	Action increases Protection of Completed Remedial Actions and builds on goals of Remedy
12	Risks to Completed Restoration or Remediation Actions	High	1	Action poses no Risk to Completed Restoration or Remedial Actions
13	Benefits Multiple Resources	High	1	Action has a ‘High’ score for Ecological, Terrestrial, and Social, but not Aquatic
14	Cost	Low	0	Completing the Action for all of Reach A is estimated to be greater than $5 million
15	Benefit:Cost	Low	0	Average Score High Priority Benefit Categories = 0.7; Cost = 0
		Total	**12**	

Restoration Action #2: Additional Revegetation (within Remedy or Contamination Removal Areas)

Evaluation Category	Description	Criterion	Score	Notes
Tier	Contribution to Achieving Remediation Goals	I	1	Action directly helps achieve remediation goals
1	Technical Feasibility	High	1	Most activities listed under this Action have been completed in the UCFRB
2	Ecological Benefit	Medium	0.5	1 to 3 benefits checked on Ecological Benefit Checklist and scale of Action is relatively small
3	Biological Benefit (Aquatic)	Medium	0.5	1 to 3 benefits checked on Aquatic Biological Benefit Checklist and scale of Action is relatively small
4	Biological Benefit (Terrestrial)	Medium	0.5	1 to 3 benefits checked on Terrestrial Biological Benefit Checklist and scale of Action is relatively small
5	Adverse Environmental Impacts	High	1	Action has no expected Adverse Environmental Impacts
6	Recovery Period	High	1	Recovery Period is estimated to be less than 5 years
7	Federal, State, Tribal Policies, Rules, and Laws	High	1	Most activities would be integrated with Remedial Actions and therefore covered by CERCLA/Superfund
8	Adverse Socioeconomic Impacts	High	1	No Social Impacts are expected
9	Data Gaps	High	1	Very few Data Gaps expected (assumed that grading plans and substrate details will be available through Remedial Action investigations)
10	Proximity to Other Restoration or Remediation Actions	High	1	Action will occur immediately adjacent to Remedial Actions
11	Benefit to Completed Restoration or Remediation Actions	High	1	Action increases protection of Remedial Actions and builds on goals of Remedy
12	Risks to Completed Restoration or Remediation Actions	High	1	Action poses no Risk to Completed Restoration or Remedial Actions
13	Benefits Multiple Resources	High	1	Action has a 'High' score for Ecological, Aquatic, Terrestrial, and Social
14	Cost	High	0.5	Completing the Action for all of Reach A is estimated to be less than $1 million
15	Benefit:Cost	Medium	0.5	Average Score High Priority Benefit Categories = 0.7; Cost = 0.5
		Total	**13.5**	

Restoration Action #3: Floodplain Diversity Enhancement (within Remedy or Contamination Removal Areas)

Evaluation Category	Description	Criterion	Score	Notes
Tier	Contribution to Achieving Remediation Goals	I	1	Action directly helps achieve remediation goals
1	Technical Feasibility	High	1	Most activities listed under this Action have been completed in the UCFRB
2	Ecological Benefit	High	1	3 or more benefits checked on Ecological Benefit Checklist
3	Biological Benefit (Aquatic)	High	1	3 or more benefits checked on Aquatic Biological Benefit Checklist
4	Biological Benefit (Terrestrial)	High	1	3 or more benefits checked on Terrestrial Biological Benefit Checklist
5	Adverse Environmental Impacts	Medium	0.5	Action has some expected short-term Adverse Environmental Impacts (i.e. potential downstream flood scour risk)
6	Recovery Period	High	1	Recovery Period is estimated to be less than 5 years
7	Federal, State, Tribal Policies, Rules, and Laws	High	1	Most activities would be integrated with Remedial Actions and therefore covered by CERCLA/Superfund
8	Adverse Socioeconomic Impacts	High	1	No Social Impacts are expected
9	Data Gaps	High	1	Very few Data Gaps expected (assumed that grading plans and substrate details will be available through Remedial Action investigations)
10	Proximity to Other Restoration or Remediation Actions	High	1	Action will occur immediately adjacent to Remedial Actions
11	Benefit to Completed Restoration or Remediation Actions	High	1	Action increases Protection of Completed Remedial Actions and builds on goals of Remedy
12	Risks to Completed Restoration or Remediation Actions	High	1	Action poses no Risk to Completed Restoration or Remedial Actions
13	Benefits Multiple Resources	High	1	Action has a 'High' score for Ecological, Aquatic, Terrestrial, and Social
14	Cost	High	1	Completing the Action for all of Reach A is estimated to be less than $1 million
15	Benefit:Cost	High	1	Average Score High Priority Benefit Categories = 1; Cost = 1
		Total	**15.5**	

Restoration Action #4: Restore Streambanks Ahead of Remediation

Evaluation Category	Description	Criterion	Score	Notes
Tier	Contribution to Achieving Remediation Goals	I	1	Action directly helps achieve remediation goals
1	Technical Feasibility	Medium	0.5	Streambanks have been constructed in the UCFRB but not ahead of Remedial Actions
2	Ecological Benefit	High	1	3 or more benefits checked on Ecological Benefit Checklist
3	Biological Benefit (Aquatic)	High	1	3 or more benefits checked on Aquatic Biological Benefit Checklist
4	Biological Benefit (Terrestrial)	High	1	3 or more benefits checked on Terrestrial Biological Benefit Checklist
5	Adverse Environmental Impacts	Medium	0.5	Action has some expected short-term Adverse Environmental Impacts (i.e. potential risk of re-contaminating clean streambanks or entrainment of exposed tailings during high flows)
6	Recovery Period	High	1	Recovery Period is estimated to be less than 5 years
7	Federal, State, Tribal Policies, Rules, and Laws	High	1	Action is a Remedial Action and would therefore be covered by CERCLA/Superfund
8	Adverse Socioeconomic Impacts	Low	0.5	Action will be done ahead of Remedial Action so there could be several Social Impacts such as longer periods of access and use restriction compared to Remedial Action alone; however resource recovery period shortened
9	Data Gaps	Low	0	Several Data Gaps are expected (assumes that action will be done prior to Remedial Action investigations)
10	Proximity to Other Restoration or Remediation Actions	High	1	Action occurs within Remedial Action area
11	Benefit to Completed Restoration or Remediation Actions	High	1	Action increases Protection of Completed Remedial Actions and builds on goals of Remedy
12	Risks to Completed Restoration or Remediation Actions	Medium	0.5	Action poses some Risk to Completed Restoration or Remedial Actions
13	Benefits Multiple Resources	Medium	0.5	Action has a 'High' score for Ecological, Aquatic, and Terrestrial, but not Social Resources
14	Cost	Low	0	Completing the Action for all of Reach A is estimated to be between $1 million and $10 million
15	Benefit:Cost	Medium	0.5	Average Score High Priority Benefit Categories = 0.9; Cost = 0.5
		Total	**11**	

Restoration Action #5: Remove High-Risk Contaminated Sediments Ahead of Remediation

Evaluation Category	Description	Criterion	Score	Notes
Tier	Contribution to Achieving Remediation Goals	I	1	Action directly helps achieve remediation goals
1	Technical Feasibility	Medium	0.5	Contaminated sediments have been removed in the UCFRB but not independent of full Remediation Actions
2	Ecological Benefit	Medium	0.5	1 to 3 benefits checked on Ecological Benefit Checklist
3	Biological Benefit (Aquatic)	Medium	0.5	1 to 3 benefits checked on Aquatic Biological Benefit Checklist
4	Biological Benefit (Terrestrial)	Low	0	0 benefits checked on Terrestrial Biological Benefit Checklist, action does not include revegetation of new floodplain
5	Adverse Environmental Impacts	Medium	0.5	Action has some expected short-term Adverse Environmental Impacts (i.e. potential risk of re-contaminating clean areas or entrainment of exposed tailings during high flows)
6	Recovery Period	High	1	Recovery Period is estimated to be greater than 10 years; however, high risk contaminated sediments would be removed allowing recovery to happen sooner
7	Federal, State, Tribal Policies, Rules, and Laws	High	1	Action is a Remedial Action and would therefore be covered by CERCLA/Superfund
8	Adverse Socioeconomic Impacts	Low	0	Action will be done ahead of Remedial Action so there could be several Social Impacts such as longer periods of access and use restriction compared to Remedial Action alone
9	Data Gaps	Low	0	Several Data Gaps are expected (assumes that action will be done prior to Remedial Action investigations)
10	Proximity to Other Restoration or Remediation Actions	High	1	Action occurs within Remedial Action area
11	Benefit to Completed Restoration or Remediation Actions	Medium	0.5	Action has some Benefits to Completed Remedial Actions, but treated areas will need to be worked around when rest of Remedial Actions are completed
12	Risks to Completed Restoration or Remediation Actions	Medium	0.5	Action poses some Risk to Completed Restoration or Remedial Actions because cleaned up areas will need to be accessed again to completed Remediation
13	Benefits Multiple Resources	Low	0	Action has no 'High' score for Ecological, Aquatic, Terrestrial, or Social Resources
14	Cost	High	1	Completing the Action for all of Reach A is estimated to be less than $1 million
15	Benefit:Cost	Low	0	Average Score High Priority Benefit Categories = 0.5; Cost = 0
		Total	**8**	

Restoration Action #6: Land Acquisition

Evaluation Category	Description	Criterion	Score	Notes
Tier	Contribution to Achieving Remediation Goals	I	1	Action directly helps achieve remediation goals
1	Technical Feasibility	High	1	This type of Action has been completed in the UCFRB
2	Ecological Benefit	High	1	Between 1 and 3 benefits checked on Ecological Benefit Checklist
3	Biological Benefit (Aquatic)	High	1	Between 1 and 3 benefits checked on Aquatic Biological Benefit Checklist
4	Biological Benefit (Terrestrial)	High	1	Between 1 and 3 benefits checked on Terrestrial Biological Benefit Checklist
5	Adverse Environmental Impacts	High	1	Action has no expected Adverse Environmental Impacts
6	Recovery Period	Medium	0.5	Recovery Period is estimated to be between 5 and 10 years (recovery from previous land use activities)
7	Federal, State, Tribal Policies, Rules, and Laws	High	1	No Rules or Laws outside of normal property acquisition anticipated
8	Adverse Socioeconomic Impacts	Medium	0.5	Some Social Impacts may occur
9	Data Gaps	Low	0	Several Data Gaps need to be filled related to property acquisition including appraisals, water rights, vegetation surveys, etc.
10	Proximity to Other Restoration or Remediation Actions	High	1	Action will occur within Remedial Action areas
11	Benefit to Completed Restoration or Remediation Actions	High	1	Action increases protection of Remedial Actions and builds on goals of Remedy
12	Risks to Completed Restoration or Remediation Actions	High	1	Action poses no Risk to Completed Restoration or Remedial Actions
13	Benefits Multiple Resources	Low	0	Action has no 'High' scores for Ecological, Aquatic, Terrestrial, or Social Resources
14	Cost	Low	0	Completing the Action for all of Reach A is estimated to be greater than $5 million
15	Benefit:Cost	Low	0	Average Score High Priority Benefit Categories = 0.9; Cost = 0
		Total	**11**	

Restoration Action #7: Conservation Easements

Evaluation Category	Description	Criterion	Score	Notes
Tier	Contribution to Achieving Remediation Goals	I	1	Action directly helps achieve remediation goals
1	Technical Feasibility	High	1	This type of Action has been completed in the UCFRB
2	Ecological Benefit	Medium	0.5	Between 1 and 3 benefits checked on Ecological Benefit Checklist
3	Biological Benefit (Aquatic)	Medium	0.5	Between 1 and 3 benefits checked on Aquatic Biological Benefit Checklist
4	Biological Benefit (Terrestrial)	Medium	0.5	Between 1 and 3 benefits checked on Terrestrial Biological Benefit Checklist
5	Adverse Environmental Impacts	High	1	Action has no expected Adverse Environmental Impacts
6	Recovery Period	Medium	0.5	Recovery Period is estimated to be between 5 and 10 years (recovery from previous land use activities)
7	Federal, State, Tribal Policies, Rules, and Laws	Medium	0.5	Easements may be subject to MEPA process
8	Adverse Socioeconomic Impacts	High	1	No Social Impacts are expected
9	Data Gaps	Low	0	Several Data Gaps need to be filled related to placing property in a conservation easement including appraisals, water rights, vegetation surveys, etc.
10	Proximity to Other Restoration or Remediation Actions	High	1	Action will occur within Remedial Action areas
11	Benefit to Completed Restoration or Remediation Actions	High	1	Action increases protection of Remedial Actions and builds on goals of Remedy
12	Risks to Completed Restoration or Remediation Actions	High	1	Action poses no risk to completed Restoration or Remedial Actions
13	Benefits Multiple Resources	Low	0	Action has no 'High' scores for Ecological, Aquatic, Terrestrial, or Social Resources
14	Cost	High	1	Completing the Action for all of Reach A is estimated to be less than $1 million
15	Benefit:Cost	High	1	Average Score High Priority Benefit Categories = 0.6; Cost = 1
		Total	**11.5**	

Restoration Action #8: Riparian Vegetation Expansion (outside of Remedy or Contamination Removal Areas)

Evaluation Category	Description	Criterion	Score	Notes
Tier	Contribution to Achieving Remediation Goals	II	0	Action does not directly helps achieve remediation goals
1	Technical Feasibility	Medium	0.5	Most activities listed under this Action are known to be technically feasible but have not been completed in the UCFRB
2	Ecological Benefit	Medium	0.5	1 to 3 benefits checked on Ecological Benefit Checklist
3	Biological Benefit (Aquatic)	Low	0	0 aquatic benefits checked on Aquatic Benefit Checklist (actions are outside of CMZ and therefore not close to the river channel)
4	Biological Benefit (Terrestrial)	Medium	0.5	1 to 3 benefits checked on Terrestrial Biological Benefit Checklist
5	Adverse Environmental Impacts	High	1	Action has no expected Adverse Environmental Impacts
6	Recovery Period	Medium	0.5	Recovery Period is estimated to be between 5 and 10 years
7	Federal, State, Tribal Policies, Rules, and Laws	High	1	No Rules or Laws expected to apply
8	Adverse Socioeconomic Impacts	High	1	No Social Impacts are expected
9	Data Gaps	Medium	0.5	Very little data is available related to activities identified under this Action, but data needs are minor so some Data Gaps exist
10	Proximity to Other Restoration or Remediation Actions	Medium	0.5	Action will occur in Reach A Clark Fork River floodplain, but may not be immediately adjacent to Remedial Actions
11	Benefit to Completed Restoration or Remediation Actions	Medium	0.5	Action has some Benefits to Completed Remediation and Restoration Actions
12	Risks to Completed Restoration or Remediation Actions	High	1	Action poses no risk to completed Restoration or Remedial Actions
13	Benefits Multiple Resources	Medium	0.5	Action has a 'High' score for Social and Medium for Ecological, Aquatic, and Terrestrial
14	Cost	Low	0	Completing the Action for all of Reach A is estimated to be more than $5 million
15	Benefit:Cost	Low	0	Average Score High Priority Benefit Categories = 0.4; Cost = 0
		Total	**8**	

Restoration Action #9: Floodplain Diversity Enhancement (outside of Remedy or Contamination Removal Areas)

Evaluation Criteria	Description	Category	Score	Notes
Tier	Contribution to Achieving Remediation Goals	II	0	Action does not directly helps achieve remediation goals
1	Technical Feasibility	High	1	Most activities listed under this Action have been completed in the UCFRB
2	Ecological Benefit	High	1	3 or more benefits checked on Ecological Benefit Checklist
3	Biological Benefit (Aquatic)	Medium	0.5	1 to 3 benefits checked on Aquatic Benefit Checklist (assumes actions are outside of CMZ and not directly connected to river)
4	Biological Benefit (Terrestrial)	High	1	3 or more benefits checked on Terrestrial Biological Benefit Checklist
5	Adverse Environmental Impacts	High	1	Action has no expected Adverse Environmental Impacts
6	Recovery Period	Medium	0.5	Recovery Period is estimated to be between 5 and 10 years
7	Federal, State, Tribal Policies, Rules, and Laws	Low	0	Several permits would be required to complete activities identified under this Action
8	Adverse Socioeconomic Impacts	Medium	0.5	Action may have a few Social Impacts related to loss of access and use during implementation and recovery periods
9	Data Gaps	Low	0	Very little data is available related to activities identified under this Action so several Data Gaps exist, assumes actions are done independently of Remedial Actions
10	Proximity to Other Restoration or Remediation Actions	Medium	0.5	Action will occur in Reach A Clark Fork River floodplain, but may not be immediately adjacent to Remedial Actions
11	Benefit to Completed Restoration or Remediation Actions	Medium	0.5	Action has some Benefits to Completed Remediation and Restoration Actions
12	Risks to Completed Restoration or Remediation Actions	Medium	0.5	Action poses some potential Risk to Completed Restoration or Remedial Actions (i.e. re-entry to completed sites, increased flood routing)
13	Benefits Multiple Resources	Medium	0.5	Action has a 'High' score for Ecological and Terrestrial, but not Aquatic or Social
14	Cost	Medium	0.5	Completing the Action for all of Reach A is estimated to be between $1 million and $5 million
15	Benefit:Cost	High	1	Average Score High Priority Benefit Categories = 0.8; Cost = 0.5
		Total	**9**	

Restoration Action #10: Channel Relocation

Evaluation Criteria	Description	Category	Score	Notes
Tier	Contribution to Achieving Remediation Goals	II	0	Action does not directly help achieve remediation goals
1	Technical Feasibility	High	1	Channel relocation has been designed and implemented in the UCFRB
2	Ecological Benefit	High	1	3 or more benefits checked on Ecological Benefit Checklist
3	Biological Benefit (Aquatic)	High	1	3 or more benefits checked on Aquatic Benefit Checklist (assumes actions are outside of CMZ and not directly connected to river)
4	Biological Benefit (Terrestrial)	Medium	0.5	1 to 3 benefits checked on Terrestrial Biological Benefit Checklist
5	Adverse Environmental Impacts	Medium	0.5	Action has some expected Adverse Environmental Impacts (sediment entrainment, potential increased flooding risk)
6	Recovery Period	High	1	Recovery Period is estimated to be less than 5 years
7	Federal, State, Tribal Policies, Rules, and Laws	Low	0	Several permits would be required to complete activities identified under this Action
8	Adverse Socioeconomic Impacts	Medium	0.5	Action may have a few Social Impacts related to loss of access and use during implementation and recovery periods
9	Data Gaps	Low	0	Very little data is available related to channel relocation opportunities or design so several Data Gaps exist
10	Proximity to Other Restoration or Remediation Actions	High	1	Action will occur within Remedial Action areas or could relocate channel out of Remedial Action area
11	Benefit to Completed Restoration or Remediation Actions	High	1	Action has several Benefits to Completed Remediation and Restoration Actions
12	Risks to Completed Restoration or Remediation Actions	Medium	0.5	Action poses some potential Risk to Completed Restoration or Remedial Actions (i.e. increased flood routing)
13	Benefits Multiple Resources	Medium	0.5	Action has a ‘High’ score for Ecological and Aquatic, but not Terrestrial or Social Resources
14	Cost	Medium	0.5	Completing the Action for all of Reach A is estimated to be between $1 million and $5 million
15	Benefit:Cost	High	1	Average Score High Priority Benefit Categories = 0.9; Cost = 0.5
		Total	**10**	

Restoration Action #11: Reach A Aquatic Habitat Enhancement

Evaluation Criteria	Description	Category	Score	Notes
Tier	Contribution to Achieving Remediation Goals	II	0	Action does not directly help achieve remediation goals
1	Technical Feasibility	Medium	0.5	Some aquatic habitat enhancement activities included in this Action have been completed in the UCFRB
2	Ecological Benefit	Medium	0.5	1 to 3 benefits checked on Ecological Benefit Checklist
3	Biological Benefit (Aquatic)	High	1	3 or more benefits checked on Aquatic Benefit Checklist (assumes actions are outside of CMZ and not directly connected to river)
4	Biological Benefit (Terrestrial)	Medium	0.5	1 to 3 benefits checked on Terrestrial Biological Benefit Checklist
5	Adverse Environmental Impacts	Medium	0.5	Action has some expected Adverse Environmental Impacts (sediment entrainment, potential increased flooding risk)
6	Recovery Period	High	1	Recovery Period is estimated to be less than 5 years
7	Federal, State, Tribal Policies, Rules, and Laws	Low	0	Several permits would be required to complete activities identified under this Action
8	Adverse Socioeconomic Impacts	Medium	0.5	Action may have a few Social Impacts related to loss of access and use during implementation and recovery periods
9	Data Gaps	Low	0	Very little data is available related to aquatic habitat enhancement opportunities so several Data Gaps exist
10	Proximity to Other Restoration or Remediation Actions	High	1	Action will occur within Remedial Action areas
11	Benefit to Completed Restoration or Remediation Actions	Medium	0.5	Action has some Benefits to Completed Remediation and Restoration Actions
12	Risks to Completed Restoration or Remediation Actions	Medium	0.5	Action poses some potential Risk to Completed Restoration or Remedial Actions (i.e. sediment entrainment)
13	Benefits Multiple Resources	Medium	0.5	Action has a 'High' score for Aquatic, but not for Ecological, Terrestrial, or Social Resources
14	Cost	Medium	0.5	Completing the Action for all of Reach A is estimated to be between \$1 million and \$5 million
15	Benefit:Cost	Medium	0.5	Average Score High Priority Benefit Categories = 0.7; Cost = 0.5
		Total	**8**	

Restoration Action #12: Modification of Mainstem Clark Fork River Diversion Structures

Evaluation Criteria	Description	Category	Score	Notes
Tier	Contribution to Achieving Remediation Goals	II	0	Action does not directly help achieve remediation goals
1	Technical Feasibility	Medium	0.5	Technical Feasibility is generally known for this Action but may not have been completed in the UCFRB
2	Ecological Benefit	Low	0	0 benefits checked on Ecological Benefit Checklist
3	Biological Benefit (Aquatic)	Medium	0.5	1 to 3 benefits checked on Aquatic Biological Benefit Checklist
4	Biological Benefit (Terrestrial)	Low	0	0 benefits checked on Terrestrial Biological Benefit Checklist
5	Adverse Environmental Impacts	Medium	0.5	Some short-term Adverse Environmental Impacts associated with Action
6	Recovery Period	Medium	0.5	Recovery Period is estimated to be between 5 and 10 years
7	Federal, State, Tribal Policies, Rules, and Laws	Low	0	Several permits would be required to complete activities identified under this Action
8	Adverse Socioeconomic Impacts	Medium	0.5	Action may have a few Social Impacts related to loss of access and use during implementation
9	Data Gaps	Low	0	Some data is available on mainstem Clark Fork River diversions and ditches that pose a risk to passage or entrainment but no survey or design data have been collected so several Data Gaps exist
10	Proximity to Other Restoration or Remediation Actions	Medium	0.5	Action may occur within Clark Fork River immediately adjacent to Remediation Actions
11	Benefit to Completed Restoration or Remediation Actions	Medium	0.5	Action may have some benefits to completed Remedial Actions through overall cumulative benefits to aquatic habitat
12	Risks to Completed Restoration or Remediation Actions	Medium	0.5	Action poses some risk to completed Restoration or Remedial Actions
13	Benefits Multiple Resources	Low	0	Action has no 'High' scores for Ecological, Aquatic, Terrestrial, or Social resources
14	Cost	Medium	0.5	Completing the Action for all identified diversions and ditches would be between \$1 million and \$5 million
15	Benefit:Cost	High	0	Average Score High Priority Benefit Categories = 0.3; Cost = 0.5
		Total	**4.5**	

Restoration Action #13: Clark Fork River Reaches B&C Aquatic Habitat Restoration

Evaluation Criteria	Description	Category	Score	Notes
Tier	Contribution to Achieving Remediation Goals	II	0	Action does not directly help achieve remediation goals
1	Technical Feasibility	Medium	0.5	Technical feasibility of most activities identified for this Action are known but have been completed in the UCFRB
2	Ecological Benefit	High	1	3 or more benefits checked on Ecological Benefit Checklist; assumes Action is being completed at a scale that maximizes ecological benefit
3	Biological Benefit (Aquatic)	High	1	3 or more benefits checked on Aquatic Biological Benefit Checklist; assumes Action is being completed at a scale that maximizes aquatic benefit
4	Biological Benefit (Terrestrial)	High	1	3 or more benefits checked on Terrestrial Biological Benefit Checklist; assumes Action is being completed at a scale that maximizes floodplain habitat
5	Adverse Environmental Impacts	Medium	0.5	Some short-term Adverse Environmental Impacts associated with Action
6	Recovery Period	Medium	0.5	Recovery Period is estimated to be between 5 and 10 years
7	Federal, State, Tribal Policies, Rules, and Laws	Low	0	Several permits would be required to complete activities identified under this Action
8	Adverse Socioeconomic Impacts	Medium	0.5	Action may have a few Social Impacts related to loss of access and use during implementation and recovery periods
9	Data Gaps	Low	0	Very little data is available for Reaches B & C related to activities identified under this Action so several Data Gaps exist
10	Proximity to Other Restoration or Remediation Actions	Low	0	Action does not occur within Reach A
11	Benefit to Completed Restoration or Remediation Actions	Low	0	Action does not protect or directly benefit Remedial Actions
12	Risks to Completed Restoration or Remediation Actions	High	1	Action poses no risk to completed Restoration or Remedial Actions
13	Benefits Multiple Resources	High	1	Action has a 'High' score for Ecological, Aquatic, and Terrestrial, but not Social
14	Cost	Low	0	Completing the Action to a scale that maximizes ecological, aquatic, and terrestrial benefits is estimated to be greater than $5 million
15	Benefit:Cost	High	1	Average Score High Priority Benefit Categories = 0.8; Cost = 0.5
		Total	**8.5**	

Restoration Action #16: Short and Long Term Management/Stewardship

Evaluation Criteria	Description	Category	Score	Notes
Tier	Contribution to Achieving Remediation Goals	I	1	Action directly helps achieve remediation goals
1	Technical Feasibility	High	1	An adaptative management program is in place for UCFRB
2	Ecological Benefit	Medium	0.5	1 to 3 benefits checked on Ecological Benefit Checklist; assumes activities under this action are passive
3	Biological Benefit (Aquatic)	Medium	0.5	1 to 3 benefits checked on Aquatic Biological Benefit Checklist; assumes activities under this action are passive
4	Biological Benefit (Terrestrial)	Medium	0.5	1 to 3 benefits checked on Terrestrial Biological Benefit Checklist; assumes activities under this action are passive
5	Adverse Environmental Impacts	High	1	Action has no expected Adverse Environmental Impacts
6	Recovery Period	Medium	0.5	Recovery is expected to occur within 5 to 10 years, assumes Action only includes passive activities such as land management changes
7	Federal, State, Tribal Policies, Rules, and Laws	High	1	No Laws or Rules expected to apply
8	Adverse Socioeconomic Impacts	Medium	0.5	Social Impacts may occur related to coordinating management actions with private land owners
9	Data Gaps	High	1	No additional data needed, assumes that management actions are tied to adaptive management program and monitoring data has identified action
10	Proximity to Other Restoration or Remediation Actions	High	1	Occurs within Remedial Action area
11	Benefit to Completed Restoration or Remediation Actions	High	1	Action has several benefits to completed Remediation and Restoration Actions
12	Risks to Completed Restoration or Remediation Actions	High	1	Action poses no risk to completed Restoration or Remedial Actions
13	Benefits Multiple Resources	Low	0	Action has no ‘High’ scores for Ecological, Aquatic, Terrestrial, or Social Resources
14	Cost	Medium	0.5	Completing the Action for all of Reach A would be between $1 million and $5 million
15	Benefit:Cost	Medium	0.5	Average Score High Priority Benefit Categories = 0.6; Cost = 0.5
		Total	**11.5**	

Additional Remedy/Restoration Design Refinements

In addition to the restoration actions identified and prioritized in previous sections, several additional actions that could lower the cost and increase the effectiveness of remedial and restoration actions were also identified. The following considerations/actions should be investigated as ways to determine additional remaining integrated Remedy/Restoration action costs and the associated direct savings to integrated Remedy/Restoration costs:

1. Design floodplains to be at lower elevations relative to Clark Fork River hydrology. As part of remedial/restoration designs completed for CFROU phases since 2011, floodplain elevations have been set relative to the 2-year return flow water surface elevation (Q2). While portions of the floodplain, including point bars, some near-bank areas, wetlands and swales have been designed at elevations below Q2, the majority of floodplain areas have been designed at or above Q2. This has resulted in some floodplain areas supporting predominantly upland vegetation, rather than more desirable riparian/wetland plant species. In addition, rebuilding the floodplain at a higher elevation requires greater volumes of imported borrow material. Based on observations from completed CFROU phases, it is clear that designing floodplain surfaces at a slightly lower elevations relative to Q2 would result in better remedial/restoration outcomes while saving money.
2. Consider seed-based restoration to reduce overall revegetation costs. Effective revegetation is an important objective for both remediation and restoration. Currently, to support revegetation, native riparian and wetland plants are grown in specialized nurseries, from locally collected seed. Nursery-grown plants are then installed by experienced planting crews within specific time windows that are constrained by hydrology and plant dormancy. While this multi-step process will likely always be necessary to achieve effective revegetation outcomes for many target species, recent developments in seed-based restoration suggest an opportunity to direct seed some species such as willows and cottonwoods. Because these species naturally establish from seed on exposed floodplain soils, adding seed-based restoration as a revegetation tool has potential to still meet revegetation objectives while reducing nursery and planting costs.
3. Use a shorter projected channel migration timeframe to determine the Channel Migration Zone (i.e. 80-year timeframe rather than 100-year timeframe for anticipated channel movement). This would result in a slightly narrower tailings removal zone, ultimately translating to a smaller remedial/restoration project footprint and lower costs.
4. Increase floodplain depression/flow path features for reduced fill volumes and increased connectivity/natural revegetation. In general, increasing surface hydrology connection between the river and floodplain will result in more effective and rapid revegetation, and quicker development of more diverse habitat.
5. Refine methods to develop design removal surface to avoid unnecessary over-excavation.
6. Increase use of wood - and root mass- based bank treatments that incorporate habitat elements. Early completed phases made substantial use of coir-based bioengineering treatments. While these bank treatments support vegetation establishment on river banks, they result in fairly uniform habitat along bank lines and provide little overhanging cover. Wood-based bank treatments are increasingly being used in river restoration, including on more recent CFROU phases, and would be an important step to address concerns about simplified aquatic habitat resulting from remedial/restoration efforts to date.

7. Identify additional and better borrow sources. Borrow sources used on completed phases have been either subsoils from lacustrine deposits or have had high sand content and therefore little water holding capacity. All borrow sources identified to date have low organic matter and require addition of compost to meet organic matter requirements. Identifying better borrow sources near yet to be completed phases could result in better remedial/restoration outcomes, cost savings from shorter hauling distances and possibly reduced need for compost.
8. Identify additional repositories closer to the project phases. Hauling tailings is a significant project cost, and as remedial/restoration work moves further down river, the haul distance to Opportunity Ponds (the current repository) increases. Identifying alternate repository locations with shorter haul distances could reduce project costs.

Data Gaps

Several key data gaps need to be addressed to better support future designs of Remedy/Restoration Actions and to further characterize stand-alone restoration opportunities. The current work flow is to begin detailed site investigations once a phase has been identified as an upcoming project, but general knowledge about Reach A is limited to existing information which sometimes dates back to when the ROD was being developed. More accurate knowledge about how much additional tailings volume needs to be removed, where high value habitats are located, and locations of important restoration opportunities would help the agencies implement long-term planning and budgeting, and reduce uncertainty about whether remaining funds are sufficient to accomplish the combined remediation/restoration work yet to be completed.

1. Refine hydrology – Q2 and Q1.5, including field calibrating hydrologic/hydraulic model
2. Identify contamination depths and extents in unsampled reaches
3. Investigate and determine where high functioning floodplain environments and unique plant communities exist in reaches that have not been investigated for purposes of restoring, re-building, preserving ahead of remedy or when remedy occurs
4. Overlay restoration opportunities on remediation designs or estimated contamination removal extents to identify hot zones for restoration
5. Collect current Reach A LiDAR and bathymetry
6. Assess aquatic habitat to identify how and where physical habitat is a limiting factor

References

CDM et al. 2016. Clark Fork River Reach A Design Approach. Memorandum prepared for Montana Department of Environmental Quality by CDM Smith, Applied Geomorphology, Inc. and Geum Environmental Consulting, Inc.

CDM. 2013. Cost Estimate for Clark Fork River Operable Unit Explanation of Significant Differences. Memorandum prepared for Montana Department of Environmental Quality by CDM Smith

CDM and AGI. 2013. Clark Fork River Operable Unit Milltown Reservoir/Clark Fork River Superfund Site Powell, Deer Lodge, and Granite Counties Geomorphology and Hydrology of Reach A. Prepared for Department of Environmental Quality by CDM Smith and Applied Geomorphology, Inc.

DEQ and EPA. 2015. Clark Fork River Operable Unit (OU #3) Milltown Reservoir/Clark Fork River Superfund Site CERCLIS Identification Number: MTD980717565 Explanation of Significant Differences. Prepared by Montana Department of Natural Resources, Helena, MT and U.S. Environmental Protection Agency Region 8, Helena, Montana.

Geum Environmental Consulting, Inc. (Geum), Applied Geomorphology, Inc. (AGI), and TetraTech. 2019. Clark Fork River Aquatic and Riparian Restoration Actions and Prioritization Analysis_Quantification. A spreadsheet analysis prepared to quantify the Clark Fork River Aquatic and Riparian Restoration Actions and Prioritization.

Geum Environmental Consulting, Inc. (Geum) and Applied Geomorphology, Inc. (AGI). 2015. Clark Fork River Operable Unit Reach A, Geomorphology and Vegetation Monitoring Plan: Clark Fork Site. Report prepared for Montana Department of Environmental Quality, Remediation Division.

U.S. Environmental Protection Agency (EPA). 2004. Clark Fork River Operable Unit Record of Decision.

Natural Resource Damage Program. 2018. Upper Clark Fork River Basin Aquatic and Terrestrial Resources Restoration Plans. Draft Updated November 2018 Public Comment Version. Montana Department of Justice, Natural Resource Damage Program, Helena, MT.

NRDP. 2007. State of Montana’s Revised Restoration Plan for the Clark Fork River Aquatic and Riparian Resources. Montana Department of Justice, Natural Resource Damage Program, Helena, MT.

Attachment A. Explanation of Significant Differences

Clark Fork River Operable Unit (OU #3)
Milltown Reservoir/Clark Fork River Superfund Site
CERCLIS Identification Number: MTD980717565

Explanation of Significant Differences

Montana Department of Environmental Quality
1225 Cedar Street
P.O. Box 200901
Helena, MT 59620

U.S. Environmental Protection Agency Region 8
10 West 15th Street, Suite 3200
Helena, Montana 59626

June 2015

1.0 INTRODUCTION AND STATEMENT OF PURPOSE

This document presents an Explanation of Significant Differences (ESD) for the Record of Decision (ROD) for the Clark Fork River Operable Unit (CFR OU) of the Milltown Reservoir/Clark Fork River Superfund Site. The CFR OU ROD was issued in April 2004 by the U.S. Environmental Protection Agency (EPA), pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act as amended (CERCLA). The Montana Department of Environmental Quality (DEQ) concurred with the ROD. A consent decree, entitled the Consent Decree for the Clark Fork River Operable Unit and for Remaining State of Montana Clark Fork Basin Natural Resource Damage Claims, and the Clark Fork Site Site-Specific Memorandum of Agreement (SMOA) designates DEQ as the Lead Agency for Remedial Design and Remedial Action (RD/RA). EPA is the support agency.

The primary sources of contamination within the CFR OU are tailings and tailings mixed with soil in streambanks and the historic floodplain. For the floodplain tailings and soils component, the ROD separated the tailings and tailings mixed with soils into three separate categories based on vegetation density and severity of contamination. The ROD states that the Clark Fork River Riparian Evaluation System (CFR RipES, or RipES), a vegetative survey developed for the CFR OU, would be used as a tool to make classifications and determine actions consistent with the standards set forth in the ROD. A review of post-ROD sampling of the CFR OU and the results of EPA's 2007 RipES mapping for the floodplain tailings and soils component of the remedy led to this ESD. It was concluded that site factors should be considered during Remedial Design to assure implementation of the Record of Decision requirements, as contemplated by the ROD. These site factors are identified in this ESD.

The modification identified in this ESD results in a significant change in the scope of the CFR OU remedy, but does not fundamentally alter the remedy with respect to scope, performance, or cost. Section 117(c) of CERCLA requires the state or federal government to publish an ESD including the reasons the changes were made. Section 300.435(c)(2)(i) of the National Contingency Plan (NCP) requires the lead agency to make the ESD and supporting information available to the public, and publish a notice in a major local newspaper of general circulation that briefly summarizes the ESD, including the reasons for such differences.

The Explanation of Significant Differences will become part of the CFR OU Administrative Record. The Administrative Record is located at EPA's Montana Records Center, 10 West 15th Street, Suite 3200, Helena, Montana 59626, and at on-site locations, and is available Monday through Friday, 8:00 a.m. - 4:30 p.m. The Records Center's phone number is (406) 457-5046.

2.0 SITE HISTORY, CONTAMINATION, AND SELECTED REMEDY

The Clark Fork River Operable Unit is comprised of approximately 120 river miles of the Clark Fork River. The CFR OU extends from the confluence of the old Silver Bow Creek channel with the reconstructed lower Mill -Willow bypass, near Anaconda, to the maximum former Milltown Reservoir pool elevation east of Missoula. Approximate boundaries are shown in Exhibit 1. The majority of the ROD cleanup will occur from the beginning of the CFR OU downstream to Garrison. This section is referred to in the ROD as Reach A.

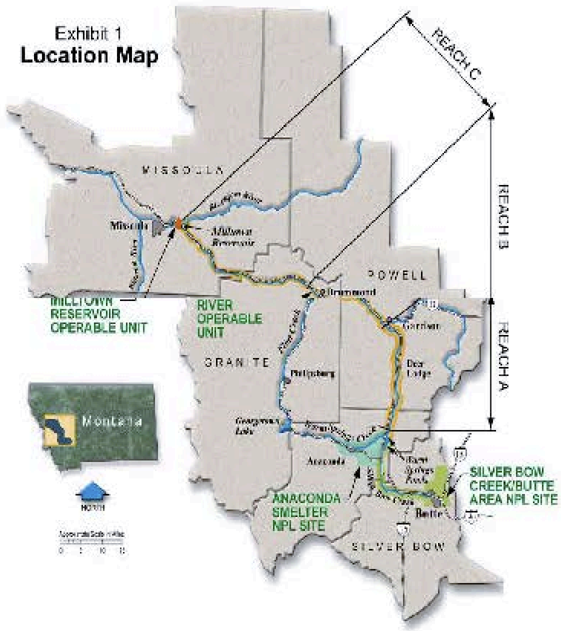


Exhibit 1: Location Map

The CFR OU consists of surface water, streambed sediments, tailings, impacted soils, groundwater, aquatic resources, terrestrial resources, irrigation ditches, and related sediment deposition and contaminated property, and air, located within and adjacent to the 100-year historic floodplain of the Clark Fork River.

2.1 Contamination

Contaminants present in the CFR OU are from historic mining and smelting processes upstream of the Clark Fork River. In the Butte area, mining companies routinely disposed of mining and milling wastes directly into Silver Bow Creek. The mining wastes were carried away and mixed with river bed sediments by the various higher seasonal flow events in Silver Bow Creek, and much was subsequently carried into the upper Clark Fork River. In the Anaconda area, large quantities of wastes from the Anaconda Company's operations also reached the Clark Fork River through Warm Springs Creek and other tributaries. In early 1908, the largest flood event on record for the Clark Fork River drainage occurred. This resulted in flooding down the entire Clark Fork River drainage. During this event, extensive quantities of waste, contaminated soils, and contaminated sediments were deposited within the Clark Fork River floodplain.

The contaminants of concern (COCs) for the site are arsenic, cadmium, copper, lead, and zinc. Copper is considered the primary contaminant associated with environmental risk, and arsenic is considered the primary contaminant associated with human risks.

The primary sources of contamination are tailings and tailings mixed with soil in streambanks and the historic floodplain. These sources provide pathways to plant and animal life, and to humans who come in contact with the soils. Contaminants move from tailings and impacted soils through the process of erosion, directly into the river and other surface waters. This movement provides pathways to terrestrial and aquatic life. In addition to erosion of tailings and impacted soils, metals and arsenic can be leached directly from the tailings and contaminated soils into groundwater and surface water. The ROD estimates the total volume of tailings in Reach A to be 7.6 million cubic yards, and the total volume of tailings in Reach B to be 1.6 million cubic yards.

2.2 Site History

EPA placed the original Silver Bow Creek Superfund Site on the NPL in 1983. The Silver Bow Creek Superfund Site was later extended to include the Clark Fork River to the Milltown Reservoir, through administrative action taken by EPA. EPA also designated a separate site for the NPL, immediately downstream of the Silver Bow Creek Superfund Site known as the Milltown Reservoir Superfund Site. In February 1990, the Clark Fork River portion of the Silver Bow Creek / Butte Area Superfund Site was administratively transferred to the Milltown Reservoir Superfund Site. After the transfer, the entire site became known as the Milltown Reservoir / Clark Fork River Superfund Site.

The Potentially Responsible Party for the Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site, ARCO, now known as the Atlantic Richfield Company, prepared the major portions of the CFR OU Remedial Investigation (RI), begun in 1995, and Feasibility Study (FS), began in 2000, pursuant to EPA order. EPA released the Proposed Plan for the CFR OU in August 2002, and the CFR OU Record of Decision was issued in April 2004. The Clark Fork River consent decree was entered in August 2008.

The Clark Fork River Human Health Risk Assessment evaluated the likely scenarios for human exposure to contaminants of potential concern for the CFR OU. Arsenic in soils and tailings is the primary concern for human exposures at this site. The ROD's cleanup level for arsenic in soils are residential – 150 ppm; rancher/farmer – 620 ppm; and recreational – 680 ppm for children at Arrowstone Park and other similar recreational scenarios or 1,600 ppm for fishermen, swimmers, and tubers along the river. An exposure area (e.g., residential yard, horse pasture) with an average concentration of arsenic in soils that exceeds the cleanup level for a particular land use, as described above, requires cleanup.

Based on ecological studies conducted within the CFR OU, especially the Ecological Risk Assessment, the ROD determined that widespread unacceptable terrestrial and aquatic risks exist in Reach A and portions of Reach B. Areas of primary concern are phytotoxic soils, and subsequent lack of or reduced vegetation, impacts on livestock and wildlife, and unacceptable acute and chronic risks to aquatic receptors, principally fish and benthic macroinvertebrates.

2.3 Exposure Pathways

The exposure pathways consist of:

- Surface water: Surface water runoff from tailings and contaminated soils into the river transports both dissolved and particulate-bound metals and arsenic to aquatic life and creates surface water contamination. Erosion of banks also provides contaminants to surface water and aquatic life.

- Groundwater: Movement of groundwater through tailings and contaminated soil causes groundwater to become contaminated.

- Streambed sediments: Stream sediments receive surface water contaminants and contain metal contamination.

- Historically irrigated fields: Irrigation ditches and fields historically irrigated with Clark Fork River water have been contaminated by surface water contaminants. Arsenic from this deposition may create unacceptable human health risks for residences near or on such fields. Sediments in irrigation channels may also present risks to certain workers, particularly at the Grant-Kohrs Ranch National Historic Site.

- Biological resources: Contaminant uptake in plants is a well-documented occurrence that prevents or limits the establishment of vegetation on the land. Aquatic plants and animals receive the contaminants through direct consumption of contaminated sediment, contaminated food sources, or through absorption in water. Wildlife may receive contamination through soil, plant, water, and animal ingestion.

2.4 Selected Remedy

As discussed in Section 2.0, the majority of the ROD cleanup will occur from the beginning of the CFR OU downstream to Garrison, referred to as Reach A, as well as limited areas within Reach B. No action is selected for Reach C. For Reach A and limited areas within Reach B:

- Exposed tailings, also referred to as slickens or severely impacted soils and vegetation,[1] are to be removed, and the excavated area revegetated, with a limited exception. The limited exception is for severely impacted areas that are 400 square feet or less, less than approximately two feet in depth, and contiguous with impacted areas. When this exception is present, in-situ treatment will be done.

[1] The terms "exposed tailings," "slickens," and "severely impacted" are all used in the ROD. This ESD utilizes the term "severely impacted areas." The terms "impacted soils and vegetation areas" and "impacted areas" are also used interchangeably in the ROD. This ESD utilizes the term "impacted areas." Similarly, this ESD utilizes the term "slightly impacted areas" for the ROD terms "slightly impacted soils and vegetation areas" and "slightly impacted areas." Therefore, the three categories identified in the ESD are: (1) severely impacted areas, (2) impacted areas, and (3) slightly impacted areas.

- In most instances, impacted soils and vegetation, also referred to as impacted areas, will be treated in place, using careful lime addition and other amendment as appropriate, soil mixing, and re-vegetation.

- Some impacted areas will be removed, where depth of contamination prevents adequate and effective treatment in place, where saturated conditions make in-situ treatment unimplementable, or where post treatment arsenic levels, after one re-treatment attempt, remain above the human health cleanup level for the current or reasonably anticipated land use.

- The RipES process will be used in remedial design to identify severely impacted areas and impacted areas, and areas where the exceptions to removal or in-situ treatment will apply.

- Streambanks will be stabilized primarily by "soft" engineering (with limited hard engineering where conditions warrant) for those areas classified and an approximate, flexible 50-foot riparian buffer zone will be established on both sides of the river.

- Opportunity Ponds will be used for disposal of all removed contamination.

- Weed control for in-situ treatment, streambank stabilization, and removal areas is required.

- Best Management Practices (BMPs) throughout Reach A and in limited areas of Reach B are required to protect the remedy and ensure land use practices are compatible with the long-term protection of the Selected Remedy.

- Institutional Controls (ICs) and additional sampling, maintenance, and possible removal or in-situ treatment of contamination, including the Trestle Area, will be required to protect human health.

- Monitoring during construction, construction BMPs, and post-construction environmental monitoring are required.

- The remedy is also modified and expanded for the Grant-Kohrs Ranch National Historic Site, located in Reach A.

2.5 Performance Standards and Remedial Goals

The ROD includes performance standards and remedial goals for the CFR OU.

The Remedial Action Objectives (RAOs) for floodplain tailings and impacted soils are:

- Prevent or inhibit ingestion of arsenic-contaminated soils/tailings where ingestion or contact would pose an unacceptable health risk.

- Prevent or reduce unacceptable risk to ecological (including agricultural, aquatic, and terrestrial) systems degraded by contaminated soils/tailings.

The ROD elaborates on the floodplain tailings and impacted soils RAOs:

> Successful reclamation of land contaminated by mining activities within the Clark Fork River OU is defined as establishing plant communities capable of stabilizing soils against wind and water erosion, reducing transport of COCs to groundwater and surface water, and compliance with ARARs or replacement standards, in perpetuity. Goals of the plant community are to establish a permanent vegetative cover to accomplish the following:
>
> - Minimize direct contact with arsenic, thus reducing the potential risk of human exposure to acceptable risk-based levels.
> - Provide geomorphic stability to streambanks, thus minimizing release of COCs to the river.
> - Improve agricultural production by reducing or eliminating phytotoxic conditions, thus providing for multiple land uses.
> - Minimize surface water erosion and COC transport to surface water through methods described in the Selected Remedy.
> - Minimize transport of COCs to groundwater.
> - Minimize wind erosion and movement of contaminated soils onto adjacent lands, thus eliminating human, agricultural, and wildlife exposure.
> - Remediate contaminated soils to be compatible with the existing and anticipated future land use with minimal future maintenance activities.

The groundwater RAOs are:

- Return contaminated shallow groundwater to its beneficial use within a reasonable time frame.
- Comply with State groundwater standards, including nondegradation standards.
- Prevent groundwater discharge containing arsenic and metals that would degrade surface waters.

The groundwater standards include arsenic (10 ug/l), cadmium (5 ug/l), copper (1,300 ug/l), iron (300 ug/l), lead (15 ug/l), and zinc (2,000 ug/l).

The surface water RAOs require compliance with surface water standards. Montana DEQ-7 copper total recoverable standards have been waived in the ROD to federal ambient water quality criteria for copper, due to technical impracticability. The surface water standards include arsenic (340 ug/l – acute, 150 ug/l – chronic, 10 ug/l – human health), cadmium (2.1 ug/l @ 100 mg/l hardness – acute, 0.27 ug/l@ 100 mg/l hardness - chronic), copper (13 ug/l – acute, 9 ug/l – chronic, 1300 ug/l – human health), lead (81 ug/l @ 100 mg/l hardness - acute, 3.2 ug/l @ 100 mg/l hardness - chronic, 15 ug/l – human health), and zinc (119 ug/l @ 100 mg/l hardness - acute, 119 ug/l @ 100 mg/l hardness - chronic, 2,000 ug/l – human health).

2.6 Remedial Design / Remedial Action

The ROD was issued in 2004. In 2006 – 2007, while consent decree discussions were in progress, EPA performed RipES mapping for the floodplain tailings and soils component. DEQ began its Remedial Design activities in 2008, following entry of the consent decree, which designated DEQ as Lead Agency. DEQ focused its first remedial actions on immediate human health concerns. DEQ, in consultation with EPA, and in accordance with consent decree requirements, performed residential yard removals,[2] necessitated by elevated levels of arsenic and lead, in fall 2010 through summer 2011. DEQ, in consultation with EPA and in accordance with consent decree requirements, performed the Trestle Area Cleanup in fall and winter 2011 - 2012, with planting in spring 2012. The trestle cleanup involved removal of residential soils with elevated levels of arsenic, and reconstruction and revegetation of 1,000 feet of streambank. In fall and winter 2012, DEQ performed the remedial action for the pasture areas that were historically irrigated with Clark Fork River water. DEQ commenced Remedial Action on the floodplain tailings and soils component in March 2013.

3.0 BASIS FOR ESD

RipES is primarily a vegetation survey, developed during the RI/FS, with later iterations by EPA. The ROD provides for the RipES process to be used as a significant tool in developing Remedial Design. However, sampling and field observations relating to vegetation health and other factors, has shown that use of RipES determination alone would not lead to implementation of the Record of Decision requirements or fully meeting RAOs.

3.1 RipES Determination of Severity of Floodplain Soils Contamination

The ROD, Section 13.6.1.1, entitled CFR RipES, states:

> CFR RipES is a tool that allows the Record of Decision requirements to be implemented on a site-specific, refined, and definitive basis. The purpose of CFR RipES is to provide a data predicated decision tool to identify and categorize polygons (delineated areas of land) based on landscape stability and plant community attributes within the Clark Fork River OU. CFR RipES will be used to make classifications and determine actions consistent with the standards set forth in the Record of Decision.

RipES concluded that high levels of contamination in floodplain soils would be identified as a result of the RipES vegetation evaluation. RipES identified and categorized "types of soils polygons" that served to "distinguish the severity of contamination of the floodplain soils." RipES used a self-described "ocular" approach to determine whether a specific soils polygon fell

[2] Though outside of the Clark Fork River floodplain, the residential yard removals are required as part of the remedy due to the use of Clark Fork River surface water for irrigation in this area. The ROD requires "continued removal of arsenic contamination in the East Side Road area as needed and further evaluation of irrigated land for human health reasons."

into the category of (1) severely impacted areas, (2) impacted areas, or (3) slightly impacted areas. The ROD then provides for remedial action for each of the three categories of RipES soils polygons. As described above, severely impacted areas in most instances require removal of contamination. Impacted areas would generally be treated in situ. Slightly impacted areas had either no action, or BMPs and ICs.[1]

3.2 Data from Application of the RipES Tool

Data obtained from sampling at the CFR site indicated that RipES, when applied by EPA in 2006 – 2007, did not fully or accurately distinguish the severity of contamination between severely impacted areas, and impacted areas and slightly impacted areas, nor between impacted areas and slightly impacted areas. This demonstrated that the RipES process as designed is not effective in differentiating tailings and contaminated soils among soil polygons, with severely impacted areas identifying the most highly contaminated, impacted areas identifying highly contaminated, and slightly impacted areas identifying primarily nonactionable contamination.

In addition, data from the State's subsequent contaminant sampling of the CFR OU demonstrates that many of the soil polygons identified as being slightly impacted in the 2006-2007 RipES application were contaminated at much higher levels, with similar levels of contamination to areas identified as severely impacted and impacted in 2006-2007. The RipES process as designed does not reliably "distinguish the severity of contamination of the floodplain soils," or fully classify areas within Reach A and limited areas of Reach B among the three categories, as set forth in the ROD.

4.0 DESCRIPTION OF SIGNIFICANT DIFFERENCE

4.1 Remedial Design Considerations

DEQ has developed Remedial Design considerations, set forth below, which through RD/RA, allow implementation of Record of Decision requirements, including Performance Standards and Remedial Goals. Each Remedial Design consideration (except Groundwater 4.1.1) matches the ROD's structural requirement for RD/RA. That structural requirement is that "areas within the Upper Clark Fork River floodplain [be] classified for purposes of determining specific remedial actions based on landscape stability, contamination, and plant community dysfunction." (ROD, p. 2-93).

4.1.1 Groundwater

The ROD found that the arsenic human health standard of 10 ug/l was exceeded at 5% of all domestic wells within the CFR OU. Exceedances of arsenic were found in 11% of all CFR OU domestic and non-domestic use wells during the RI/FS, prior to the lowering of the arsenic standard from 18 ug/l to 10 ug/l. The ROD found 5% of groundwater samples exceeded standards for cadmium, lead, and zinc.

[1] The ROD's miscellaneous site types fall outside the soils and vegetation areas categorizations.

Remedial Design therefore requires an analysis of the presence or absence of saturated substrate where contamination is present, in order to address groundwater RAOs to return contaminated shallow groundwater to its beneficial use within a reasonable time frame, comply with State groundwater standards, including nondegradation standards, and prevent groundwater discharge containing arsenic and metals that would degrade surface waters. This analysis will be considered in Remedial Design.

4.1.2 Riparian Vegetation

The ROD considers the establishment of appropriate woody and herbaceous vegetation key to the success of the Selected Remedy. The ROD states that "successful reclamation of land contaminated by mining activities within the Clark Fork River OU is defined as the establishment of plant communities capable of stabilizing contaminated soils against wind and water erosion, reducing COCs transport to groundwater, reducing the risk to human health and the environment, and compliance with Performance Standards, in perpetuity." (ROD, p. 2-113). Remedial Design has found an overall decay trajectory in vegetation, with little sign of regeneration.

Under RipES, all vegetation other than tufted hair grass was considered appropriate riparian vegetation, including other metals-tolerant species, noxious weeds, and invasive species. Remedial Design, in order to meet the remedial requirements, including vegetation performance standards (such as a viable self-sustaining plant community), instead focuses on riparian plant community diversity in species, health, and age. Remedial Design requires an analysis of existing and prospective native hydrophytic vegetation, where contamination is present, in its determination of self-sustaining riparian vegetation. This analysis will be considered in Remedial Design.

4.1.3 Geomorphic Stability

For surface water, the ROD found that COC concentrations are higher in the Clark Fork River than in the reference streams, and are often above State and federal water quality standards and criteria, especially for copper and arsenic. The ROD found that concentrations of metals and arsenic in river water are higher in Reach A and decrease in downstream reaches, primarily because of dilution by tributary streams. The ROD found that COCs are supplied to the river as streambank tailings, and contaminated sediments are eroded into the river. Also, water quality may change dramatically in response to storm events and overbank flows.

The ROD states that, "geomorphic stability is characterized by a dynamically stable floodplain that allows for lateral adjustment through normal streambank erosion and bar building." (ROD, p. 3-15). Remedial Design requires a geomorphic analysis to establish the present and needed hydraulic conditions of the Clark Fork River to maintain geomorphic stability, where contamination is present. This analysis will be considered in Remedial Design. Achieving geomorphic stability will likely have the effect of lowering the floodplain, which has the added benefit of providing the necessary floodplain function for ROD required self-sustaining riparian vegetation.

4.1.4 Contaminant Sampling

Included in RAOs related to floodplain tailings and impacted soils are the prevention or inhibition of ingestion of arsenic-contaminated soils/tailings where ingestion or contact would pose an unacceptable health risk, and prevention or reduction of unacceptable risk to ecological (including agricultural, aquatic, and terrestrial) systems degraded by contaminated soils/tailings. All other RAOs also relate to contamination as a direct or indirect source, as would be expected.

Any sampling under RipES considered average pH and average copper and arsenic concentrations, and primarily relied on an ocular approach to determine depth of contamination. Remedial Design sampling expands sampling to include all ROD COCs, involving lab analysis and X-ray fluorescence (XRF) screening. Results will be compared to human health levels, and those which represent a significant loading source. High levels of arsenic found in CFR OU's floodplain setting will also be factored into Remedial Design in order to avoid increasing mobility of arsenic under higher pH conditions.

Remedial Design includes other ROD considerations, such as ownership, infrastructure, land use, and site-specific remedy requirements. These will be considered in the Remedial Design site-specific design plans.

4.1.5 Ownership

The ROD states that within Reach A, almost 300 landowners live along the Clark Fork River, with fourteen major landowners owning more than 70% of Reach A. DEQ will work with landowners as set forth in the ROD during RD/RA.

4.1.6 Infrastructure

The ROD notes that the CFR OU includes highways, railroads, pipelines, and various other infrastructure, which will need to be considered in RD/RA.

4.1.7 Land use

As stated in the ROD, differing land uses exist within the CFR OU. For example, the ROD notes that livestock grazing and hay production are common land uses within the OU. Remedial Design will consider current and reasonably anticipated land uses, as set forth in the ROD.

4.1.8 Site-Specific Remedy Requirements

Some areas may be affected by compliance with site-specific remedy requirements. For example, the ROD notes that remediation of Grant-Kohrs Ranch National Historic Site must meet additional requirements set forth in the ROD.

4.2 Conclusion

All of the above factors will be analyzed in the manner described above, to make final Remedial Design determinations for severely impacted areas, impacted areas, and slightly impacted areas. ROD requirements for each of these classifications will then be applied as final design documents are prepared.

The weight or specific manner in which the Remedial Design considerations will be applied in Remedial Design will vary depending on site-specific conditions ascertained as part of Remedial Design. Severely impacted areas will tend to have dominant factors, for example, extensive contamination within the channel migration zone, a significant loading source to groundwater, or human health exceedances necessitating removal. Slightly impacted areas will represent the other end of the spectrum, such as areas with no human health exceedances, and little to no contamination. Impacted areas will generally be areas without a dominating factor, but still necessitating treatment in order to meet ROD requirements.

Application of design level factors to site-specific conditions will be discussed at DEQ's design review team (DRT) meetings, consistent with DEQ's practice to date. The DRT is comprised of members of the public, local governments, and members of the environmental remediation and restoration community with technical expertise. The DRT meetings, coupled with the high level of public involvement at the CFR OU (reflected in DEQ's Community Involvement Plan), will assure a predictable Remedial Design going forward, and assure that the public understands how Remedial Design considerations will be applied.

In addition, technical memoranda will be developed to provide a more definitive bases for certain aspects of Remedial Design (e.g., contamination benchmarks, specific application of in situ treatment). These technical memoranda will be included in the administrative record.

4.3 Scope, Performance, and Cost Differences

This ESD outlines Remedial Design components that are needed to best implement the ROD, based on field conditions involving contamination, geomorphology, vegetation, and groundwater, as well as other considerations, such as ownership, infrastructure, land use, and site-specific remedy requirements.

The performance of the remedy is not altered by this modification.

This modification significantly changes the scope of the floodplain tailings and soils component of the remedy described in the ROD by explicitly adding factors that will be considered during remedial design to determine which of the three classes a given piece of property will fall in. This will result in a different mix of removal, in-situ treatment, and other remediation (i.e., best management practices, institutional controls), for a given Reach and Phase as design is conducted than what was contemplated in the ROD's original description of the remedy.

The proposed actions available for the floodplain tailings and soils component (removal, in-situ treatment, BMPs, ICs, and no action) have not changed. Nor has there been a significant change to the amount of time needed to implement the remedy. The ROD includes estimates of ten to fifteen construction seasons. DEQ anticipates that using best efforts, Remedial Action will require fifteen construction seasons, in order to limit the duration of impacts on individual landowners and perform Remedial Action in a protective and cost-effective manner. The ROD notes that while the general approach will be to work from the headwaters down, remediation can be done more rapidly and effectively and with less threat to river stability by working on discontinuous stretches of the river. Therefore, work will be performed in a discontinuous manner to prevent jeopardizing the integrity of the floodplain.

Estimated costs associated with the modified remedy remain similar to ROD estimates. The estimated cost of the modified remedy is $112,900,372 at a real discount rate of 3%. This correlates to $97,691,082 at a real discount rate of 5%. For comparison, the ROD estimated $122,017,549 (10 year construction period) and $141,557,274 (15 year period) using a corresponding real discount rate of 3%, and $117,338,024 (15 year period) at a real discount rate of 5%.[4]

5.0 SUPPORT AGENCY COMMENTS

The Support Agency, the U.S. Environmental Protection Agency, supports this ESD.

6.0 STATUTORY DETERMINATIONS

The CFR OU remedy, as modified through this ESD, satisfies CERCLA § 121. The modified remedy provides acceptable overall protection of human health and the environment and complies with applicable or relevant and appropriate requirements, except where previously waived.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted no less often than each five years after the initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

7.0 PUBLIC PARTICIPATION COMPLIANCE

The public participation requirements of Section 300.435(c)(2)(i) of the NCP, set forth in the Introduction and Statement of Purpose, have been met by making this ESD and supporting information available to the public, including this ESD in the Administrative Record files, publishing a notice in the Montana Standard, the Silver State Post, the Anaconda Leader, the Philipsburg Mail, and the Missoulian, briefly summarizing the ESD, including the reasons for such differences, and making the ESD available online at http://www.deq.mt.gov/fedsuperfund/cfr.mcpx.

---

[4] The real discount rates of 3% and 5% approximately equal the ROD's 5% and 7% nominal rates of return less an assumed inflation rate of 2%.

Copies of the ESD are available at:

- DEQ's Record Center, 1225 Cedar Street, Helena, Montana 59620, (406) 444-6444.
- EPA's Montana Records Center, 10 West 15th Street, Suite 3200, Helena, Montana 59626, (406) 457-5046.

Copies of the ESD are also available at the following information repositories:

- Hearst Free Library, 4th and Main Street, Anaconda, Montana 59711, (406) 563-6932
- EPA Butte Office, 155 West Granite, Butte, Montana 59701, (406) 782-3838
- Montana Tech, 1300 West Park, Butte, Montana 59701, (406) 496-4281
- Grant-Kohrs Ranch National Historic Site, 266 Warren Lane, Deer Lodge, Montana 59722, (406) 846-2070
- Powell County Planning Office, 409 Missouri Street, Deer Lodge, Montana 59722, (406) 846-3680
- Mansfield Library, University of Montana, Missoula, Montana 59812, (406) 243-6860
- Missoula City/County Library, 301 East Main Street, Missoula, Montana 59802, (406) 721-2665

8.0 REFERENCES

- Montana Department of Environmental Quality. Cost Estimate for Clark Fork River Operable Unit Explanation of Significant Differences. Prepared by CDM Smith (2013).

- Montana Department of Environmental Quality. Final Community Involvement Plan (2012).

- U.S. Environmental Protection Agency. Results of Application of CFR-RipES. Prepared by Ecological Solutions Group, CH2M HILL, and Reclamation Research Group (2007).

- U.S. Environmental Protection Agency. Clark Fork River Operable Unit Record of Decision (2004).

- U.S. Environmental Protection Agency. Clark Fork River Evaluation System—A Remedial Design Tool. Prepared by CH2M HILL, Montana State University Reclamation Research Unit, and Bitterroot Restoration, Inc. (2004).

- U.S. Environmental Protection Agency. A Guide to Preparing Superfund Proposed Plans, Record of Decision, and Other Remedy Selection Documents (1999).

AUTHORIZING SIGNATURES

Tom Livers   6/8/15

Tom Livers, Director
State of Montana
Department of Environmental Quality

Date

Martin Hestmark
Assistant Regional Administrator
Office of Ecosystems Protection and Remediation
U.S. Environmental Protection Agency Region 8

Date

AUTHORIZING SIGNATURES

Tom Livers, Director
State of Montana
Department of Environmental Quality

Date

6/12/15

Martin Hestmark
Assistant Regional Administrator
Office of Ecosystems Protection and Remediation
U.S. Environmental Protection Agency Region 8

Date

Attachment B. Clark Fork River Reach A Design Approach

Memorandum

To: *Brian Bartkowiak – DEQ*

From: *B. Bucher, Karin Mainzhausen – CDM Smith*
K. Boyd – Applied Geomorphology, Inc.
T. Parker, A. Sacry, M. Sowles – Geum Environmental Consulting, Inc.

CC. *T. Mostad - NRDP*

Date: *September 1, 2016*

Subject: *Clark Fork River Reach A Design Approach*

Introduction

The purpose of this memorandum is to document the design approach that has evolved based on this Design Team (CDM Smith, Applied Geomorphology, Inc. and Geum Environmental Consulting, Inc.) collaboratively completing designs for several Phases of the remedial action along the Clark Fork River since 2010. The remedial action is being conducted by the Montana Department of Environmental Quality (DEQ) and the Natural Resource Damage Program (NRDP) of the Montana Department of Justice. This design approach memorandum is necessary for several reasons:

- Phase 5-6 followed a different design approach which led to fatal flaws in the design, resulting in increased project costs and a need to redesign the project. The Phase 5-6 experience exposed the need for more rigorous QA/QC protocols and peer review during the engineering design process.
- Multiple engineering firms are working on the Clark Fork River remediation and restoration, and documenting successful design methodologies and how design methodologies have evolved over the last several years can help the design team(s) avoid unnecessary learning curves, filter out inappropriate and inadequate methodologies, and ultimately save costs.
- As new engineering firms are hired to work on the Clark Fork River, this document can serve as a road map to help them develop Scopes of Work and assign appropriate resources to the project.
- Because project phases are connected, and all are part of the same river, a consistent design approach will result in a continuous project that consistently supports remedial action objectives and related restoration goals.
- The design process presented herein has been accepted by federal and state agencies involved in the work.

Pre-Design Activities

DEQ selects project Phases based on access, priority of the Phase based on the ROD and other agency coordination, and in priority order from upstream to downstream.

DEQ selects a design team which typically includes one or more engineering firms, a geomorphologist and a revegetation consultant. To help achieve continuity and consistency, the geomorphologist and revegetation consultant are common among several Phases and work as a team with different engineering firms.

The **Revegetation Consultant** assists DEQ to coordinate procurement of nursery grown plants with contracted growers approximately 2 years in advance of the design process to ensure that the necessary plant materials are available for each project phase. Either early design layouts or estimated project acreages are used to develop plant orders.

The **Revegetation Consultant** maintains an inventory of willow cutting collection sources to ensure that willows will be available for streambank construction in each project phase.

The **Engineer** develops a Sampling and Analysis Plan (SAP) for each phase to guide the determination of the extent of contamination. This plan is submitted to DEQ and EPA for approval.

Investigations

Test Pit Investigation:

The **Engineer** excavates test pits on a 125 ft. by 125 ft. grid based on the extent of the available RIPES boundary. The boundary may be extended during sampling to capture the extents of contamination (i.e. sampling continues beyond the RIPES boundary if contamination levels that meet the removal criteria are found). Additional test pits on point bars, old channels and unique features like old oxbows, islands, etc. are added to the investigation. The grid can be modified based on observations made during sampling and other available data.

The test pit investigation is conducted as described in the SAP. During the investigation, enough data is collected to determine the horizontal and vertical extent of contamination based on the removal criteria (see below for removal criteria used in Phases 3 and 4). The test pit locations are staked and existing ground elevations for each test pit are surveyed by the **DEQ** contracted **Surveyors**.

Contamination Analysis and Tailings Removal Criteria:

A worksheet is created that shows the northing/easting and depth of each pit and the depth of contamination based on the removal criteria. The criteria used in Phases 3 and 4 and described in the Phases 3 and 4 PDP are presented below.

Tailings/impacted soil will be removed under the following conditions:

1. Arsenic levels exceed the human health standard in the surface interval (620 ppm).

2. The sum of Contaminants of Concern (COCs) (As, Cd, Cu, Pb, Zn) exceeds 1,400 mg/kg (parts per million) and any of the following:

- The lowest contaminated interval of metals is deeper than 24 inches,
- The contamination lies within the Channel Migration Zone (CMZ, described below) regardless of depth,
- Arsenic exceeds the human health standard at the surface (620 ppm) and the sum of COCs exceeds 1,400 mg/kg at an interval shallower than 24 inches, or
- In areas where floodplain connectivity is desired, the removal surface is lower than the floodplain connectivity elevation.

3. Limited areas outside the CMZ where contaminated material is shallower than 24 inches but that are contiguous to removal areas for construction efficiency.

4. Areas of uncommon native vegetation may be preserved and contamination left in place.

Channel Migration Zone (CMZ) Delineation:

A 100-year CMZ is developed for each phase based on measured historic migration rates. The 90th percentile, 100-year migration distance is applied as an erosion buffer to each bankline; these values are listed in Table 2-6 of the Reach A Geomorphology and Hydrology Report (CDM Smith and AGI, 2013). Additional areas prone to avulsion (typically meander cores), are delineated and included in the CMZ to develop a meander corridor that shows demonstrable potential for sediment recruitment over the next century.

Determination of Overexcavation:

Each test pit is evaluated to determine if an additional 6 inches should be removed or feature lines should be added to the Bottom of Excavation (BOE) surface.

1. If the next depth interval result of the test is >1,000 ppm, assume there is a reasonable amount of variability that the test pit depth could be lowered 6 inches.

2. If the surrounding test pits are at a lower elevation. For example, the test pits around the test pit to be evaluated are 24 inches but the test pit being evacuated is 6-12 inches at 6,000 ppm and the lower one (12-18) is 1,000 ppm. The depth should be lowered to 18-inches. Also look at the XRF data to see what the readings were to get an idea if the concentration at the higher interval might be an anomaly.

3. If the test pit sample depth is 18-24 inches at 1,450 ppm and the next deeper sample is 300 ppm, the excavation depth could be terminated at 24 inches.

Other considerations that can modify the depth of contamination/BOE are:

1. Look at the existing topography and identify any old oxbows, channels, point bars and other distinct features. Evaluate the test pit depths within the features and surrounding the features. For example, there are two test pits in the bottom of the old oxbow at 48 inches, the surrounding test pits depths are 12 inches. We could assume that the contamination depth in the oxbow is 48 inches and the contamination depth in the banks of the old oxbow are only 12

inches. By adding a feature line at the top of the bank and the bottom of the oxbow and assigning elevations that are 48 inches and 12 inches below existing ground, respectively, the interpolated depths will be a lot more representative of actual conditions than if the interpolation is performed between the 12-inch test pits and the 48-inch test pits. This procedure was done in Phase 2 – Work Area A, and the old channel was contaminated as expected but was in fact still contaminated somewhat deeper. So, lowering the test pits in the bottom of the old channel another 6 inches might be appropriate. XRF data can also be very helpful in the evaluation.

2. Evaluate the point bar test pits. We have seen that in Phases 1 and 2 the contamination was considerably deeper in the test pits within the point bars and higher than predicted on the adjacent floodplain side of the test pits. Adding feature lines around the point bars on the river and adjacent floodplain side and assigning the point bar test pit elevation to the depth of contamination within the point bar polygon will account for the deep pockets of contamination. We have also seen that contamination in the upstream end of point bars was deeper than in the downstream area of the point bars. This might be due to the migration pattern of the channel.

3. Add feature lines in the river and lower them to the depth of contamination elevation of the test pits next to the river. If this is not done and the points are interpolated across the river, the elevations seem to be skewed to the elevation of the opposite bank test pit. In the field it appears that contamination on one side of the river is independent from the opposite side.

Once the spreadsheet of BOE depths is reviewed internally, maps are prepared with the topography/aerial photography and test pit information. A draft contamination boundary is added to the maps based on the removal criteria described above (or specific for the phase being investigated).

Existing Conditions Hydrology/Hydraulics Investigation:

Hydrology:

The hydrology investigation is performed by the **Engineer.** The 2-year and 10-year peak annual flows need to be determined based on available data and compared to previous analyses. There is good information on these more frequent peak flows from the USGS gages at Galen and Deer Lodge and a short period of record for the Clark Fork just above the Little Blackfoot River. There is also gage information on some tributaries (Racetrack Creek, Lost Creek) as well as historic data on Cottonwood Creek. This information was analyzed in the *Geomorphology and Hydrology of Reach A* (CDM Smith and AGI, 2013). If tributaries entering the phases are being modeled, these flows need to be evaluated to determine if mainstem flows should be remain the same throughout the model or if the flows need to be adjusted. For example, in Phases 3 and 4, the flows were increased downstream from the confluence of the CFR with Lost Creek.

Existing Conditions HEC-RAS Model:

The HEC-RAS modeling is also performed by the **Engineer.** As part of the field investigations, river cross sections are identified in the field, surveyed and used to build the HEC-RAS models for the 2-year flow existing condition. Because the 2-year water elevation typically stays within the channel, the model uses the surveyed cross-sections to build the 2-year flow model and no additional LiDAR data is needed. Sections are surveyed to capture major changes in channel geometry including narrow sections and wide section and pools and riffles. Other features require additional sections such as bridges and junctions and split flows. Initially it was thought that a 200-spacing on sections would be adequate, but, given the typical complexity of the river, the average spacing on recent surveys has been about 100 feet. The surveyed section should include top of bank because the LiDAR mapping often does not map the banks with precision.

For Phases 15 and 16, the river bed was mapped using a boat equipped with sonar and GPS. This is a very efficient method of data collection but bank heights (if not well defined by LiDAR) will need to be surveyed separately. The river bottom surface can then be incorporated into the LiDAR mapping and cross sections can be cut efficiently without the need for spicing sections in.

The first run of the Existing Conditions 2-year model usually can be accomplished with just the surveyed cross sections and no LiDAR data is needed because banks tend to be higher than the 2-year flow. The model is then evaluated and, if additional data is needed, it is collected and added to the model. The model is reviewed internally and revised as needed. Then the model is expanded to include the entire floodplain by extending the cross-sections using the Existing Conditions surface (EG) created from LiDAR data and run for the 10-year recurrence flow. If there are infrastructure concerns, the model may also be expanded to calculate the 50-year or 100-year return floods. These conditions are reviewed for areas of high velocity, shear stress and supercritical flow that may be concerns in the design. To improve understanding of river function, the stream is broken into sub reaches of similar hydraulic conditions to evaluate average conditions through these sub reaches. Inundation maps are developed for 2-year and 10-year flows to document existing out of bank flows. A memorandum is prepared with discussion of results, appended model outputs, and maps showing cross section locations and inundation for the 2-year and 10-year flows.

Existing Conditions Geomorphology Investigation:

The geomorphic investigation is performed by the contracted **Geomorphologist.** The geomorphology of each phase is summarized for the Preliminary Design Plan (PDP) using existing data previously compiled in the report *Geomorphology and Hydrology of Reach A* (CDM Smith and AGI, 2013) supplemented with original field data collection and analysis. The field investigation includes an evaluation of geomorphic surfaces and geologic controls in the reach, the collection of a series of pebble counts in riffles to capture general bed substrate conditions, an erosion inventory, and an inventory of residual pool depths to support post-construction monitoring. Typical information summarized may include channel slope, meander patterns and radius of curvature, bank erosion rates and patterns, typical channel morphology derived from the HEC-RAS cross sections or model output, and any other aspects of geomorphology that may provide context or assist in the design. For example, historic planform changes such as cutoffs should be documented, and any areas of rapid channel evolution should be identified. The geomorphology summary typically includes the discussion of floodplain access under existing conditions based on HEC-RAS 2-year discharge modeling results.

Existing Conditions Vegetation Investigation:

The **Revegetation Consultant** completes the vegetation investigation. The purpose of the vegetation investigation is to document existing conditions in each project phase and identify unique vegetation communities. The vegetation investigation includes mapping vegetation communities and assigning specific attributes to each vegetation community. Vegetation community mapping is typically done after the test pit investigation has been completed by the **Engineer**. Vegetation communities are mapped to the extents of the test pit investigation, or further where appropriate. Vegetation mapping is done during the growing season in order to identify distinguishing plant species. Detailed methods on vegetation community mapping are currently being developed (Geum, 2016).

Vegetation communities are initially mapped in GIS using aerial photographs and LiDAR data. Mapped communities are then verified in the field. Vegetation community boundaries are then finalized in GIS based on field verified boundaries.

Two primary analyses are done using the vegetation community mapping including determining the average and range of depths of contamination in each vegetation community and determining the average and range of ground elevations relative to river hydrology in each vegetation community. The latter analysis evaluates vegetation community elevation relative to the 2-year return flow water surface elevation. These analyses are typically done during development of the Preliminary Design Plan when the Existing Conditions HEC-RAS Model, draft final grading surface, test pit investigation results, and Proposed Conditions HEC-RAS Model become available. This information is needed to complete the vegetation analysis.

To evaluate vegetation communities in relation to contamination depths, a surface is created using the soil pit data delivered by the **Engineer**, and statistics are generated in ArcGIS that provide a minimum, maximum and average contamination depth for each vegetation community.

To determine vegetation communities in relation to the 2-year water surface elevation (WSE), an existing ground surface created by the **Engineer** is used, if resolution is sufficient. If resolution has been degraded to make AutoCAD analysis feasible, an existing ground surface is created from LiDAR data provided by DEQ, in addition to ground survey data if it is available. The original LiDAR data (xyz format) is processed using tools in ArcGIS to create a terrain data set. This results in files that retain the original resolution of the xyz file. Next, a 2-year WSE surface is created using HEC-RAS cross sections provided by the **Engineer**. These cross section elevations are used to generate a raster within the channel margins, and then extrapolated out into the floodplain as points that are located based on topography. The 2-year WSE surface is developed using tin-interpolation which is then converted to a raster. The existing ground surface is then subtracted from the 2-year WSE surface, generating a surface displaying existing ground elevation relative to the 2-year WSE. This Relative Elevation Model (REM) is usually presented as a color ramp, and it is used in various steps of the revegetation design process.

Based on recent conversations, the vegetation community data will be used to determine the extent of woody vegetation in each project phase to be used as a target for replacing woody vegetation cover in the design process. Criteria for determining a replacement proportion are being developed.

Design

Design Team Meeting:

Typically, after the test pit, hydrology, hydraulics, geomorphology, and vegetation investigations are complete, a design team meeting is held to develop the proposed contamination removal boundary and evaluate the BOE surface. Each discipline brings their investigation results and this information is used to help establish the removal boundary extents. During the meeting, the team discusses any features like old channels, oxbows, or secondary channels that should be preserved or rebuilt. Potential restoration opportunities may also be identified and discussed. Any channel realignment or necessary structures should be discussed. At this time, areas are identified where floodplain connectivity can be increased through additional removals. Results of vegetation mapping are used to identify unique areas that may need to be preserved, or land uses that must continue post-remediation.

BOE Surface:

Once the Design Team agrees with the contamination removal boundary, the Draft BOE surface is built in AutoCAD. The Existing Ground Surface (EG) elevation at the contamination boundary and bank lines are added as feature lines to the surface and sloped at a 1:1 to the depth of contamination.

The Draft BOE is then compared to the EG that was created from the bare points provided by the LiDAR Company. We keep the EG in tiles or combination of tiles due to their smaller size and ease to work with. Algorithms could be used to reduce the file size, but it appears that a lot of the resolution is lost especially next to the river. We also add the bank feature lines created by the **Surveyor** to account for the movement of banks since the LiDAR points were taken.

The comparison/volume surface is then assigned colors for cut and fill to determine if any of the BOE surface is higher than the EG. Those areas are further evaluated to make sure no features were missed.

The approximate removal volume is also calculated for planning purposes. For example, the large volume of tailings removal led to the splitting of Phases 3 and 4 into Phase 3A, Phase 3B and a redefined Phase 4.

Once the Draft BOE is completed, an internal review is conducted to make sure that the test pit data is consistent with the BOE surface.

The design team(s) are currently having discussions about how to develop a consistent method for a bottom of tailings surface using AutoCAD and/or GIS that can be used to analyze average thickness of tailings in vegetation communities as part of the vegetation investigation, and to calculate a BOE that provides the most accurate estimate possible of material to be removed. Currently, the **Revegetation Consultant** develops a bottom of tailings surface by first creating a tin-interpolated volume surface using depth of tailings as the z-value. This "tailings thickness" surface is subtracted from the existing ground surface to estimate a bottom of tailings surface. There may be some advantages to combining these methods with AutoCAD methods described above.

Preliminary Landowner Plans:

After a proposed removal boundary has been developed, an initial meeting with landowners and members of the design team typically occurs to present the findings to the landowner, ask questions about existing land uses, and solicit input and information relative to design elements. Existing land uses within the removal boundary and the potential for borrow source development are typically important topics at these meetings. The **Revegetation Consultant's** role in these meetings is typically to describe the approach to revegetating the areas and gather information to group mapped vegetation communities into land use cover types (groupings of vegetation communities where similar revegetation treatments can be applied to meet the long-term land use goals for a given area).

Landowner plans are developed by the **Engineer** with input from other members of the design team and typically include: a site map, excavation extents and depth with test pit depths, land use with depth of vegetated backfill and microtopography, proposed new fence locations, potential borrow source investigation areas, and anticipated areas of inundation at a 2-year flood event, and conceptual revegetation by land use cover type. For each cover type, initial revegetation treatment criteria are provided in addition to examples of where floodplain features might be located, planting locations, and floodplain woody debris placement areas. Floodplain elevations, revegetation treatments and potential plant species are often the issues that land owners are most interested in as they will affect the ultimate appearance of the site and future land uses. In some cases, the need to reclaim land for agricultural purposes may be an over-riding criteria that arises from discussions with a landowner, and this can be an important driver for design.

Field Visit – Preliminary Bank Treatments:

A field visit is conducted with the Design Team to determine the preliminary bank treatments and specifically locate point bars, lateral bars, secondary channels and any other features that could influence the hydraulics of the channel. Toe conditions are also evaluated if possible as part of the initial investigation. Toe conditions are evaluated in terms of the potential to preserve the native bank toe in any bank treatment. This assessment can be facilitated by having field maps that show historic bankline migration rates. Resource grade GPS coordinates are taken in the field.

A map with the preliminary bank treatments is prepared and reviewed by the Design Team. After additional evaluation with the Proposed Conditions HEC-RAS model, this map is included in the PDP.

Draft Final Grading Surface (FG)/Proposed Conditions HEC-RAS Model:

With the information collected during the site visit on bank treatments, secondary channels and any other features (bridges-culvert) and the HEC-RAS Existing Condition 2-year WSE, the bank feature lines are modified to the expected 2-year WSE at each cross section. The bank feature lines are interpolated at a constant slope from one cross section to the next. Point bars, lateral bars, any secondary channels, and oxbows are added to the Draft FG surface. Feature lines are added at the point bars at the location identified in the field and graded to slopes around 20:1 or shallower, if possible. Lateral bars are also added to the surface. These lines form the basis of the Draft FG. Avulsion paths are determined by the **Geomorphologist** and added to the surface. The **Revegetation Consultant** provides criteria and conceptual locations for wetlands, oxbow features, swales, preservation areas, and areas where a specific land use will occur. The outside bank elevations are raised by 6-inches throughout the avulsion paths, and the elevations transition for approximately 100 to 150 feet upstream or downstream of the avulsion path to tie into 2-year flow bank elevations.

Avulsion paths are determined by the **Geomorphologist**, by comparing avulsion route slopes to existing channel slopes. Where that ratio (Sa/Sc) exceeds 5.0, avulsion risk is considered high and these paths are treated as a defined avulsion path. Ratios of 3-5 are considered moderate and are assessed more site-specifically in terms of overall slope values and implications of a cutoff. For example, if a cutoff would abandon an irrigation diversion, the moderate risk path may be included as a risk in the grading plan.

The surveyed cross sections are modified in the HEC-RAS model to the 2-year WSE (except at the upstream ends of the avulsion paths where they are 6-inches higher) and point bars and lateral bars are added to those cross sections where they will be constructed. The model is run to determine if any of the existing conditions 2-year WSE change once these features are added. Typically, we have seen that the upstream and downstream cross section elevations of the 2-year flow near point bars/lateral bars changes slightly. The same is true for any added secondary channels or oxbows that are activated at flows less than 2-year WSE. The bank elevations are adjusted in the proposed model until the bank elevations and the 2-year WSE are the same or within ~0.1 ft. This procedure will have to be repeated if any of the features are modified that could impact the hydraulics of the system.

Once the proposed conditions HEC-RAS model is finalized and reviewed internally, the bank feature lines in the draft FG surface are revised to reflect any changes in the model's water elevations. The bank feature lines are then offset by 10 feet and raised at a 2 percent slope (sloping towards the channel). Depending on the topography and tie-in elevations, the floodplain is graded at 0.3 to 0.5 percent towards the outside design boundary. Any special features are designed and added to the surface.

Special attention is paid to grading within the avulsion paths. The risk of high flows activating these pathways is reduced by constructing higher ground over the meander tab. In addition to the 2 percent slope mentioned previously, for the upstream end of avulsion paths there is a further raise in finished grade within the next 20-50 feet, a distance which depends on the length of the avulsion path. This ground is raised by another 0.3 feet. This high point on the avulsion path is typically one foot higher (bank height raise 0.5 ft. + 10 ft. offset raise 0.2 ft. + meander tab raise of 0.3 ft.) than the 2-year WSE at the upstream end of the avulsion path. The downgradient slope of the avulsion path should not exceed 3 percent if possible. The **Geomorphologist** is involved closely in this process to make sure the velocities across the downgradient slopes are not too high at the 10-year flow to avoid erosion of the larger grain sizes of the Type A material (a mixture of alluvium and vegetated backfill material that has recently been specified for some higher risk avulsion paths) during out of bank events. The avulsion path slopes, expected velocities, and particle size that is expected to move are documented in a table. It might take a few iterations to arrive at a solution and on tight meander bends not all criteria can be satisfied.

The outside boundary of the FG is added to the model and sloped towards the floodplain at a 4:1 slope. The surface is then cleaned up and reviewed by the Design Team. Any comments/revisions are addressed by modifying the surface before the surface is used to cut cross sections for the Proposed Conditions model.

The runs of the 2-year flow and 10-year flow (and higher flows if required) model are reviewed for areas of high shear stress or velocity, supercritical flow conditions, changes in split flows, and any other potential for increases risk of instabilities in the channel and floodplain. Comparisons are made with the existing conditions. Any issues are addressed and the model is revised until the floodplain meets the requirements of the Design Team, clients, and landowners. An inundation map for the proposed conditions 2-year flow and 10-year flow models are prepared and the areas of inundation are calculated for each design flow. This information is presented in a memorandum summarizing model development, presenting the modeling results, appending model output, and showing cross sections and inundation surface. Model outputs and drawings are also appended to the PDP.

The models are then provided to another **Engineer** for review. Comments are addressed and documented as part of the QA procedures. Each comment is discussed and the resolution action is documented.

Additional analysis is performed to calculate incipient motion of different substrate particle sizes that will move under the 10-year flow. This is used to determine if bank toes need to be replaced or are sufficient as is. The bank toe material is intended to be stable at the 10-year flow. Additional analysis is also performed to identify the critical d_{50} for sections with high shear stress in support of a general discussion in the PDP report on channel stability. The design team has discussed the potential value of having this analysis complete prior to bank treatment lay-out so the information can be used to select appropriate bank treatments.

Once modeling and preliminary floodplain grading are complete, the **Revegetation Consultant** begins to refine revegetation treatments in coordination with other members of the Design Team. The main revegetation-related items refined at this stage include: streambank treatments, floodplain treatment grading (swales and wetlands), microtopography (discussed below), vegetative backfill depths (discussed under Borrow Areas Investigation/Design), and planting locations. Planting locations are typically identified fairly early as they influence floodplain treatments and fencing locations.

Using the Draft FG and BOE, preliminary floodplain fill volumes (alluvium and vegetated backfill) are calculated to determine borrow area needs.

Borrow Areas Investigation/Design:

Borrow Area locations are identified and evaluated based on discussions with the DEQ, the NRDP, and landowners. The preliminary investigation is conducted to verify if the materials meet the design criteria for alluvium and vegetative backfill, general fill, etc. If they do, additional test pit data is collected and a borrow area design is prepared for each of the identified locations. Typically, 12-inches of topsoil are stripped from the borrow areas and stockpiled for reclamation purposes. Preliminary volumes are calculated and additional needs are identified. The **Revegetation Consultant** evaluates the potential to use material below the top 12 inches as vegetative borrow. Soil properties such as texture, organic matter (OM), and salinity/sodicity metrics are considered. If needed, a compost recommendation is developed with the objective of achieving 1.5% OM in the soil. Vegetative borrow material suitability criteria are provided in the Phases 2, 3 & 4 borrow investigation reports. Results of the borrow investigations are delivered to DEQ and NRDP as Data Summary Reports.

Estimated volumes of compost, vegetative borrow, and alluvium are needed for planning purposes. Alluvium is used for floodplain reconstruction, and construction of on-site and other non-public roads. Volumes for these items are calculated and used to produce the engineer's estimate. Cost information is generally not included in the PDP, but is provided to DEQ separately from the final design bid package.

Microtopography, Wood and Brush Placement:

Using the Draft FG, initial locations for microtopography and wood placement in the floodplain are developed and provided by the **Revegetation Consultant** as a shapefile. This information is presented in the landowner plans, in the PDP and used to determine microtopography/brush placement areas and wood needs. Microtopography includes both floodplain roughness (1/2 foot variations in topography) and woody material placement. Woody material can be placed at either a normal density or high density. High density wood is placed in high risk areas such as avulsion paths. Generally, floodplain roughness is implemented in all areas within the remediation boundary except for areas designed for agricultural land use (i.e., hay production). Woody material is prioritized for use along streambanks, within avulsion paths, and within planting units. In all phase except Phase 1, there has not been enough woody material available to place it in all designated areas. Re-prioritization of woody material placement has been required during construction when woody debris is lacking. Criteria for re-prioritization has been phase specific and dependent on the amount of material left.

Draft Final Bank Treatments:

The Design Team finalizes bank treatments including integrating the treatment transitions with floodplain grading.

Dewatering Plan:

During the test pit investigation, depth to groundwater elevations are collected and used to create a groundwater surface for the season during which the investigation was conducted. Additional piezometer information may be available to estimate the depth to groundwater during different times of the year.

This groundwater surface is compared to the BOE surface and areas are identified that would require dewatering. Based on the estimated depth of contamination, dewatering trench/well point locations and sediment pond locations are identified. These locations are compared to the location of the internal haul roads, if known, to minimize potential conflicts. In addition, any conflict between the bank treatment construction/structures/etc. and dewatering trench/sediment ponds are identified. If necessary, trenches/well points/sediment ponds are moved to reduce any conflicts.

Work Areas and Haul Roads:

Work areas are delineated and named. The delineations of the work areas are assigned with the input of the construction team to make sure the work flow makes sense and that they are close to 10 acres. The locations of temporary bridges and culverts are also identified and internal haul roads are designed and included in the Haul Road Plans. Primary haul roads normally outside the removal boundary are also planned and shown on the drawings.

Clearing Areas:

Woody vegetation clearing areas are identified using aerial photography (or layers provided by the **Revegetation Consultant**). The surface areas are calculated for the engineer's estimate. These areas are added to the site plan to show where the clearing should take place.

Fencing Types and Locations:

Locations and types of fencing area also evaluated and integrated into the design at this time. Fence locations are based on existing fence locations and types, where wildlife protection fence is needed, where construction protection fence is needed, planting locations, property boundaries, etc. This is often an iterative process involving the landowners. The **Revegetation Consultant** typically provides the fencing lay-out (for wildlife protection fence) via shapefile. Once the fence locations are reviewed by the Design Team and the landowners, they are added to the Site Plan and presented in the PDP. This item is always subject to change as the design proceeds. A memo is in the works that will outline vegetation protection measure criteria and specific recommendations for Phases 1 through 9.

Details:

All details are reviewed by the construction oversight team and the Design Team to incorporate design changes or improvements noted during construction. This has been a very valuable process and many improvements to design aspects or new treatments have been developed. These items are also addressed in the special provisions and specifications.

Preliminary Design Plan (PDP) and Draft Design Drawings:

Most of the information described above is reviewed by the Design Team and presented in the PDP for review by DEQ and NRDP. The PDP includes sections with results of the investigations on vegetation (**Revegetation Consultant**), geomorphology (**Geomorphologist**), Hydrology and Bank Toe Material (**Engineer**). It may be preferable to submit these investigations as stand-alone documents as is done for the tailings/impacted soils investigation and the borrow area investigations. Results of the existing conditions and proposed conditions hydraulic models are discussed in the PDP and appended to the document. An outline of a recent PDP report is attached to this memorandum. Draft Design Drawings are also presented with the PDP and contain all the major elements of the design but do not include subgrade surfaces, swale elevations and other items specific to the site. The report and drawings are the main elements of the PDP and result from a collaborative effort among members of the design team who are involved in development of the surfaces and plans as they are prepared. This iterative approach reduces the amount of review necessary to complete the PDP before delivery to the client.

Before delivery to the client, the draft PDP is reviewed by the Technical Review Committee (TRC). The TRC consists of personnel involved in the design as well as other design experts not involved in developing the design. The TRC members produce comments which are reviewed in the TRC meeting and resolved. The TRC chairman documents the meeting and the responses to comments and ensures that all comments are addressed. After this internal review, the draft PDP is reviewed by DEQ, NRDP and the Environmental Protection Agency (EPA) and then modified as needed for further review by the Design Review Team (DRT), a group of interested parties including local government, state and federal agencies.

Draft and Final Bid Packages

The following Items are generally produced for the first time after the PDP for submittal with the draft Bid Package:

Subgrade Surface:

The draft FG is used to create the draft SG (subgrade surface) which is typically 0.5 feet (vegetated backfill) below the FG surface except next to the banks, point bars, wetlands, and some areas of specific land uses (i.e., hayfields). The draft final bank treatments are used to create feature lines that reflect the type of material designated in the details for each of the treatments. Geum provides a shapefile with the vegetative backfill depths. In areas where oxbow or secondary channels will be re-built, grading is often more detailed and developed closely with Geum to ensure that the surfaces reflect pre-remediation surfaces to support successful revegetation.

Once the surface is reviewed, a volume surface (SG vs FG) is created and colors assigned for each vegetative backfill depth. This surface is used to check the vegetative backfill depths. Any discrepancies are evaluated and corrected before the volume calculations for vegetative backfill are finalized. Keep in mind that some treatments might change during the final-walk though and might have to be adjusted.

The avulsion paths and CMZ shapefiles provided by the **Geomorphologist** are added to the drawings and areas where general fill can be placed are identified to ensure that materials balance with the available borrow area materials. As part of the CMZ shapefile submittal, areas of the originally defined CMZ that are not contaminated are clipped out of the total CMZ area, so that the modified CMZ contains only those areas that are contaminated. Areas where Type A material is needed are also identified and volumes are calculated.

Non-impacted Material:

In addition to the vegetative backfill analysis, a volume surface (BOE vs SG) is created to determine the volume of non-impacted material and alluvium/general fill. Non-impacted material is material that does not exceed the contaminant levels of tailings/impacted soil but needs to be removed to allow construction of the final grade with sufficient provision for vegetative backfill. This sometimes occurs where the FG is lower than the EG. The volume surface (BOE vs SG) is also used to determine where the non-impacted material is located, if any, and its depths. Some areas are too small to extract the material while others provide significant volume. We have noticed that only a fraction of the initially identified non-impacted material can be used - any areas with less than 0.2 feet tend not to be feasible to remove and use. Adjustment to the quantities are made. The suitable non-impacted material is subtracted from the general fill needs.

Figures are created with depth ranges of non-impacted material and presented to the Design Team for review during the next design submittal.

Final Grading Review and Refinement:

The FG surface is then provided to another **Engineer** for review. Comments are addressed and documented as part of the QA procedures. Each comment is discussed and the resolution action is documented.

The **Revegetation Consultant** reviews the FG surface in ArcGIS to ensure that design criteria are still being met for floodplain features. This review is based on the 2-year WSE provided by the **Engineer**. The **Revegetation Consultant** does not review the HEC-RAS model itself. The **revegetation consultant** provides written comments to the Engineer describing their findings.

A final step usually conducted after the FG has been reviewed by the landowners and client is to assign elevations to wetlands and swales based on design criteria that are specific to each Phase, mainly due to varying groundwater influences. The revegetation consultant provides swale and wetland locations in a shapefile format. The Design Team reviews the final FG and any comments/revisions are addressed.

Continued Landowner Meetings:

Landowner involvement continues through the design process, so that the final FG and other design elements are acceptable to the landowner.

Final Field Review

After development of the draft Final Plans, the Design Team conducts a final walk through to evaluate bank treatments and other design issues that may warrant a field check.

Draft Bid Package:

With the additional elements developed since the PDP, a draft Bid Package is prepared that includes Design Drawings, Special Provisions, and Technical Specifications. The **Revegetation Consultant** provides updated drawings, details and specification language for fencing, haul road and staging area reclamation, floodplain roughness and wood placement, and other revegetation-related items. All members of the Design Team review the final plan set and special provisions for content and clarity, and a final Technical Review Committee meeting is held at which remaining issues with the design are resolved.

DEQ and NRDP review and comment on the draft Bid Package. Once DEQ/NRDP comments are addressed and incorporated into the package, the package is submitted to EPA for approval.

Final Bid Package:

Any final comments from EPA, DEQ, NRDP, and the Design Team are addressed in the bid package. The engineer's estimate is finalized with bid items and volumes from the final surfaces and final design package before it goes out to bid.

Revegetation Plan Development and Implementation:

A preliminary revegetation plan is included in the PDP; however, the detailed, final revegetation plan is not prepared until a few months prior to construction completion in a phase. The final revegetation plan includes planting locations, seeding locations, seedbed prep locations, and installation of vegetation protection measures (other than fence installation, which is typically done by the general contractor. The revegetation plan includes plant installation quantities, species mixes and container sizes. Planting polygons are created in ArcGIS using the FG surface. A Tier II Solicitation is issued to select a vegetation contractor to implement the revegetation plan. Revegetation is implemented as construction is completed in portions of a project area.

Monitoring

Monitoring Plan Development:

A vegetation and geomorphology Sampling and Analysis Plan is developed for each project phase, based on the *Clark Fork River Operable Unit Reach A Geomorphology and Vegetation Monitoring Plan* (DEQ, 2015). This sampling plan is developed near project completion so final surfaces and remediation/restoration treatments can be used as a spatial basis for the plan. Monitoring schedules, protocols and adaptive management strategies are described in detail in those plans. Information gathered during monitoring cycles and annual Qualitative Rapid Assessments (QRA) is used to identify maintenance actions and refine future designs.

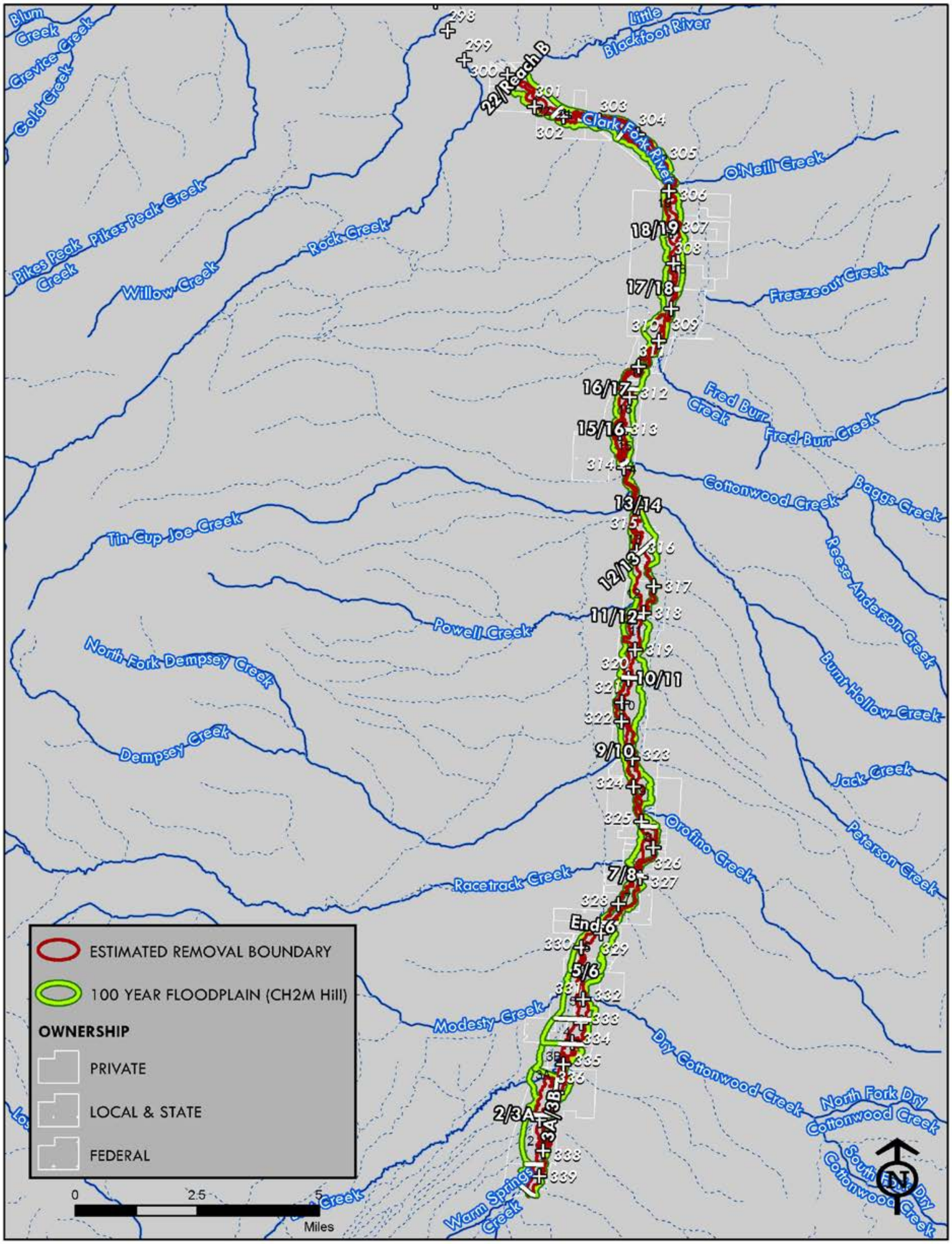
References:

CDM Smith CDM Smith and AGI, 2013. Geomorphology and Hydrology of Reach A, Clark Fork River Operable Unit Milltown Reservoir/Clark Fork River Superfund Site, Powell, Deer Lodge, and Granite Counties. Prepared for the Montana Department of Environmental Quality. September.

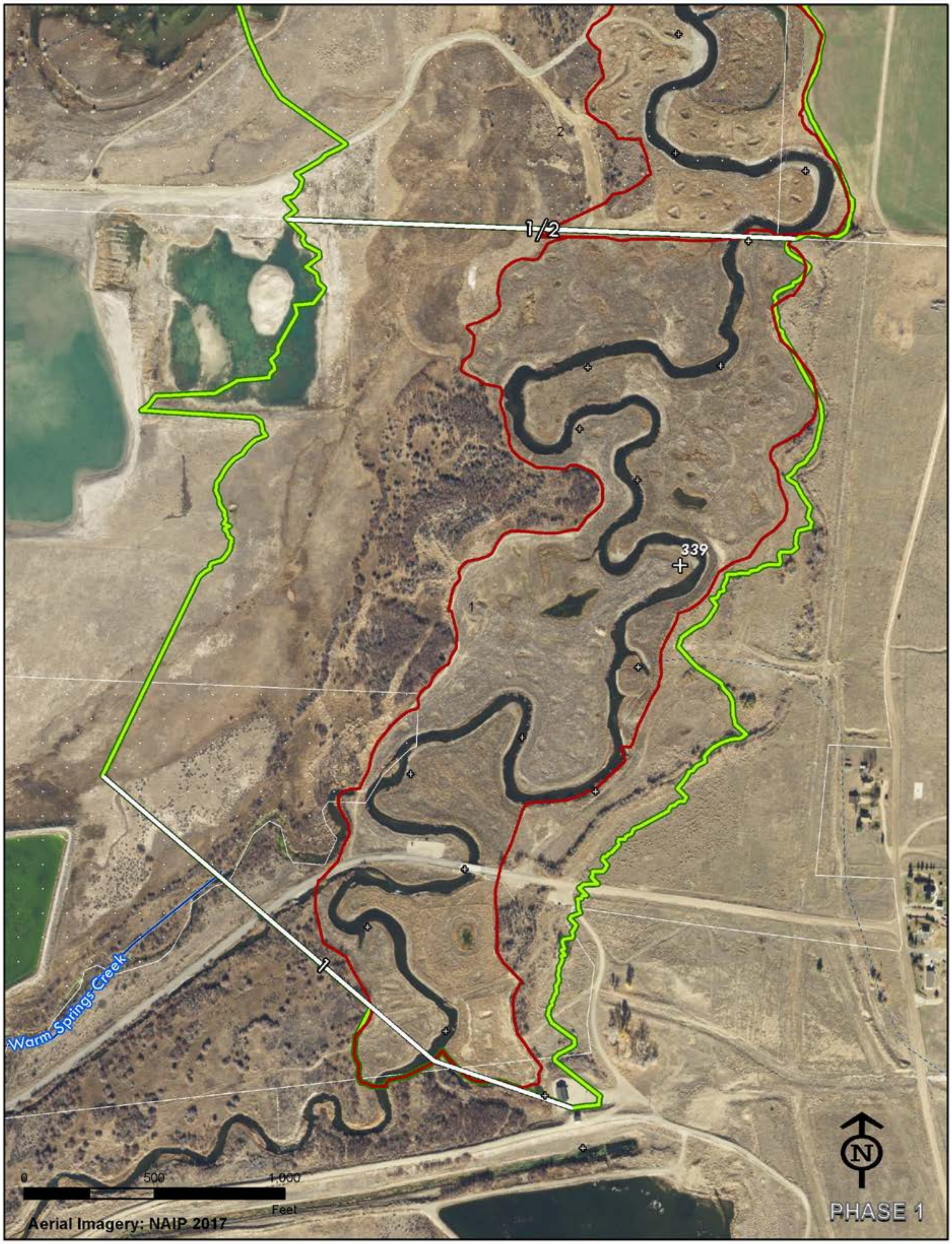
Department of Environmental Quality, 2015. Clark Fork River Operable Unit Reach A Geomorphology and Vegetation Monitoring Plan.

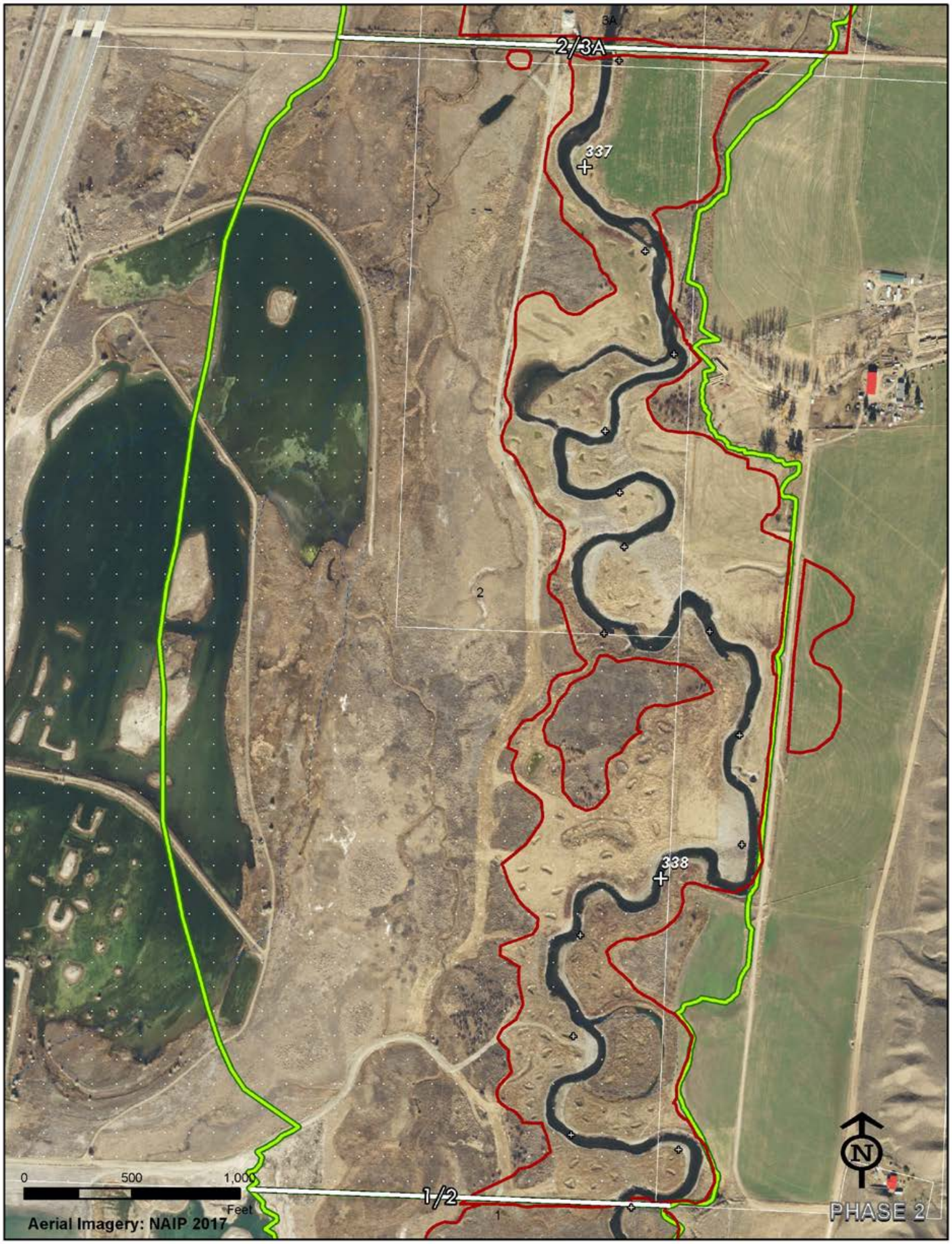
ATTACHMENT: Table of Contents for Preliminary Design Report

Attachment C. Maps Showing Estimated Removal Boundary for Reach A

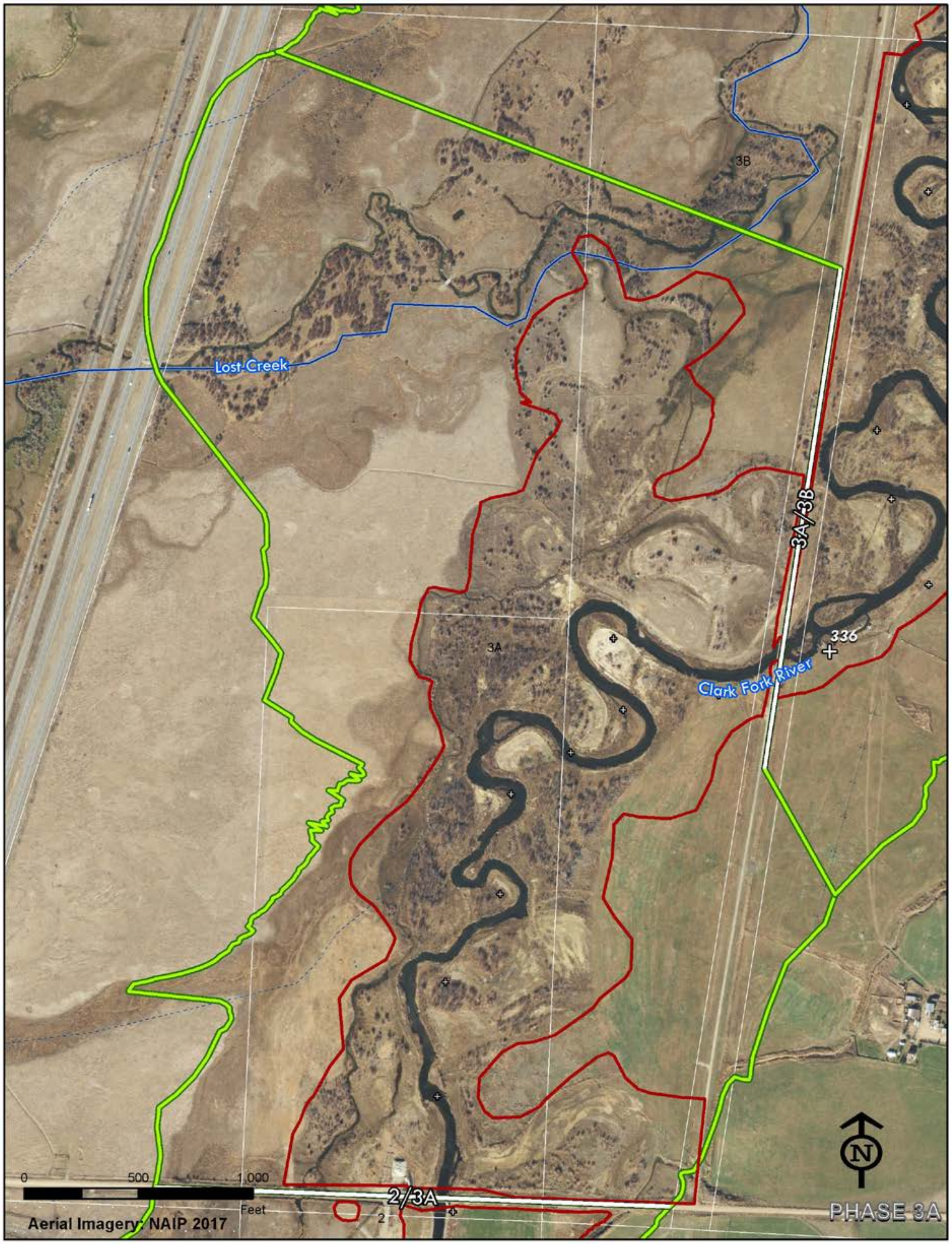


ESTIMATED REMOVAL BOUNDARY
100 YEAR FLOODPLAIN (CH2M Hill)
OWNERSHIP
PRIVATE
LOCAL & STATE
FEDERAL
0
2.5
5
Miles
Clark Fork River
Little Blackfoot River
O'Neill Creek
Freezeout Creek
Fred Burr Creek
Cottonwood Creek
Baggs Creek
Reese Anderson Creek
Burnt Hollow Creek
Jack Creek
Peterson Creek
Orofino Creek
Dry Cottonwood Creek
North Fork Dry Cottonwood Creek
South Fork Dry Cottonwood Creek
Warm Springs Creek
Modesty Creek
Racetrack Creek
Dempsey Creek
North Fork Dempsey Creek
Powell Creek
Tin Cup Joe Creek
Rock Creek
Willow Creek
Pikes Peak Creek
Gold Creek
Grevice Creek
Blum Creek
22/Reach B
18/19
17/18
16/17
15/16
13/14
12/13
11/12
10/11
9/10
7/8
End 6
5/6
2/3A
3A/3B

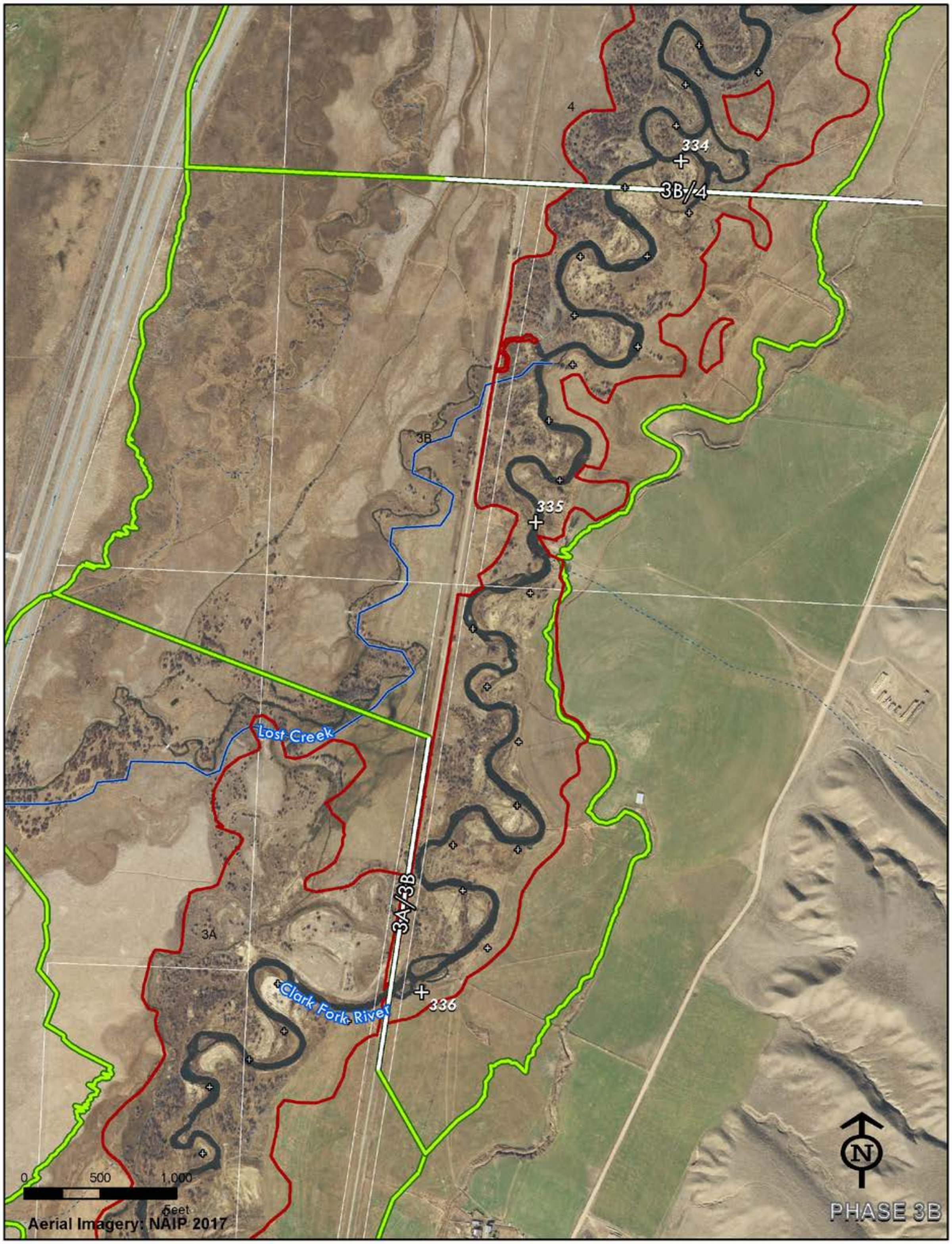

1/2
2
339
1
1
Warm Springs Creek
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
N
PHASE 1

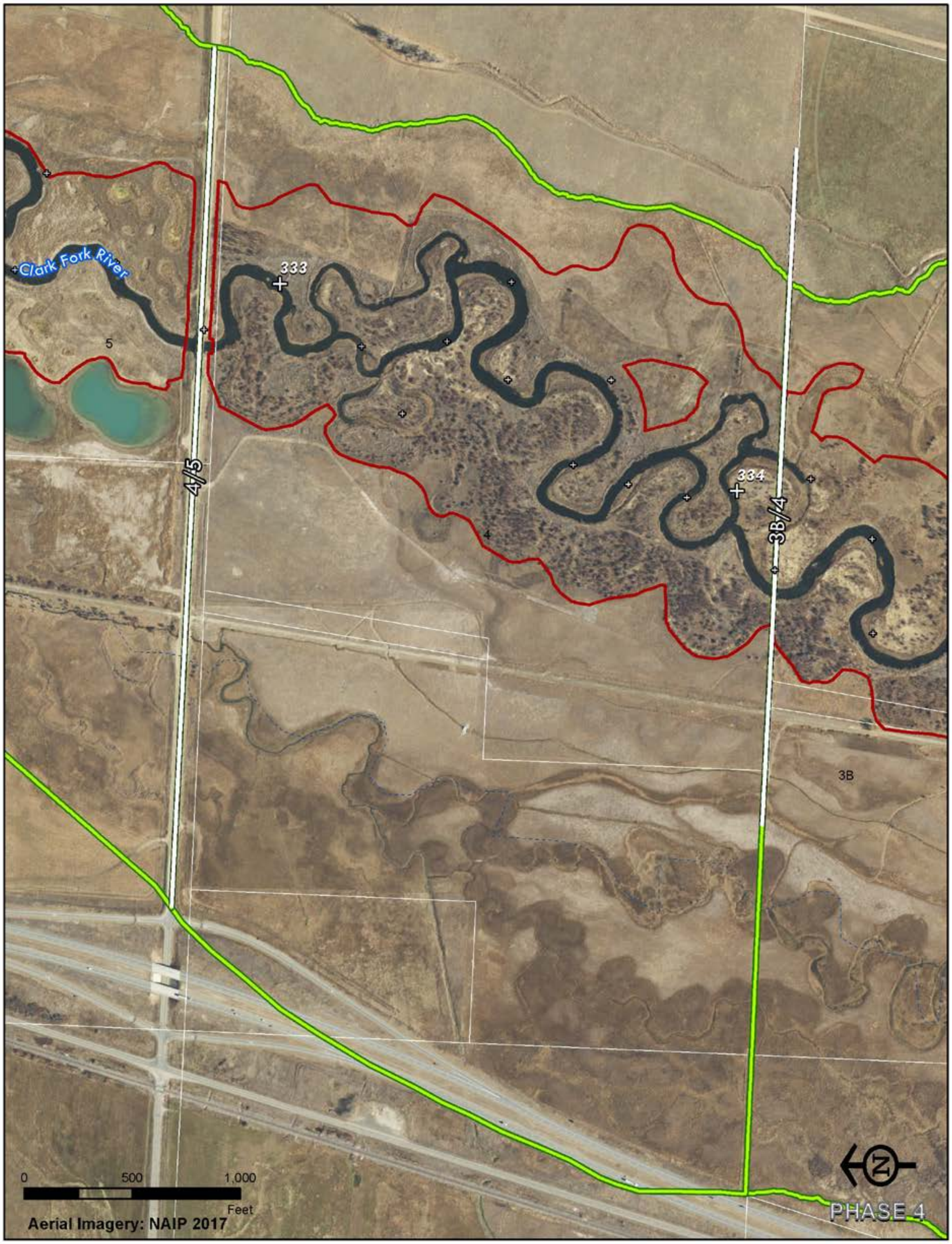


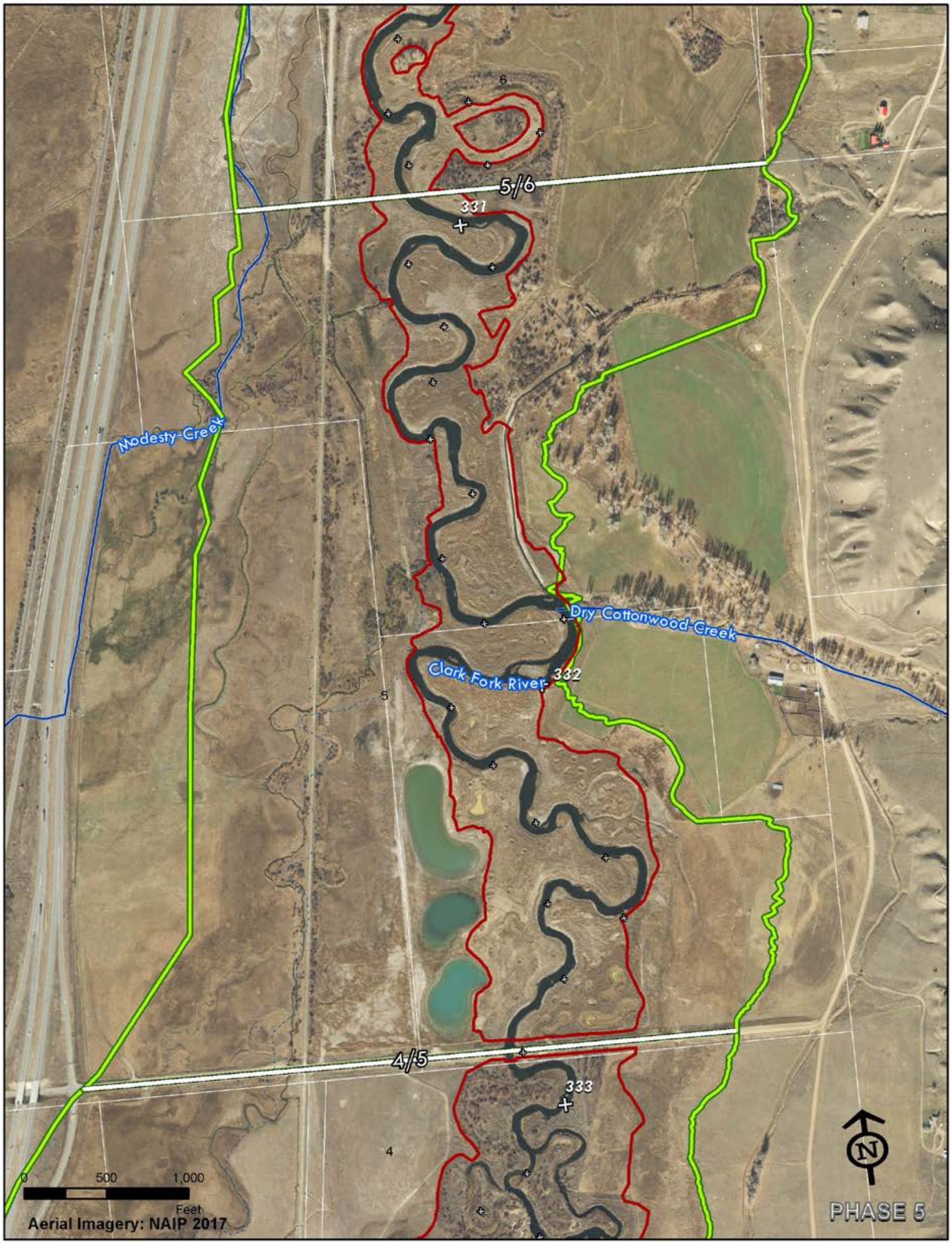
3A
2/3A
337
2
338
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
1/2
1
N
PHASE 2

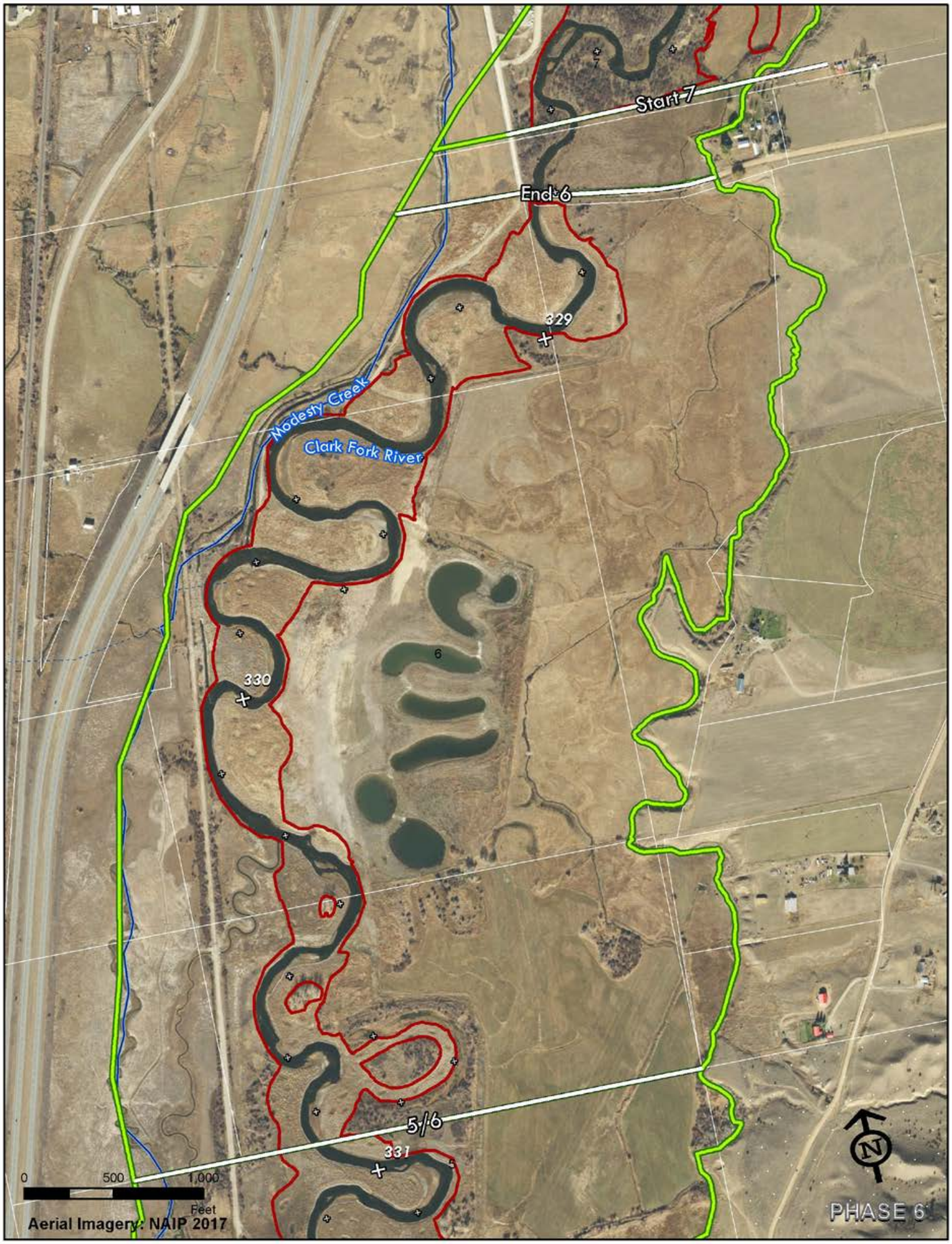


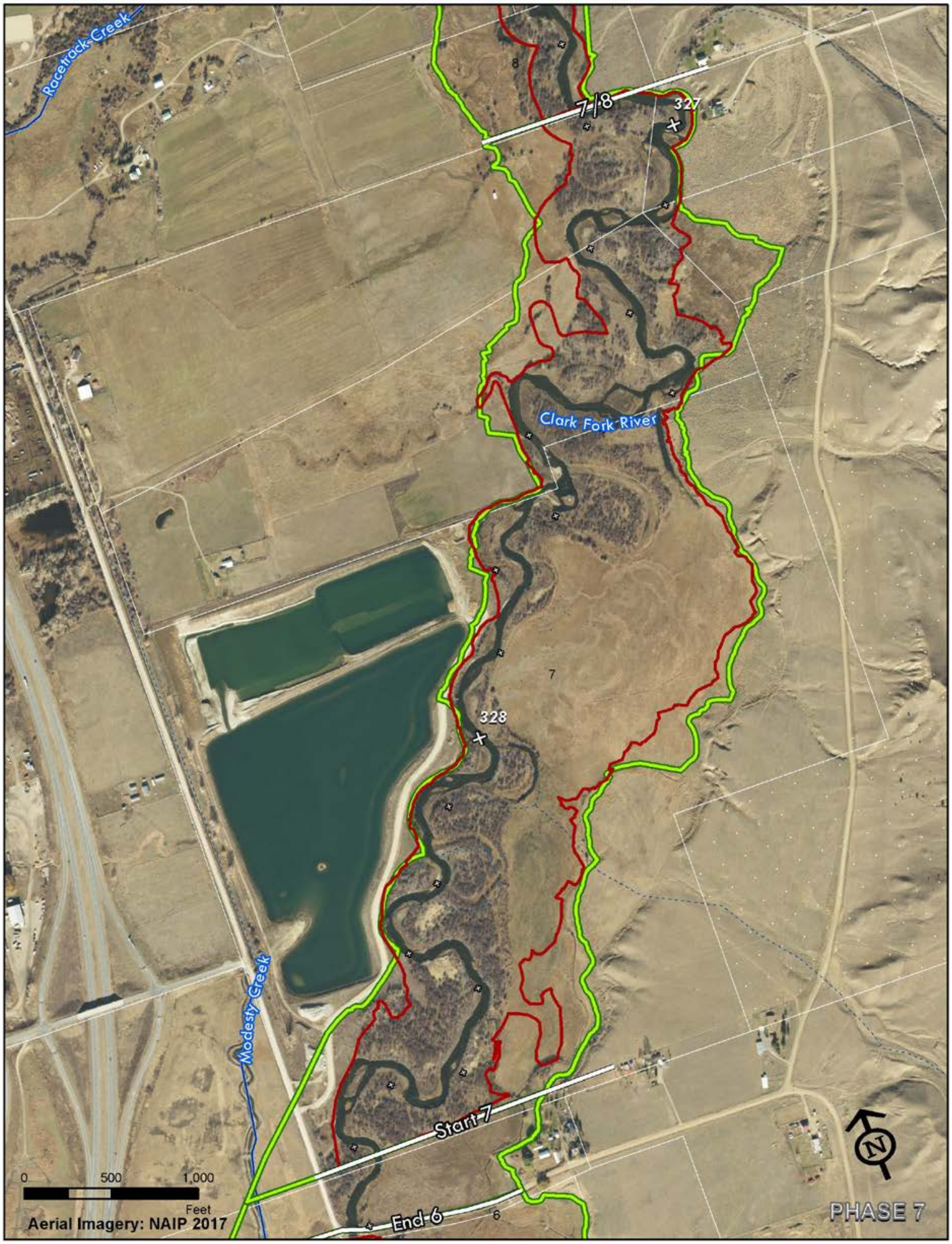
3B
Lost Creek
3A/3B
3A
336
Clark Fork River
0
500
1,000
Feet
2/3A
2
Aerial Imagery: NAIP 2017
N
PHASE 3A


334
3B/4
4
3B
335
Lost Creek
3A/3B
3A
Clark Fork River
336
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
N
PHASE 3B

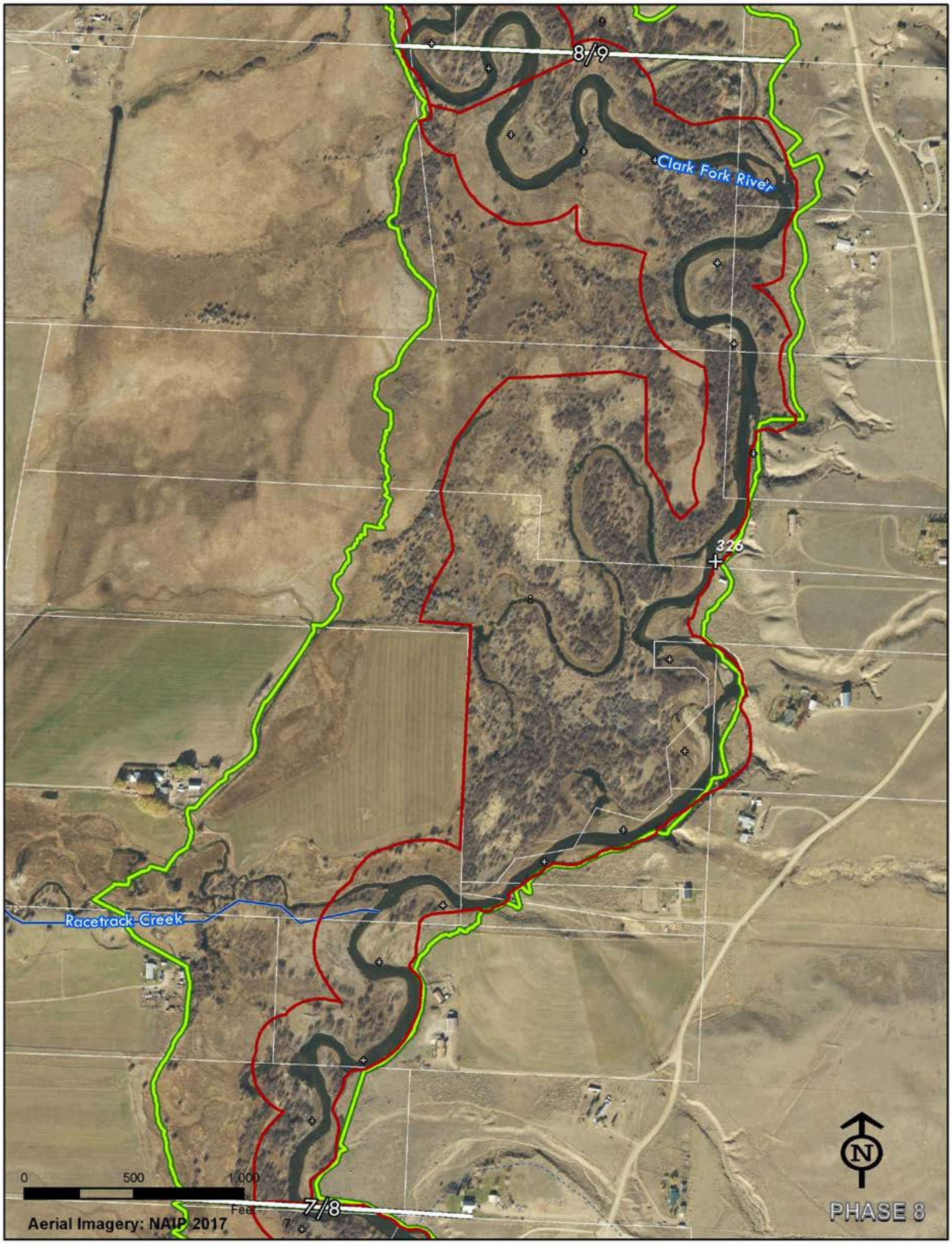

Clark Fork River
333
334
5
4
3B
4/5
3B/4
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
PHASE 4

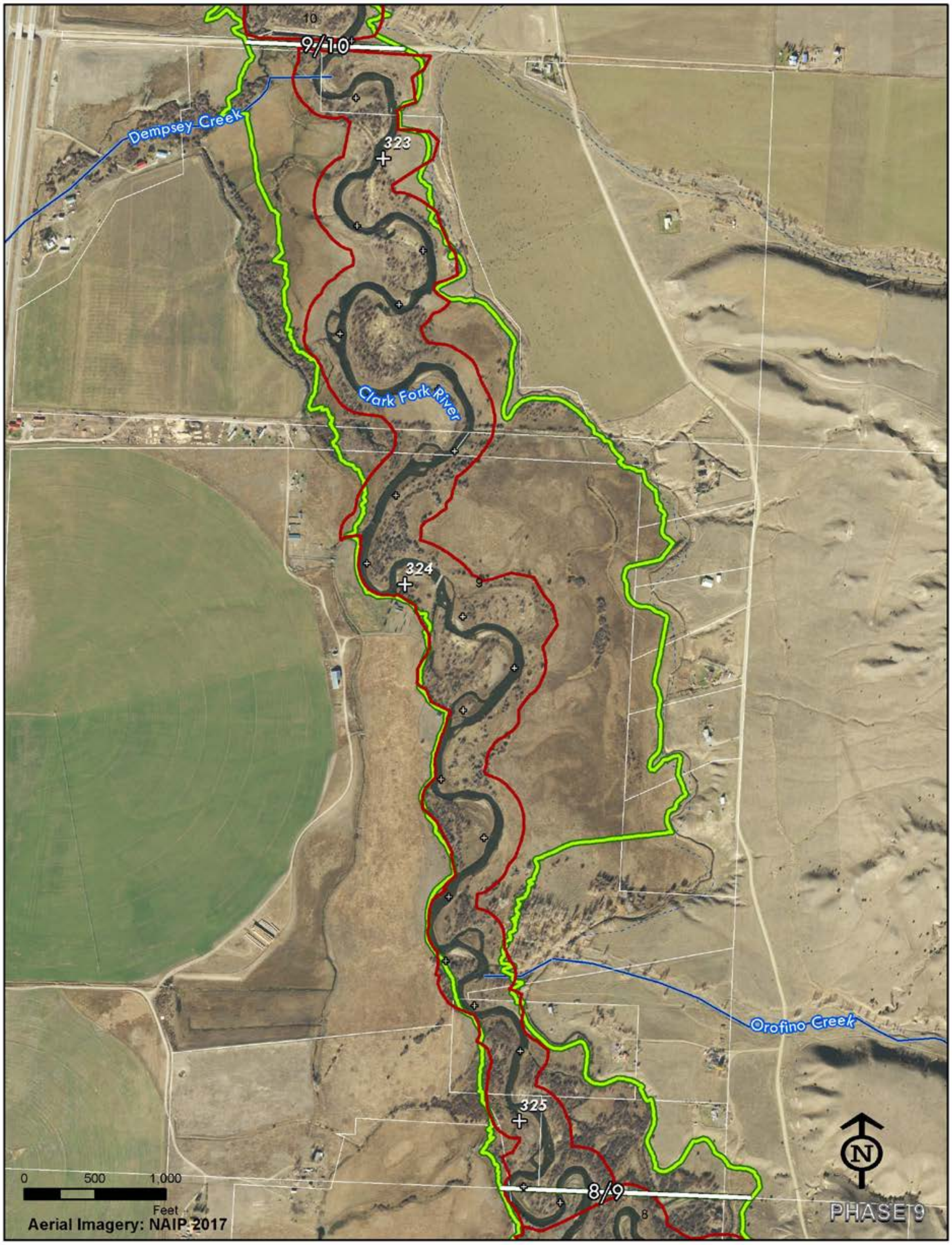

5/6
331
Modesty Creek
Dry Cottonwood Creek
Clark Fork River
332
4/5
333
6
5
4
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
N
PHASE 5


Start 7
End 6
329
Modesty Creek
Clark Fork River
6
330
331
5/6
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
PHASE 6

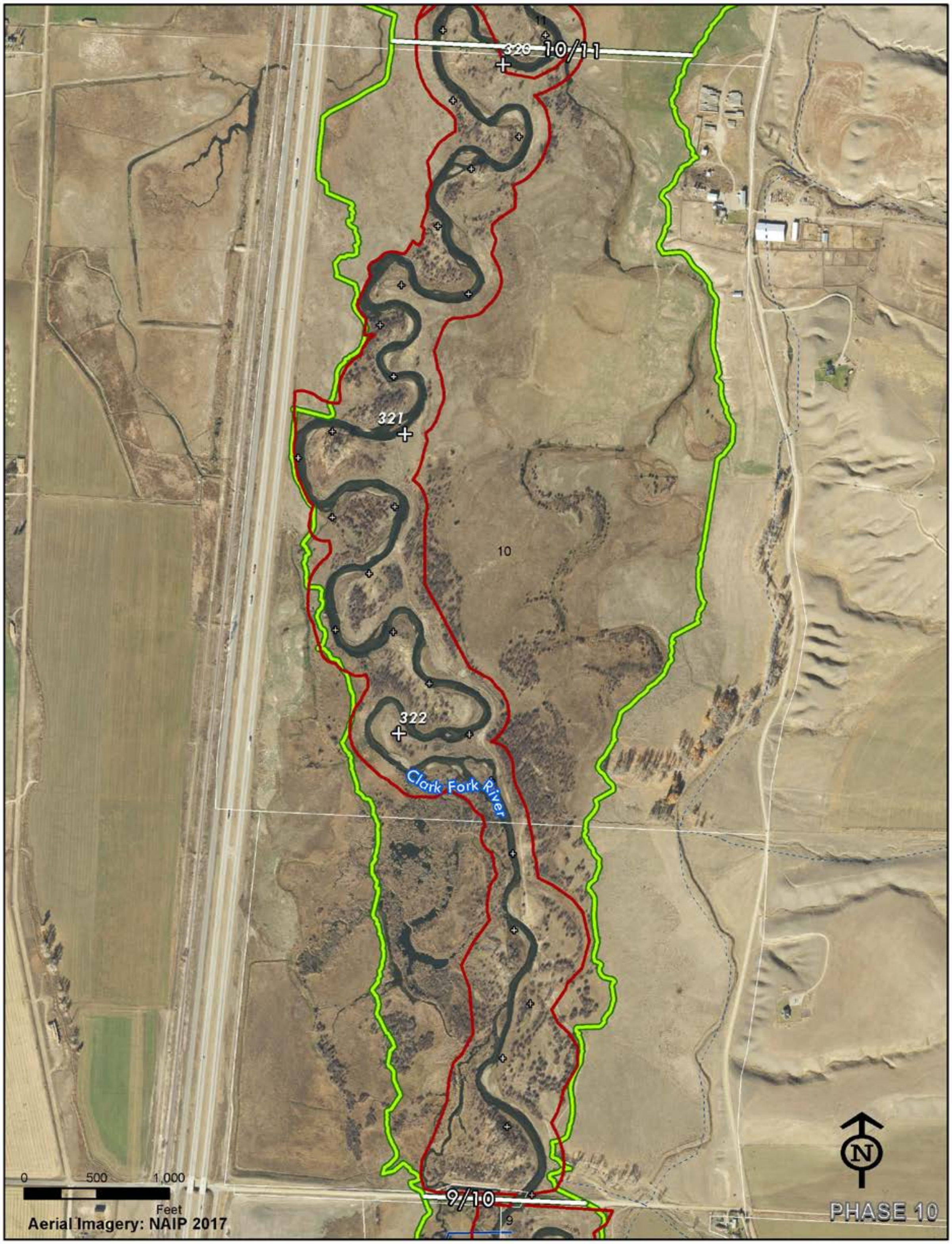


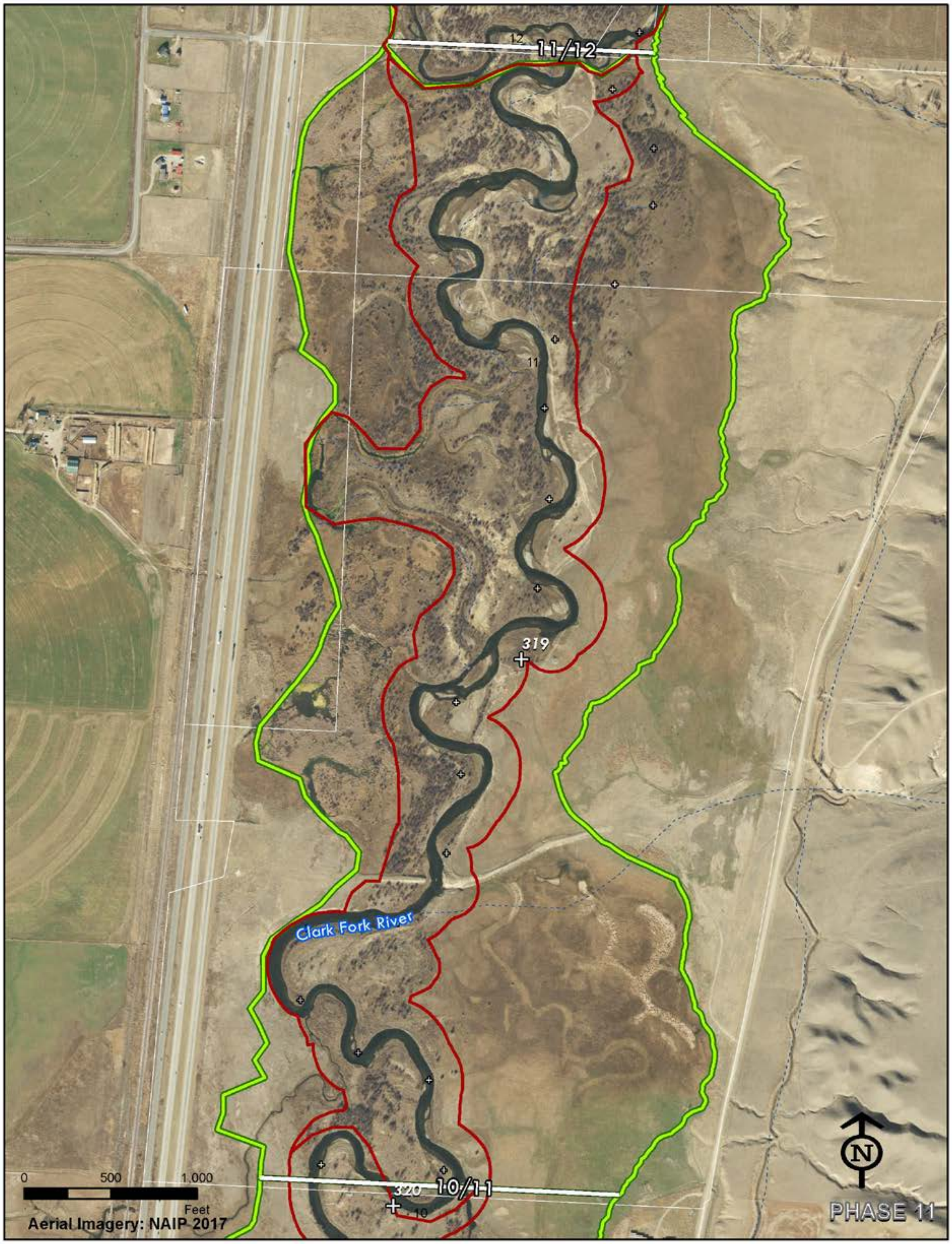
Racetrack Creek
7/8
327
8
Clark Fork River
7
328
Modesty Creek
Start 7
End 6
6
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
N
PHASE 7


8/9
Clark Fork River
326
Racetrack Creek
0
500
1,000
Feet
7/8
Aerial Imagery: NAIP 2017
N
PHASE 8

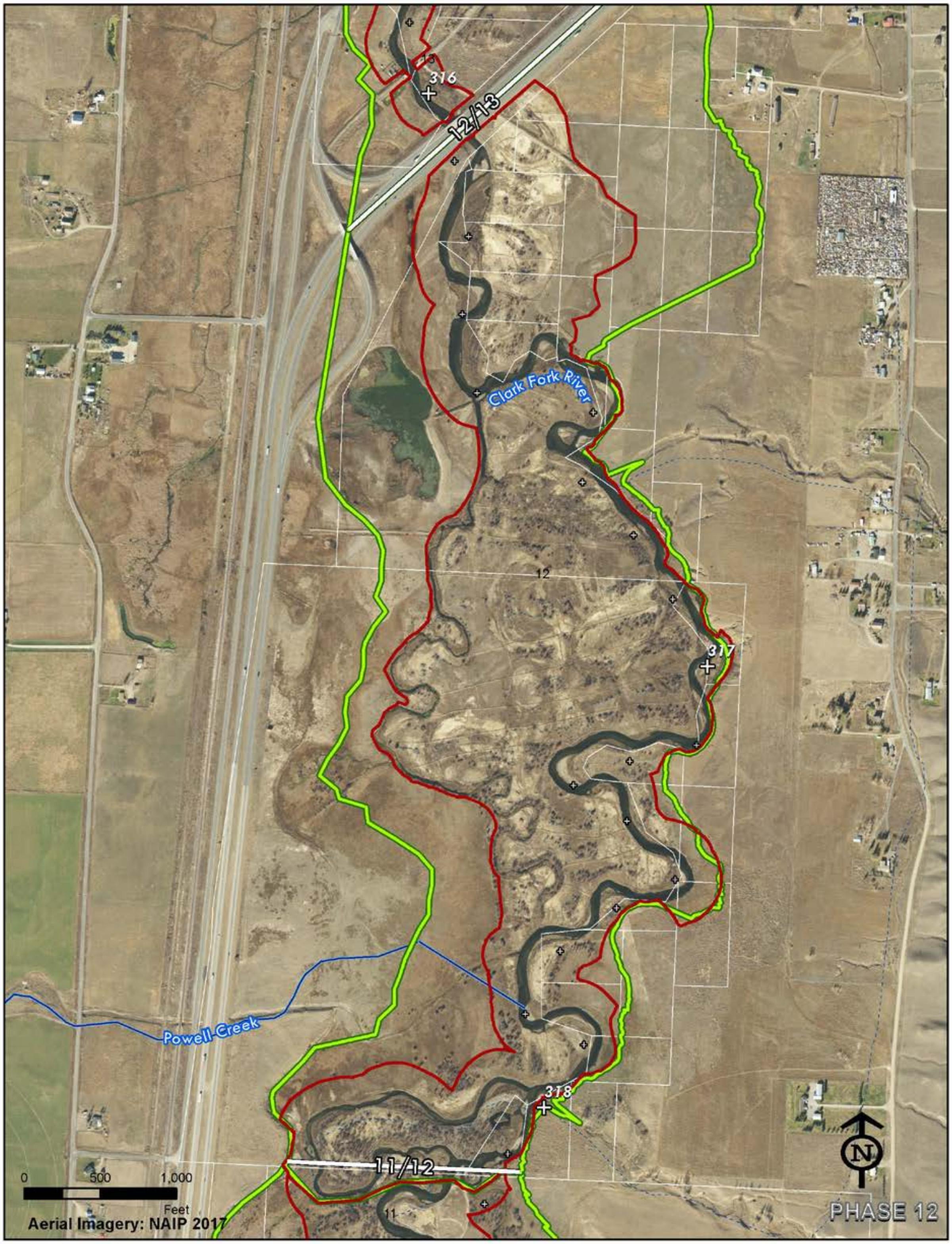


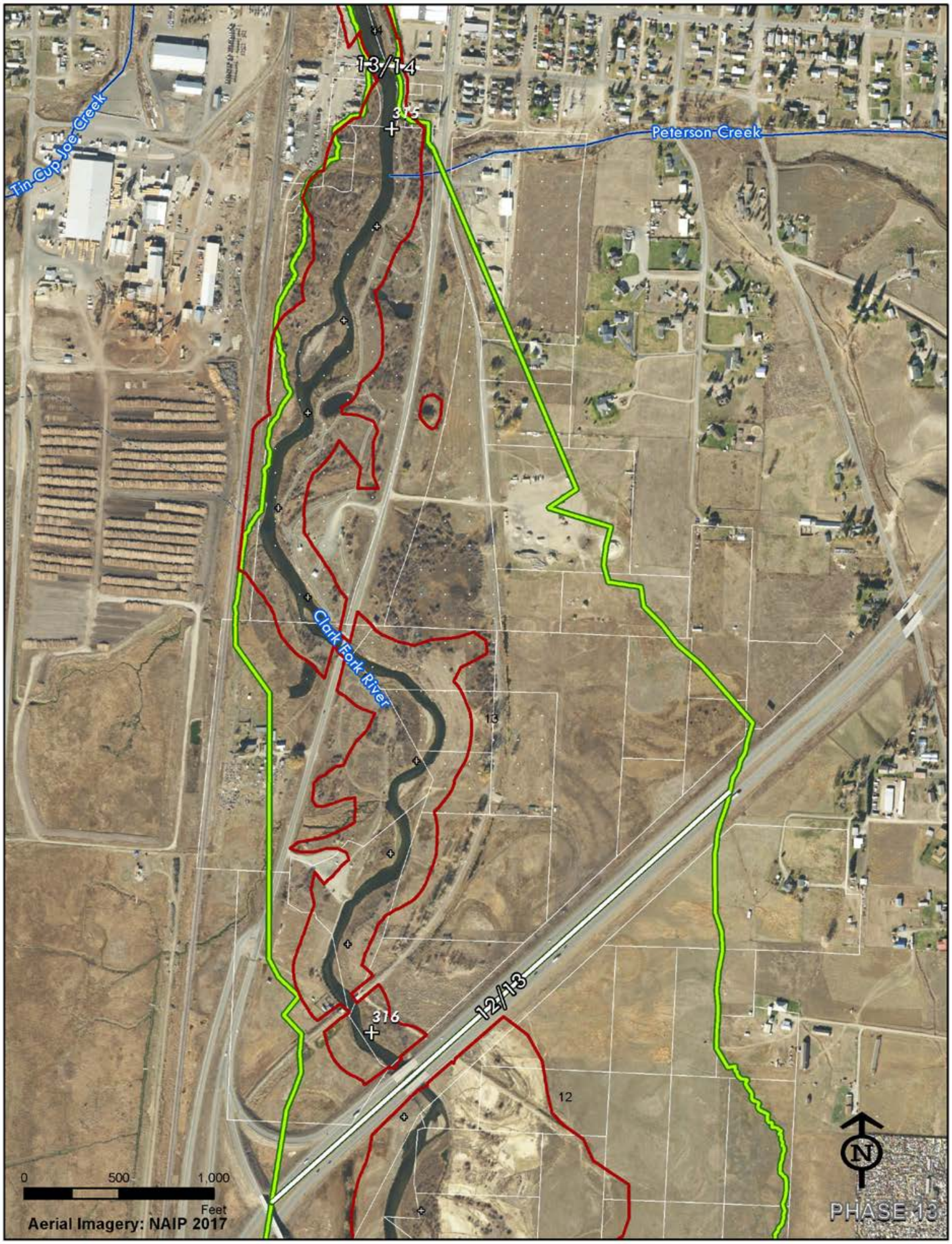
10
9/10
Dempsey Creek
323
Clark Fork River
324
9
Orofino Creek
325
8/9
8
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
N
PHASE 9


11
320
10/11
321
10
322
Clark Fork River
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
9/10
9
N
PHASE 10

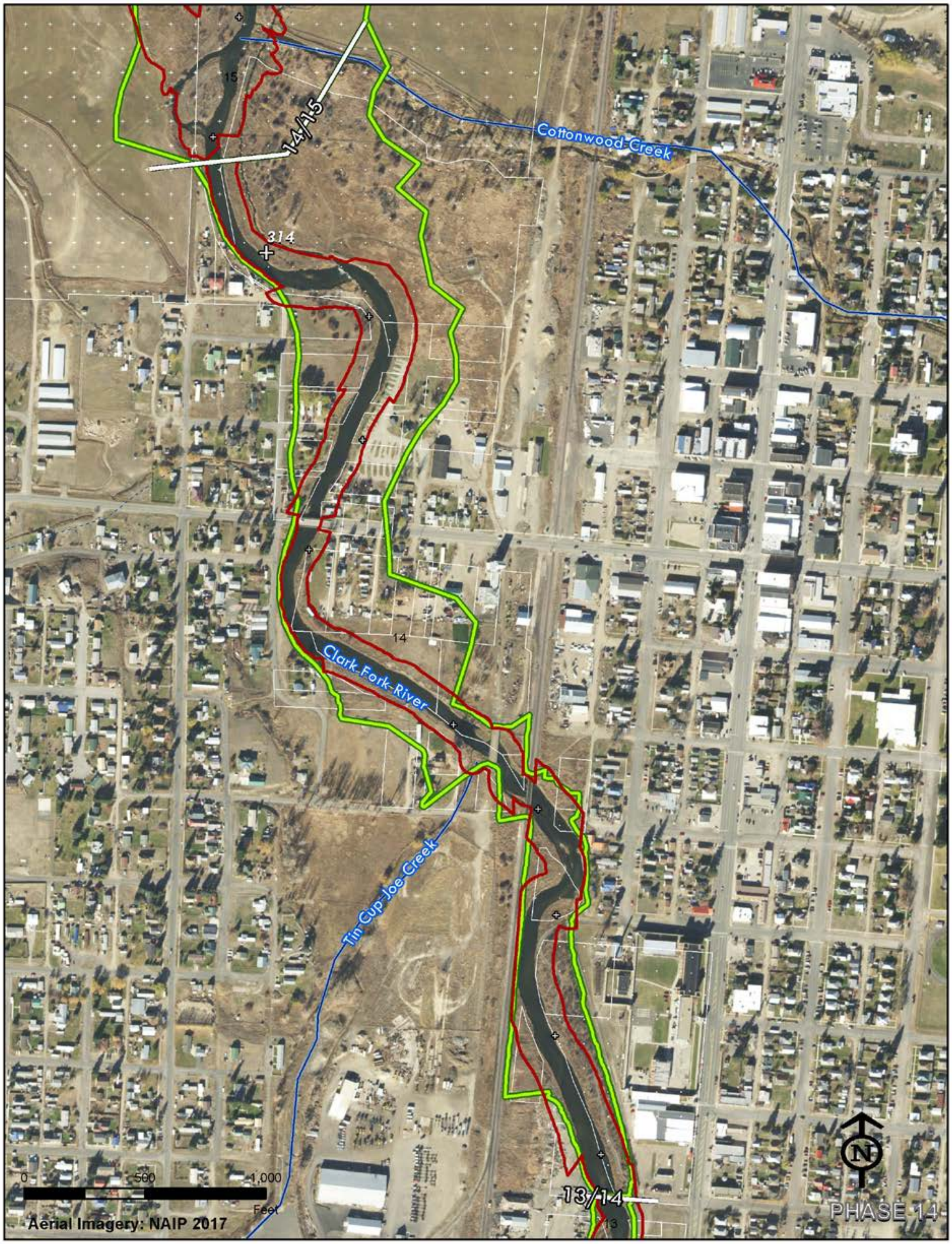


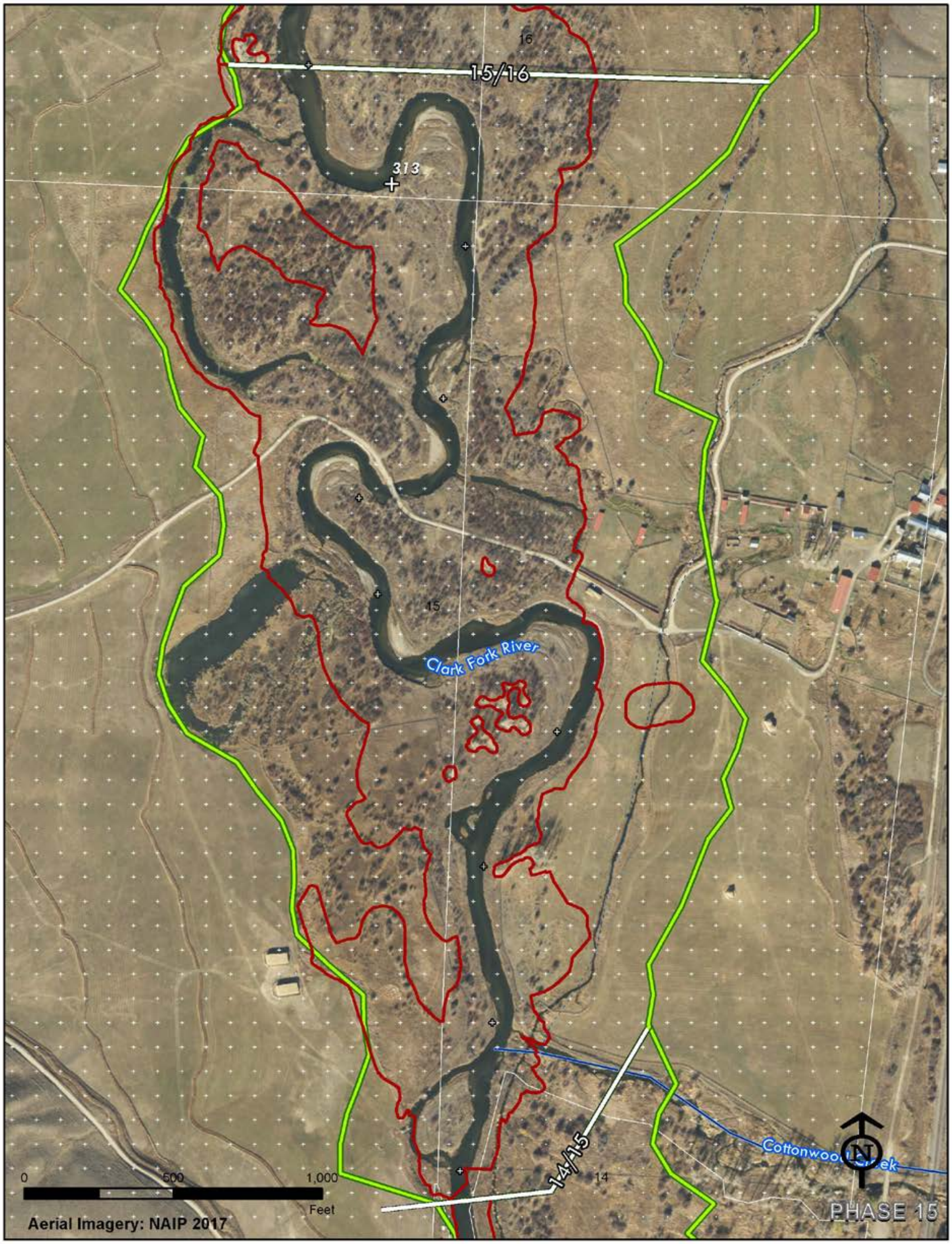
11/12
12
11
319
Clark Fork River
10/11
320
10
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
N
PHASE 11

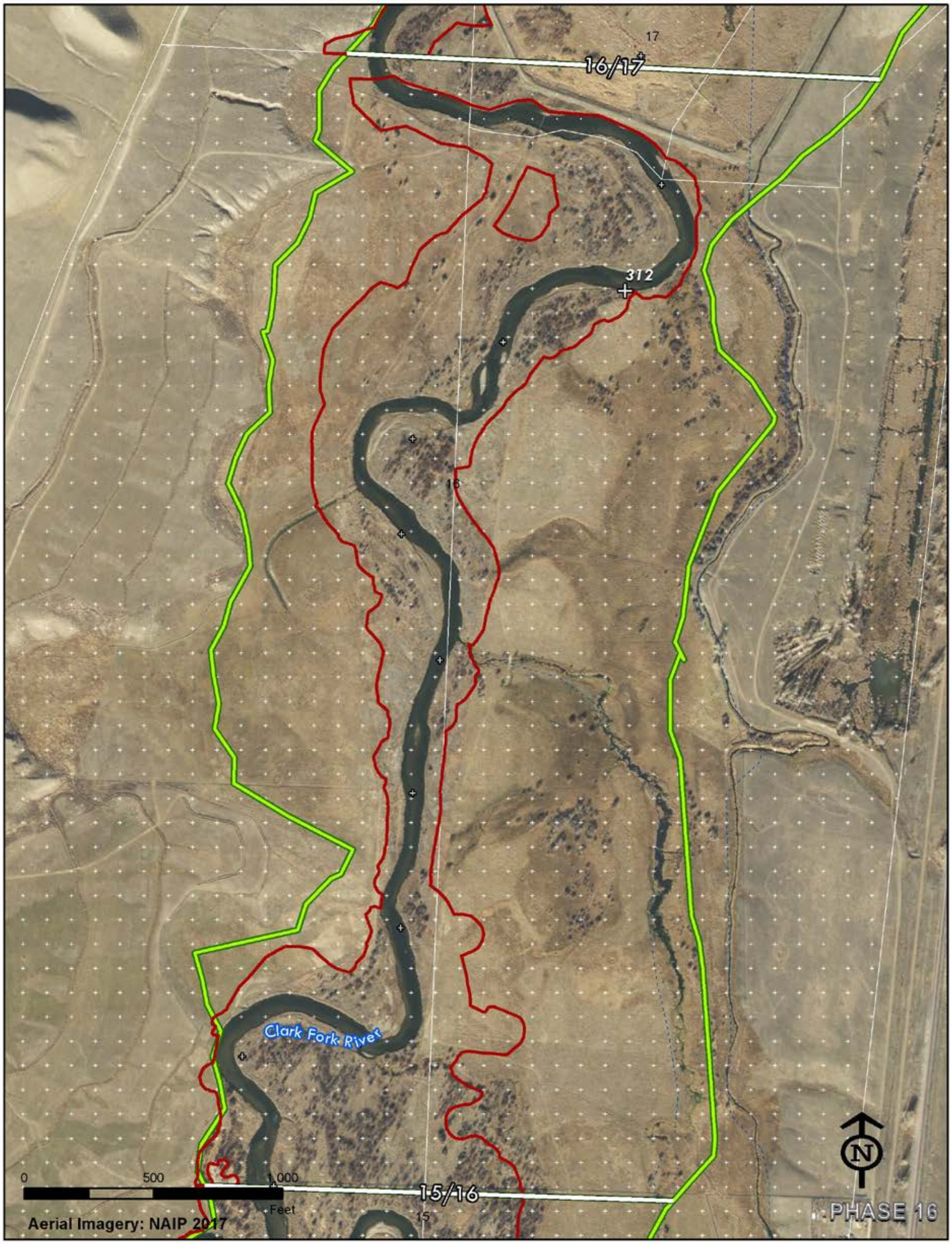

316
12/13
Clark Fork River
12
317
Powell Creek
318
11/12
11
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
PHASE 12

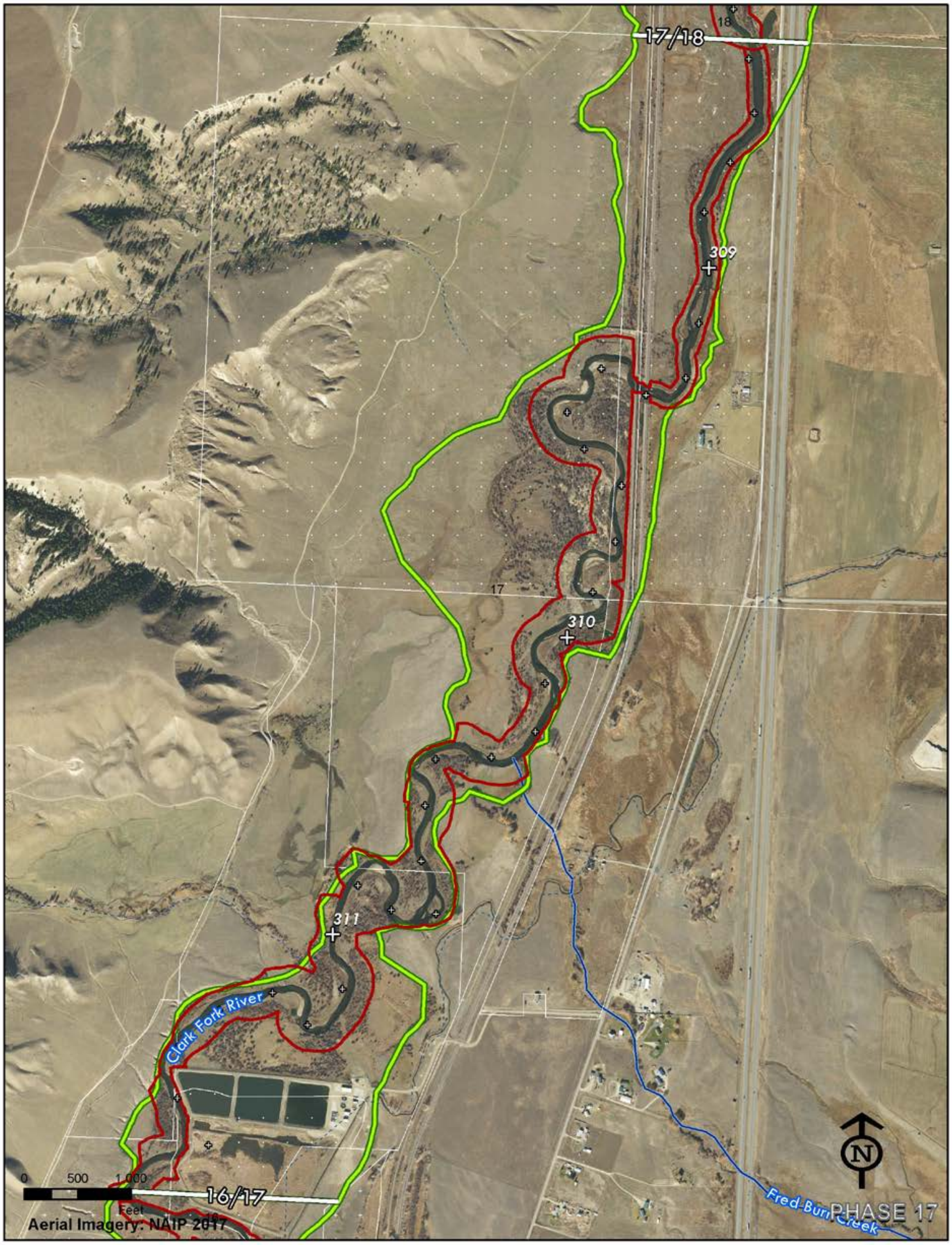


13/14
315
Peterson Creek
Tin Cup Joe Creek
Clark Fork River
13
12/13
316
12
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
N
PHASE 13


15
14/15
Cottonwood Creek
314
14
Clark Fork River
Tin Cup Joe Creek
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
13/14
13
N
PHASE 14

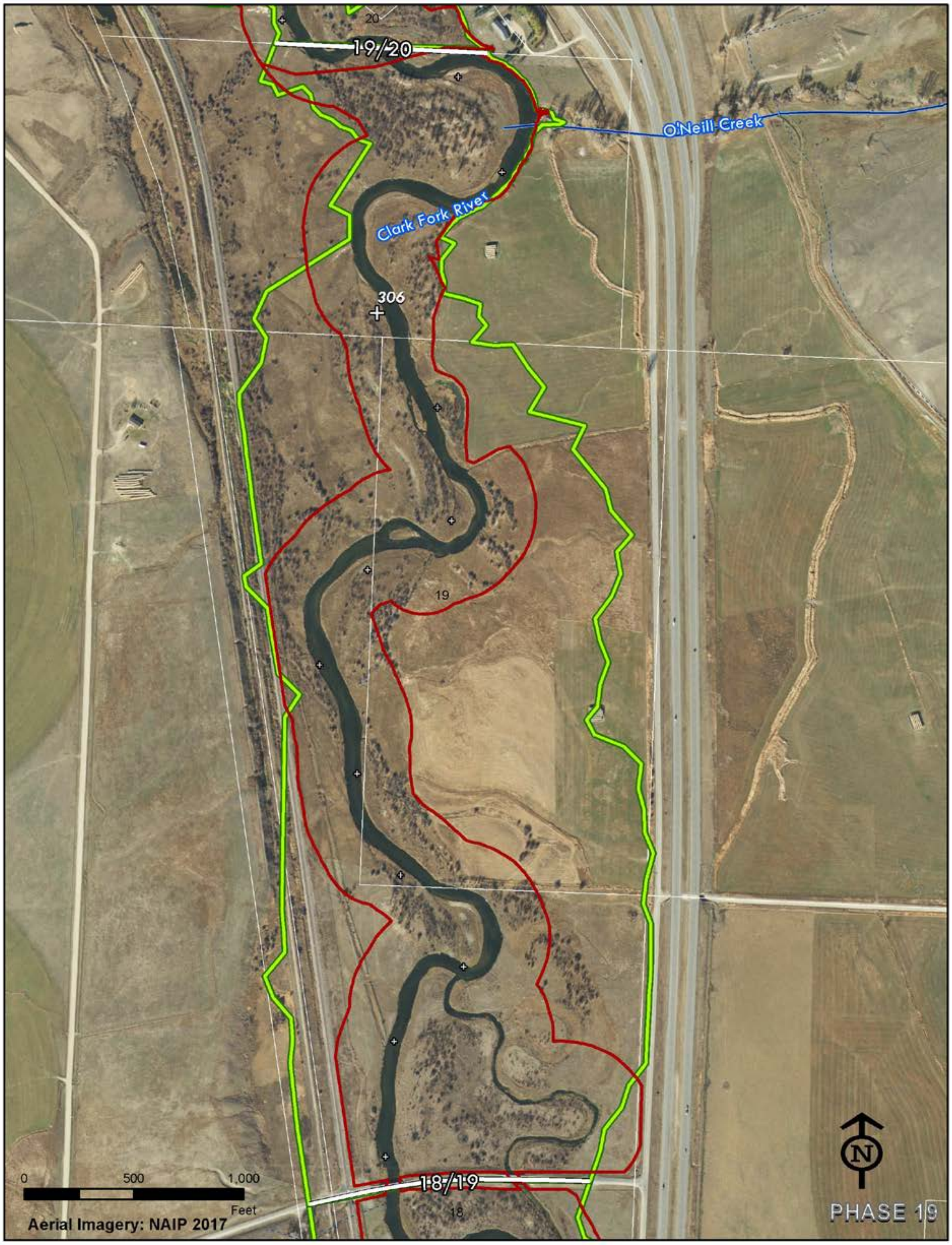

16
15/16
313
15
Clark Fork River
14/15
14
Cottonwood Creek
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
PHASE 15

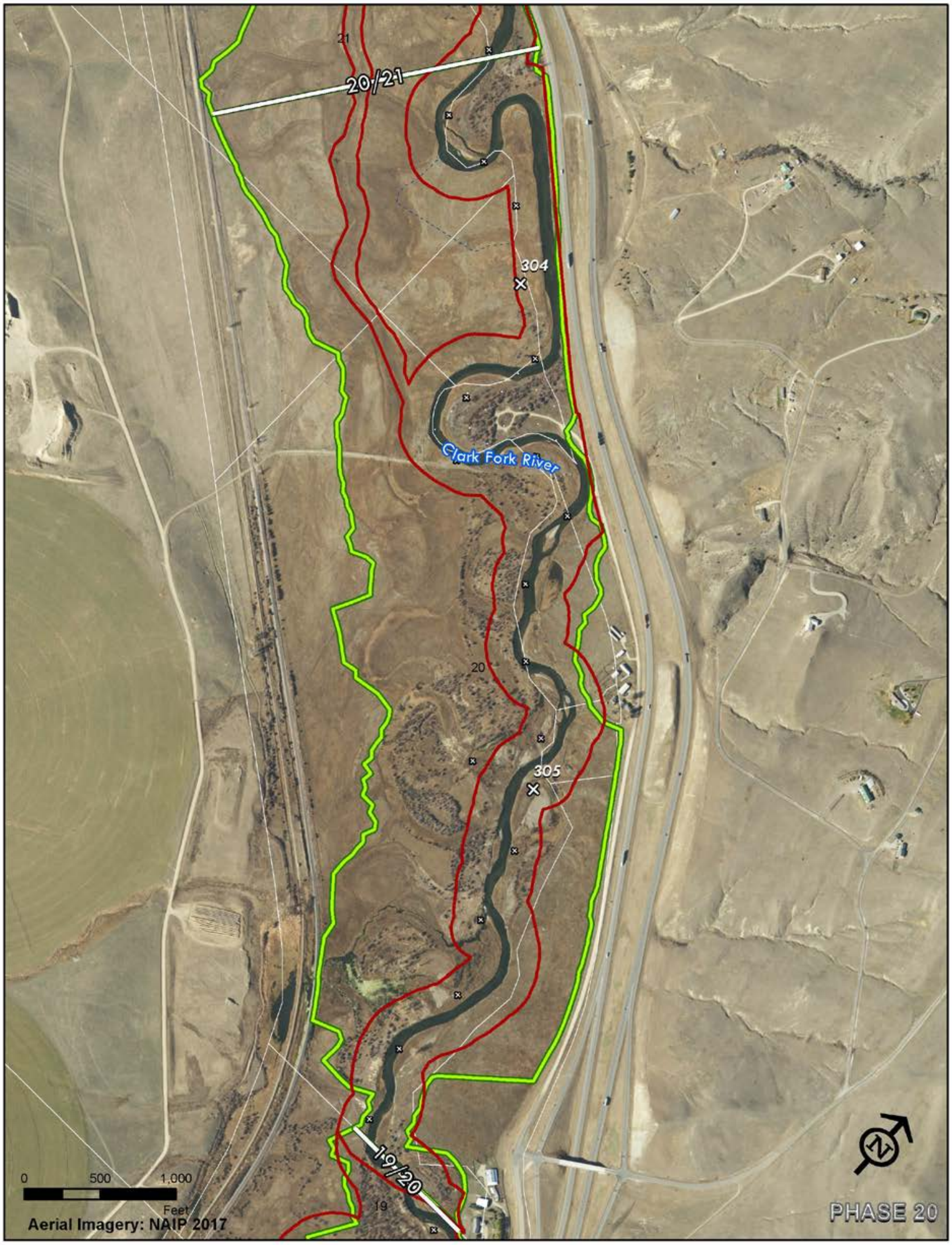

16/17
17
312
16
Clark Fork River
0
500
1,000
Feet
15/16
15
Aerial Imagery: NAIP 2017
N
PHASE 16



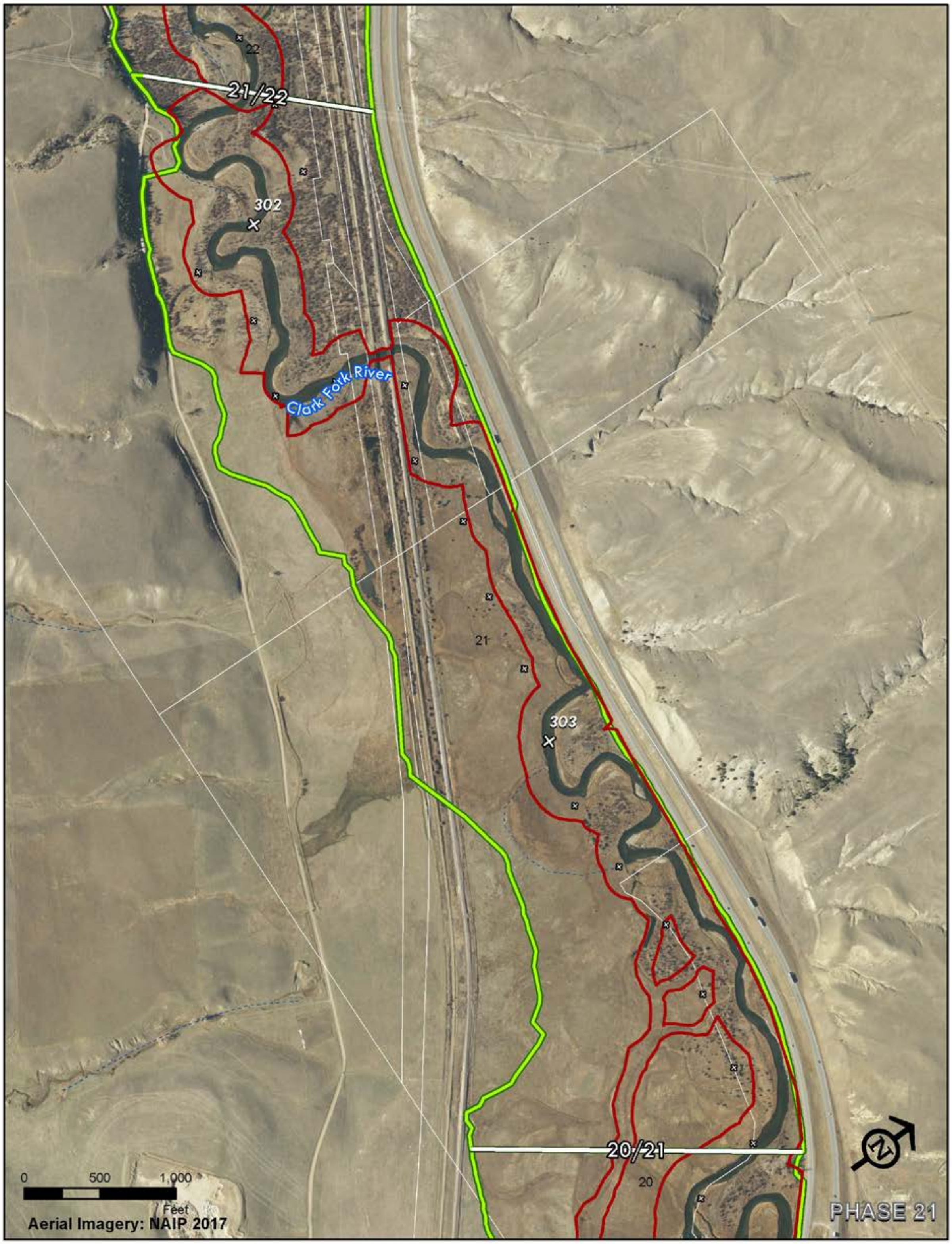
17/18
18
309
17
310
311
Clark Fork River
0 500 1,000
Feet
16/17
Aerial Imagery: NAIP 2017
N
PHASE 17
Fred Burr Creek


19
18/19
Clark Fork River
307
18
308
17/18
17
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
N
PHASE 18

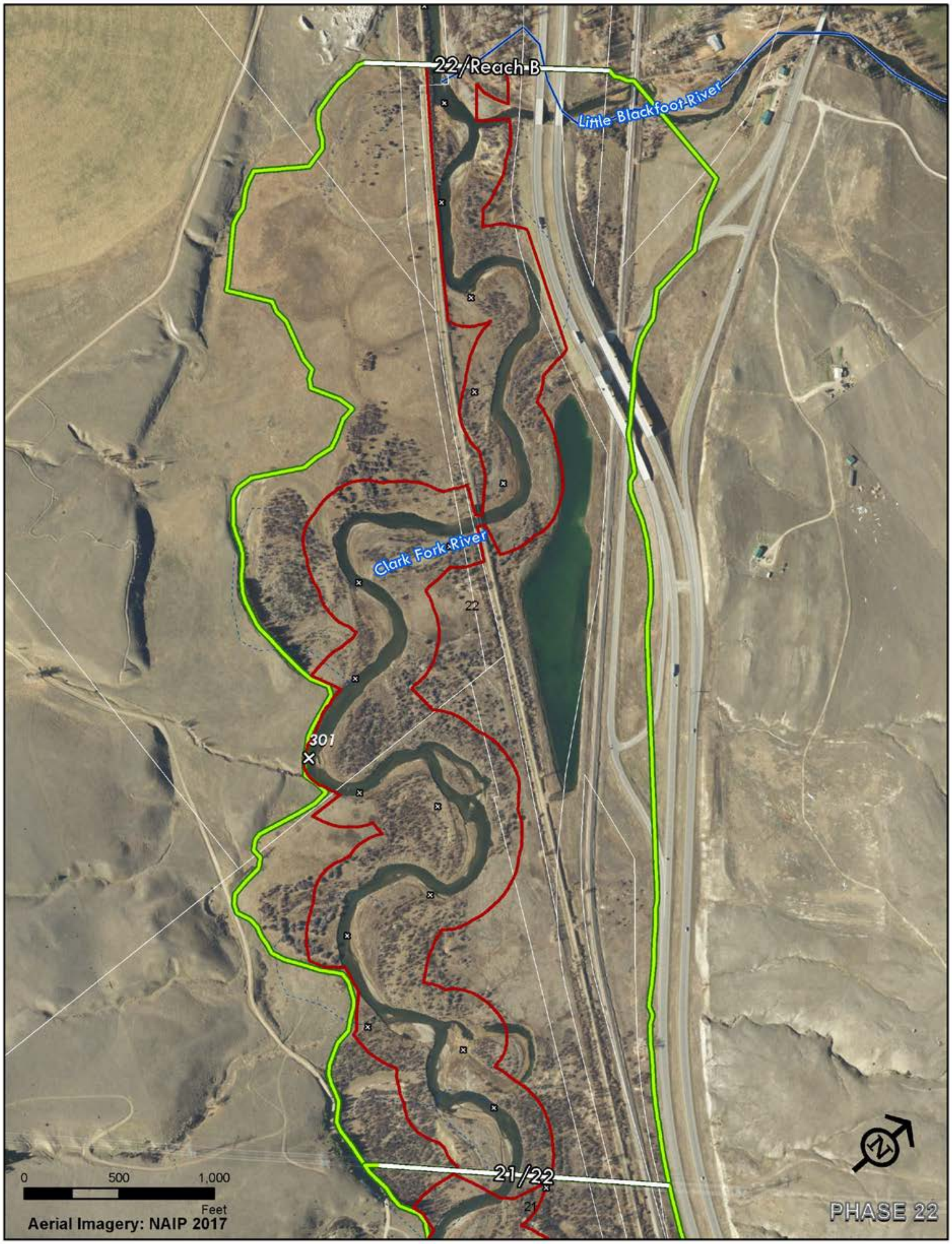

20
19/20
O'Neill Creek
Clark Fork River
306
19
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
18/19
18
PHASE 19



20/21
21
304
Clark Fork River
20
305
19/20
19
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
N
PHASE 20



22
21/22
302
Clark Fork River
21
303
20/21
20
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
PHASE 21


22/Reach B
Little Blackfoot River
Clark Fork River
22
301
21/22
21
0
500
1,000
Feet
Aerial Imagery: NAIP 2017
N
PHASE 22