TETRA TECH

Draft Final Preliminary Design Plan

Clark Fork River Operable Unit Phases 15 and 16

Grant-Kohrs Ranch

National Historic Site

Montana Department of Environmental Quality
1100 North Last Chance Gulch
Helena, MT 59620

Montana Department of Environmental Quality

Applied Geomorphology, Inc.

Geum Environmental Consulting, Inc.

TETRA TECH

Draft Final Preliminary Design Plan

#114-560435
January 31, 2015

PRESENTED TO

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

PRESENTED BY

Tetra Tech
303 Irene Street
Helena, MT 59601

P +1-406-443-5210
F +1-406-449-3729
tetratech.com

Geum Environmental Consulting, Inc
P.O. Box 1956
Hamilton, MT 59840

P +1-406-363-2353
geumconsulting.com

Applied Geomorphology, Inc
211 North Grand, Suite C
Bozeman, MT 59715

P +1-406-587-6352
appliedgeomorph.com

Prepared by:

Name	Date
Title	

Reviewed by:

Name	Date
Title	

TABLE OF CONTENTS

1.0 INTRODUCTION 9
1.1 Grant-Kohrs Ranch Background 10
1.2 Site Background 12
1.3 Geologic Setting 12
1.4 Contaminate Processes 15
1.5 Desired Post Remedial Condition 16
1.6 Design Concepts 16
2.0 EXISTING CONDITIONS INVESTIGATION, ANALYSIS AND DATA COLLECTION 18
2.1 Geomorphic Investigation 18
2.2 Channel Profile 20
2.2.1 Pools 20
2.2.2 Channel Morphology and Floodplain Access 21
2.2.3 Bed Material 23
2.2.4 River Planform and Channel Migration 26
2.2.5 Streambank Tailings Exposures 29
2.2.6 Geomorphic Evolution of Phases 15 and 16 32
2.3 Contaminant Characterazation 33
2.4 Hydrologic Analysis 34
2.4.1 Flood Frequency Analysis 34
2.4.2 Comparison with other Flood Frequency Analyses 36
2.4.3 Flow Duration Analysis 37
2.5 Hydraulic Analysis 40
2.5.1 Hydraulic Model Output 40
2.5.2 Water Surface Profiles 40
2.5.3 Reach Average Hydraulics 43
2.5.4 Channel Capacity and Floodplain Inundation 43
2.6 Floodplain material and borrow investigation 45
2.7 Groundwater investigation 45
2.8 Vegetation Assesment 46
2.8.1 Previous Assessments 46
2.8.2 Historical Vegetation 51
2.8.3 Existing Vegetation 52

3.0 DESIGN CRITERIA ... 66
3.1 Strategies and objectives ... 66
3.1.1 Desired Post-remediation Condition ... 68
3.1.2 Performance Targets ... 68
3.2 Applying Design Considerations ... 69
3.3 Components of the decision ... 70
3.3.1 Floodplain areas with contaminated soils ... 70
3.3.2 Channel Migration Zone ... 70
3.3.3 Contamination Depth Greater Than or Equal to 2 Feet ... 70
3.3.4 Local Rare Vegetation Communities ... 70
3.3.5 Floodplain Connectivity and Restoration Efforts ... 71
3.3.6 Arsenic Cleanup Level ... 71
3.3.7 Waste Removal and Over-excavation ... 71
3.3.8 Evaluation of Institutional Controls and Best Management Practices ... 71
3.3.9 Restoration in Lieu of Remedy ... 72
3.4 Application of the Decision Process ... 72
3.4.1 Extents of Contamination ... 72
3.4.2 Channel Migration Zone Analysis ... 72
3.4.3 Contamination Depth (Greater Than or Equal to Two Feet) ... 74
3.4.4 Floodplain Connectivity ... 74
3.5 Streambank Reconstruction ... 75
3.5.1 Streambank Reconstruction ... 78
3.5.2 Hydraulic Analysis of Streambanks ... 80
3.5.3 Hydraulic Analysis of Floodplain ... 82
3.6 Borrow Area and Backfill Material Criteria ... 82
3.6.1 Vegetative Backfill ... 82
3.6.2 Alluvium Material ... 83
3.6.3 Design Components ... 84
3.7 Floodplain Vegetation Design ... 85
3.7.1 Basis of Revegetation Plan Design ... 85
3.7.2 Design Criteria and Components by Cover Type ... 93
3.7.3 Revegetation Treatments ... 100
3.7.4 Preservation Areas within Removal Boundary ... 113
3.7.5 Weed Management and Long Term Maintenance ... 114

3.8 Supporting design elements 115
3.8.1 Groundwater Dewatering 115
3.8.2 Haul Roads 116
3.8.3 Landowner 118
3.8.4 Traffic Control 119
3.8.5 Irrigation 119
3.8.6 Mine Waste Repository 119
3.8.7 Construction Sequencing 120
3.9 Supporting Plans 121
3.9.1 Construction Quality Control and Quality Assurance 121
3.9.2 Construction Stormwater Best Management Practices 122
3.9.3 Dust Control Plan 122
3.9.4 Weed Control 122
3.9.5 Performance Targets 122
4.0 REFERENCES 126

LIST OF TABLES

Table 2-1. Summary of Geomorphic Parameters, Phases 15 and 16 Clark Fork River 19
Table 2-2. Summary of Cross Section Parameters Derived from HEC-RAS Modeling 21
Table 2-3. Pebble Count Gradations, Phases 15 and 16 24
Table 2-4. Measured Migration Rates at Actively Migrating Banklines, Phases 15 & 16 27
Table 2-5. Annual peak discharges at USGS Gage No. 123243000, Clark Fork River at Deer Lodge (1980 through 2011) 34
Table 2-6. Flood Frequency Analysis 35
Table 2-7. Estimated Peak Annual Flows – Phases 15 and 16 36
Table 2-8. Estimated Flood Frequency USGS Gages Clark Fork River 37
Table 2-9. Reach Averaged Hydraulic Conditions 43
Table 2-10. Priority Plant Species to be Managed on the Grant-Kohrs Ranch 48
Table 2-11. Vegetation Classification. 49
Table 2-12. Existing Vegetation Community Descriptions 53
Table 3-1. Maximum Arsenic Concentrations by Land Use 71
Table 3-2. Results of Migration Rate Analysis 73
Table 3-3. Summary of Phases 15 and 16 Tailings Excavation 75
Table 3-4. Bank Length Erosion Potential 78
Table 3-5. Length Summary of Various Bank Treatments in Phases 15 and 16 80
Table 3-6. Chemical and Physical Criteria for Vegetative Backfill 83
Table 3-7. Cover Types and Hansen Ecological Types (Hansen et al., 1995) 86
Table 3-8. Design Criteria for Floodplain Cover Types 91
Table 3-9. Exposed Depositional Cover Type Criteria and Revegetation Treatments 93
Table 3-10. Colonizing Depositional Cover Type Criteria and Revegetation Treatments 94
Table 3-11. Emergent Wetland Cover Type Criteria and Revegetation Treatments 95

Table 3-12. Riparian Wetland Cover Type Criteria and Revegetation Treatments 97
Table 3-13. Floodplain Riparian Shrub Cover Type Criteria and Revegetation Treatments 98
Table 3-14. Outer Bank Riparian Shrub Cover Type Criteria and Revegetation Treatments 99
Table 3-15. Upland Transition Cover Type Criteria and Revegetation Treatments 100
Table 3-16. Summary of Revegetation Treatments and General Locations for the Phases 15 and 16 Project Area 100
Table 3-17. Relationship of Floodplain Cover Type to Geomorphic Features, Elevation Relative to the 2-Year WSE, and Total Area Based on the Preliminary Design Grading Surface 101
Table 3-18. Substrate Criteria and Volumes for Floodplain Cover Types...................................... 102
Table 3-19. Summary of Dormant Willow Cutting Needs for Streambank Treatments.................... 104
Table 3-20. Floodplain Cover Type Planting Locations, Plant Material and Plant Spacing 105
Table 3-21. Colonizing Depositional - Herbaceous Plant Mix 105
Table 3-22. Colonizing Depositional - Shrub Plant Mix... 106
Table 3-23. Emergent Wetland – Herbaceous Plant Mix 106
Table 3-24. Riparian Wetland – Shrub Plant Mix.. 107
Table 3-25. Floodplain Riparian Shrub Swales – Tree and Shrub Plant Mix.................................. 107
Table 3-26. Outer Bank Riparian Shrub – Tree and Shrub Plant Mix.. 108
Table 3-27. Total Plants for Phases 15 and 16 Project Area by Species 109
Table 3-28. Summary of Seed Mixes for Floodplain Cover Types 111
Table 3-29. Wetland Floodplain Seed Mix 111
Table 3-30. Floodplain Seed Mix.. 112
Table 3-31. Wetland Seed Mix 112
Table 3-32. Upland Seed Mix... 113
Table 3-33. Noxious Weed Species Found in Phases 15 and 16 and Listing Priority 114
Table 3-34. Geomorphology Monitoring Metrics and Associated Performance Targets.................. 124
Table 3-35. Vegetation Monitoring Metrics and Associated Performance Targets.......................... 125

LIST OF FIGURES

Figure 1-1. Clark Fork River Operable Unit of Milltown Reservoir/Clark Fork River Superfund Site. .. 9
Figure 1-2. Geologic Map of Grant Kohrs Ranch (Berg, 2004) 14
Figure 2-1. View downstream (Station 90+00) Showing Entrenched Cross Section 18
Figure 2-2. View Downstream (Station 66+00) Showing High Uncontaminated Bank...................... 19
Figure 2-3. Channel Bed and 2-year Water Surface Profiles, Phases 15 and 16, Clark Fork River.. 20
Figure 2-4. Box and Whisker Plot of Measured Residual Pool Depths, Phases 15 and 16 20
Figure 2-5. Wetted Top-Width Values Plotted by Station, Phases 15 and 16................................. 22
Figure 2-6. Changes in Channel Width as Measured on Air Photos from 1947-2001, Grant-Kohrs Ranch (from Swanson, 2002) 22
Figure 2-7. View Upstream from Station 130+00 Showing Coarse Riffle Feature 23
Figure 2-8. Pebble Count Gradations, Phases 15 and 16... 23
Figure 2-9. Grain Size Parameters Plotted by River Mile, Phases 15 and 16 24
Figure 2-10. View Downstream of Large Prograding Gravel/Cobble Bedform, Station 72+00. 25
Figure 2-11. View Downstream of Coarse- Grained, Recent Bar Deposit, Station 108+00 25
Figure 2-12. Radius of Curvature and Migration Rates, Phase 15 and 16 26
Figure 2-13. Maximum Migration Rate vs. Residual Pool Depth.. 27
Figure 2-14. 1955 and 2011 Banklines Plotted on 1869 GLO Map 28
Figure 2-15. Massive Upper Bank Tailings Deposit, Station 111+00R... 30
Figure 2-16. Tailings Deposition in an Old Channel, Station 84+00R 30

Figure 2-17. Laminated Tailings Exposure Indicating Multiple Depositional Events, with Apparent Tilling of Upper ~6" of Bank Material ... 31
Figure 2-18. Tailings Under Manure-rich Fill, Station 94+00R ... 31
Figure 2-19. Blue-colored Bone on Bar Surface, Station 56+00L ... 32
Figure 2-20. Peak Flow Frequency Analysis for Clark Fork River at Deer Lodge, Montana (USGS Gage No. 12324200) ... 38
Figure 2-21. Mean Daily Flow-Duration Curve for Clark Fork River at Deer Lodge, Montana (USGS Gage No. 12324200) ... 39
Figure 2-22. Estimated Water Surface Profiles for Phases 15 and 16 ... 41
Figure 2-23. Clark Fork River Phases 15 and 16 with Subreaches ... 42
Figure 2-24. CFROU Phases 15 and 16 – 2-Year Inundation ... 44
Figure 2-25. Example of 2012 vegetation mapping (Rice et al., 2012) ... 50
Figure 2-26. Results of Vegetation Community Mapping in the Phase 15 Project Area Showing Sample Plot Locations ... 58
Figure 2-27. Results of Vegetation Community Mapping in the Phase 16 Project Area Showing Sample Plot Locations ... 59
Figure 2-28. Mapped Vegetation Communities and Soils Pits Labeled with Depth of Contamination Overlaying Elevation Relative to the 2-year WSE for Phase 15 ... 60
Figure 2-29. Mapped Vegetation Communities and Soils Pits Labeled with Depth of Contamination Overlaying Elevation Relative to the 2-year WSE for Phase 16. ... 61
Figure 2-30. Existing Areas within Phase 15 Considered to be Hydrologically Connected to the River Based on Surface at or Below Half a Foot Above the 2-year WSE ... 62
Figure 2-31. Existing Areas within Phase 16 Considered to be Hydrologically Connected to the River Based on Surface at or Below Half a Foot Above the 2-year WSE ... 63
Figure 3-1. Measured Migration Distances by Geomorphic Reach ... 74
Figure 3-2. View Downstream from Station 111+50R Showing Variable Toe Materials ... 76
Figure 3-3. View Downstream (Station 58+00) Showing Bank Undercutting/Topple Failure ... 76
Figure 3-4. View Downstream at Station 62+00 Showing Coarse Bank Toe ... 77
Figure 3-5. Typical Cohesive Bank Toe ... 77
Figure 3-6. Migration Rate and Field-Identified Toe Materials ... 78
Figure 3-7. Decision Path for Bank Construction ... 79
Figure 3-8. Example Cross-Section of the Existing Floodplain Surface with Tailings/Impacted Soils Deposits, the Immediate Post-Remediation Floodplain Surface, and the Desired Future Condition of the Floodplain Once Vegetation Has Established ... 87
Figure 3-9. Phase 15 Design Cover Types, Planting Areas, Swale Features, and Cottonwood Stands to be Preserved ... 88
Figure 3-10. Phase 16 Design Cover Types, Planting Areas, Swale Features, Example Valley Cross-Section Location, and Cottonwood Stands to be Preserved ... 89
Figure 3-11. Mean Daily Discharge Exceedance ... 92
Figure 3-12. Examples of Constructed Floodplain Swale Features ... 103
Figure 3-13. Microtopography Placed on a Constructed Floodplain Surface ... 103
Figure 3-14. Examples of Browse Protection Measures: Wildlife Exclosure Fence (left) and Individual Browse Protectors (right) ... 110

APPENDICES

APPENDIX A – RESULTS FROM HEC-RAS MODELS

APPENDIX B - INUNDATION BOUNDARIES AFTER REMEDIATION

APPENDIX C - NATIONAL WETLANDS INVENTORY, SOIL SURVEY DATA, AND VEGETATION COMMUNITY DESCRIPTIONS

APPENDIX D - CLARK FORK SMOA, EXIBIT A; STREAMBANK GUIDELINES

APPENDIX E – FEDERAL RESTORATION PLAN (TEXT ONLY)

ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
AGI	Applied Geomorphology, Inc.
bcy	bank cubic yards
BLM	Bureau of Land Management
BMPs	Best Management Practices
BNSF	Burlington Northern Santa Fe
CDM	Camp, Dresser, McKee, Inc.
CFR	Clark Fork River
CFROU	Clark Fork River Operable Unit
cfs	cubic feet per second
cm	centimeter
CMZ	Channel migration zone
COCs	Contaminants of concern
CQAP	Construction Quality Assurance Plan
CSWBMPP	Construction Stormwater Best Management Practices Plan
cy	cubic yard(s)
DEQ	Montana Department of Environmental Quality
dS/m	deciSiemens per meter
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FEWA	Functional Effective Wetland Area
ft	foot
ft/ft	feet per feet
ft/yr	feet per year
FSA	Farm Service Agency
GIS	Graphical Information System
GKR	Grant-Kohrs Ranch
GLO	General Land Office
GPS	Global Positioning System
HEC-RAS	Hydraulic Engineering Center – River Analysis System
HEC-SSP	Hydraulic Engineering Center – Statistical Software Package
ICs	Institutional Controls
IDW	Inverse Distance Weighted
kg	kilogram

LiDAR	Light Detection and Ranging
MDT	Montana Department of Transportation
mg/kg	milligrams per kilogram
mm	millimeter
MPM	Meyer-Peter Müller
MT	Montana
MUTCD	Manual on Uniform Traffic Control Devices
NAIP	National Agriculture Imagery Program
NHS	National Historic Site
NPS	U.S. National Park Service
NRCS	Natural Resource Conservation Service
NRDP	State of Montana Natural Resource Damage Program
NVC	U.S. National Vegetation Classification
NWI	National Wetlands Inventory
OTR	Over The Road
OU	Operable Unit
PDP	Preliminary Design Plan
ppm	parts per million
psf	pounds per square foot
PTS	Pioneer Technical Services
QA	Quality Assurance
QC	Quality Control
Rc/W	Ratio of bend radius of curvature (Rc) to channel width (W).
RipES	Riparian Evaluation System
ROD	Record of Decision
SMOA	Site-Specific Memorandum of Agreement
sq. mi.	square miles
USACE	U.S. Army Corp of Engineers
USDA	U.S. Department of Agriculture
USDI	U.S. Department of Interior
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Society
WSE	Water Surface Elevation
XRF	X-ray Fluorescence
yr	Year
yrs	years

1.0 INTRODUCTION

The Clark Fork River Operable Unit (CFROU) is part of the Milltown Reservoir/Clark Fork River Superfund Site ("Clark Fork Site" or "Site") and includes the uppermost 120 miles of the Clark Fork River (CFR) between Warm Springs Ponds and Missoula, Montana. The Operable Unit is divided into three Reaches (A, B, and C) as shown on Figure 1-1.

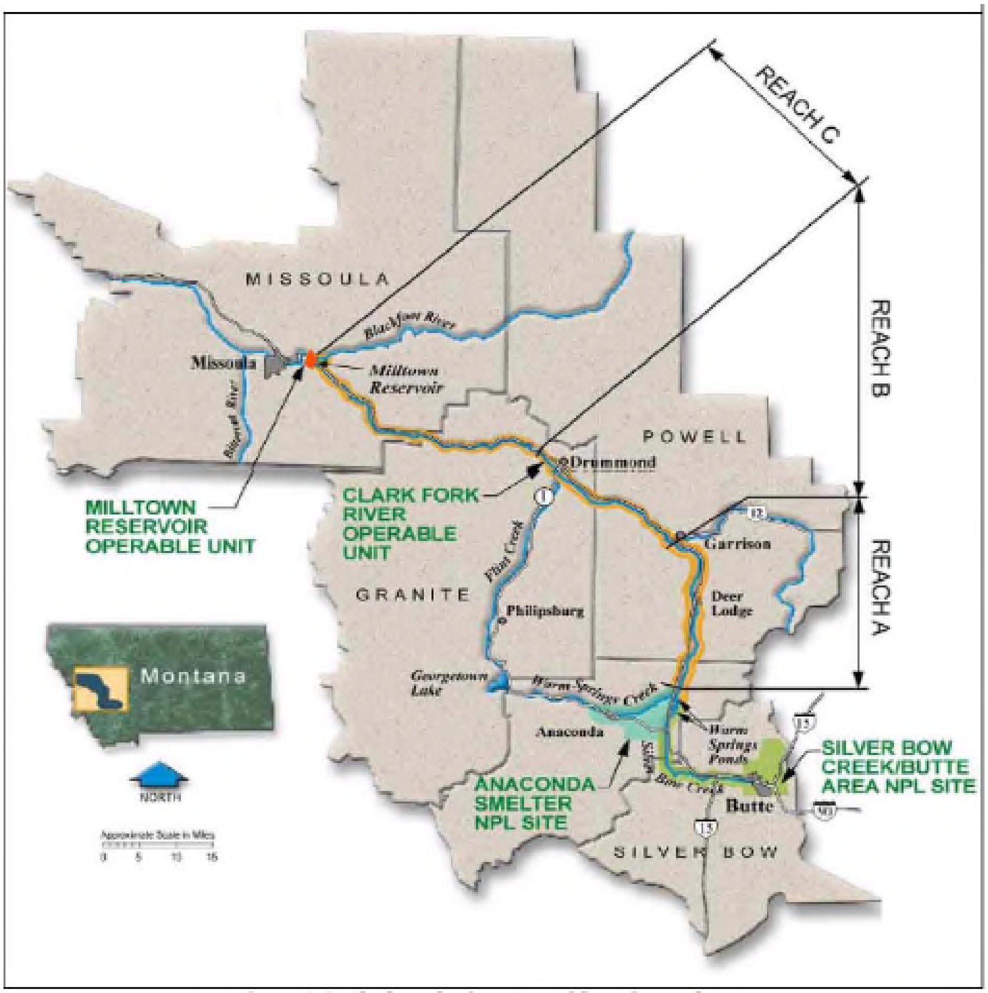


Figure 1-1. Clark Fork River Operable Unit of Milltown Reservoir/Clark Fork River Superfund Site.

The Montana Department of Environmental Quality (DEQ), as lead agency, oversees, manages, coordinates, designs and implements the remedial actions for the Clark Fork Site in consultation with the U.S. Environmental Protection Agency (EPA). For activities affecting Grant-Kohrs Ranch National Historic Site (hereinafter, GKR) DEQ also works in consultation with the U.S. National Park Service (NPS). DEQ coordinates with the State of Montana Natural Resource Damage Program (NRDP; State restoration) and the NPS (federal restoration) for the implementation and integration of restoration components into the Work. "Agency" or "the Agencies" referred to in subsequent text collectively refers to the above entities.

Four primary functions of consultation and coordination among the agencies for the Clark Fork Site are to:

1. Understand and receive the information to be collected;
2. Understand how that information is to be analyzed;
3. Provide review and comment; and,
4. Maximize the use of the resources available for, and the environmental benefits to, the Clark Fork Site in the successful and cost-effective implementation and completion of the Work.

This Preliminary Design Plan (PDP) has been prepared for the DEQ) by the design consultants Tetra Tech Inc., Applied Geomorphology, Inc., (AGI) and Geum Environmental Consulting, Inc. (Geum). This PDP presents the scope of the Agencies' intended activities for CFR Reach A, Phases 15 and 16 of the Clark Fork Site. Phases 15 and 16 are located just downstream of the town of Deer Lodge and cover approximately 2.6 river miles of stream channel and floodplain primarily located on the GKR.

1.1 GRANT-KOHRS RANCH BACKGROUND

The Grant-Kohrs Ranch was founded in 1862 by pioneer stockgrower John Grant, succeeded in 1866 by cattle baron Conrad Kohrs, and operated/preserved 1940-1972 by his grandson, Hereford rancher Conrad Kohrs Warren. Grant-Kohrs Ranch joined the National Park System on August 25, 1972. Congress authorized this site's establishment to:

> *"…provide an understanding of the frontier cattle era of the Nation's history, to preserve the Grant-Kohrs Ranch, and to interpret the nationally significant values thereof for the benefit and inspiration of present and future generations."*

The Park Mission is to commemorate the Nation's frontier cattle era, whose timeless old West values and vestiges are preserved, unimpaired for the enjoyment and inspiration of this and future generations. Grant-Kohrs Ranch NHS is significant because it is

- the only unit of the national park system designated to commemorate the frontier cattle era and its role in American history;
- one of the nation's best surviving examples of a successful economic strategy based on the cattle industry prevailing from 1850-1972, evident in its original buildings, features, objects, and records;
- provides an authentic historic setting to experience the cattle industry as it matured and contributed to Western cultural. The Home Ranch's integrity is illustrated by its original structures, family furnishings, personal papers, ranching equipment and its continued use of land and heritage skills for livestock production.

The GKR is a unit of the NPS and was designated a National Historic Landmark in 1960. This designation is reserved for only those sites that possess a high level of integrity and national significance. The GKR is significant in the NPS-defined areas of Agriculture and Developing the American Economy. It has been the headquarters for cattle ranching for more than 150 years and has a rich, well documented history. See Cultural Landscape Report: http://www.nps.gov/history/online_books/grko_cir_1.pdf.

The majority of the ranch property has been used for forage and hay production for livestock grazing (USDI, 2007). Remedial action on GKR (and any restoration activities) will take into consideration the unique values and significance of the area and work in cooperation with the National Park Service to preserve and/or document cultural resources and archeological sites within its boundaries.

The Record of Decision (ROD; EPA 2004a) for the Clark Fork Site identifies certain location-specific requirements with respect to hazardous substance releases within or potentially affecting Grant-Kohrs Ranch (EPA 2004b). These requirements are in addition to other remedy requirements and are derived from the NPS Organic Act, 16 U.S.C. §§ I et seq. (the Organic Act), and the enabling legislation for Grant-Kohrs Ranch (Pub L. 92-406, 86 Stat 7632 [1972]; Grant-Kohrs Act). The goal of these location-specific requirements is to re-establish self-producing and sustaining native riparian vegetative communities and species on the GKR so to ensure the historic ranch landscape of the late nineteenth century is re-established, preserved and sustained for future generations in a condition unimpaired by hazardous substances.

This PDP applies design-level factors (or considerations) to property-specific conditions, outlining the scope of DEQ's intended remedial activities on the GKR for Agency review and comment (prior to development of a draft Remedial Action Work Plan). The PDP will also identify any specific design information likely to be necessary in evaluating and designing these activities. Considerations include groundwater, riparian vegetation, geomorphic stability, contaminant sampling, ownership, infrastructure, land use and certain site-specific remedy requirements. The PDP will present pertinent information on site-specific conditions, the basis of the design approach (design components), and the desired outcomes for the proposed design. This PDP is accompanied by a preliminary design drawing set showing, among other things, property specific floodplain grading and proposed streambank treatments.

DEQ, EPA and NPS are parties to a Site-Specific Memorandum of Agreement ("SMOA") outlining roles and responsibilities for conducting Remedy and Federal Restoration on the GKR. The State and EPA, their employees and contractors are granted access to the GKR at all reasonable times upon reasonable notice (which generally consists of two business days prior to field work). NPS's general parameters for access are:

- Use the Outer Loop Road for vehicle traffic and avoid vehicle traffic in the historical district of GKR to the extent practicable;
- Leave gates open or closed, as they are found;
- Ensure that livestock and wildlife are not harassed or unduly disturbed;
- Do not exceed load limits on bridges within GKR; and
- Vehicles shall not leave existing roads, unless specified in approved remedial action work plans.

Actions to implement the Remedy or Federal Restoration will be done during operating hours for the GKR to the extent practicable. NPS will use best efforts to adjust operating hours when necessary for Remedy or Federal Restoration actions in cooperation with DEQ.

During NPS review of any property-specific remedial design plan for GKR or any design plan that includes components of the Work or Federal Restoration on GKR, NPS shall identify any specific operations or management criteria, requirements, or plans specific to GKR that may affect the State's implementation of the Remedy or Federal Restoration at the GKR. NPS agrees that if it does not identify any such specific operations or management criteria, requirements, or plans within the time frames identified in Paragraph 19 of Part 1 of the SMOA during the remedial design process, DEQ is not required to incorporate such considerations into the Work or into Federal Restoration.

1.2 SITE BACKGROUND

Heavy metals originating from historic mining activities, milling and smelting processes associated with the Anaconda Company operations in Butte and Anaconda have accumulated on the CFR stream banks and floodplain over a period of at least 100 years. The primary sources of contamination are tailings and contaminated sediments mixed with soils in the stream banks and floodplains, which erode during high flow events and enter the river and other surface waters. In addition to erosion, heavy metals are leached from the contaminated sediments and tailings directly into the groundwater and eventually to surface water. These contaminant transport pathways result in impacts to terrestrial and aquatic life along the CFR as described in the ROD for the CFROU (EPA, 2004a).

The primary sources of contamination in Reach A are tailings / impacted soil in stream banks and the historic floodplain. These sources directly impact plant and animal life through uptake and ingestion, and also impact humans who come in contact with the soils. Contaminants move from tailings / impacted soils directly into the river through the process of erosion, increasing impacts on aquatic life. Metals also leach directly from the tailings into groundwater and surface water.

Because tailings / impacted soils have accumulated on the historic floodplain surface, this has caused the floodplain to be artificially elevated relative to the river, resulting in a lack of hydrologic connection between the river and floodplain. While remnant riparian plant communities are present, they lack access to natural processes such as frequent floods which are necessary to sustain and rejuvenate riparian plant communities. As a result, many existing plant communities are on a decay trajectory, meaning shrub patches are dominated by older age classes because they have a diminished ability to reproduce. Where shrubs are present, they have understories dominated by upland plant species which are not adapted to providing stability during floods. Because the elevated surface is made up of contaminated sediments, varying degrees of phytotoxic effects are present depending on several factors, including soil pH; degree and duration of saturation during the growing season; soil texture and length of time since sediments were deposited. Particularly within the channel migration zone (CMZ), large, infrequent floods can still access the elevated surface, and these floods are capable of causing mass erosion of tailings / impacted soils and delivering contaminated sediments directly to the aquatic ecosystem.

The lack of typical floodplain vegetation in Phases 15 and 16 is caused primarily by acid generation, metals uptake, and disconnection between the aggraded floodplain and underlying groundwater. These factors prevent existing vegetation from maintaining the stability of streambanks and the floodplain.

1.3 GEOLOGIC SETTING

Reach A, Phases 15 and 16 are located within the northern portion of the Deer Lodge Valley. The Deer Lodge Valley is a north-south trending half-graben with front range faults on its west side, and no major faults on its east side (Berg, 2004). On the west side of the valley, the Flint Creek Range forms a distinct series of high peaks and glaciated valleys. This range is part of the Sapphire Block, a large mass of sedimentary rock that was thrust eastward from Idaho about 70 million years ago. Granites have intruded into the sedimentary rocks, forming the high peaks of the Flint Creek Range such as Mount Powell. Gold Creek, on the northern end of the Flint Creek Range, was the location of the first gold discovery in Montana in 1852. The eastern side of the valley consists of granites of the Boulder Batholith that are overlain by volcanic rocks. Dissected Pleistocene-age pediments overly the volcanics, and typically lie hundreds of feet above the river corridor.

The sedimentary fill of the Deer Lodge Valley consists of an extremely thick sequence of Tertiary basin fill that is overlain by a thin veneer of Quaternary alluvium. The depth of the basin fill was recorded about

7 miles south of Phase 15, where a well drilled through 10,052 feet of Tertiary sediments before reaching Eocene volcanic rocks (Berg, 2004).

Approximately 10,000 years ago, alpine glaciers scoured the high valleys of the Flint Creek Range and extended down into the Deer Lodge Valley. Large glacial outwash deposits, which consist of coarse braided stream gravels, extend into the core of the Deer Lodge Valley, and can be found on both the east and west sides of the CFR (Figure 1-2). Till distributions suggest that on the east side of the valley, alpine glaciers were present in the drainages of Cottonwood Creek and Baggs Creek east of Deer Lodge (Derkey, et. al, 1993).

Reworking of the outwash gravels by the CFR has created a series of terraces that border the river bottom; these terraces range in height from 3 to 30 feet above the modern floodplain. Derkey and others (1993) suggest that the Holocene terraces that bound the CFR corridor record a continual narrowing of the CFR floodplain as the river reworked and down-cut into the glacial outwash. This was driven by a dramatic reduction in sediment loading and streamflow from the mountains as the alpine glaciers receded, and conversion of the CFR from a broad, glacially-fed braided stream system to the single-thread meandering condition of today.

Within the Phases 15 and 16 project reach, the river flows through recent alluvial floodplain deposits, although course hillslope colluvium intersects the river on the left bank just upstream of the historic Cattle Drive Road Bridge at Station 100+00, and downstream near Station 66+00. On the right bank, a low terrace extends into the river corridor near Station 34+00. These surfaces tend to be several feet above the modern floodplain, and test pits show them to be free of tailings contamination.

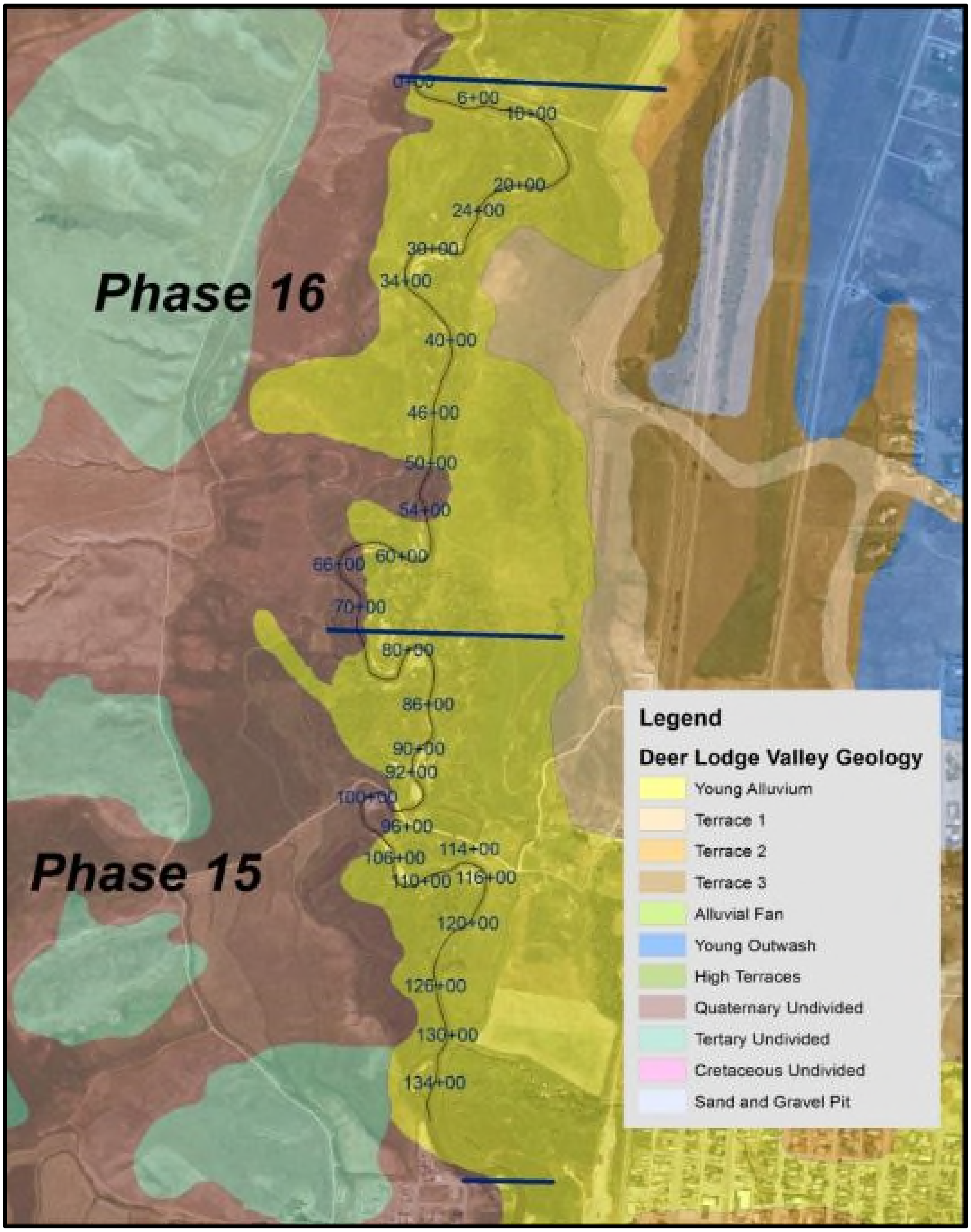


Figure 1-2. Geologic Map of Grant Kohrs Ranch (Berg, 2004)

Geologic units that are proximal to the CFR in Phases 15 and 16 include the following:

- **Qal:** Alluvium -- Gravel, sand, silt, and clay along active channels of rivers, creeks, and intermittent streams.
- **Qat1:** Alluvial terrace deposit, youngest -- Poorly sorted alluvial deposits on irregularly shaped, unpaired terraces 3-6 feet above the modern floodplain.

- **Qat2:** Alluvial terrace deposit, second youngest -- Poorly sorted alluvial deposits on irregularly shaped, unpaired terraces 6-16 feet above the modern floodplain.
- **Qat3:** Alluvial terrace deposit, third youngest -- Poorly sorted alluvial deposits on irregularly shaped, unpaired terraces 20-30 feet above the modern floodplain.
- **Qac:** Colluvium and alluvium – Colluvial (hillslope deposits) and alluvium (river deposits) that are combined where indistinguishable.
- **Qgo:** Glacial outwash deposit – Extensive glacial deposits found on both sides of the valley.
- **Qpg:** Pediment gravels ranging in thickness from 1-20 feet.
- **Ts:** Undivided sedimentary rocks, predominantly massive sandy or silty mudstone.
- **Sg:** Sand and gravel pit.

1.4 CONTAMINATE PROCESSES

Section 2.0 provides information on groundwater, riparian vegetation, geomorphic stability, contaminant sampling, ownership, infrastructure, land use, and site-specific remedy requirements. As the information makes clear, CFR Reach A, Phases 15 and 16 exhibit extensive contamination within the CMZ, dominating the floodplain system. Phases 15 and 16 polygons within the CMZ meet the classification of slickens / severely impacted areas. In addition, certain areas outside the CMZ exhibit extensive contamination:

- Such as those areas where tailings and impacted soils extend deeper than 2 feet or are below the 2-year water surface elevation. These tailings / impacted soils are too wet to effectively treat. These outside the CMZ polygons also meet the classification of severely impacted areas
- Certain discrete areas demonstrate arsenic levels above 620 milligrams per kilogram (mg/kg), and are also in the 2-year water surface elevation, and therefore meet the classification of severely impacted areas.

The primary sources of contamination in Reach A are concentrated tailings deposits and tailings mixed with soil along the river banks and on the floodplain. These contaminant sources directly impact plants, terrestrial wildlife, aquatic organisms, and humans through uptake and ingestion. Effects of tailings deposition include but are not limited to degraded vegetation communities, stands of dead willows, and areas devoid of vegetation. These impacts are caused by acid generating potential of tailings during oxidation and phytotoxicity of metals in the soil. In addition to these geochemical impacts, tailings aggraded on the floodplain have physically perched the floodplain above the normal hydrologic regime of the river, causing reduced floodplain inundation frequency and duration, reduced riparian vegetation access to groundwater, and concentrated in-stream flows.

Contaminants have also been physically recruited into the channel by bank erosion, and some of those reworked contaminants have been deposited within in-channel depositional features such as point bars and low bank-attached bars. In addition to these processes, metals also move through the soil column or are dissolved in the water during fluctuating periods of oxidizing and reducing conditions and can be taken up by plants. Until the contaminants are removed, these conditions will persist within the river system and metals will be available for biologic uptake.

Therefore, to meet the ROD requirements this design for CFR Reach A, Phases 15 and 16 will:

1. Remove severely impacted areas,

2. Provide geomorphic stability during reestablishment of riparian vegetation after construction, and, ultimately,

3. Revegetate through the establishment of plant communities capable of stabilizing soils against wind and water erosion, reducing transport of contaminants of concern (COCs) to groundwater and surface water. Success in revegetation shall be measured against these revegetation performance standards set out in the ROD. Revegetation on GKR will also be evaluated against the location-specific requirements and goals derived from the Grant-Kohrs Act and the NPS National Organic Act.

1.5 DESIRED POST REMEDIAL CONDITION

The desired post-remedial condition includes a lowered floodplain surface that will improve hydrologic connectivity with the CFR and thus sustain riparian plant communities. Microtopography will be developed and coarse woody debris will be imbedded in the floodplain to provide erosion resistance, sediment and seed trapping, micro-sites for plant establishment and a source of organic material. Passive margins on meander bends will be redeveloped as point bars, and existing in-stream geomorphic features will be preserved to the extent possible.

Actively eroding stream banks will be rebuilt after removal of contaminated material while banks with existing robust, woody vegetation will be preserved to the extent possible. A suite of bank treatments and revegetation treatments will be applied that correspond to these different bank conditions. Bank treatments will use a combination of locally salvaged wood, biodegradable materials, and live plant material such as willow cuttings, transplanted shrubs, and containerized nursery stock.

Revegetation is closely integrated with floodplain and bank designs. Floodplain surfaces will be constructed to support natural recruitment of willows and other riparian and wetland plant species by using gravel and sand substrate and building surfaces at elevations close to the water table. Active revegetation, such as planting and vegetation associated with bank construction, will be done in places where plants have a high likelihood of survival. These locations include micro-depressions in the areas where groundwater is especially shallow, and within bank structures that have high water-holding capacity. Plant communities are designed to correspond closely with geomorphic surfaces; for example, different plant communities will develop on point bar surfaces vs. wetlands due to difference in substrate, shear stress, groundwater elevation, and ground surface elevation.

1.6 DESIGN CONCEPTS

This section outlines the general remedial approach for the remedial action in CFR Reach A Phases 15 and 16. Components of the design are described in detail in later sections of this document. The design in CFR Reach A, Phases 15 and 16 relies on machine excavation to remove tailings / impacted soil materials from streambanks and the floodplain in the project area.

These contaminated materials will be hauled by truck to the B2.12 cell at Opportunity Ponds for disposal. The lateral and vertical extents of excavation is determined by the extent of contamination as well as the CMZ, locations of impacted vegetation, and topography. Clean substrates consisting of vegetative backfill and alluvial materials will be used to rebuild streambanks and the floodplain.

The method of floodplain reconstruction shall be consistent with the intended future uses for the GKR which is re-establishing, preserving and sustaining the historic ranch landscape of the late nineteenth century for future generations unimpaired by hazardous substances.

Pasture, riparian floodplain and hay fields, may be included land uses. In places, the reconstructed floodplain will be lower than the existing floodplain to allow for reconnection with the river. Some bends will be redeveloped as point bars and existing depositional features will be preserved to the extent possible. Microtopography will be developed and coarse woody debris will be imbedded in the floodplain to provide erosion resistance, sediment and seed trapping, micro-sites for plant establishment and a source of organic material. Microtopography is small scale variation in topography of 3 to 10 feet horizontally and about one-foot vertically. For pasture or hay field end uses on the privately owned properties, a largely planar floodplain surface will be built and pasture grasses will be established and interspersed with native woody vegetation. Where riparian areas will be used as pasture, a combination of riparian and pasture vegetation will be established.

Eroding, contaminated stream banks will be rebuilt after removal of contaminated material. Banks with existing robust, woody vegetation will be preserved to the extent possible. Passive margins, which border the stream and are generally not subject to high water velocity, will be preserved or redeveloped as point bars. A suite of bank reconstruction and revegetation treatments will be applied that correspond to the range of bank conditions. Bank treatments will use a combination of locally salvaged wood, purchased biodegradable materials such as coir logs and coir fabrics, and live plant material such as willow cuttings, and containerized nursery stock.

Revegetation is closely integrated with floodplain and streambank designs. In areas designed to re-establish native habitats, floodplain surfaces will be constructed to support natural recruitment of willows and other riparian and wetland plants species by using gravel and sand substrate and building surfaces at elevations close to the water table. The entire floodplain will be seeded. Active revegetation, such as planting and placement of vegetation associated with bank construction, will be done in places where plants have a high likelihood of survival. These locations include micro-depressions in the areas where groundwater is near the surface, and within bank structures that have high water-holding capacity due to the absorbent properties of coconut fiber (coir).

Plant communities are designed to correspond closely with geomorphic surfaces; for example, different plant communities will develop on point bar surfaces versus wetlands due to differences in substrate, shear stress, groundwater elevation, and ground surface elevation. Other activities will be conducted in support of the remedial action including dewatering, road construction, borrow area development, and reclamation. Dewatering is needed to facilitate removal of tailings from the floodplain.

Temporary roads will be constructed for hauling tailings and borrow materials within CFR Reach A Phases 15 and 16. Unless otherwise mutually agreed these temporary roads will be reclaimed at the end of the project. Borrow areas will also need to be reclaimed and revegetated after removal of the borrow materials. Borrow areas will be seeded and planted in conformance with the final land use. Best Management Practices (BMPs) will be implemented to control erosion and minimize increased river turbidity during construction.

Further information on CFR Reach A, Phases 15 and 16 remedial design is found in the following Sections. Section 2, Existing Conditions Investigation, Analysis and Data Collection, summarizes design investigations which were conducted to support the design. Section 3, Basis of Design, outlines key technical components of the design.

2.0 EXISTING CONDITIONS INVESTIGATION, ANALYSIS AND DATA COLLECTION

2.1 GEOMORPHIC INVESTIGATION

A field inventory was undertaken in late July and early August 2012 to assess project reach geomorphology. This consisted of walking the entire reach, recording observed geomorphic patterns and conditions, inventorying pool habitat features, and describing eroding banks in terms of erosion severity, bank height, presence/absence of tailings, and vegetation density. This information has been supplemented with historic and recent air photo analysis, pebble count data, and available literature.

Within Phases 15 and 16 through GKR, the CFR is a single thread meandering stream that is largely entrenched below at least the 2-year water surface elevation (Figure 2-1). Phase 15 is approximately 1.2 river miles long, and Phase 16 is 1.4 river miles long. The riverbed consists primarily of well-sorted gravels and cobbles that support the formation of discreet riffles, pools and long run features. Bank erosion is concentrated on demonstrably migrating cutbanks on meander bends. These cutbanks are commonly associated with lateral scour pools, and the deepest pools tend to form against relatively slowly migrating cutbanks. In general, the channel is a C3/C4 channel type (Rosgen, 1996), with a gravel/cobble bed, width to depth ratios on the order of 28 at the 2-year event, a 0.2 percent slope, and moderate sinuosity. Table 2-1 contains a summary of basic planform and pool inventory data.

Figure 2-1. View downstream (Station 90+00) Showing Entrenched Cross Section

Table 2-1. Summary of Geomorphic Parameters, Phases 15 and 16 Clark Fork River

Parameter	Phase 15	Phase 16	Total Reach
Length (miles)	1.21	1.36	2.58
Slope (percent)	0.22	0.18	0.19
Sinuosity	1.68	1.64	1.66
Maximum 1955-2011 Migration Distance (ft)	162	121	162
Maximum 1955-2011 Migration Rate (ft/yr)	2.9	2.2	2.9
Pools per Mile	10.4	9.4	9.9
Average Bankfull Widths Between Pools	6.4	7.1	6.8
Max Residual Depth (ft)	5.7	4.2	5.7
Average Residual Depth (ft)	3.1	3.1	3.1

ft – feet
ft/yr – feet per year

Bank stratigraphy is variable throughout the reach, especially with respect to the bank toe. Toe materials range from fine-grained cohesive sediments to coarse, non-cohesive gravel bar deposits. In some cases, toe gravels are slightly cemented. Upper bank materials typically consist of overbank deposits that include visually discernible orange to beige colored tailings. Kapustka (2002a) measured an average tailings thickness of 14.6 inches (37centimeters (cm)) in banks containing observable deposits. Tailings are present as thick, massive channel fill deposits, laminated, reworked floodplain and point bar deposits, and within abandoned channel threads. Where erosion is occurring into higher surfaces such as terraces, tailings are notably absent both in the bank stratigraphy and in test pits (Figure 2-2). Vegetative reinforcement of the CFR bankline is notably limited in this area. A bank inventory through GKR by Kapustka (2002a) identified 39 percent of concave banks as having woody bankline vegetation, with 20 percent of these banks having additional shrubs within 2 meters (m) of the top of bank.

Figure 2-2. View Downstream (Station 66+00) Showing High Uncontaminated Bank

2.2 CHANNEL PROFILE

Surveyed thalweg and modeled 2-year water surface profiles indicate channel slopes of 0.22 percent in Phase 15 and 0.18 percent in Phase 16 (Figure 2-3). The surveyed bed profiles show vertical complexity that reflects pool/riffle sequences throughout the extents of both phases.

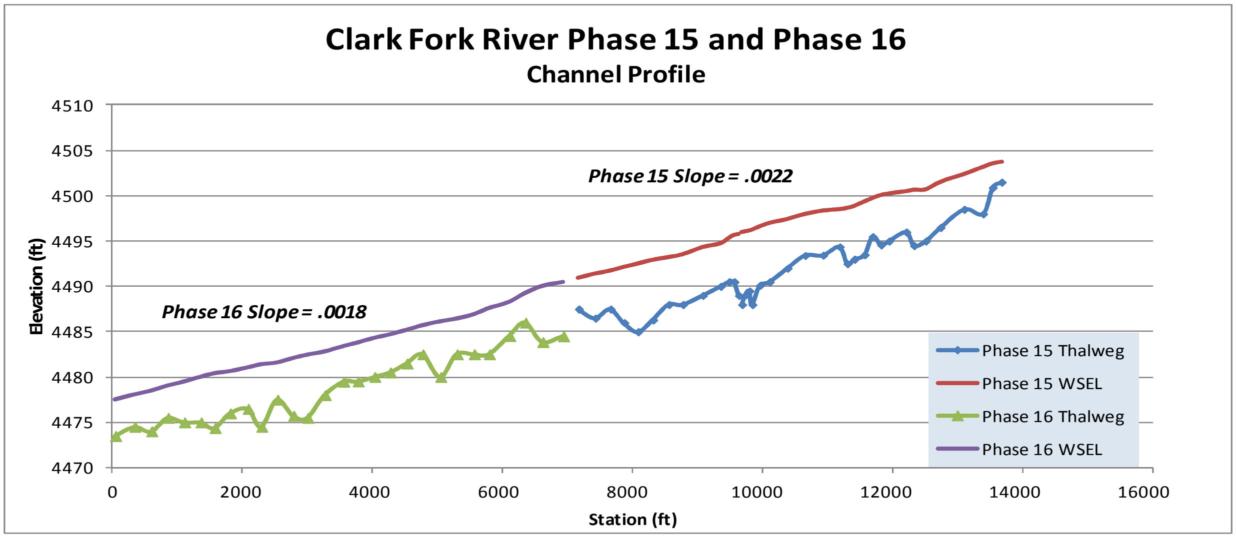


Figure 2-3. Channel Bed and 2-year Water Surface Profiles, Phases 15 and 16, Clark Fork River

2.2.1 Pools

During the field investigation of July 31-August 1, 2012, pool features were inventoried for location, depth, residual pool depth, and pool type. A total of 12 pools were measured in Phase 15 and 11 pools in Phase 16. Pool frequencies for the phases are very similar, with 10.4 pools per mile in Phase 15 and 9.4 pools per mile in Phase 16. Residual pool depths show a median value of 2.8 feet in Phase 15, and 3.0 feet in Phase 16 (Figure 2-4).

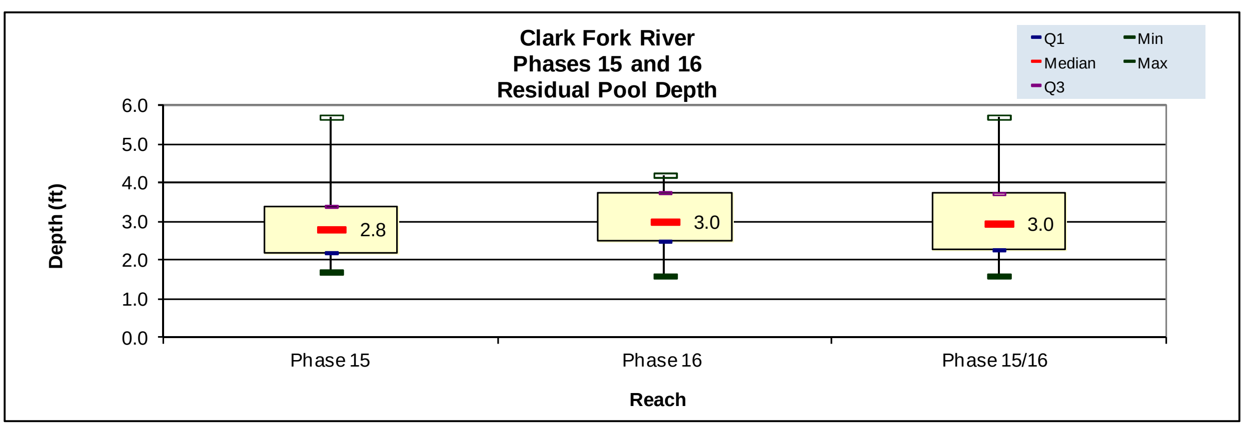


Figure 2-4. Box and Whisker Plot of Measured Residual Pool Depths, Phases 15 and 16

2.2.2 Channel Morphology and Floodplain Access

A total of 65 cross-sections were surveyed through the project reach, including 37 in Phase 15 and 28 in Phase 16. These cross sections have been used along with hydraulic modeling output to describe channel morphology through the reach. Table 2-2 summarizes hydraulic output for the 2-year, 1.25 year, and 1.01 year events.

Table 2-2. Summary of Cross Section Parameters Derived from HEC-RAS Modeling

Phase Modeled		1.01-yr (190 cfs)			1.25-yr (514 cfs)			2-yr (922 cfs)		
		Max Depth (ft)	Wetted Width (ft)	Width/Depth	Max Depth (ft)	Wetted Width (ft)	Width/Depth	Max Depth (ft)	Wetted Width (ft)	Width/Depth
Phases 15 and 16	Average	2.7	62.9	47	4.0	72.5	31	5.1	83.9	28
Phase 15	Minimum	0.9	36.9	15	1.5	50.4	12	2.2	56.8	11
	Maximum	5.3	132.9	134	6.9	147.7	66	8.3	192.0	75
	Average	2.9	59.8	43	4.2	71.7	30	5.4	84.7	28
Phase 16	Minimum	1.3	40.6	17	2.2	55.9	20	3.2	65.1	17
	Maximum	4.4	103.6	174	5.8	105.4	64	6.9	121.0	61
	Average	2.5	67.0	52	3.7	73.4	32	4.7	83.0	28

ft – feet
yr – year
cfs – cubic feet per second

A plot of wetted top-width versus station indicates that major top-width expansion occurs only locally between the 1.25-year and 2-year events, indicating overall flow confinement at the 2-year discharge. This entrenchment up to the 2-year flood event [922 cubic feet per second (cfs)] is most pronounced in Phase 15 of the project, which extends from near the Cottonwood Creek confluence to a point approximately 2,500 feet downstream of the historic Cattle Drive Road Bridge (Figure 2-5). Although top-widths locally exceed 120 feet in Phase 16, the results indicate that the reach is also entrenched such that the 2-year discharge results in minimal floodplain inundation.

Swanson (2002) measured channel top-widths from air photos dated 1947, 1960, 1983, 1994, 1997, and 2001, and showed a continual increase in mean channel width through the study reach from approximately 46 feet in 1947 to 66 feet in 2001 (Figure 2-6). These changes suggest continual channel migration and widening within the entrenched cross-section.

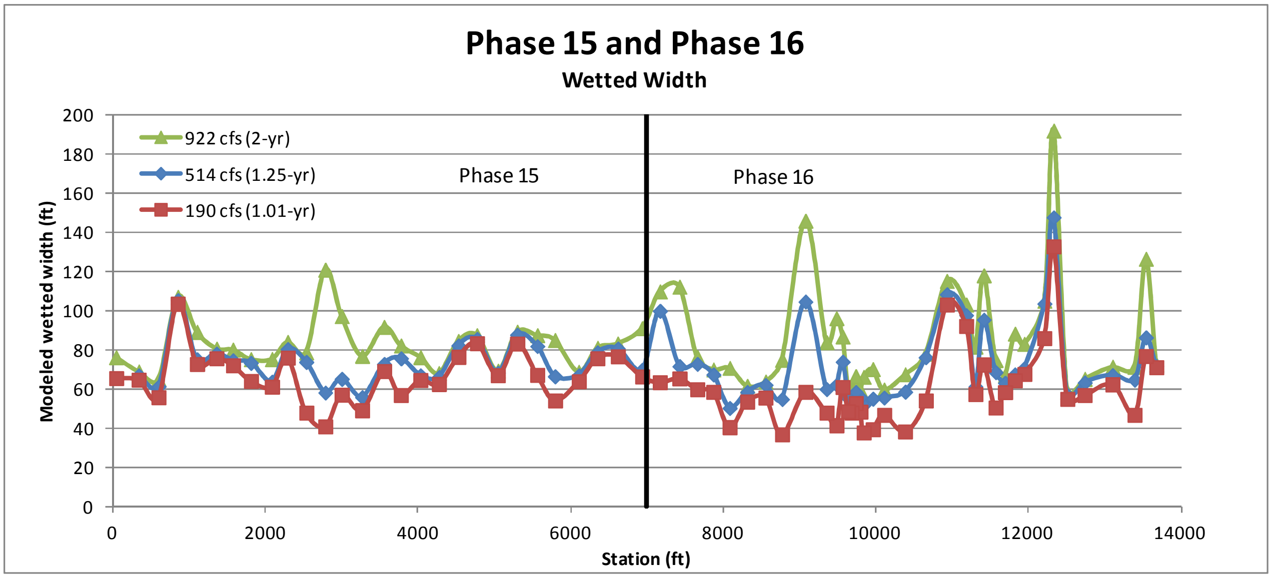


Figure 2-5. Wetted Top-Width Values Plotted by Station, Phases 15 and 16

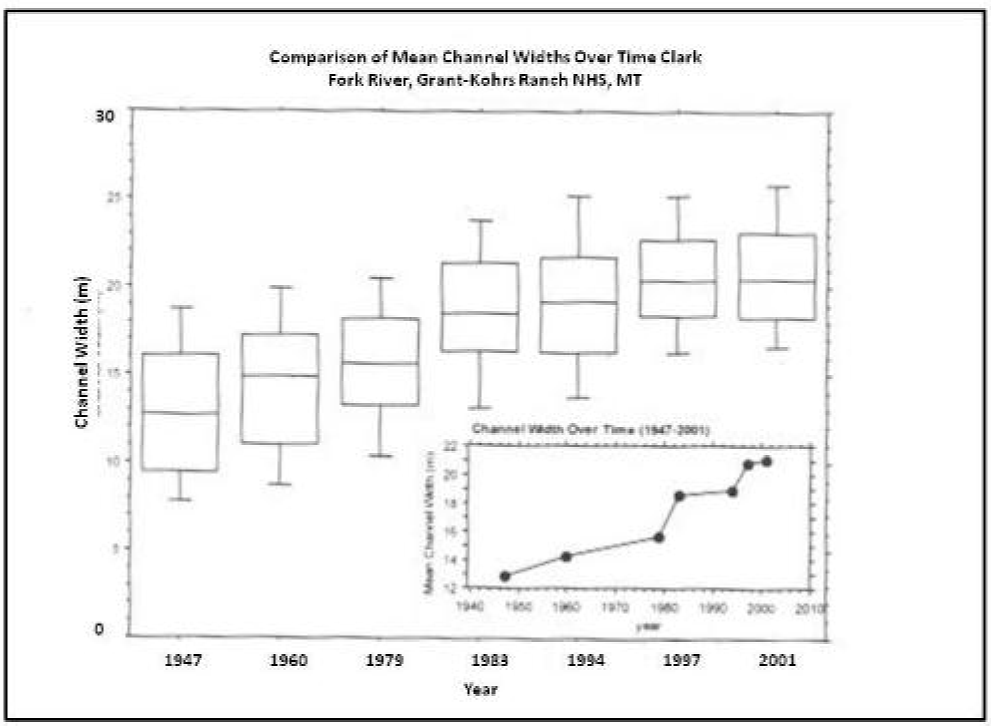


Figure 2-6. Changes in Channel Width as Measured on Air Photos from 1947-2001, Grant-Kohrs Ranch (from Swanson, 2002)

2.2.3 Bed Material

Five pebble counts were collected in the project reach, including three riffles in Phase 15 and two in Phase 16 (Tetra Tech, 2012a). Riffle features in both phases are well-formed, creating discreet grade breaks in the channel bed (Figure 2-7). The riffle sediment gradation curves are steep, reflecting a high degree of sorting for the coarse gravel to cobble size fractions (Figure 2-8). D84 particle sizes range from approximately 2 inches to almost 6 inches in diameter (Table 2-3). The results showed a slight coarsening in the downstream direction (Figure 2-9). All of the samples were classified as moderately to well-sorted.

Figure 2-7. View Upstream from Station 130+00 Showing Coarse Riffle Feature

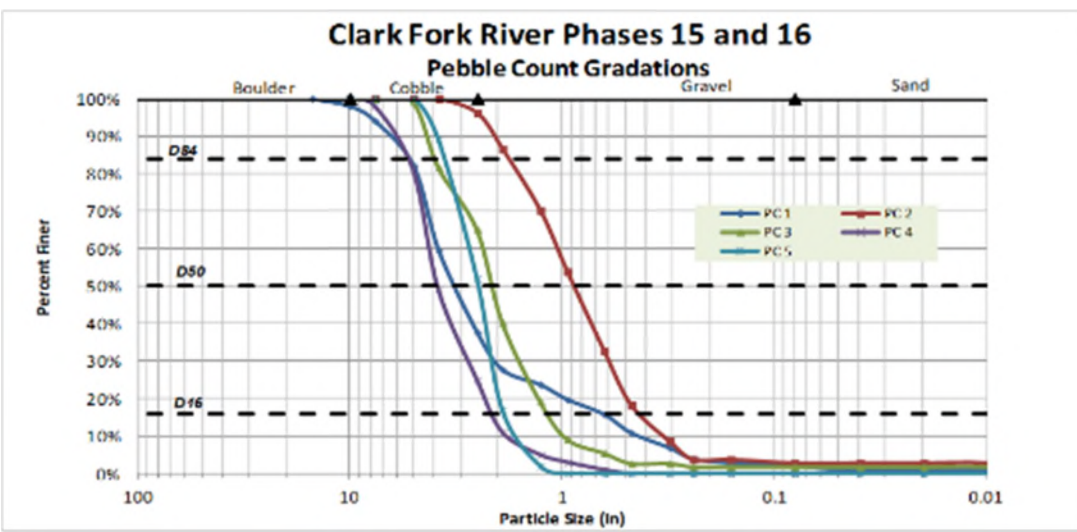


Figure 2-8. Pebble Count Gradations, Phases 15 and 16

Table 2-3. Pebble Count Gradations, Phases 15 and 16

Sample	Station (ft)	Location	Gradation (inches)			Gradation (mm)		
			D16	D50	D84	D16	D50	D84
Site 1	13200	Just upstream of mouth of Cottonwood Creek	0.6	3.1	4.7	14	78	120
Site 2	11650	Large bendway ~2,000 feet upstream of historic Cattle Drive Road Bridge	0.3	0.9	1.7	8	22	43
Site 3	9250	~250 feet downstream of Cattle Drive Road Bridge	1.2	2.1	3.6	30	52	92
Site 4	4700	Straight section ~2,300 feet downstream of Phases 15 and 16 boundary	2.1	3.5	5.9	52	90	150
Site 5	1200	Lowermost bendway just upstream of right bank riprap	1.8	2.6	4.7	45	65	120

ft – feet
mm - millimeter

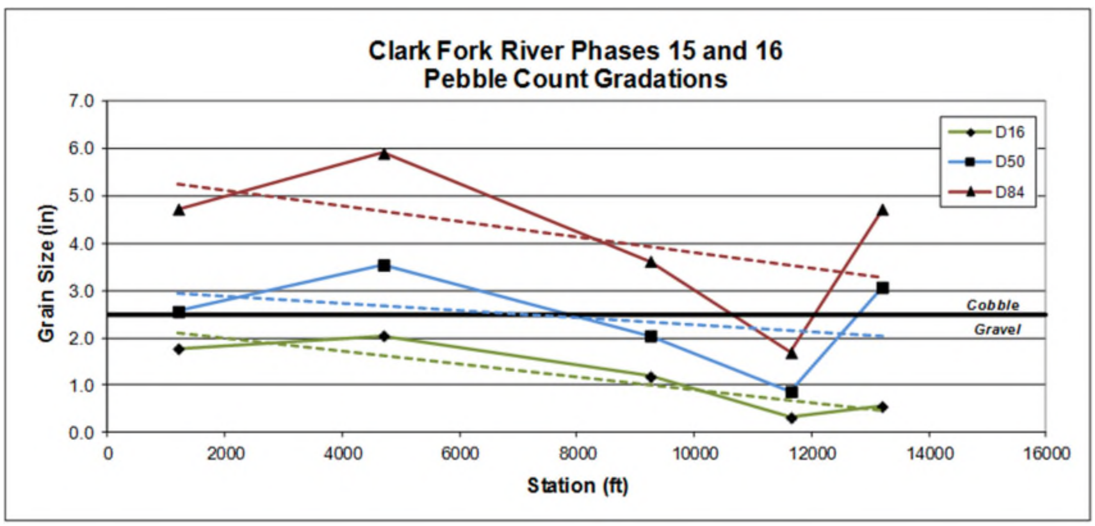


Figure 2-9. Grain Size Parameters Plotted by River Mile, Phases 15 and 16

Active sediment transport of coarse bedload in the reach is evidenced by the presence of coarse-grained, unvegetated, high elevation point bars (Figure 2-11) as well as in-stream migrating bedload features with convex downstream margins that form steep progradational wedges (Figure 2-10). The presence of these materials, coupled with measurable migration of cutbanks between 2009 and 2011 suggests that high flows in 2010 and 2011 effectively mobilized the coarse bedload. Swanson (2002) concluded that most bank erosion and sediment transport in this reach occurs at flows greater than 1,100 cfs. The 2010 peak (1,540 cfs) was between a 2- and 5- year event, whereas the 2011 peak (1,970 cfs) was between 5- and 10-year event. In 2011, the high flows were also of long duration; the 2-year discharge of 922 cfs was exceeded at the Deer Lodge gaging station for several weeks between mid-June and mid-July.

Figure 2-11. View Downstream of Coarse- Grained, Recent Bar Deposit, Station 108+00

Figure 2-10. View Downstream of Large Prograding Gravel/Cobble Bedform, Station 72+00.

2.2.4 River Planform and Channel Migration

The CFR through Phases 15 and 16 has a moderately dynamic planform where bank erosion is concentrated on outside meander bends. Measured sinuosities for Phase 15 and Phase 16 are 1.68 and 1.63, respectively. Bankline movement was measured at 15 sites where the river had migrated over 1/3 of the channel width (20 feet) since 1955. Migration rates on these bends range from 0.5 feet per year (ft/yr) to a maximum of 2.9 ft/yr at Station 80+00, where severe right bank erosion is on-going in the lowermost portion of Phase 15, located approximately 1,500 feet downstream from the Cattle Drive Road Bridge. A plot of channel migration versus bendway radius of curvature indicates that high rates of bankline movement occur at a bendway radius of curvature to width ratio between 2 and 3.5, which is typical of planform-derived erosion in alluvial river systems (Figure 2-12; Hooke, 1997).

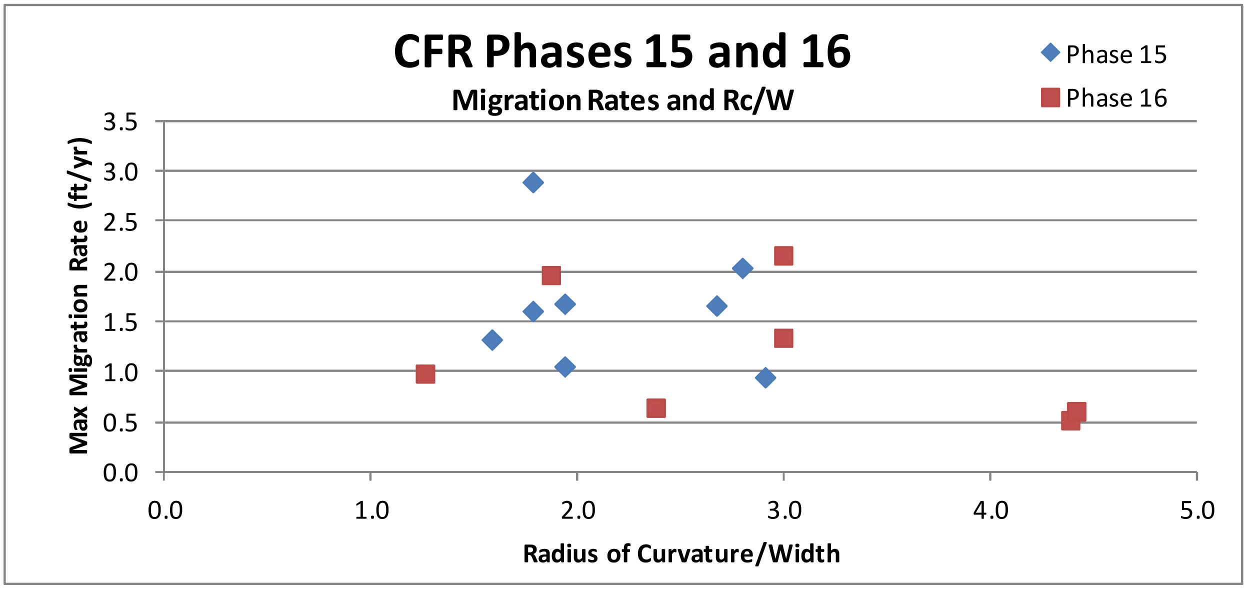


Figure 2-12. Radius of Curvature and Migration Rates, Phase 15 and 16

Woody vegetation is notably absent from eroding banklines in Phases 15 and 16 (Table 2-4). Of the 15 banks evaluated for migration rate, only two hosted either willow or water birch, and in both of those locations woody vegetation density is sparse. Vegetation densities in the river corridor were likely higher historically as the 1869 General Land Office (GLO) Survey notes describe the vegetation in this area as follows: “The timber is confined to the borders of the Deer Lodge River and consists of cottonwood, swamp alder, birch, and a thick undergrowth of willows.” Alder is consistently described as a bank vegetation component in the GLO notes throughout Reach A; its conspicuous absence likely reflects poor groundwater connectivity and soil conditions on the aggraded floodplain, and perhaps greater sensitivity to phytotoxic effects (Kapustka, 2002b; Gaulke et. al, 2006), and less resiliency in the sense of re-sprouting ability than willow or birch.

Table 2-4. Measured Migration Rates at Actively Migrating Banklines, Phases 15 & 16

Bendway Station	Radius of Curvature (ft)	Sinuosity (Rc/W)	Maximum 1955-2011 Migration Distance (ft)	Maximum 1955-2011 Migration Rate (ft/yr)	Topbank Vegetation	Phase
114+00	190	2.8	114	2.0	Mixed Grass	15
112+00	198	2.9	53	0.9	Mixed Grass	15
110+00	132	1.9	59	1.1	Mixed Grass	15
100+00	108	1.6	74	1.3	Mixed Grass	15
94+00	121	1.8	90	1.6	Mixed Grass	15
91+00	182	2.7	93	1.7	Mixed Grass	15
80+00	121	1.8	162	2.9	Mixed Grass	15
76+00	132	1.9	94	1.7	Grass/Shrub	15
72+00	204	3.0	75	1.3	Mixed Grass	16
68+00	162	2.4	36	0.6	Mixed Grass	16
58+00	127	1.9	110	2.0	Mixed Grass	16
30+00	204	3.0	121	2.2	Mixed Grass	16
28+00	86	1.3	55	1.0	Mixed Grass	16
20+00	298	4.4	29	0.5	Mixed Grass	16
8+00	300	4.4	34	0.6	Grass/Shrub	16

Rc/W – Ratio of bend radius of curvature (Rc) to channel width (W).
ft – feet
ft/yr – feet per year

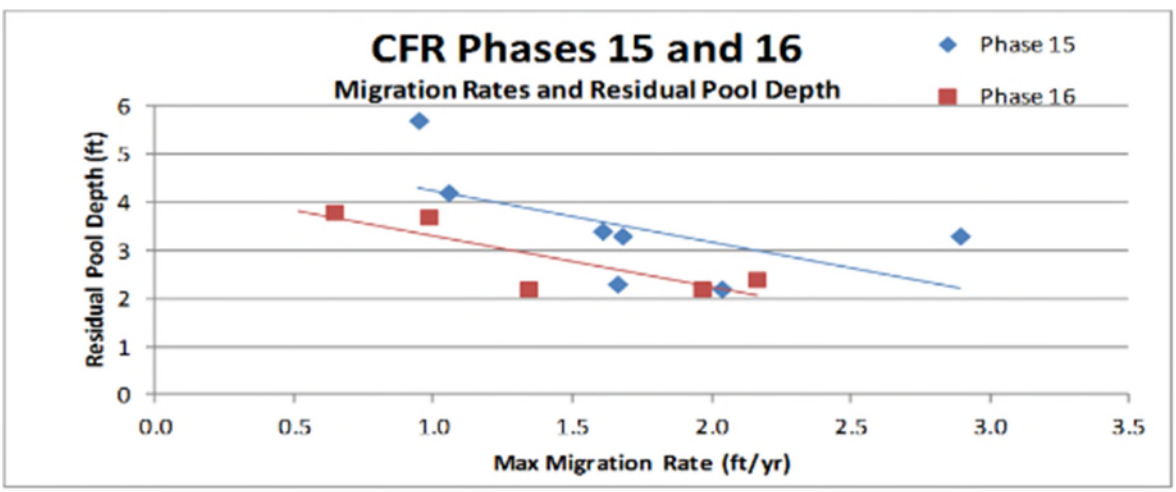


Figure 2-13. Maximum Migration Rate vs. Residual Pool Depth

Deep pools in the project reach are associated with relatively slowly migrating banklines. This reflects the maintenance of deep scour holes against competent outer bank materials (Figure 2-13).

A GLO map from 1869 suggests that substantial shifts in channel location have occurred in this reach over the last 140 years. On the GLO maps, the 1869 river location can be considered most reliable where the river crosses section lines. The 1869 map of Phases 15 and 16 shows the river course west of the modern channel in four primary locations, including three at section line crossings (Figure 2-14). The river has since moved several hundred feet eastward at these locations; Swanson (2002) showed that these changes largely occurred by 1914. Also notable on the 1892 map is a "slough" near the corner of Sections 28, 29, 32, and 33; this slough is described as being 26 to 33 feet wide in the GLO survey notes, indicating that in at least a section of the reach, the river had multiple threads. This was also the case in 1955, when there was split flow between Station 92+00 and Station 75+00 (middle red arrow in Figure 2-14). This abandoned 1955 channel swale locally contains over 2 feet of tailings deposits.

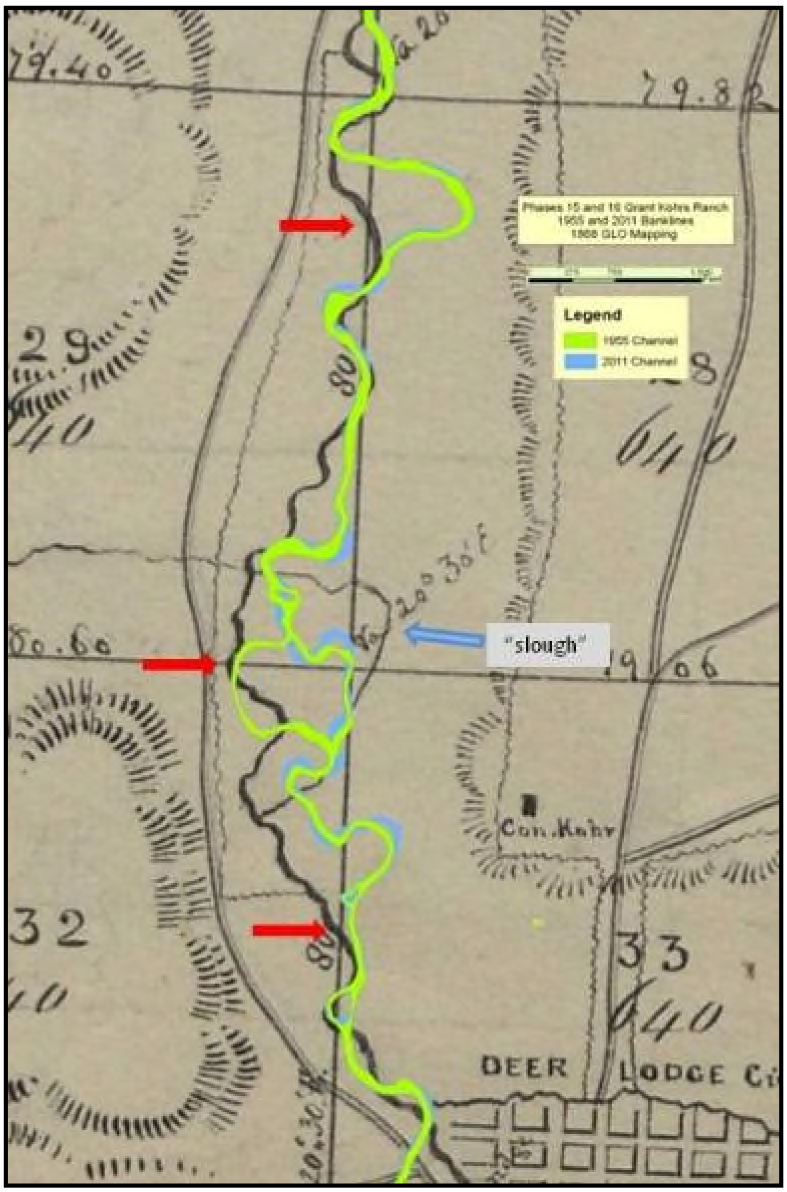


Figure 2-14. 1955 and 2011 Banklines Plotted on 1869 GLO Map

2.2.5 Streambank Tailings Exposures

Tailings deposition as observable in Phases 15 and 16 streambanks is highly variable in terms of form, thickness, and depth, which reflect a complex history of initial tailings delivery, subsequent tailings reworking, and land management. According to Swanson (2002), an estimated 100,000 tons of tailings were dumped along Silver Bow Creek prior to the 1880's, and by 1880, that number had increased by a factor of ten. Even before the turn of the century, Silver Bow Creek was a source of tailings loading to the CFR. During that time, farmers in the valley bottoms constructed dikes and levees to keep tailings out of their fields, creating local "bottlenecks" in transport rates through the system (Quivik, 1998).

Swanson (2002) quoted an 1892 fisheries survey by Evermann (1892) that described the CFR as "a constantly shifting mass of fine silt-like material from the concentrators and reduction works at Anaconda and Butte". In 1892, Evermann referred to the river as "muddy" throughout Reach A, or all of the way to the mouth of the Little Blackfoot River at Garrison. The massive flood of 1908 then caused especially extensive and thick deposition of tailings on the CFR floodplain. In Phases 15 and 16, the GKR ranch caretaker of the 1930's described the floodplain as containing "kind of yellowish colored dirt with essentially nothing growing on it and lots of animal carcasses lying around" (Swanson, 2002). In addition to the flooding, the tailings accumulations on the floodplain may also have been delivered through irrigation systems. Work on GKR in the early part of the twentieth century included plowing irrigated fields and floodplain affected by tailings and dumping of extra hay and manure on them to help reclaim the land for agricultural use (Swanson, 2002).

These historic accounts are corroborated by extensive tailings exposures in streambanks. In places, thick tailings deposits have filled relatively small historic channel features that are exposed in cross-section along the bankline (Figure 2-16). These exposures document a pre-1908 floodplain that supported multiple channel threads, which may have been associated with beaver activity. Tailings are also commonly laminated indicating multiple depositional events of reworked material (Figure 2-15). The most visible tailings are typically found in the upper third of the streambank, creating high banks and channel entrenchment over a native bank toe (Figure 2-17). At Station 94+00, approximately 2 feet of massive overlying organic rich material appears to exemplify the practice of dumping manure on banks as part of early reclamation efforts (Figure 2-18; Swanson, 2002). Bones found on bars and in banks show bright blue staining from the contaminants (Figure 2-19).

Figure 2-16. Tailings Deposition in an Old Channel, Station 84+00R

Figure 2-15. Massive Upper Bank Tailings Deposit, Station 111+00R

Figure 2-17. Laminated Tailings Exposure Indicating Multiple Depositional Events, with Apparent Tilling of Upper ~6" of Bank Material

Figure 2-18. Tailings Under Manure-rich Fill, Station 94+00R

Figure 2-19. Blue-colored Bone on Bar Surface, Station 56+00L

2.2.6 Geomorphic Evolution of Phases 15 and 16

The geomorphic evolution of Phases 15 and 16 includes the post-glacial conversion of the ancestral CFR from a wide braided glacially-fed stream system in Pleistocene time to a single-thread meandering river. As the alpine glaciers retreated, the river incised through valley bottom glacial outwash deposits, leaving terraces on the river corridor margin that occasionally form high banklines on either side of the river. Currently, coarse bed and lower bank material that is prevalent throughout the system likely in part represents a lag deposit from that process of glacial outwash reworking.

Early descriptions of the Deer Lodge Valley, and the GKR area in particular, describe dense woody vegetation including birch, willows, and alder on the stream banks and floodplain. In the early 1800's, beaver were present and aggressively trapped from tributary streams in the valley, and although beaver activity has been suggested on the main stem CFR (Smith et al., 1988), their historic presence on the CFR in Reach A is poorly documented (Swanson, 2002). To date, no mention of beaver on the main stem CFR through the Deer Lodge Valley has been identified in the GLO Survey notes of the late 1800's, although beaver may have been fully trapped out by then. The common exposure of small channel fill deposits in the modern streambanks of the river support the concept of historic beaver activity, and there have been accounts of buried dams being encountered in floodplain sediment (Swanson, 2002).

Large-scale cattle operations were introduced into the Deer Lodge Valley in the 1850s, which would have impacted the previously dense woody riparian corridor. This land use change, along with potential eradication of beaver, would have degraded the riparian corridor, and potentially caused some down-cutting, widening, and consolidation of channels. Agricultural land uses in Phases 15 and 16 included draining of fields in the 1880s, indicating that the floodplain was wetter than today (Swanson, 2002).

Sediment loading from upstream mining operations apparently affected this area starting in the late 1860s due to hydraulic mining for gold in Silver Bow Creek (Swanson, 2002). This sediment loading continued through the late 1800s as smelters and concentrators in Anaconda and Butte produced a combined total of 1,400 tons of tailings per day. Tailings were deposited in Ramsay Flats as early as the late 1880s, and landowners in the Deer Lodge valley were building dikes to keep tailings within the channel in the 1890s (Quivik, 1998). Even before the great flood of 1908, agriculturalists were seeing the accumulation of tailings in their fields from flooding and/or irrigation practices. Charles Williams, who owned a farm six miles north of Deer Lodge, believed by 1898 that irrigation water was damaging his crops, and by the early twentieth century had many spots in his fields “where nothing grew”. Hugh Magone ranched in the Race Track area and noticed that by the early 1900s tailings had settled over all of the low-lying areas of his bottom land; some areas were white, some green, some “slate gray”, and many of these areas no longer supported vegetation (Quivik,1998). The 1908 flood then caused massive additional deposition of tailings on the CFR floodplain.

Warm Springs Ponds were built in 1911 to trap mine tailings before they entered the CFR, cutting off the supply of these materials shortly after the 1908 flood. The modern geomorphology of the system currently reflects that rapid reduction in sediment loading. In the uppermost Phases of Reach A, tailings that had accumulated in the channel appear to have been rapidly flushed out, leaving dense woody vegetation on the banks and a high, perched floodplain with up to several feet of tailings contamination. Further downstream, sediment loading of contaminated material continued due to upstream bank erosion and tailings entrainment. That sediment loading resulted in continued floodplain deposition of contaminants, as well as in-channel deposition of tailings as observed in modern point bars, and abandoned floodplain channels.

Phases 15 and 16, like most Phases of Reach A, currently have poor floodplain access, for frequent flood flows such as the 2 year event, due to floodplain aggradation. On GKR, high contaminated banks are very common, overlaying a historic fine-grained floodplain unit which in turn overlays a complex mosaic of coarse gravels (bar deposits) and fine-grained abandoned channel fills. Sediment storage in the reach drives planform evolution and bank migration into the contaminated materials.

Swanson (2002) documented continued channel widening in the reach since the late 1940’s, indicating a trend towards developing an inset floodplain surface within the entrenched channel. This process, although effective for long-term riparian recovery, will result in further bank erosion and associated contaminant recruitment.

2.3 CONTAMINANT CHARACTERAZATION

The CFROU Reach A, Phases 15 and 16 contaminant characterization investigation was conducted between July 6, 2011 and September 13, 2011 to collect and identify design-level data concerning the nature and extent of soil contamination. The investigation included measurement of the thickness of contaminated materials, evaluation of contaminant concentrations within the soil profile, and depth to groundwater; all of which are required to complete remedial design (Tetra Tech, 2012b).

The Phases 15 and 16 contaminant characterization consisted of excavation and sampling of test pits based on sampling areas delineated with the Riparian Evaluation System (RipES) preliminary polygons (CH2MHill and others, 2004) including slickens, impacted soils and vegetative areas, miscellaneous site types and slightly impacted soils and vegetation areas. The investigation sampling approach consisted of test pit locations, spaced on a north-south to east-west grid pattern with 125-foot centers. Additional sample locations were identified outside of the 125-foot grid system within historic channels or old oxbows. Samples were collected at 6-inch depth intervals until one of the following conditions was met:

- Evaluation of field X-ray Fluorescence (XRF) data indicated that the sum of arsenic, copper, lead and zinc concentrations [i.e. total concentrations of COCs] was below 800 mg/kg, or

- Course alluvium having a rock content of 60 percent or more (visual estimation), or bedrock was encountered. These conditions are believed to provide sufficient protection from erosion.

The vertical extent of tailings/impacted soil for each test pit is displayed on Sheets C1 – C3, Existing Conditions. Tailings/impacted soil depths ranged from 0 inches (no tailings/impacts) to greater than 48 inches at various test pit locations.

2.4 HYDROLOGIC ANALYSIS

A detailed flood frequency analysis was conducted to evaluate the magnitude and recurrence interval of annual expected flood peaks. A flow duration curve using daily measured flows from a gaging station just upstream of Phase 15 was also prepared. The results of both of these analyses are described in the following sections.

2.4.1 Flood Frequency Analysis

The U.S. Geological Survey (USGS) Clark Fork at Deer Lodge gage station (USGS Gage No. 12324200) has been operating continuously since 1978, yielding 32 years of daily and annual peak flow data. The gage is located just upstream of Phase 15 within the town of Deer Lodge. Table 2-5 summarizes the annual observed peak discharges.

Table 2-5. Annual peak discharges at USGS Gage No. 123243000, Clark Fork River at Deer Lodge (1980 through 2011)

Date	Discharge (cfs)		Date	Discharge (cfs)		Date	Discharge (cfs)
May 26, 1980	1,710		Jun 08, 1991	1,020		Jun 10, 2002	461
May 23, 1981	2,500		Nov 05, 1991	367		Jun 01, 2003	1,060
Jun 25, 1982	1,450		Jun 17, 1993	613		Mar 10, 2004	286
Jul 10, 1983	1,190		May 13, 1994	462		Jun 18, 2005	848
Jun 22, 1984	1,730		Jun 07, 1995	1,240		Jun 10, 2006	654
May 04, 1985	492		Feb 08, 1996	1,400		Jun 07, 2007	1,130
Feb 25, 1986	2,090		Jun 14, 1997	2,020		Jun 05, 2008	1,020
May 28, 1987	463		Jul 04, 1998	1,200		Jun 02, 2009	1,180
Apr 22, 1988	409		Jun 04, 1999	819		Jun 17, 2010	1,540
Mar 09, 1989	1,430		Nov 26, 1999	263		Jun 14, 2011	1,970
May 31, 1990	507		Jun 04, 2001	310			
cfs – cubic feet per second							

The largest annual peak flow on record occurred on May 3, 1981, at 2,500 cfs. The lowest annual peak was 263 cfs, which occurred on November 26, 1999. A statistical analysis of the annual peak flow data was performed using Hydraulic Engineering Center-Statistical Software Package (HEC-SSP) 2.0

(USACE, 2010a) which incorporates the methodology of Bulletin 17B (WRC, 1981). The reported regional skew of -0.1 and the regional skew mean standard error of 0.64 was used in the analysis (Parrett and Johnson, 2004). There are no outliers in the data set of peak discharge values. The results of the analysis are summarized in Table 2-6.

Table 2-6. Flood Frequency Analysis

Flood Frequency Analysis Results Clark Fork River at Deer Lodge, Montana				
Flow (cfs)	Percent Chance Exceedance	Return Period (yrs)	Confidence Limits Flow (cfs)	
			0.05	0.95
5,052	0.2	500	8,309	3,587
4,241	0.5	200	6,694	3,089
3,665	1	100	5,594	2,725
3,121	2	50	4,594	2,372
2,445	5	20	3,414	1,917
1,962	10	10	2,663	1,577
1,498	20	5	1,910	1,232
884	50	2	1,065	734
514	80	1.25	624	403
385	90	1.11	479	287
302	95	1.05	387	214

cfs – cubic feet per second
yrs - years

Cottonwood Creek, with a drainage area of approximately 45 square miles (FEMA, 1980) flows into the CFR below the USGS gage in Deer Lodge but above Phase 15. During low flows, all or most of the flow of Cottonwood Creek is intercepted by the Kohrs-Manning ditch on the right (east) overbank of the CFR. However, flood flows from this tributary would likely bypass the irrigation ditch and contribute to flood flows within Phases 15 and 16. To adjust the predicted flood flows at the USGS gage in Deer Lodge for the effect of Cottonwood Creek, a drainage-area ratio adjustment developed by the USGS (Parrett and Johnson, 2004) was applied as follows:

$$Q_{T,U} = Q_{T,G} \{D_{AU} / D_{AG}\}^{EXP_T}$$

Where:

$Q_{T,U}$ = Peak Annual Discharge (cfs) within Phases 15 and 16 for return period T.
$Q_{T,G}$ = Peak Annual Discharge (cfs) at the USGS gage in Deer Lodge for return period T.
D_{AU} = Drainage area (square miles; sq. mi.) within Phases 15 and 16.
D_{AG} = Drainage area (sq. mi.) at the USGS gage in Deer Lodge.
EXP_T = Regression coefficient for return period T.

The regression coefficients for the CFR, located in the western hydrologic region of the state, are shown in Table 2-7 (ibid) along with the results of the estimated peak annual flows for the project reach. Figure 2-20 also depicts the peak flows within Phases 15 and 16 as estimated by the drainage-area ratio calculations.

Table 2-7. Estimated Peak Annual Flows – Phases 15 and 16

Return Period (yrs)	Regional Coefficient (West)	Peak Annual Discharge at USGS Gage (cfs)	Peak Annual Discharge Phases 15 and 16 (cfs)
500	0.717	5,052	5,233
200	0.734	4,241	4,396
100	0.747	3,665	3,802
50	0.761	3,121	3,240
25	0.776	2,675	2,779
10	0.798	1,962	2,040
5	0.818	1,498	1,559
2	0.851	884	922

yrs – years
cfs – cubic feet per second

Of particular note are the 2-year (Q_2) and 10-year (Q_{10}) annual peak flows along Phases 15 and 16, which are 922 cfs and 2,040 cfs, respectively. These values were used in the design of various features in subsequent sections of this PDP.

Others have speculated that the upstream Warm Springs Ponds, which intercept and attenuate the flows of Silver Bow Creek, may someday be decommissioned (CDM et al., 2011). If Silver Bow Creek is no longer attenuated by the Warm Springs Ponds, it may increase the magnitude of flood events in Phases 15 and 16. However, no analysis of the impact of the removal of Warm Springs Ponds has been performed for this PDP.

Some small tributaries enter the CFR between Cottonwood Creek and the downstream end of Phase 16 and there is likely overland flow from adjacent riparian areas and hillsides during extreme runoff events. However, the combined impact on flood flows from these small sources is likely negligible in comparison to the large drainage area of the USGS Clark Fork at Deer Lodge gage and Cottonwood Creek. Because of the small size of other sources of floodwater below Cottonwood Creek, the predicted flood flows below Cottonwood Creek are used as design flows for Phases 15 and 16.

2.4.2 Comparison with other Flood Frequency Analyses

Camp Dresser McKee, Inc. (CDM et al., 2011) and TerraGraphics (Personal communication, 2012) examined the flood hydrology of the CFR at locations upstream from Phase 15. These estimates of flood hydrology are based primarily on recorded flows at upstream gaging stations, including the USGS Clark Fork gage at Galen. One of the other methods also partly relied on recorded flow at the USGS Clark Fork gage at Deer Lodge. Table 2-8 compares peak flood estimates derived from these various approaches.

Table 2-8. Estimated Flood Frequency USGS Gages Clark Fork River

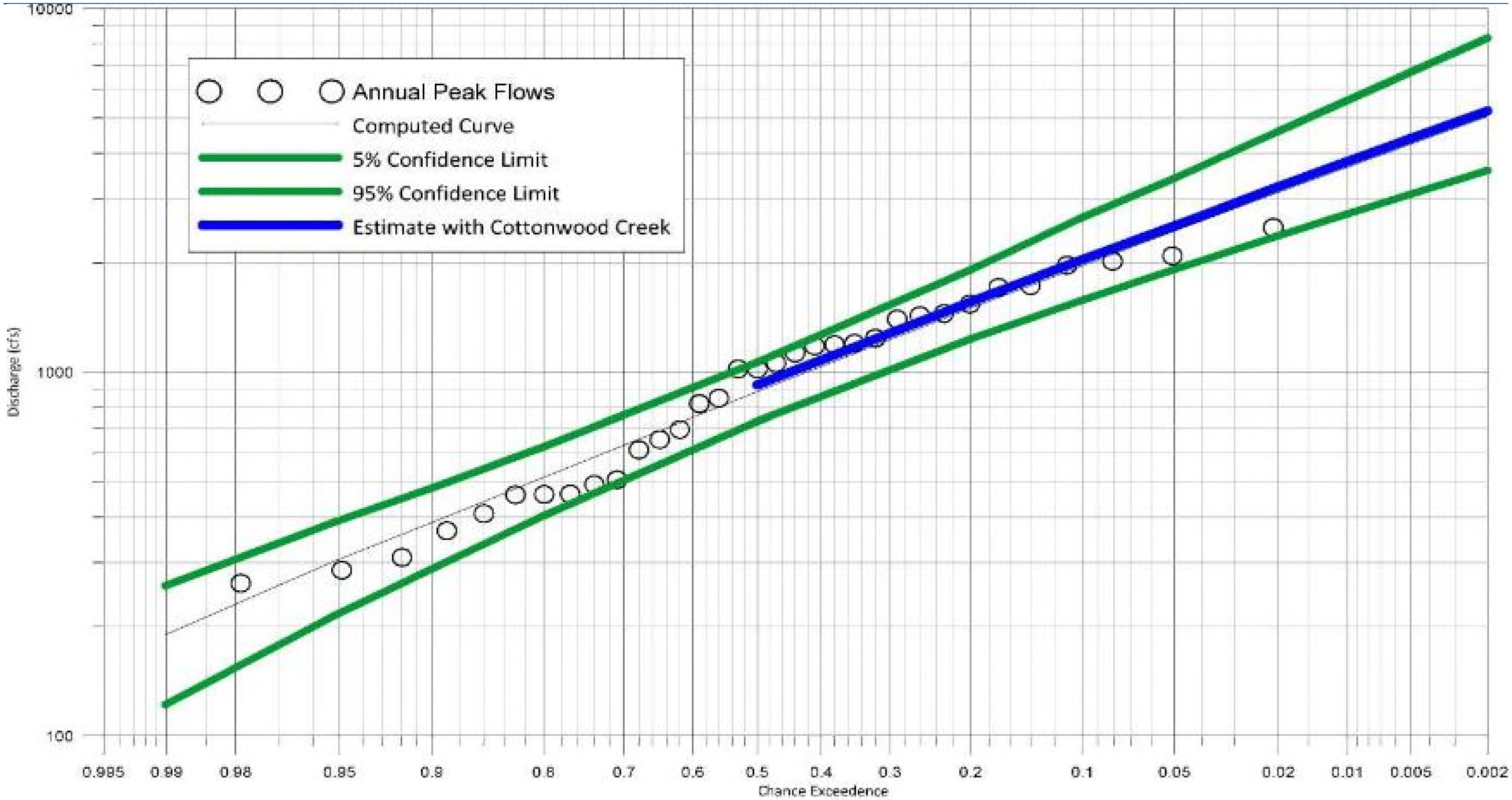
Return Period (yrs)	USGS Gage Clark Fork at Galen (cfs)		USGS Gage Clark Fork at Deer Lodge (cfs)	
	Source: CDM et al., 2011	Source: Terragraphics, 2012	Source: Terragraphics, 2012	From Table 2-7
2	522	636	893	884
5	861	936	1,502	1,498
10	1,094	1,134	1,946	2,040
25	1,286	1,179	2,542	2,779
50	1,415	1,558	3,006	3,240
100	1,533	1,733	3,484	3,802

cfs – cubic feet per second
yrs – years

These estimates of flood peaks show some variability among themselves at the Galen gage and there is some variability between the Terragraphics estimates at Deer Lodge with those determined for this report (Table 2-8). However, the difference between Terragraphics estimates and the estimates for this report for the 2-year and 10-year flood flows at Deer Lodge is negligible (5 percent or less).

2.4.3 Flow Duration Analysis

A flow-duration curve was created based on the 34 years of mean daily flow data available for the USGS Clark Fork gage at Deer Lodge. The curve, shown in Figure 2-21, represents the probability of mean daily flow being equaled or exceeded over the course of a year. It should be noted that no adjustment to the mean daily flows was made to account for inflow from Cottonwood Creek, since non-flood flows from this tributary are mostly intercepted by the irrigation ditch on the east overbank. Results from the flow-duration analysis indicate the median discharge (the discharge that is equaled or exceeded 50 percent of the time) is about 210 cfs, and the 10 percent exceedance discharge is about 400 cfs.



Note: Also shown are drainage-area ratio estimates

Figure 2-20. Peak Flow Frequency Analysis for Clark Fork River at Deer Lodge, Montana (USGS Gage No. 12324200)

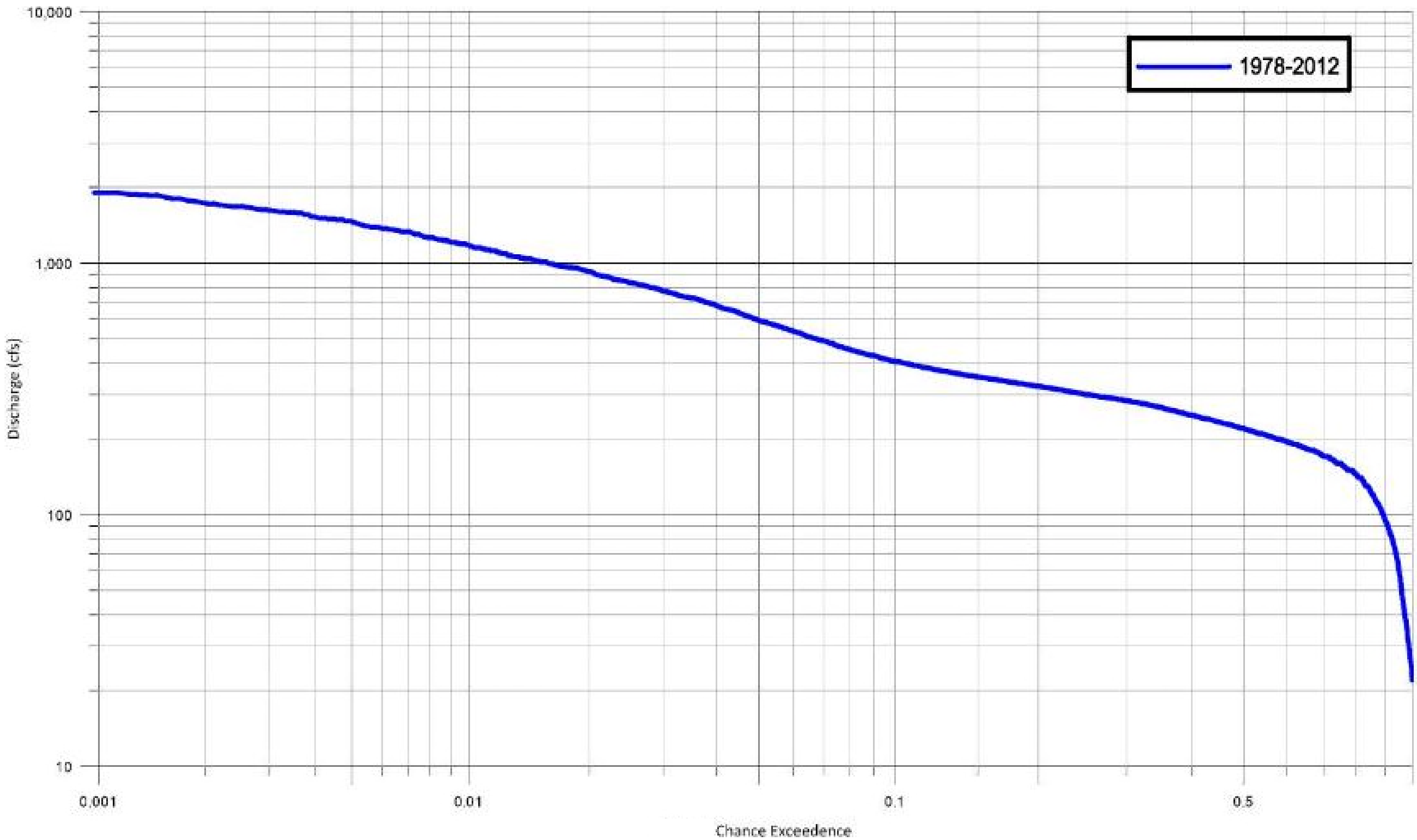


Figure 2-21. Mean Daily Flow-Duration Curve for Clark Fork River at Deer Lodge, Montana (USGS Gage No. 12324200)

2.5 HYDRAULIC ANALYSIS

The Hydraulic Engineering Center – River Analysis System (HEC-RAS) program was used to evaluate the hydraulic properties of the Clark Fork River within the project reach (USACE, 2010b). LiDAR data were used to extend the surveyed cross-section geometry into the floodplain and overbank areas. Ineffective flow areas were delineated based on field observations, overbank topographic mapping, and aerial photography. The HEC-RAS model was executed over a range of flows, including those shown in Table 2-9.

The downstream boundary condition was determined by assuming normal depth conditions with a slope of 0. 002 ft/ft, which is consistent with the local bed slope at the downstream model limit and close to the average energy grade slope of 0.0022 ft/ft throughout the project. A discharge of 330 cfs, which represents the streamflow during the cross-section survey effort, was also included in the range of modeled flows to assist in model calibration. The downstream boundary condition for that flow level was set at the known surveyed water-surface elevation.

Manning's n-values were selected based on field observations of the channel and overbank conditions. In general, the bed material consists of well-graded, rounded gravels and cobbles. A roughness value of 0.036 was initially selected for the main channel portion of the cross sections. The model was calibrated, to the extent possible, by adjusting the roughness values until the predicted water-surface elevation matched the water surface elevations measured during the cross section survey, when the discharge in the channel averaged 330 cfs. Model calibration was generally achieved by increasing the roughness values in a few selected areas, most notably in the area of the Cattle Drive Road Bridge, where the main channel n-value was increased to as high as 0.06 to better match the surveyed water-surface elevations. The resulting predicted water surface elevation matches the surveyed water-surface elevation reasonably well (Tetra Tech, 2012).

2.5.1 Hydraulic Model Output

Results from the HEC-RAS model were used to evaluate criteria important in the remediation design. Selected results from the HEC-RAS models developed for this PDP are contained in Appendix A.

2.5.2 Water Surface Profiles

Estimated water surface profiles for Phases 15 and 16 were computed by the HEC-RAS Model. Figure 2-22 shows the computed profiles for flood events ranging from the 2-year to the 100-year recurrence interval events. The Cattle Drive Road Bridge located near Station 96+00 produces a backwater for all events shown on Figure 2-22. The drop through the Cattle Drive Road Bridge becomes significant for flood events with a 10-year or higher recurrence interval.

For purposes of this report, Phases 15 and 16 were divided into four subreaches that are hydraulically or geomorphically similar. Subreach 16b consists of a relatively sinuous reach that begins at the downstream end of Phase 16 and runs to approximately station 41+00. Subreach 16a consists of a relatively straight reach and begins at station 41+00 and runs upstream to approximately station 52+00. Subreach 15b consists of a relatively sinuous reach and runs from station 52+00 upstream to approximately station 121+00. Subreach 15a consists of a relatively straight reach and begins at station 121+00 and runs upstream to the upstream boundary of Phase 15 at approximately station 136+68. Figure 2-23 shows these subreaches.

Figure 2-22. Estimated Water Surface Profiles for Phases 15 and 16

December 2012

N:\PROJECTS\Montana Dept of Env. Quality\CFR Reach A\114-560356 - GKR Preliminary Design Report\CAD\SheetFiles\Figures\F-2-23 Clark Fork River Phases 15 and 16.dwg SAVED: 12/14/12 PRINTED: 12/14/12 BY:STEVE.FIELD 114-560356

CLARK FORK RIVER
PHASES 15 & 16
WITH SUBREACHES
FIGURE 2-23

2.5.3 Reach Average Hydraulics

Hydraulic conditions in the channel determine flow depths and velocities, energy gradient, shear stress on the channel materials, and related design parameters. Reach-averaged hydraulic conditions from the HEC-RAS model for flows from the 2-year to the 100-year recurrence interval events are listed in Table 2-9.

Table 2-9. Reach Averaged Hydraulic Conditions

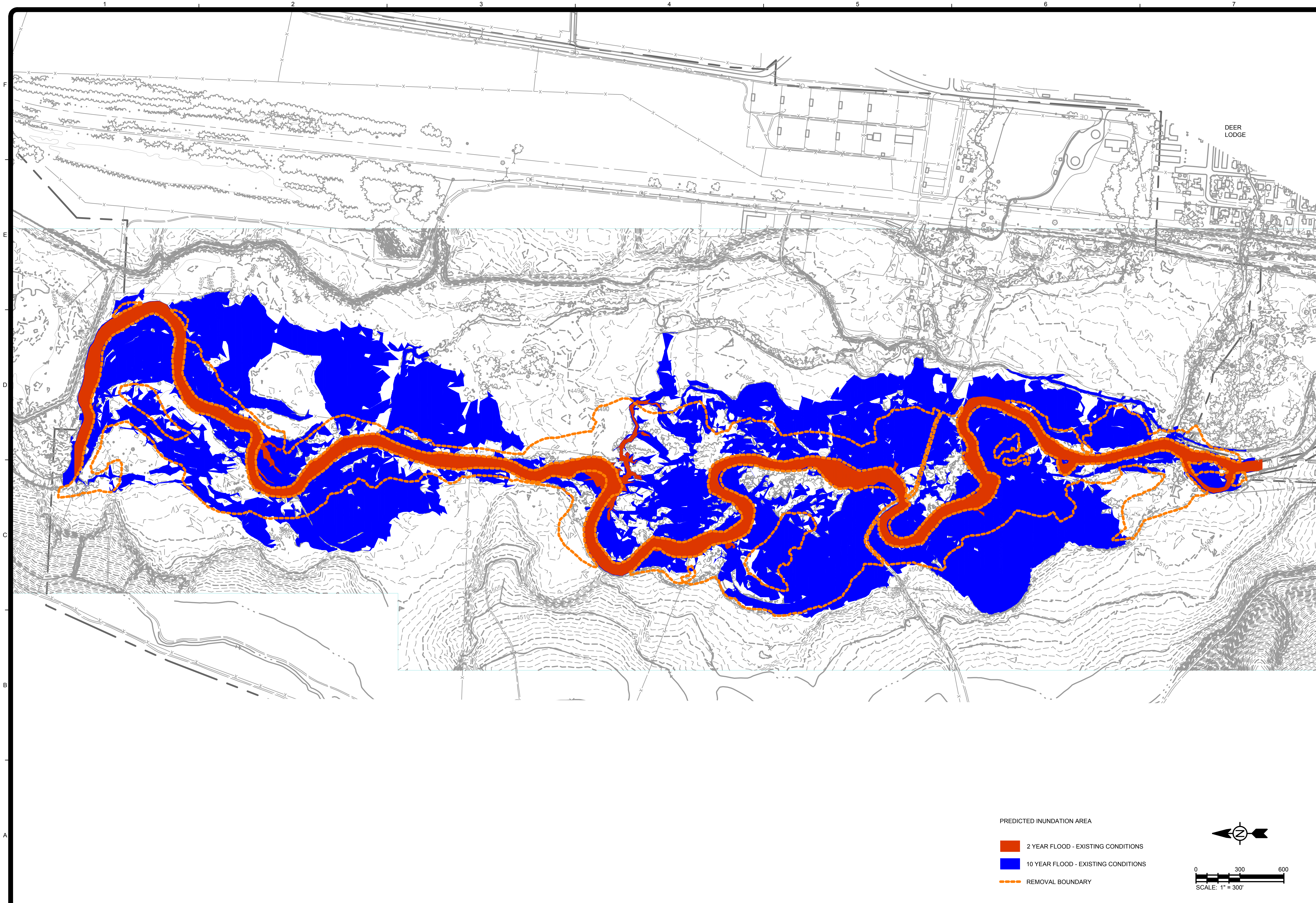
	Flow event				
Subreach	**2-year**	**5-year**	**10-year**	**50-year**	**100-year**
Discharge					
All	922	1566	2009	3024	3465
Hydraulic Depth (ft)					
16b	3.02	1.85	1.70	1.98	2.19
16a	3.33	3.70	2.47	1.65	1.86
15b	3.41	2.71	2.02	2.28	2.57
15a	2.98	2.80	1.99	2.18	2.37
Main Channel Velocity (ft/sec)					
16b	3.8	4.5	4.8	5.2	5.3
16a	3.6	4.5	5.0	5.7	5.9
15b	3.5	4.1	4.4	4.6	4.8
15a	3.9	4.2	4.6	5.4	5.7
Energy Gradient (ft/ft)					
16b	0.0017	0.0017	0.0017	0.0016	0.0015
16a	0.0017	0.0017	0.0018	0.0020	0.0020
15b	0.0022	0.0021	0.0020	0.0017	0.0017
15a	0.0026	0.0027	0.0024	0.0026	0.0026

ft – feet
ft/ft – feet per feet
ft/sec – feet per second

2.5.4 Channel Capacity and Floodplain Inundation

Model results indicate that the 2-yr recurrence interval flood event is generally contained within the existing channel and banks. Results also indicate that the 5-year recurrence interval event spills out of the existing main channel and onto the adjacent floodplain in many locations. During the 10-year recurrence interval and larger flood events, the floodplain is inundated to various degrees.

Reconstructing the banks and floodplain according to the proposed excavation and bank replacement plans derived herein is designed to allow greater access to the floodplain from more frequent events such as the 2-year flood peak. Figure 2-24 compares HEC-RAS predicted inundation boundaries for the 2-year event with existing topography and after floodplain and bank reconstruction. Appendix B includes inundation boundaries after remediation for the 5-, 10- and 100-year recurrence interval events.



TETRA TECH
www.tetratech.com
303 Irene Street
Helena, Montana 59601
PHONE: 406-443-5210 FAX: 406-443-3729

Montana Department of Environmental Quality

MARK	DATE	DESCRIPTION	BY

Client: DEPARTMENT OF ENVIRONMENTAL QUALITY
Proj. Loc.: DEER LODGE, MONTANA

REACH A, PHASE 15 AND 16
CLARK FORK RIVER OPERABLE UNIT

2 & 10 YEAR INUNDATION

Project No.:	114-560356
Designed By:	MEH
Drawn By:	RED
Checked By:	MEH

2-24

1/9/2013 2:18:26 PM - N:\PROJECTS\MONTANA DEPT OF ENV. QUALITY\CFR REACH A\114-560356 - GKR PRELIMINARY DESIGN REPORT\CAD\SHEETFILES\FIGURES\F-2-24-2YR-INNO.DWG - DAVENPORT, ROSS

2.6 FLOODPLAIN MATERIAL AND BORROW INVESTIGATION

Floodplain borrow material will be developed from a parcel of land owned by the State of Montana, referred to as the Beck Ranch. The property consists of 343 acres of primarily pivot-irrigated cropland that is located on the western foot slopes of the Flint Creek Range, approximately 3 miles south-southwest of Deer Lodge, Montana, in Sections 18 and 19 of Township 7 North, Range 9 West. The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) has mapped the area as predominantly loams (Con loam and Varney-Con loams). Sheet C20 Borrow Area Plan and Cross Sections displays the Beck Ranch borrow area.

In 2002, Pioneer Technical Services (PTS) performed an initial soil borrow investigation on the property for Atlantic Richfield Company. The results were summarized in a technical memorandum (PTS, 2003). The 2003 investigation included soil pedon descriptions, laboratory analyses of soil physical and chemical characteristics, and an estimate of the volume of suitable cover soil (growth media) and general fill. The investigation concluded that the majority of material was comprised of sandy loam with suitable chemical characteristics for use as coversoil and general fill. However, total arsenic concentrations in soil samples collected from the upper 18 inches of the test pits exceeded the current CFROU regulatory criteria (<30 mg/kg arsenic).

In 2008, PBS&J performed a field investigation for DEQ of the same Beck Ranch soil borrow area (PBS&J, 2008). The objectives of the investigation were to determine the physical and chemical characteristics of the soil material relative to the cover soil criteria for the CFROU and to develop volume estimates based on these criteria. PBS&J excavated 25 soil test pits in Section 18 of the property and four soil test pits in Section 19 of the property. Based on the borrow investigation conducted by PBS&J, an estimated 198,576 cubic yards (cy) of suitable A Horizon soil material is available at the Beck Ranch Borrow Area.

The Beck Ranch borrow source has been utilized for other remedial actions in CFROU Reach A and has a small open pit in which the top 12 inches of topsoil was stripped and stockpiled; primarily due to arsenic concentrations and reclamation requirements. Samples collected and analyzed from materials excavated at the Beck Ranch Borrow source for other CFR projects (Deer Lodge Trestle Area Cleanup and the Deer Lodge Yard Replacement) have demonstrated compliance with project requirements. In 2011, a new access road was completed into the borrow area which will accommodate the haul traffic required for CFR Reach A projects.

2.7 GROUNDWATER INVESTIGATION

Tetra Tech performed a site characterization in 2011 in which groundwater occurrences were noted during test pit excavations (Tetra Tech 2012b) The investigation was conducted during July, August, and September of an extremely high runoff year with high water contributions from surrounding benches, mountain slopes, and drainages leading to elevated river and floodplain water levels.

Test pits were excavated using a track-mounted excavator (trackhoe) and field observations of groundwater levels were noted as either standing water in the bottom of the excavated test pit or the occurrence of groundwater entering the test pit from seeps in the sidewalls. Soil moisture content visual estimates were also utilized as an indication of static groundwater levels. Depth to groundwater was recorded based on measurements from ground surface to the top of groundwater encountered in the test pit or side wall seeps.

Of the 334 test pits excavated during the Phases 15 and 16 site characterization, 238 test pits encountered groundwater. Depth to water observations in test pits ranged from zero (water at ground surface) to not encountered within the test pit.

In 2002, a series of studies were conducted on the GKR in association with the NPS to identify the effects of contamination to plants and groundwater on site. Woessner and Johnson (2002) determined the type and extent of contamination in soil water and groundwater by sampling wells throughout the GKR. Groundwater was determined to occur near the ground surface with a water table approximately 5 feet below land surface in the floodplain, 10 to 20 feet below land surface under gravel terraces in the eastern portion of GKR, and 30 feet below land surface in portions of the west side fields. Contours of the water table from 2000 and 2001 indicate that the groundwater slopes towards the CFR, from uplands to the floodplain area. The water table within the floodplain was found to be higher than stream stage indicating groundwater discharge to the river.

2.8 VEGETATION ASSESMENT

Vegetation assessments for portions of the CFROU, including Phases 15 and 16, have been completed by various agencies and researchers to assist with remediation and restoration efforts.

2.8.1 Previous Assessments

Previous studies have shown that vegetation along the CFR is variable. Smith et al. (1998) stated that, while some streambanks and floodplain areas are covered by phytotoxic slickens, willows (*Salix* spp.) re-grew after the 1908 flood of record in areas where tailings have been covered by levy sands. Griffin and Smith (2002) examined the density and distribution of floodplain vegetation to assess the vulnerability of floodplain surfaces to erosion during overbank flow events. The results of their analysis showed that 74 percent of the floodplain tabs (floodplain areas between meander bends) have less than 40 percent of their surface covered by shrub canopy, and an average of 29 percent of the tab surface areas are covered by shrub canopy. Tailings and historical grazing practices have suppressed vegetation development, and few younger age classes of shrubs are present (Griffin and Smith, 2002).

Wetland and riparian areas were mapped in the upper CFR watershed as part of the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI; USFWS, 2005). Following the NWI methodology, wetlands are classified using the Cowardin classification system (Cowardin et al., 1979) and riparian areas are classified using the USFWS riparian classification system (USFWS, 2005). To support this preliminary design, the NWI data set was used to identify the location and extent of wetland and riparian areas in Phases 15 and 16 to help guide vegetation community mapping.

To support development of the ROD, the EPA assessed vegetation and wetlands. This included: 1) distinguishing tree- and shrub-dominated areas as polygons; 2) mapping jurisdictional wetlands to be used as a baseline for evaluating wetland credits that develop as part of remedial activities; and 3) distinguishing and mapping three broad categories of vegetation condition (RipES) based on the assumption that plant community composition and structure correlates with the degree of contamination (Bitterroot Restoration, Inc. and Reclamation Research Unit, 2004). This latter mapping effort provided a basis for CFROU remedial actions anticipated by the ROD. Results from these assessments are in the form of Graphic Information Systems (GIS) data layers developed by the EPA and their contractors as part of developing the ROD. Although RipES applies throughout the Upper Clark Fork drainage, a more specific landowner document was developed for the GKR that includes figures of these spatial data layers as well as wetland and weed maps (CH2MHill, 2008).

Thompson et al. (1995) mapped and analyzed vegetation on the GKR and determined that there were 390 acres of wetlands and riparian areas. Dominant wetland/riparian communities include 101 acres of Geyer willow (*Salix geyeriana*) and 78 acres of arctic rush (*Juncus arcticus*) vegetation communities. Dominant upland communities included 172 acres of needle and thread (*Hesperostipa comata*)/blue grama (*Bouteloua gracilis*) and 102 acres of crested wheatgrass (*Agropyron cristatum*). A comprehensive vascular plant survey conducted in 2002 (Rice and Hardin) found 341 taxa on the GKR, with 81 of these species considered non-native. Of these non-native species, 11 are considered noxious weeds in the state of Montana.

Bedunah and Jones (2001) released a report comparing the vegetation mapping documented by Thompson et al. (1995) to the 2000 vegetative conditions. In the 7 year interim period, livestock was excluded from the riparian zone. Results showed an improvement in shrub regeneration, decreased shrub utilization, decreased decadent and down woody material, improved deep binding rootmass and decreased lateral cutting. However, these improvements were not quantified, only recognized by the authors as “small”. They were unable to determine if improvements may have been hindered by contaminated soils. Additionally, the 2000 season was much drier than the 1993 season when vegetation was mapped. Thus climatic conditions provide an additional variable to the results.

The Natural Resource Injury Report (Kapustka, 2002a) on the GKR examined soil respiration in relation to levels of contamination. Soil respiration is the decomposition of organic carbon by microbes and organic material such as roots within the soil medium (Gannon and Rillig, 2002). This process is part of the nutrient cycling process and supports plant growth and production (Gannon and Rillig 2002). Kaputska’s studies at the GKR demonstrate that higher levels of metal contamination reduce soil respiration and that 75 percent of riparian soils in the uppermost layers are impaired at biologically meaningful levels. They concluded that inhibition of soil respiration will not cease unless metal concentrations are returned to a baseline condition and a lack of these processes may decrease vegetation productivity, reduce root growth, decrease survival and alter community composition (Kaputska, 2002a). Kaputska stresses that the repercussions of elevated metal levels may not be currently evident in many areas of the floodplain, but due to climatic changes and hydrological regimes, metals in buried tailings may migrate to the surface during dry periods and cause injury to existing vegetation and inhibit vegetation regrowth in the future.

In 2002, a study was conducted to determine the impacts of pH-adjusted metal contamination concentrations on riparian plant community structure (Rice, 2002). Results of this study showed that pH-adjusted metal concentrations are strongly related to plant community composition in the riparian zone at the GKR. The Kapustka (Kapustka et al., 1995) pH-adjusted metal loading is a summation of arsenic, copper, and zinc concentrations. This adjusted metal concentration was determined to be the most useful measurement for relating metal availability to plant community structure. The abundance of three plant species was positively correlated with increasing pH-adjusted metal concentrations of the soil including tufted hairgrass (*Deschampsia cespitosa*), redtop (*Agrostis gigantea*), and Booth’s willow (*Salix boothii*). Several species had significant negative correlation with increasing pH-adjusted metal concentrations including marsh hedgenettle (*Stachys palustris*), whitetop (*Cardaria draba*), Kentucky bluegrass (*Poa pratensis*), crested wheatgrass, and smooth brome (*Bromus inermis*).

The authors attributed these vegetation patterns to metals that have altered the plant communities of the riparian zone by favoring certain species at the expense of others. As noted below in Section 2.8.3, most of these species are common and widespread on the GKR, so this information supports the idea that contaminated sediments have degraded floodplain function by reducing plant species diversity. However, this information likely does not provide a tool to refine contamination mapping more than can be done by direct soil sampling in test pits.

In 2011, a *Northern Rocky Mountains Invasive Plant Management Plan* (NPS, 2011) prepared for the NPS identified high priority plant species that need focused attention on the GKR. Fifteen species were identified and are listed in Table 2-10, ranked by difficulty of treatment (most difficult to least difficult).

Table 2-10. Priority Plant Species to be Managed on the Grant-Kohrs Ranch

Common Name	Scientific Name
field bindweed	*Convolvulus arvensis*
yellow toadflax	*Linaria vulgaris*
leafy spurge	*Euphorbia esula*
perennial pepperweed	*Lepidium latifolium*
common tansy	*Tanacetum vulgare*
Canada thistle	*Cirsium arvense*
whitetop	*Cardaria draba*
cheatgrass	*Bromus tectorum*
tall buttercup	*Ranunculus acris*
Russian knapweed	*Acroptilon repens*
houndstongue	*Cynoglossum officinale*
spotted knapweed	*Centaurea stoebe*
kochia	*Kochia scoparia*
baby's breath	*Gypsophila paniculata*
sulphur cinquefoil	*Potentilla recta*

In 2012, a draft vegetation classification and mapping effort (Rice et al., 2012) was completed for the GKR as part of the NPS Inventory and Monitoring Program. The U.S. National Vegetation Classification (FGDC, 2008) was used to categorize plant communities on site. Three major vegetation types were found on the GKR including native bunchgrasses on upland benches, pasture grasses in irrigated and sub-irrigated hay fields, and tall riparian shrubs and wetland communities within the floodplain. Approximately 60 percent of the mapped acreage consists of introduced pasture grasses including smooth brome, timothy (*Phleum pratense*), quackgrass (*Elymus repens*), Kentucky bluegrass, meadow fescue (*Festuca pratensis*), and redtop. Twelve vegetation types were identified using NVC. Dominant riparian vegetation communities include water birch (*Betula occidentalis*) and seven willow species of which Geyer willow and Booth's willow are most common. Approximately 346 acres are comprised of smooth brome/timothy, 22.8 acres of water birch, 53.8 acres of Geyer willow, 13.64 acres of sandbar willow (*Salix exigua*), and 19.8 acres of Geyer willow/Northwest Territory sedge (*Carex utriculata*). A complete summary of the extent of mapped vegetation types can be found in Rice et al. (2012). Table 2-11 lists the vegetation classifications and their associated map code exported from the GIS spatial file. Figure 2-25 shows a small sample of mapping from this study. Polygons are labeled using this vegetation map code.

Table 2-11. Vegetation Classification.

Map Code	Description
AGCR	Agropyron cristatum - (Pascopyrum smithii, Hesperostipa comata) Semi-natural Herbaceous
AGIN	Thinopyrum intermedium Semi-natural Herbaceous Vegetation
AGSP/AGSM	Pseudoroegneria spicata - Pascopyrum smithii Herbaceous Vegetation
AGSP/POSE	Pseudoroegneria spicata - Poa secunda Herbaceous Vegetation
AGST	Agrostis (gigantea, stolonifera) Seminatural Herbaceous Vegetation
BARE SOIL	Bare soil
BEOC	Betula occidentalis Shrubland
BRIN	Bromus inermis - (Pascopyrum smithii) Seminatural Herbaceous Vegetation
CAAQ	Carex aquatilis Herbaceous Vegetation
CAPE	Carex pellita Herbaceous Vegetation
CARO	Carex utriculata Herbaceous Vegetation
DEVELOP	Developed Area
ELPA	Eleocharis palustris Herbaceous Vegetation
EQFL	Equisetum fluviatile Herbaceous Vegetation
H2O	Water
JUBA	Juncus balticus Herbaceous Vegetation
PASTURE	(Bromus inermis - Elymus repens - Phleum pratense - Poa pratensis - Schedonorus pratensis) Irrigated Pasture Cultural Herbaceous Vegetation
POPR	Poa pratensis Semi-natural Seasonally Flooded Herbaceous Vegetation
POTR	Populus balsamifera ssp. trichocarpa / Mixed Herbs Forest
POTR/SYOC	Populus balsamifera (ssp. trichocarpa, ssp. balsamifera) / Symphoricarpos (albus, occidentalis, oreophilus) Forest
RIPARIAN	Rocky Mountain Riparian Bar Sparse Vegetation
ROAD	Road
SAEX	Salix exigua Temporarily Flooded Shrubland
SAGE	Salix geyeriana / Mesic Graminoids Shrubland
SAGE/CARO	Salix geyeriana / Carex utriculata Shrubland
SLICKEN	Deschampsia caespitosa Slickens Semi-natural Sparse Vegetation
STCO/BOGR	Hesperostipa comata - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation
SYOC	Symphoricarpos occidentalis Shrubland
TYLA	Typha (latifolia, angustifolia) Western Herbaceous Vegetation
UNSAMPLED	Unsampled

(Rice et al. 2012) Map Code and description from GIS spatial file.

Figure 2-25. Example of 2012 vegetation mapping (Rice et al., 2012).

Polygons are labeled by map code.

Aerial imagery and vegetation polygons may no longer accurately overlap as a result of updated aerial imagery and channel migration changes.

Approximately 60 percent of the mapped acreage consists of introduced pasture grasses including smooth brome, timothy (Phleum pratense), quackgrass (Elymus repens), Kentucky bluegrass, meadow fescue (Festuca pratensis), and redtop. Twelve vegetation types were identified using NVC. Dominant riparian vegetation communities include water birch (Betula occidentalis) and seven willow species of which Geyer willow and Booth's willow are most common. Approximately 346 acres are comprised of smooth brome/timothy, 22.8 acres of water birch, 53.8 acres of Geyer willow, 13.64 acres of sandbar willow (Salix exigua), and 19.8 acres of Geyer willow/Northwest Territory sedge (Carex utriculata). A complete summary of the extent of mapped vegetation types can be found in Rice et al. (2012).

2.8.2 Historical Vegetation

According to the Cultural Landscape Report (John Milner Associates, Inc., 2004) prepared for GKR, Johnny Grant over-wintered his cows in the Deer Lodge Valley in 1857 which marked the first event where non-native fauna grazed within the project area. Between 1859 and 1866, Johnny Grant settled on the GKR and began to cultivate crops including wheat, oats and other grains. He dug an informal irrigation ditch that drew water from the CFR which was extended by Conrad Kohrs and Judge Manning between 1866 and 1887. This ditch is now known as the Kohrs-Manning Ditch.

Con Warren took over the GKR and expanded acreage of irrigated land from 500 acres to 900 acres. In the 1930's, he graded the west-side fields and moved the existing ditch system. He cultivated additional crops including: barley, timothy, clover, native hay, intermediate wheatgrass, alfalfa, and mangels-wurzel. In the 1940's, Warren participated in the Agricultural Conservation Program where he reclaimed bottomland meadows adjacent to the CFR, which included plowing, fertilizing, and crop rotation. In 1985, the NPS planted willows along sections of the CFR in an attempt to stabilize banks and then in 1994, permanent riparian fencing was installed along the river.

GLO survey notes completed in 1868 (BLM, 2012) describe areas along the Deer Lodge River (historical name for CFR) in Phases 15 and 16 as having dense willow and alder thickets, as well as cottonwood stands present. Several sloughs and scattered cottonwoods were noted along the river. Cottonwoods may have been used for lumber or other industrial purposes, and consequently significantly thinned from the GKR landscape. The Cultural Landscape Report (John Milner Associates, Inc., 2004) indicated that Johnny Grant constructed a cabin of cottonwoods in 1859. Some of these may have been replaced between 1866 and 1877 when cottonwoods where planted in a grid like pattern east of the GKR. Historical vegetation communities and variable topography within the floodplain may have been influenced by beaver dams (Smith et al., 1998). Both springs and beaver impoundments would have supported a much wetter floodplain that included dense willow thickets, sloughs, marshes, and aspen swamps (BLM, 2012). Prolonged saturation from beaver dams may explain peat development in areas along the CFR.

Smith and Griffin (2002) suggest that the historical conditions, including variable topography and densely vegetated streambanks and floodplain, influenced the distribution of deposited tailings following large flood events in the early 1900s. Dense vegetation on the channel margin slowed overbank flows and promoted deposition on the channel edges, creating natural levees that slope away from the channel. Conveyance of flood flows over these natural levees into the adjacent floodplain drove deposition of suspended material as flow velocities slowed on the floodplain surface. Variations in tailings thickness reflect deposition on topographically irregular ground.

Within the project area, deposition of up to several feet of tailings on the CFR floodplain in the early 1900s resulted in the formation of elevated streambanks and reduced floodplain hydrologic connection with the river (Smith et al., 1998; Smith and Griffin, 2002). While stream channel entrenchment is commonly the result of channel incision, in this case entrenchment was caused by rapid floodplain aggradation resulting from tailing deposition prior to the activation of Warm Springs Ponds as a sediment trap. Within Phases 15 and 16, tailings are deepest on meander tab features where the Bare Ground and Tufted Hairgrass vegetation communities are located. Tailings have deposited more recently as bar features across from laterally eroding banks, and these features correspond with the Colonizing Willow, Depositional, and Vegetated Bar vegetation communities described below.

2.8.3 Existing Vegetation

To support preliminary design and refine remedial actions, DEQ completed site-specific vegetation assessments and compared these results with contamination data from soil pits (Tetra Tech, 2012b) and geomorphic features identifiable from detailed topography provided by LiDAR elevation data (Horizons, 2011). Based on results from these site-specific vegetation assessments, observed vegetation patterns do not correspond to contamination thickness and concentration (Table 2-12).

Rice (2002) noted correlations between pH-adjusted metals concentrations and some plant species as described above, these species are so widespread they do not serve as useful indicators for identifying spatial patterns of tailings distribution, particularly considering land use effects on vegetation composition. Rather, variations in plant community composition and structure appear to be driven more by geomorphic position, elevation relative to river-influenced hydrology, and land use.

2.8.3.1 Methods

Existing vegetation communities were evaluated using a stepwise approach. First, vegetation was mapped in the field according to species composition within Phases 15 and 16. Later, these mapped polygons were overlaid with other data such as elevation, geomorphic position, and depth of contamination to further characterize patterns of vegetation establishment.

Table 2-12. Existing Vegetation Community Descriptions

Community Type (Acres)	Community Type Description	Elevation (ft) Relative to 2-year WSE			Contamination Depth (ft)			Hydro-logically Connect. Areas[1] (acres)	Geomorph. Feature	Land Managment Effects
		Min	Max	Ave	Min	Max	Ave			
Upland Herbaceous (46.6 acres)	Dominated by upland species such as wild rye, redtop, and wheat grasses. Lacks shrubs and trees. Dry weed species often present.	-3.8	9.0	1.8	0.0	4.5	1.3	2.8	Outer meanders and high terraces, occasionally elevated areas on meander tabs.	Often hayed or grazed
Agriculture (45 acres)	Cultivated land including pasture grasses and alfalfa.	-2.0	12.5	2.4	0.0	3.6	0.5	1.0	Floodplain	Often irrigated, hayed or grazed
Willow/Birch (42.5 acres)	Willow and/or birch dominated canopy. Understory can include upland vegetation such as currant and rose, or wetland herbaceous vegetation such as sedges.	-3.2	9.1	1.7	0.0	4.5	1.6	2.6	Generally within the belt width; meander tabs, tributaries or ditches; occasionally small patches further from the channel.	Impacted by cattle, many higher elevation shrubs heavily browsed; shrubs at lower, wetter elevations have significant soil pugging from cattle use
Wet Meadow (24.4 acres)	Dominated by wetland species primarily in temporarily or seasonally flooded wetlands.	-3.0	7.2	1.9	0.0	4.5	0.7	2.4	Abandoned meander channels and low elevation areas in floodplain, irrigated hay fields	Often irrigated, hayed or grazed
Emergent Marsh (17 acres)	Dominated by wetland species found in semi-permanently to permanently flooded wetlands.	-3.8	6.6	1.5	0.0	4.3	1.0	3.5	Abandoned meander channels and oxbows in floodplain and meander tabs	None observed
Willow/Birch – Depression (7.4 acres)	Willow and/or birch dominated canopy. Understory dominated by wetland species such as sedges.	-3.0	3.3	0.7	0.0	4.0	1.0	2.5	Depressions, often old meander tabs or oxbows, occasionally low swales	Areas outside of riparian fencing are used for agriculture, including livestock grazing and hay production

Community Type (Acres)	Community Type Description	Elevation (ft) Relative to 2-year WSE			Contamination Depth (ft)			Hydro-logically Connect. Areas[1] (acres)	Geomorph. Feature	Land Managment Effects
		Min	Max	Ave	Min	Max	Ave			
Vegetated Bar (3.8 acres)	Recently deposited sediment, now vegetated with wetland plants and often colonizing willows.	-3.3	2.8	0.3	0.0	4.4	1.7	2.0	Point bar	None observed
Open Water (1.8 acres)	Open water areas with no emergent vegetation.	-2.8	3.9	0.3	0.0	3.9	1.4	1.1	Depressions and oxbow features in the floodplain	None observed
Bare Ground (1.6 acres)	Areas of exposed substrate with minimal vegetative cover. When present, species include salt grass.	-2.5	3.6	1.6	1.1	4.0	2.4	0.1	Generally on low meander tabs.	None observed
Willow/Birch-Cottonwood Overstory (0.7 acres)	Willow and/or birch dominated canopy with black cottonwood in the overstory.	-0.6	2.2	0.9	0.0	3.0	1.3	0.1	Meander tabs	Impacted by cattle
Cottonwood Stand (0.5 acres)	Black cottonwood stand with an understory dominated by upland herbaceous vegetation.	-0.8	3.0	1.7	0.1	2.0	1.3	0.0	Meander tabs	Some areas are grazed while others have recently been excluded from grazing
Depositional (0.5 acres)	Recently deposited sediment that lacks colonizing vegetation.	-2.5	1.0	-0.8	0.6	3.0	1.9	0.4	Point bar	None observed
Low Shrub (0.2 acres)	Dense low growing shrubs including snowberry, Wood's rose, and gooseberry. No herbaceous understory. Lacks willow/birch overstory.	0.3	2.4	1.6	0.5	2.2	1.2	0.0	Variable	Recently excluded from grazing

Community Type (Acres)	Community Type Description	Elevation (ft) Relative to 2-year WSE			Contamination Depth (ft)			Hydro-logically Connect. Areas[1] (acres)	Geomorph. Feature	Land Managment Effects
		Min	Max	Ave	Min	Max	Ave			
Tufted Hairgrass (0.2 acres)	Tufted hairgrass is dominant vegetative cover.	-0.4	3.3	1.8	2.3	3.0	2.8	0.0	Meander tabs; adjacent to bare ground	None observed
Colonizing Willows (0.2 acres)	Depositional areas that are dominated by colonizing sandbar willow.	-2.0	0.9	-0.04	1.6	2.5	2.0	0.1	Point bars	None observed
Island (0.02 acres)	Vegetated island in active river channel.	-0.8	0.7	-0.2	1.2	3.5	1.6	0.0	Vegetated islands in channel	None observed
Willow-Aspen Overstory (0.3 acres)	Willow dominated canopy intermixed with aspens. Understory is often dominated by wetland herbaceous vegetation such as sedges.	NA	NA	NA	NA	NA	NA	0.0	Along abandoned channel; low areas	Some areas are grazed while others have recently been excluded from grazing
Aspen Stand (0.08 acres)	Aspen stand.	NA	NA	NA	NA	NA	NA	0.0	Floodplain	None observed

Comm. – Community Descr. – Description Connect. – Connected Contam. – Contaminated Geomorph. – Geomorphic Mgmt. – Management WSE – Water Surface Elevation

[1] Areas located at or below half a foot above the 2-year WSE are considered hydrologically connected to the river because it is estimated to be a reasonable maximum elevation that relates to sufficient hydrologic connectivity to sustain native riparian plant communities.

Table presents existing communities, elevations relative to 2-year WSE, depth of contamination, percent of surfaces hydrologically connected to the river, associated geomorphic features, and observed effects of land management within the project boundary of Phases 15 and 16. Vegetation communities are in order from greatest acreage to least. Additional vegetation communities observed outside of the limits of soils sampling are also included at end of table.

Existing vegetation communities were mapped and verified by Geum during the 2012 growing season. Vegetation communities were mapped in the field using the following spatial data for reference:

- 2009 National Agriculture Imagery Program (NAIP) imagery (USDA FSA, 2009),
- 2011 aerial photography (Microsoft, 2012),
- Updated National Wetlands Inventory mapping, including wetland and riparian areas (USFWS, 2005),
- Powell County Area Soil Survey (USDA NRCS, 2012) and
- Elevations relative to the 2-year water surface elevation using processed LiDAR elevation data (Horizons, 2011).

NWI and soil survey data for Phases 15 and 16 are shown in Appendix C. During field mapping, the extents of distinct vegetation communities were delineated over aerial photographs of the project areas. Within each vegetation community, species lists were generated and information on topography and hydrology were collected for examples of each vegetation community. A Global Positioning System (GPS) point was recorded and photographs were taken at each location where data were collected. Based on this information, descriptive vegetation community categories were developed according to dominant plant species composition and structure, geomorphic position, elevation relative to river hydrology, and land use (Table 2-12)

Field mapping of the vegetation communities was later used to digitize a spatial data layer using ArcMap 10 (ESRI, 2011) that could be combined with other spatial data for the project area for further analysis. Additional data layers included the 2-year water surface elevation (WSE) derived from LiDAR elevation data and flow models, and depth of soil contamination derived from soil pit data collected by Tetra Tech (Tetra Tech, 2012b).

Half a foot above the 2-year WSE was used to determine areas that are currently connected to river hydrology because this elevation corresponds with conditions and processes such as soil moisture, nutrient transport, scour and deposition, and seed availability required for riparian vegetation to establish and be sustained. Based on previous floodplain restoration projects, half a foot above the 2-year WSE is estimated to be a reasonable maximum elevation that relates to sufficient hydrologic connectivity to sustain native riparian plant communities. These areas are considered hydrologically connected to the channel for purposes of vegetation because they receive either frequent overland flow from the channel, or groundwater is present in the rooting zone during significant portions of the growing season. To quantify existing floodplain hydrologic connection, the area of surfaces at or below half a foot above the 2-year WSE was calculated for each mapped vegetation community (Table 2-12).Soil pit data were interpolated using an inverse distance weighted (IDW) method in ArcMap 10 (ESRI, 2011) to generate a raster representing the depth where COCs equal or exceed 800 milligrams per kilogram (mg/kg) [or parts per million (ppm)] throughout the project area.

The ArcMap tool “Zonal Statistics by Table” was used to determine the minimum, maximum, and average elevation of each plant community relative to the 2-year WSE and determine the depth of tailings contamination by vegetation community. This tool “…summarizes the values of a raster within the zones of another data set” (ESRI, 2011). In this case, the raster values were elevations relative to the 2-year WSE and the depth of contamination, and the zones used to summarize these data were vegetation communities. The findings of the vegetation community mapping and data analyses are described in the next section.

2.8.3.2 Results

Approximately 192 acres were mapped and 18 vegetation communities were characterized within the limits of soil sampling for Phases 15 and 16. These vegetation communities are summarized in Table 2-12 and described in detail in Appendix C, Vegetation Community Descriptions. Figure 2-26 and Figure 2-27 below show the results of the vegetation community mapping in Phases 15 and 16, respectively. Sixteen (16) of the communities are within the limits of soil sampling. Two vegetation communities, Aspen Stand and Willow – Aspen Overstory, are outside and adjacent to where soil sampling occurred but are included because they represent vegetative potential within the project area. The bulk of the floodplain within the project area boundary is Upland Herbaceous (46.6 acres), Agriculture (45 acres), Willow/Birch (42.5 acres), and Wet Meadow (24.4 acres) vegetation communities. Other vegetation communities comprise small areas within the project area and are often associated with dominant vegetation communities.

Analyses overlaying vegetation communities with soil contamination thickness (Table 2-12) found that the Tufted Hairgrass vegetation community had the greatest average depth of contamination (2.8 feet) followed by Bare Ground (2.4 feet), and Colonizing Willows (2.0 feet). These communities generally are present on meander tabs, point bars, and within the channel migration zone. The Depositional and Vegetated Bar vegetation communities had 1.9 and 1.7 feet of contamination, respectively, which may be attributed to their low topographic position. Figure 2-28 and Figure 2-29 show the depths of soil contamination overlaying elevations relative to the 2-year water surface elevation to the geomorphic patterns in the floodplain.

Results of the analyses overlaying vegetation communities with elevations relative to half a foot above 2-year WSE, (Figure 2-30 and Figure 2-31) found that only 18.7 of the 192 acres of mapped vegetation communities are hydrologically connected to the river. Vegetation communities that do not occupy large areas within the floodplain, but are located at lower geomorphic positions, including the Vegetated Bar, Depositional, and Colonizing Willow vegetation communities, have a higher proportion of their areas that are at or below half a foot above the 2-year WSE that corresponds with hydrologic connection.

2.8.3.3 Discussion

Existing vegetation communities were mapped and analyzed in order to describe vegetation on-site relative to contamination based on repeatable visual patterns. Few apparent patterns were observed that directly linked the composition and structure of vegetation communities to contamination. However, relationships were observed between vegetation structure and composition, geomorphic position, hydrology relative to the river channel, and land use.

Within the limits of soil sampling, the most common vegetation community is Upland Herbaceous (46.6 acres, 24 percent of mapped area). This community lacks tree and shrub species and is characterized by upland grasses such as smooth brome, timothy, redtop, and wheat grasses. The average elevation of these communities is 1.8 feet above the 2-year WSE with an average depth of contamination of 1.3 feet.

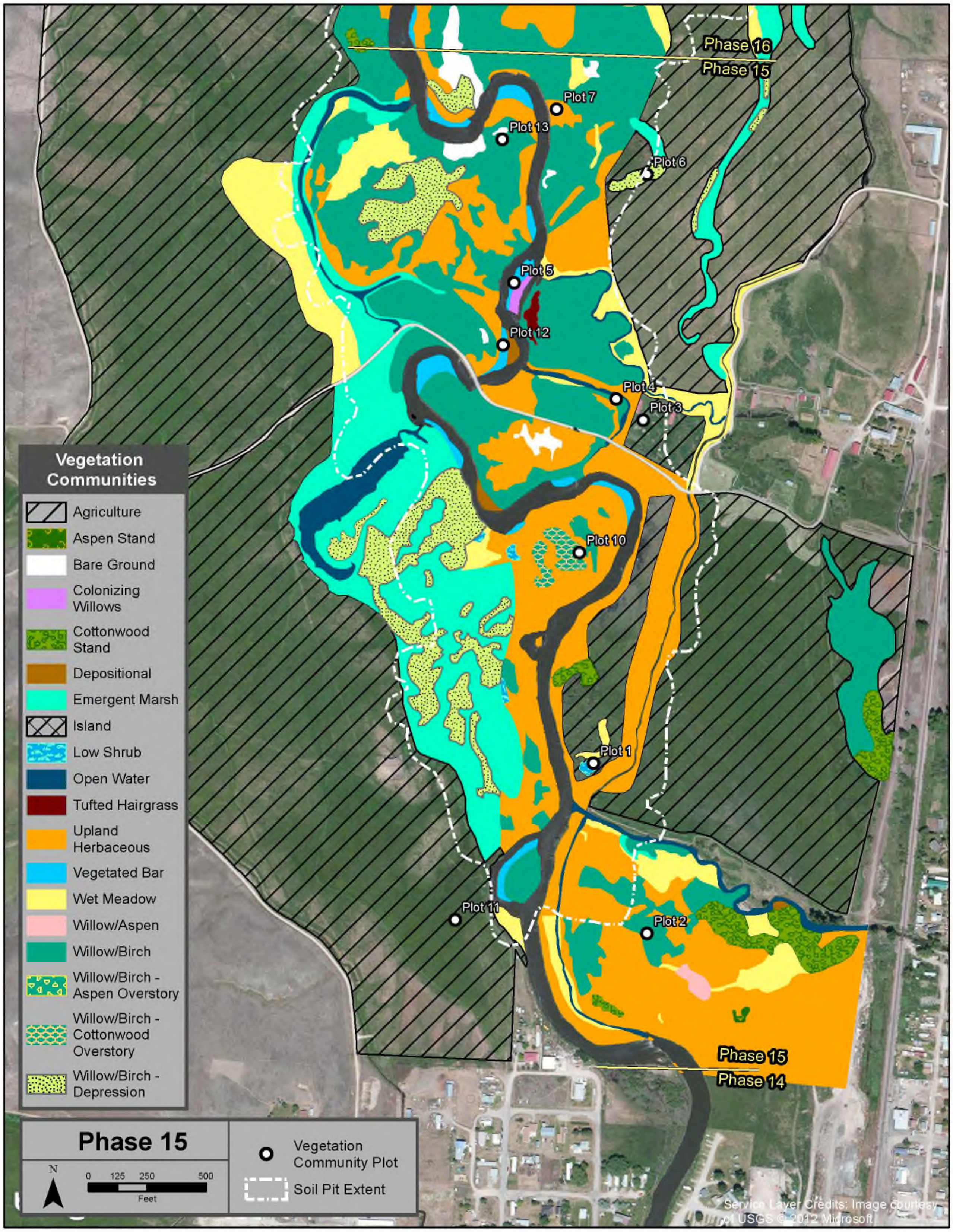


Figure 2-26. Results of Vegetation Community Mapping in the Phase 15 Project Area Showing Sample Plot Locations

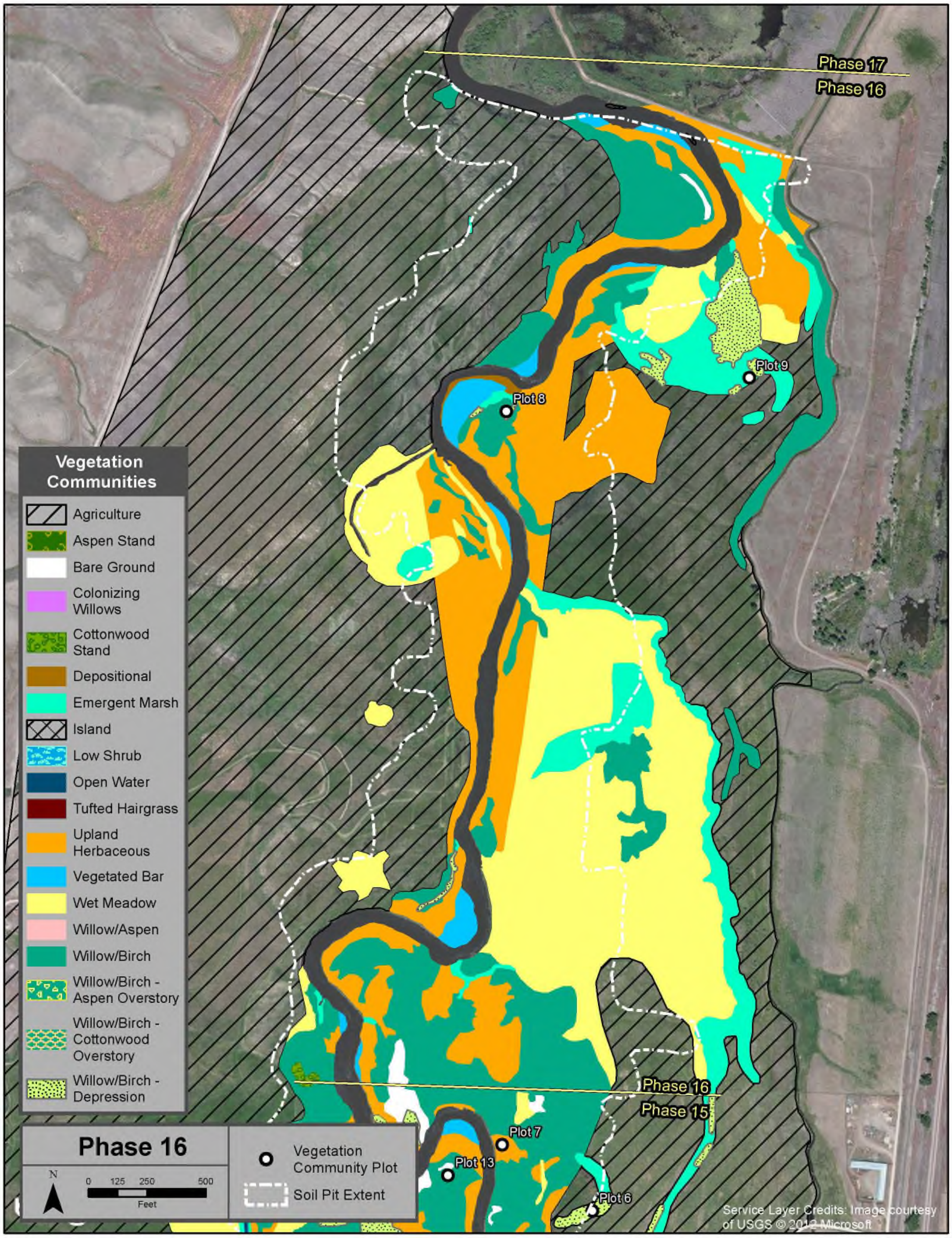


Figure 2-27. Results of Vegetation Community Mapping in the Phase 16 Project Area Showing Sample Plot Locations

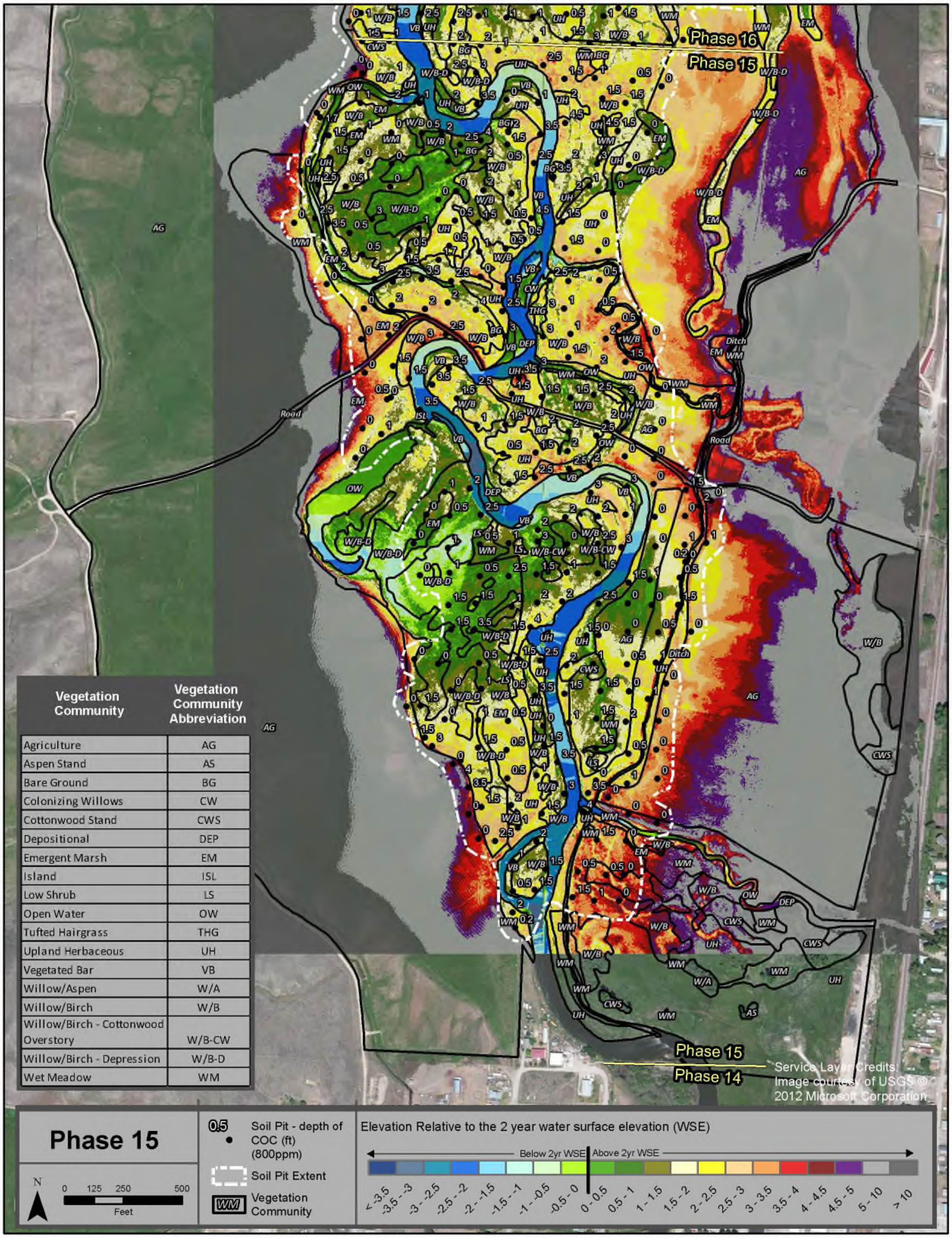


Figure 2-28. Mapped Vegetation Communities and Soils Pits Labeled with Depth of Contamination Overlaying Elevation Relative to the 2-year WSE for Phase 15

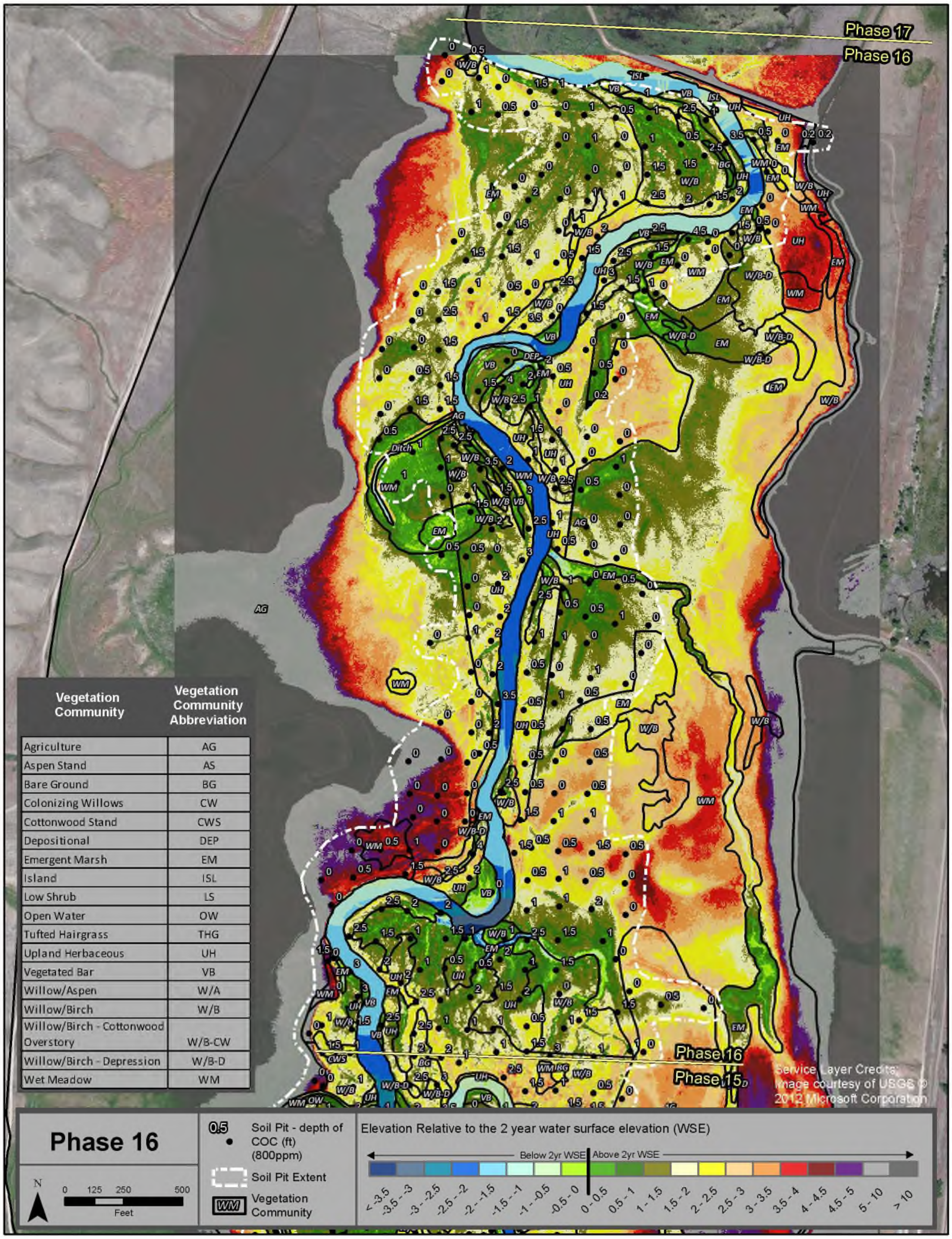


Figure 2-29. Mapped Vegetation Communities and Soils Pits Labeled with Depth of Contamination Overlaying Elevation Relative to the 2-year WSE for Phase 16.

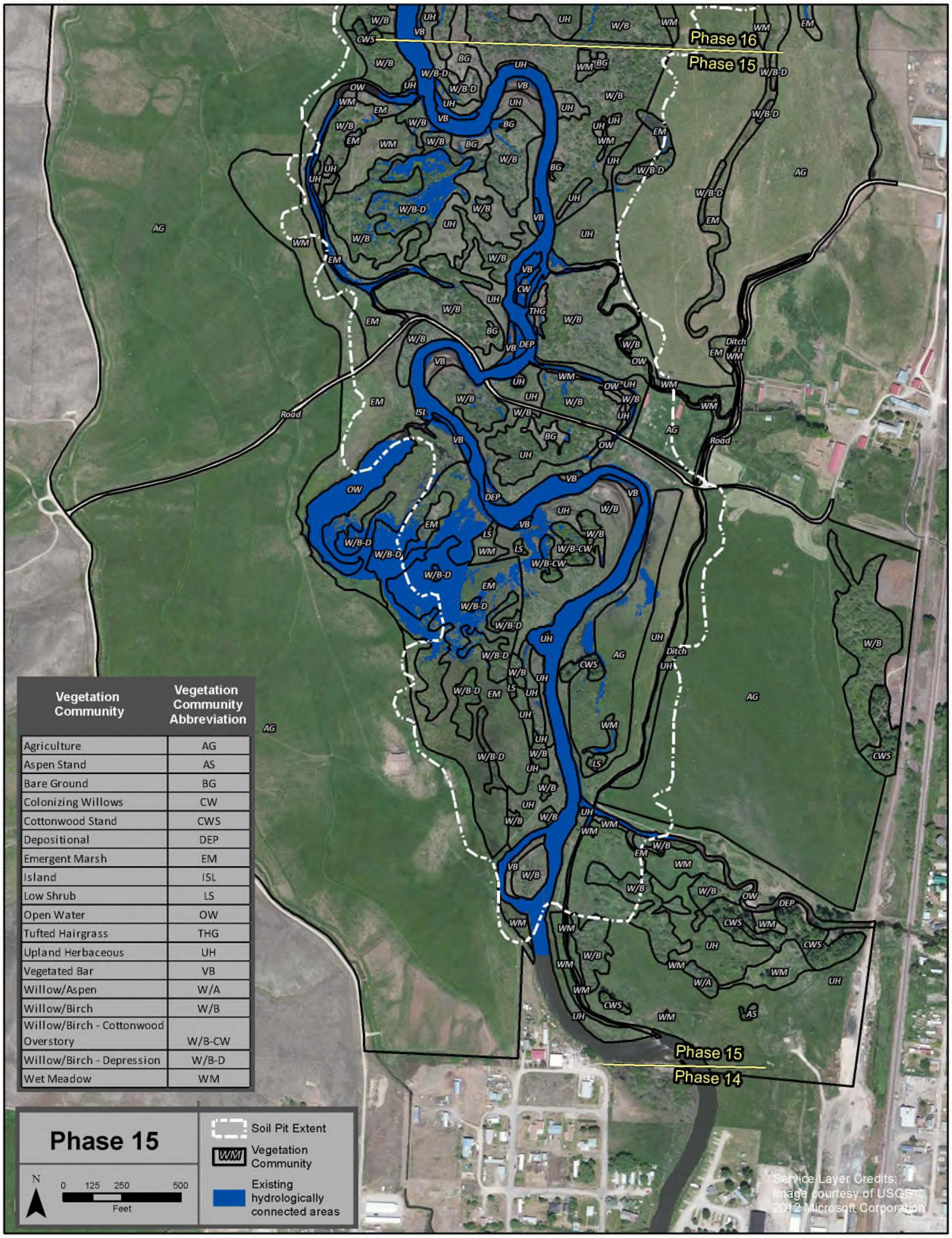


Figure 2-30. Existing Areas within Phase 15 Considered to be Hydrologically Connected to the River Based on Surface at or Below Half a Foot Above the 2-year WSE

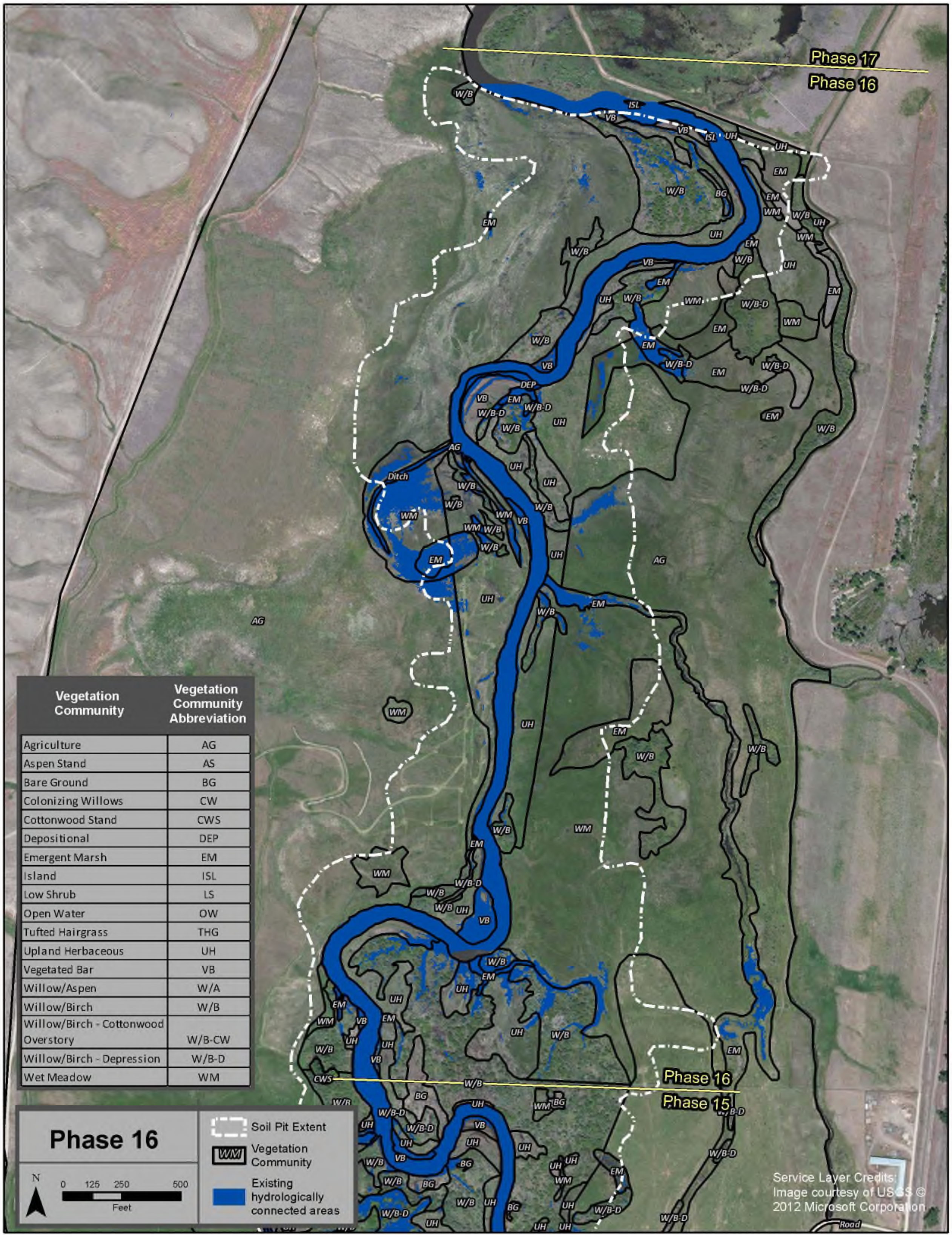


Figure 2-31. Existing Areas within Phase 16 Considered to be Hydrologically Connected to the River Based on Surface at or Below Half a Foot Above the 2-year WSE

The Agriculture vegetation community is a similar vegetation community occupying 45 acres (23 percent) and consists of irrigated, cultivated land that is dominated by pasture grasses. Vegetation composition in both communities is primarily driven by land use including grazing and hay production.

The Willow/Birch vegetation community occupies 42.5 acres (22 percent) and is characterized by a willow and/or birch dominated shrub canopy with an herbaceous understory that includes either upland or wetland herbaceous vegetation. The average elevation of the Willow/Birch vegetation community is 1.7 feet above the 2-year WSE with an average depth of contamination of 1.6 feet. Willow/Birch occupies a broad range of elevations with mature shrubs that range from vigorous to decadent. There is no apparent relationship between the degree of contamination and integrity of this community; however elevation relative to the 2-year WSE does appear to influence its condition because vegetation in wetter areas tends to be more vigorous while hydrologically disconnected areas are more decadent.

Historically, Willow/Birch areas were hydrologically connected to the river channel, but tailings deposition aggraded the floodplain, and currently only 2.6 acres (6 percent) of this community is connected to river hydrology. Current willow and birch shrubs are the product of vegetative regrowth from buried roots and branches through elevated surfaces where tailings were deposited. New individuals are unable to colonize these areas from seed or other propagules because of the elevated geomorphic position and lack of connection to river hydrology. This has resulted in a static shrub community that lacks young to middle age classes. Removing tailings from aggraded areas in the floodplain that were historically connected to the river channel prior to tailings deposition will help to establish willow and birch communities similar to historic conditions described in GLO notes (BLM, 2012) and similar studies. The Willow/Birch – Cottonwood Overstory community is another similar community that is a minor floodplain component (0.7 acres, 0.3 percent) characterized by a willow- and birch-dominated shrub canopy with black cottonwoods (Populus balsamifera) in the overstory. These areas will be preserved since cottonwoods are rare within the floodplain, provide important wildlife habitat and seed source, and would take a long time to re-establish.

The Wet Meadow vegetation community comprises 24.4 acres (13 percent) of the assessed area within the limits of soil sampling and is characterized by plant species found in temporarily or seasonally flooded wetlands. This community is found at elevations that average 1.9 feet above the 2-year WSE and have an average depth of 0.7 feet of contamination. This community occupies more area in Phases 15 and 16 compared to previous phases which may be attributed to irrigation practices and beaver activity being more common on the GKR. The Emergent Marsh vegetation community comprises 17 acres (8 percent) of the assessed area and is located within abandoned meander channels, depressions, oxbows, and a large wetland complex located in Phase 15 west of the river channel. This community is characterized by plant species primarily found in semi-permanently to permanently flooded wetlands. The Willow/Birch – Depression vegetation community occupies 7.4 acres (4 percent) of the assessed area within swales, oxbows, and depression features and is characterized by a willow and/or birch overstory and an understory dominated by emergent marsh species. Approximately 3.5 acres (21 percent) of Emergent Marsh and 2.5 acres (34 percent) of Willow/Birch - Depression are considered to be connected to river hydrology.

Several mapped vegetation communities are on recently formed depositional features that are found at lower elevations relative to the 2-year WSE but have greater tailing depths relative to other vegetation communities located at higher elevations. The Vegetated Bar vegetation community is a minor floodplain component that occurs on point bars and is dominated by wetland plants. The average elevation of this community is 0.3 feet above the 2-year WSE and it has an average contamination depth of 1.7 feet. The Depositional vegetation community is similar, except it lacks a major vegetation component. This community is located at 0.8 feet below the 2-year WSE and the average depth of contamination is 1.9 feet. Similarly, the Island vegetation community is located in the active river channel and is on average 0.2 feet below the 2-year WSE and has an average contamination depth of 1.6 feet. The Colonizing

Willow vegetation community is located at the same approximate elevation as the 2-year WSE and has an average depth of contamination of 2 feet. These high levels of contamination may be attributed to all four communities being recently formed depositional features that accumulate mobilized, contaminated sediment from eroding banks during flood events.

The Bare Ground vegetation community has sparse to no vegetation. These areas often have visibly contaminated soil as evidenced from accumulated metal salts on the soil surface that previous studies have identified as slickens. These areas comprise approximately 1.6 acres (1 percent) of the assessed area and typically are present on low meander tabs close to the channel. Vegetation is sparse, possibly because tailings are slightly thicker than in other vegetation communities (average depth of contamination of 2.4 feet) and elevations are relatively high; therefore, the effects of thick contamination are less likely to be buffered by anaerobic, saturated conditions. The Tufted Hairgrass vegetation community only occupies 0.2 acres (0.1 percent) of the assessed area and is found around the edges of the Bare Ground vegetation community.

The Cottonwood Stand vegetation community is a very minor component of the project area (0.5 acres, 0.2 percent). This community is characterized by an overstory dominated by black cottonwood and an understory dominated by upland herbaceous vegetation. Because these areas are considered rare and provide important habitat, they will be preserved despite an average contamination depth of 1.3 feet.

The Low Shrub vegetation community occupies 0.2 acres (0.1 percent) of the assessed area and consists of dense, low growing shrubs with an understory dominated by upland herbaceous vegetation. This community is located on average 1.6 feet above the 2-year WSE and has an average depth of contamination of 1.2 feet.

Within Phases 15 and 16, floodplain aggradation has resulted in a floodplain that is largely disconnected from the river channel, thereby affecting the composition and structure of vegetation communities compared to historical conditions. Currently, only 10 percent of the mapped floodplain and associated riparian vegetation within the project area are estimated to be hydrologically connected to the CFR. Areas that are presently connected to river hydrology are able to perform ecological functions including sediment and nutrient transport and storage, flood water storage, food web support, and supporting aquatic habitat. Areas not connected to the river channel are unable to provide similar ecological functions. Removing tailings to increase areas of hydrologically connected floodplain will make it possible to sustain a range of native riparian and wetland plant communities and related floodplain functions.

3.0 DESIGN CRITERIA

Section 3 outlines the scope of the Agencies' intended activities for performing Remedy and State or Federal Restoration at the GKR and identifies any specific design information likely to be necessary in evaluating and designing these activities.

The ROD provides for the removal or treatment of tailings contamination and stabilization of streambanks and the floodplain by the establishment of permanent vegetative cover to lessen the high rate of erosion and contaminant input into the CFR. The ROD defines areas of impacted soils and vegetation, and determined that slickens ("severely impacted areas") would be removed. However, the ROD assumed that in most instances, areas of impacted soils and vegetation would be treated in place, using careful lime addition and other amendment as appropriate, soil mixing, and re-vegetation. Removal would be required where the depth or saturation of the contamination prevents adequate and effective in-place treatment or where arsenic levels would not be reduced below the human health level for current or reasonably anticipated land use.

This PDP applies a number of design-level considerations to the conditions on the GKR. These considerations are necessary to meet ROD requirements, including ROD-specified Performance Standards and Remedial Goals, and include groundwater, riparian vegetation, geomorphic stability, contaminant sampling, ownership, infrastructure, land use, and certain other site-specific remedy requirements.

3.1 STRATEGIES AND OBJECTIVES

Strategies were developed to address the various impacts in Phase 15 and Phase 16 to maintain consistency with the selected remedy described in the ROD for the CFROU (EPA, 2004a). Those strategies include stabilizing eroding, contaminated streambanks and the adjacent floodplain; removal of tailings and contaminated soils to a central disposal area; replacement with clean soils; and revegetation of the riparian corridor and other removal areas.

Design objectives were developed to achieve these general goals. These design objective activities include the removal of tailings and contaminated soils within the 100-year floodplain that are greater than 24-inches thick and reconstruction of the floodplain to an elevation supportive of the desired land use. Other important objectives include the reconstruction of contaminated banks that are eroding or have inadequate native woody vegetation to maintain desired stability while maintaining the banks with healthy vegetation and deep, binding root mass. Establishing healthy native vegetation communities on the reconstructed banks and floodplain as land uses allow are equally important to achieve the desired design objectives. The design relies on a combination of the following remedial strategies to accomplish these objectives.

To offset and reduce the impacts from the tailings / impacted soils contamination:

- Remove the severely impacted areas from the CMZ in the floodplain.
- Dispose of contamination at the B2.12 Cell at Opportunity Ponds.

To provide system stability during reestablishment of the floodplain after removal:

- Topographically reconnect the floodplain and river, which will allow for increased groundwater access for riparian vegetation, and increased frequency and duration of floodplain inundation.

This reconnection is absolutely critical to meet remedial goals and performance standards in the ROD.

- Reconstruct the floodplain as a topographically diverse, hydrologically-connected surface that will support a permanent vegetative cover including robust woody riparian and wetland species.
- Revegetate the reconstructed floodplain with appropriate native riparian species.
- Reinforce floodplain areas that are at a higher risk of erosion using specific substrate gradations, bank treatments, and topographic grading strategies.
- Preserve those streambanks that are at a lower risk of accelerated erosion and in particular those banks exhibiting mature and stable vegetation stands.
- Stabilize actively eroding streambanks as necessary with bioengineered treatments designed to manage erosion and bankline migration during the period of floodplain vegetation establishment.

In the long term, these strategies are intended to collectively meet the following requirements:

- Prevent or reduce unacceptable risk to ecological (including agricultural, aquatic, and terrestrial) systems degraded by contaminated soil.
- Minimize direct contact with arsenic, thus reducing the potential risk of human exposure to acceptable risk-based levels.
- Prevent or inhibit ingestion of arsenic-contaminated soils/tailings where ingestion or contact would pose an unacceptable health risk.
- Remediate contaminated soils to be compatible with the existing and anticipated future land use with minimal future maintenance activities.
- Improve agricultural production by reducing or eliminating phytotoxic conditions, thus providing for multiple land uses.
- Minimize wind erosion and movement of contaminated soils onto adjacent lands, thus eliminating human, agricultural, and wildlife exposure.
- Provide geomorphic stability to streambanks, thus minimizing release of COCs to the river.
- Minimize surface water erosion and COC transport to surface water through methods described in the Selected Remedy.
- Comply with surface water standards.
- Reduce and minimize transport of COCs to groundwater.
- Return contaminated shallow groundwater to its beneficial use within a reasonable time frame.
- Comply with State groundwater standards, including non-degradation standards.
- Prevent groundwater discharge containing arsenic and metals that would degrade surface waters.

3.1.1 Desired Post-remediation Condition

The desired post-remediation condition to meet ROD requirements includes the following characteristics:

- Human health risks have been addressed. Streambanks are stabilized until floodplain vegetation is established, after which erosion occurs at rates typical of the geomorphic setting.
- Overall trends in channel planform reflect a dynamic equilibrium condition.
- The floodplain is largely uncontaminated by mine waste within the CMZ.
- The floodplain is reconnected to river hydrology, evidenced by overbank flows and frequencies and relatively shallow groundwater conditions.
- A mosaic of native riparian and wetland plant communities and age classes is present on the floodplain and in the riparian zone.

3.1.2 Performance Targets

Performance targets will be used to evaluate whether the Remedy is moving to accomplish and objectives. Performance targets are presented in terms of monitoring metrics that have target ranges or values. Two guiding monitoring plans have been developed for the CFROU. These plans are as follows:

- Interim Comprehensive Long-Term Monitoring Plan for the Clark Fork River Operable Unit—2011 (Atkins, 2011). This plan addresses surface water, groundwater, in-stream sediments, and aquatic biota, including macroinvertebrates and fish. This plan provides a framework for monitoring the CFROU as remedial activities are implemented, to evaluate the environmental effectiveness of these remedial actions. Specific performance targets have been developed for surface water and groundwater, but not for sediments and aquatic biota. Performance targets are described in detail in Atkins (2011).
- CFR Reach A, Phase 1 Geomorphology and Vegetation Monitoring Plan (Monitoring Plan) (DEQ, 2012): This plan provides a framework to evaluate physical- and vegetation-related components of the CFR and its floodplain that will be influenced directly by remedial and restoration actions. Effectiveness monitoring described in this plan will evaluate progress toward achieving project goals and objectives related to geomorphology and vegetation. The focus will be on collecting data that can be used to calculate metrics to measure performance targets for remedial and restoration activities.

Monitoring locations, schedule, and methods will be established in a site-specific monitoring plan that will be developed for CFR Reach A, Phase 15 and Phase 16 and will be similar to those in the CFR Reach A, Phase I Geomorphology and Vegetation Monitoring Plan (DEQ, 2012).

3.2 APPLYING DESIGN CONSIDERATIONS

Although tailings/impacted soils tend to have a distinct boundary with native materials, there are areas where contaminants may be mixed with soil and therefore are not readily identified. Accordingly, the design criteria for determining if mixed tailings/impacted soils are contaminated require a chemical component. The ROD provides for the removal or treatment of tailings contamination and stabilization of streambanks and the floodplain by the establishment of permanent vegetative cover to lessen the high rate of erosion and contaminant input into the CFR.

A remedial assumption is applied to remedial design considerations to assist with identifying the presence of tailings / impacted soils contaminated by mining activities and, when combined with other remedial design considerations, determining the severity of such impacts (e.g., severely impacted, impacted or slightly impacted). This numeric threshold will be used on a site-specific basis to judge the adequacy and appropriateness of removal when applying the other design criteria. This Remedial Design Assumption is based on phytotoxicity, a key to meeting remedial action objectives and performance standards.

<u>Design Assumption:</u> Tailings / impacted soils are contaminated when the sum of the COCs (As, Cd, Cu, Pb, Zn) exceeds 800 mg/kg (or parts per million). The 800 mg/kg value is not used as a risk-based screening level or cleanup level. Instead, the sum of the COC's greater than 800 mg/kg is used as a Remedial Design Assumption in the design process to help identify areas of contamination in site-specific locations. Levels of contamination will be used alongside additional contamination criteria, such as the severity of contamination; thickness of contamination; likelihood of contamination to be re-entrained via bank erosion or avulsion; and the capability of the vegetation to hold the contamination in place. The use of 800 mg/kg as a Remedial Design Assumption indicating contamination will not be viewed in isolation, but in conjunction with other design criteria.

Criteria for removing contaminated soils are based on a combination of several factors, including: the presence and depth of contaminated tailings, the CMZ, patches of vegetation that could be preserved, and opportunities to reconnect the floodplain by removing tailings. Tailings or contaminated soil will be removed under the following conditions:

4. Arsenic levels exceed the human health standard in the surface interval as discussed below.
5. The sum of COCs (As, Cd, Cu, Pb, Zn) exceeds 800 mg/kg and any of the following:
   - The lowest contaminated interval of metals is deeper than 24 inches, or
   - The contamination lies within the CMZ.
6. Limited areas where contaminated material is shallower than 24 inches but are contiguous to removal areas will be removed to promote floodplain connectivity or construction efficiency.
7. In areas where removal occurs, 6 inches of material below the base of tailings (as defined by the removal criteria) will be excavated to ensure sufficient removal of contaminants.

In applying these design considerations to the design of the Remedy on the GKR, the design team will:

1. Identify areas within the floodplain where contaminated soils are present. Contaminated soils are denoted as soils where the sum of COCs (arsenic, cadmium, copper, lead, and zinc) is greater than or equal to 800 mg/kg.

2. Identify the CMZ, which is defined as the portion of the floodplain that demonstrates a high potential for contaminant recruitment over the next century, either through bank erosion or channel avulsion processes. All contaminated soils will be removed within the CMZ, except for areas where historic structures, cultural resources, locally rare vegetation communities, or stabilizing bank vegetation exists.

3. Identify areas outside the CMZ where the depth of contaminated soils is greater than or equal to 2 feet. Within these areas, all contaminated soils will be removed, except for areas where historic structures, cultural resources, or locally rare vegetation communities exist.

4. Identify remaining areas outside the CMZ where the arsenic concentration exceeds the cleanup level of 620 mg/kg (as determined by the land use). Within these areas, all contaminated soils will be removed, except for areas where historic structures, cultural resources, or locally rare vegetation communities exist.

All areas will be evaluated to determine if Institutional Controls (ICs) or BMPs are needed to address future potential contaminant pathways.

3.3 COMPONENTS OF THE DECISION

This section provides definitions and descriptions of the different components within the design.

3.3.1 Floodplain areas with contaminated soils

Contaminated soils are denoted as soils where the sum of the COCs (arsenic, cadmium, copper, lead and zinc) is greater than or equal to 800 mg/kg or where arsenic exceeds 620 mg/kg in surface soils.

3.3.2 Channel Migration Zone

In order to assess the risk of continued direct entrainment of contaminants by fluvial processes, an evaluation of historic rates of change was used to develop a modified CMZ for Phase 15 and Phase 16. The CMZ was developed by evaluating measured migration rates in geomorphic sub-phases and applying an erosion buffer to the 2011 digitized banklines. This zone was then reshaped to exclude higher elevation areas such as terraces and colluvial deposits that do not show contamination based on test pit data. The intent of the CMZ is to identify a contaminant removal corridor that empirically addresses direct tailings entrainment hazards.

3.3.3 Contamination Depth Greater Than or Equal to 2 Feet

Within the project area for Phase 15 and 16, test pits are excavated and soil contamination characterized according to methods described in the CFR Reach A, Phase 15 and Phase 16 DSR (Tetra Tech 2012a) completed for each phase. Depth of contaminated soils was identified in each test pit based on XRF sample results taken from 6-inch intervals along the profile of the test pit. All test pits with tailings/impacted soils present to depths of 2 feet or deeper outside the CMZ were identified for removal.

3.3.4 Local Rare Vegetation Communities

Locally rare vegetation communities include all mature cottonwood stands, and wetlands with high native diversity outside the CMZ. Areas with patches of mature cottonwoods (Populus balsamifera ssp. trichocarpa) will be preserved regardless of contamination depth and location relative to the CMZ.

Cottonwoods are rare in the CFR floodplain in Reach A upstream from Deer Lodge, so these mature stands provide habitat and seed sources that would take 25 to 50 years to replace with newly planted or naturally recruited trees. There are no local rare vegetation communities within the removal boundary in Phase 15 and Phase 16. During construction some areas outside of the removal boundary may be fenced off to preserve vegetation.

3.3.5 Floodplain Connectivity and Restoration Efforts

In some cases, the removal boundary is adjusted to increase floodplain connectivity. For purposes of identifying the tailings/impacted soils removal extents, a connected floodplain surface is defined as the area that is 0.5 feet above the 2-year WSE or lower. This elevation is used to determine those areas low enough to be regularly inundated by surface flows or saturated by groundwater within the rooting zone. This range of elevations typically supports native riparian and wetland vegetation. Removal occurs in some areas that are not currently connected, but would be connected if removing tailings/impacted soils plus 6 inches of over excavation would result in the surface being 0.5 feet above the 2-year WSE or lower. This would result in restoring areas of the floodplain to pre-sediment elevations that are adjacent to areas where sediment is being removed as part of remedial activities.

3.3.6 Arsenic Cleanup Level

The land use and corresponding maximum arsenic concentrations requiring remedial action are shown in Table 3-1 below as identified in the ROD (EPA, 2004a).

Table 3-1. Maximum Arsenic Concentrations by Land Use

Land Use	Concentrations
Residential	150 mg/kg
Recreational	680 mg/kg (children at Arrowstone Park and other recreational scenarios)
	1,600 mg/kg for fishermen, swimmers, and tubers along the river
Rancher/Farmer	620 mg/kg
mg/kg – milligrams per kilogram	

3.3.7 Waste Removal and Over-excavation

Areas with tailings/impacted soils identified for removal based on the criteria described above will also require an additional 6 inches of over-excavation. Over-excavation is a common construction practice. The 6-inch over-excavation is included to account for the inherent variability within the floodplain where tailings were deposited and practical limitations with regard to characterization. Tailings/impacted soils that are removed will be hauled for disposal to the B2.12 Cell at Opportunity Ponds.

3.3.8 Evaluation of Institutional Controls and Best Management Practices

Prior to completion of remedial action, all areas with remaining tailings/impacted soil will be evaluated to determine whether ICs or BMPs are needed to address potential future contaminant pathways. ICs include the following:

- Deed restrictions and/or county zoning regulations to prevent land use changes or future residential development where contamination is left in place;

- Groundwater use controls to prevent use or domestic consumption of contaminated groundwater until groundwater cleanup levels are obtained;
- Education Program;
- Best Agricultural Management Practices where contamination is left in place; and
- Maintenance and Monitoring.

3.3.9 Restoration in Lieu of Remedy

No State restoration in lieu of remedy is included in this remedial design.

3.4 APPLICATION OF THE DECISION PROCESS

3.4.1 Extents of Contamination

The extents of contamination were identified during the site characterization as those areas within the floodplain where soils were characterized as having a sum total of all COC concentrations greater than or equal to 800 mg/kg. The sum of COCs is the sum of total metals concentration for arsenic, cadmium, copper, lead, and zinc. Site characterization results are included in the Data Summary Report (DSR; Tetra Tech, 2012b). Soils characterized as having COC concentrations greater than 800 mg/kg are shown on the Depth of Contamination Maps, Sheet C1 through C3, Existing Conditions.

3.4.2 Channel Migration Zone Analysis

Swanson (2002) estimated the 1947 through 2001 metals recruitment via bank erosion through the GKR. Swanson estimated that an excess of approximately 12,440 kilograms (kg) excess arsenic, 183 kg excess cadmium, 98,480 kg excess copper, 12,630 excess lead, and 57,710 kg excess zinc eroded into the river during that time period. In order to assess the risk of continued direct entrainment of contaminants by fluvial processes, an evaluation of historic rates of change was used to develop a modified CMZ for Phases 15 and 16. The CMZ was developed by evaluating measured migration rates in geomorphic subreaches and applying an erosion buffer to the 2011 digitized banklines. This zone was then reshaped to exclude higher elevation areas such as terraces and colluvial deposits that do not show contamination based on test pit data. The intent of the CMZ is to identify a contaminant removal corridor that empirically addresses direct tailings entrainment hazards.

To develop the CMZ, migration was measured on all banklines that displayed in excess of 20 feet of movement since 1955. Vectors were collected at approximately 20 foot station frequencies on eroding banks to capture the range of migration distances expressed at a given site. The results are summarized in Table 3-2 and Figure 3-1. In two segments of the project reach, no significant migration has occurred since 1955. These segments are two very straight channel segments described as Subreach 15a and Subreach 16a (Figure 2-23). Because of the lack of movement, an erosion buffer width of 50 feet was added to the 2011 banklines to provide a nominal corridor of contaminant removal in the event that more active bank erosion occurs in this reach over the next century.

The two remaining channel segments (Subreach 15b and Subreach 16b) show substantial measureable channel movement. A total of 56 migration measurements were made in Subreach 15b, which is the highly sinuous channel segment in the vicinity of the Cattle Drive Road Bridge. In the lower portion of Phase 16, a total of 23 measurements were made. The mean measured migration rates in Subreach 15a and Subreach 16a are 1.1 ft/yr and 0.8 ft/yr respectively. In developing a buffer, a migration rate reflecting the 90th percentile measurement was selected and extrapolated to a 100-year erosion buffer.

This buffer was applied to the digitized 2011 banklines on both banks to allow for future channel movement including bendway migration, bendway compression, and stochastic processes such as woody debris lodging and associated channel movement. CMZ buffers applied in Subreach 15b and Subreach 16b are 174 feet and 148 feet, respectively. Based on the historic analysis, this buffer is anticipated to accommodate the vast majority of channel movement over the next century, thus addressing the risk of entrainment due to channel migration.

In addition to channel migration, tailings recruitment by the river can occur due to channel avulsion, or a rapid relocation of the channel into a new thread. Avulsions are most common across bendway cores where elevations are low and floodplain channels are present. Two contaminated areas were identified as potential avulsion risks and added to the CMZ. These areas include the bendway core at Station 16+00, and the existing slough that crosses the ranch road, re-entering the channel at Station 94+50.

Once the CMZ was developed, areas where test pits show no contamination were clipped from the boundary to develop an initial removal boundary based on the demonstrated risk of direct tailings entrainment over the next century.

Table 3-2. Results of Migration Rate Analysis

Station		Subreach 15a	Subreach 15b	Subreach 16a	Subreach 16b
		13600 - 12100	12100 - 5200	5200 - 4100	4100 - 0
Number of Measurements		0	56	0	23
1955-2011 Migration Distance (ft)	Mean	--	65.4	--	46.8
	90th Percentile	--	91.1	--	84.4
	Maximum	--	161.5	--	121.0
1955-2011 Migration Rate (ft/yr)	Mean	--	1.1	--	0.8
	90th Percentile	--	1.7	--	1.5
	Maximum	--	2.8	--	2.1
100-Yr Migration Distance (ft)	Mean	--	115	--	82
	90th Percentile	--	174	--	148
	Maximum	--	283	--	212
Basis of Buffer Selection		**Minimal Buffer Width (ft)**	**90th Percentile 100-Year Migration Distance (ft)**	**Minimal Buffer Width (ft)**	**90th Percentile 100-Year Migration Distance (ft)**
100-Year Migration Buffer		50	174	50	148

ft – feet
ft/yr – feet per year

3.4.3 Contamination Depth (Greater Than or Equal to Two Feet)

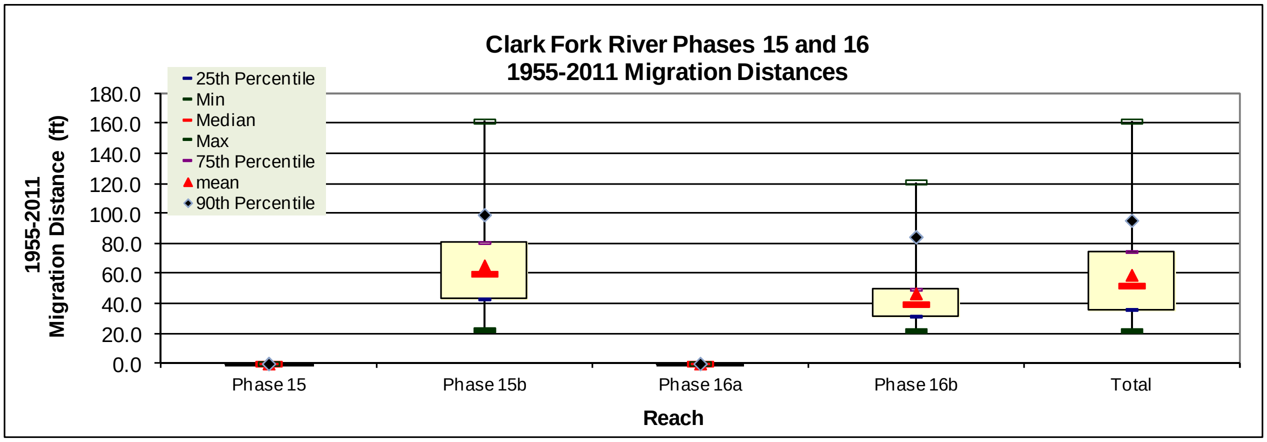


Figure 3-1. Measured Migration Distances by Geomorphic Reach

Contamination depth, which is defined here to include tailings mixed with soil, is determined based on laboratory data for arsenic and metals concentrations. After reviewing the CMZ, areas with sum COCs greater than 800 mg/kg and greater than 2 feet in depth were included in the removal boundary. The sum of COCs is the sum of total metals concentration for arsenic, cadmium, copper, lead, and zinc (Tetra Tech, 2012b).

If the sum of the COCs is greater than 800 mg/kg and greater than 2 feet in depth, the soil shall be removed. The concentrations used in the COC calculation are taken from test pit sample intervals of 6 inches thick, so accuracy of the depth of tailings is approximately 0.5 feet (Tetra Tech, 2012b). An additional 0.5-foot layer will be over-excavated from within the removal boundary to allow for uncertainty and variability in estimates of tailings/impacted soils depth. This over-excavation allowance has worked well to ensure removal of a high percentage of floodplain tailings on Streamside Tailings Operable Unit sites and has been recommended on other CFR phases.

3.4.4 Floodplain Connectivity

For purposes of identifying the contamination removal extents, a connected floodplain surface has been defined as an area that is 0.5 feet above the 2-year flow water surface elevation (WSE) or lower. This elevation was used to determine those areas low enough to be regularly inundated by surface flows or saturated by groundwater within the rooting zone. This range of elevations typically supports native riparian and wetland vegetation.

3.4.4.1 Removal

Removal may occur in areas that are not currently connected, but would be connected if removing tailings plus 0.5 feet of over excavation would result in the surface being 0.5 feet above the 2-year WSE or lower. This would result in restoring areas of the floodplain to pre-sediment elevations that are adjacent to areas where sediment is being removed as part of remedial activities described above.

3.4.4.2 Preservation

Some areas having patches of uncommon native vegetation, such as mature cottonwoods (Populus balsamifera ssp. trichocarpa), will be preserved regardless of contamination depth and location relative to the CMZ. Cottonwoods are rare in the CFR floodplain in Reach A, and provide habitat and seed sources where preserving these would be consistent with remedial and restoration objectives.

3.4.4.3 Total Excavation Volumes and Areas

Excavation volumes and areas were calculated utilizing AutoCAD Civil 3D computer software. The calculated volumes combine the CMZ buffers, contamination depth, and floodplain connectivity into three-dimensional (3D) surface modeling.

The total excavation volume for Phases 15 and 16 is estimated at 387,500 cy. Table 3-3 summarizes the total excavation calculations.

Table 3-3. Summary of Phases 15 and 16 Tailings Excavation

Excavation Area	Removal Area (acres)	Removal Area (square feet)	Average Removal Depth (feet)	Removal Volume (bcy)
Phase 15	55.11	2,400,591	2.29	220,300
Phase 16	49.72	2,165,803	2.29	167,200
Total	**104.83**	**4,566,394**	**2.29**	**387,500**
bcy – bank cubic yards				

3.5 STREAMBANK RECONSTRUCTION

As described in Section 2, a streambank inventory was completed in late July and early August of 2012 to assess overall streambank conditions. The field mapping included streambank descriptions that show evidence of active erosion in terms of location, tailings presence, erosion severity, bank height, geologic unit, vegetation, and materials.

The bank stratigraphy in Phases 15 and 16 typically consists of four units: a bank toe that consists of a variety of fluvial deposits, including coarse bar sediments and fine-grained channel fills (Figure 3-2). Over that toe unit, a fine-grained pre-mining floodplain deposit contains massive to laminated organic-rich silts. Orange/beige tailings drape the floodplain sediments, infilling the pre-flood floodplain topography. The uppermost bank unit consists of several inches of soil, tilled soil, fill, and/or reworked tailings.

In general, vegetative reinforcement of banklines through Phases 15 and 16 is minimal. Bank failure typically consists of undercutting at the interface between the mid-bank and unconsolidated toe gravels, and subsequent topple failure of the upper bank (Figure 3-3). Where the toe consists of more cohesive silt, undercutting appears to occur on deeper gravel horizons.

Figure 3-2. View Downstream from Station 111+50R Showing Variable Toe Materials

Figure 3-3. View Downstream (Station 58+00) Showing Bank Undercutting/Topple Failure

Even within a single eroding bankline, toe materials can be highly variable (Figure 3-4 and Figure 3-5); as such it is difficult to correlate migration rates directly to the composition of the bank toe. A general comparison of migration rates and recorded toe materials shows that on the inventoried banklines, all types of toe materials show bank retreat in the reach (Figure 3-6). Banks that have composite toe materials tend to have the highest migration rates, although this may reflect planform location as much as materials controls.

Figure 3-4. View Downstream at Station 62+00 Showing Coarse Bank Toe

Figure 3-5. Typical Cohesive Bank Toe

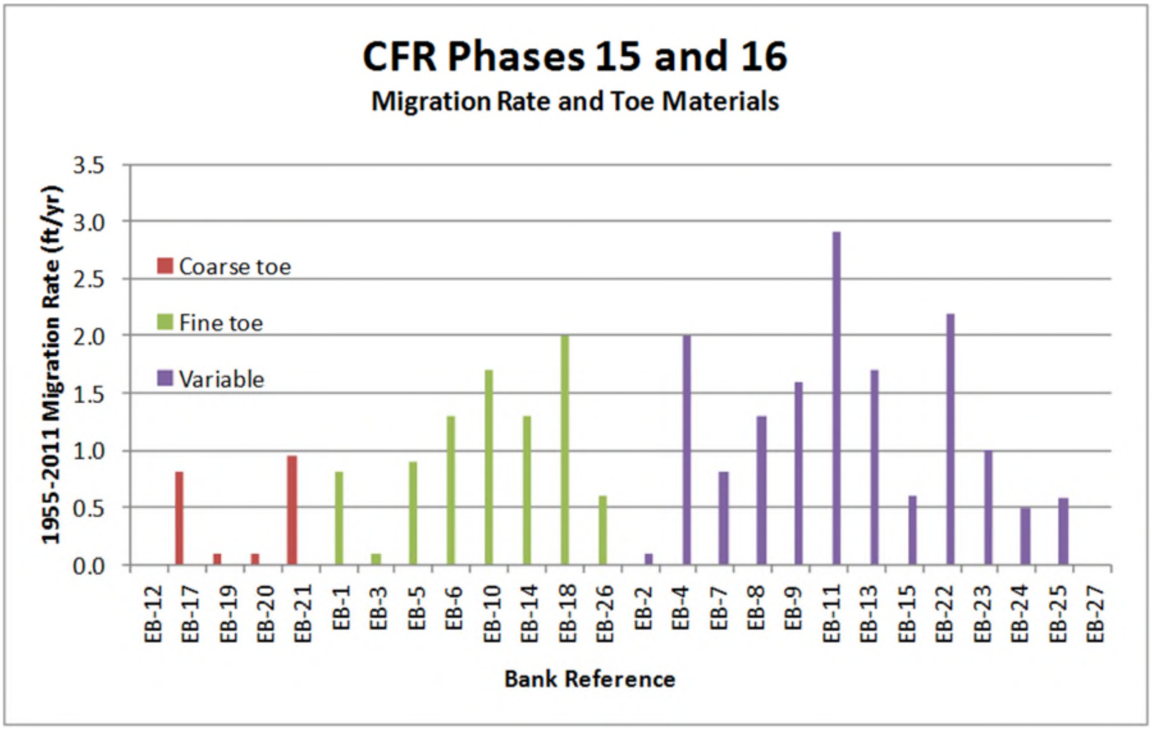


Figure 3-6. Migration Rate and Field-Identified Toe Materials

In order to help determine appropriate bank treatments, field data were combined with migration rate attributes to identify those banklines with the highest erosion risk based on demonstrable rates of movement (>0.6 ft/yr) and presence of contamination behind the banks. Results defined an overall erosion severity rating for the bankline. The extent of bankline identified as high severity is 7,732 feet, or 27 percent of the total bankline (Table 3-4). These sites are located on outside, actively migrating meander bends, with documented adjacent floodplain contamination.

Table 3-4. Bank Length Erosion Potential

Erosion Potential	Length (ft)	Percent of Bankline
High	7732	27.0
Moderate or Low	20,870	73.0
ft - feet		

3.5.1 Streambank Reconstruction

Most streambanks in Phases 15 and 16 will be reconstructed at a lower elevation than existing banks. The purpose for lowering banks is to allow more frequent overbank flooding events. Reconstructed banks will have a top of bank elevation equivalent to the elevation of the 2-year Water Surface Elevation. Some streambanks that have either been stabilized with riprap or show no contamination in either exposed bank materials or in floodplain materials behind the bank will be left in place without reconstruction.

Bank reconstruction methods for specific locations will be finalized during the final design phases, and will vary depending on observed bank migration rates and other factors defining the erosion severity rating described above, hydraulic conditions, the presence or absence of tailings in existing banks and the presence or absence of stabilizing vegetation on existing banks. Banks will be designed to withstand hydraulic and sediment transport conditions associated with the 10-year flood.

A conceptual decision tree for determining bank reconstruction methods at specific locations is shown on Figure 3-7. The decision tree leads to three general groups of bank treatments designated as Group 1, Group 2 and Group 3 treatments.

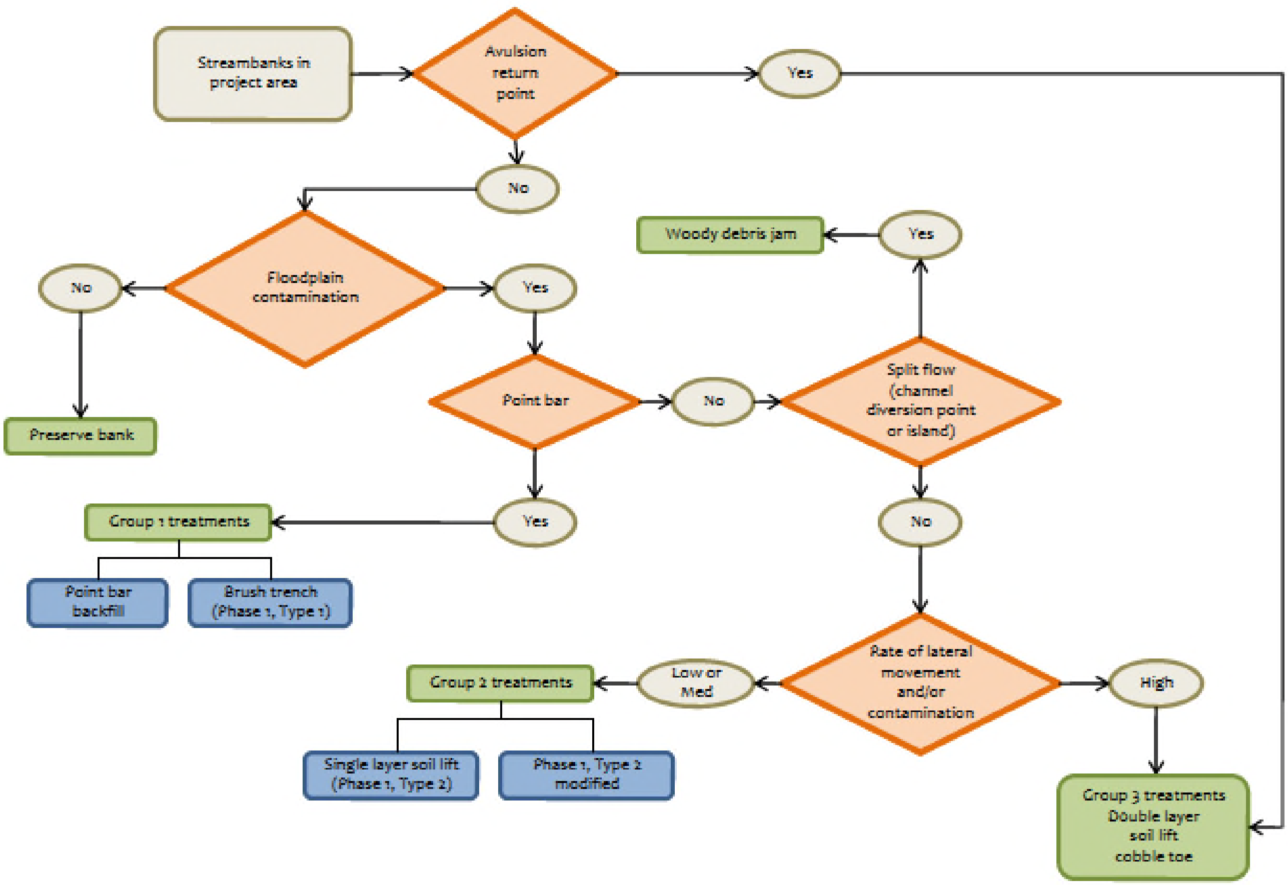


Figure 3-7. Decision Path for Bank Construction

Bank treatments include:

- Group 1 treatments: Group 1 treatments are used in low shear stress (passive) margins such as straight runs, on the insides of meander bends and transitions to point bars.
- Group 2 treatment: Group 2 treatments are used in locations identified as having low or moderate priority based on the bank inventory results. These areas usually exhibit very low rates of lateral movement. Because Group 2 banks are relatively stable, bank toes (transition to bed materials below base flow elevation) and lower banks (zone between base flow and the 2 year water surface

elevation) are expected to remain in place and continue to define the channel margins while vegetation becomes established in near-bank areas of the floodplain.

- Group 3 treatments: Group 3 banks are located on outer meanders and exhibit high rates of lateral movement, or are located at potential avulsion return points. Because these banks are in high stress locations, treatments involve reconstruction of the entire bank, including the lower bank, and in some cases the bank toe if existing toe materials are deformable at or below the 10 year return flow.

The upstream end of islands will be stabilized in the short term using small diameter woody debris jams made from native birch and willow stems salvaged from floodplain excavation areas. The purpose of all stabilization measures included as part of bank treatments is to hold bank materials and near-bank floodplain soils in place long enough for vegetation to become established. Because the long-term goal is to allow banks to be deformable, only soft materials such as biodegradable fabric, small-diameter wood, and native alluvium will be used in bank structures. The Streambank Treatment Plan, Sheets C16 through C18 displays the streambank treatment type location.

Table 3-5. Length Summary of Various Bank Treatments in Phases 15 and 16

Bank Treatment Length and Type	
Bank Treatment Type	**Distance of Treatment (ft)**
Group 1	6,008
Group 2	11,907
Group 3	7,732
Woody Debris	92
No Treatment	2,863
Ft - feet	

3.5.2 Hydraulic Analysis of Streambanks

Reconstructed streambanks will be built to replace banks at locations along the existing channel where shear stresses are high and bank movement is evident. The hydraulic conditions consisting of shear stresses on the bed and banks are variable throughout the existing channel. In some locations such as inside bends, passive margins upstream and downstream of bends and in straight portions of the channel, bank shear stresses are likely to be small. These features tend to be stable with low migration rates and some woody vegetation.

Where these situations occur, the existing banks will be preserved. Bank treatments in these situations will rely on the existing bank toe materials to provide stability with a secondary reinforcement behind it, at the interface between excavated floodplain area and the bank. The secondary treatment type depends on the environment but in general, consists of establishing deep-rooted shrubs behind the existing banks. In some cases, woody material is added to the floodplain backfill material at the elevation of the banks to serve as another secondary reinforcement material if the existing preserved bank toe should fail.

The most erosive hydraulic conditions generally will occur in high energy gradient sections of the stream, at constrictions and at outer bends. The HEC-RAS program predicts shear stresses at each of the model cross sections. However, these predicted shear stresses are average values that do not account for stress concentrations that occur at depth and against the outer banks of bends. Stress concentration factors to account for deeper flows and higher velocities that occur in outer bends can be determined by methods (CDM et al., 2012) using data from the HEC-RAS output and bend geometry described in

Section 2.4.1. Using these methods, the highest predicted total shear stress during the 10-year flood event at the toe of outer banks in bendways occurs not far below the existing Cattle Drive Road Bridge at Station 94+79 where a total stress of 2.7 pounds per square foot (psf) is predicted to occur. This total stress can be partitioned into grain stress and other stress using the following relation:

$$\tau' = \gamma Y' S$$

Where:

Y' = the portion of the total hydraulic stress associated with grain resistance (Einstein, 1950), and

S = the energy slope at the cross section.

The value of Y' is computed by iteratively solving the semi-logarithmic velocity profile equation:

$$\frac{V}{V^{*\prime}} = 6.25 + 5.75 log \frac{Y'}{K_s}$$

Where:

V = mean velocity at the cross section,

Ks = characteristic roughness of the bed, and

$V^{*\prime}$= shear velocity due to grain resistance given by:

The characteristic roughness height of the bed (Ks) was assumed to be 3.5 D_{84} (Hey, 1979).

Using these methods the grain stress during the 10-year flood event is estimated to be approximately 0.72 psf. The size of the toe material required to resist this grain stress can be estimated using the Shield's Equation:

$$\tau_c = \tau_c^* (\gamma_s - \gamma_w) D_{50}$$

Where:

τ_c= critical shear stress for particle motion,

τ_c^* = dimensionless critical shear stress (often referred to as the Shields parameter),

γ_s= unit weight of sediment (~165 lb/ft3),

γ_w= unit weight of water (62.4 lb/ft3), and

D_{50} = median particle size of the bed material

Reported values for the Shields parameter range from 0.03 (Neill, 1968; Andrews, 1984) to 0.06 (Shields, 1936). A value of 0.047 is commonly used in engineering practice, based on the point at which the Meyer-Peter Müller (MPM) bed-load equation indicates no transport (MPM, 1948). Detailed evaluation of the MPM data and other data (Parker et al., 1982; Andrews, 1984) indicate that true incipient motion occurs at a value of about 0.03 in gravel- and cobble-bed streams. Neil (1968) concluded that the dimensionless shear value of 0.03 corresponds to true incipient motion of the bed-material matrix while 0.047 corresponds to a low, but measurable transport rate. A value of 0.03 was used in this analysis. Using the 0.03 Shields parameter, a D_{50} of approximately 4.2 inches is required to maintain bank toe stability at a 10-year design discharge event. This size is slightly larger than the observed D_{50} of bed sediments in the existing channel (see Section 2.2.3) but given that the existing banks are thought to be mobilized at flows less than the 10-year event (see Section 2.2.2), this is not unexpected.

Scour depths have been estimated for bendways within Reaches 15 and 16 (Tetra Tech, 2012a). Average scour depths during the 10-year event are estimated to be approximately six feet below the existing bank toe elevation in bendways.

3.5.3 Hydraulic Analysis of Floodplain

The reconstructed floodplain initially will consist of an unvegetated, variable, undulating surface adjacent to the stream. The uppermost surface of the floodplain will consist of a one-foot thick layer of vegetative backfill whose design basis is discussed in Section 3.6.1. In some locations, alluvial material may be placed as backfill below the vegetative fill. Until such time as the floodplain is vegetated, the floodplain may be subject to flooding, resulting erosion of the vegetative material and underlying alluvial fill. To resist entrainment of the alluvial fill, gradation of the alluvial fill has been selected so as to be able to resist entrainment.

The predicted overbank shear stresses during the 10-year flood event were obtained from the HEC-RAS model and used to size the alluvial material. Shear stresses averaged generally less than about 0.10 psf with a maximum overbank shear stress of 0.38 psf. Using the Shields Equation with a Shields parameter of 0.03 yields the result that the alluvial fill material needs to have a mean particle size (D_{50}) of 1.5 inches to resist the maximum shear stress predicted during the 10-year flood.

3.6 BORROW AREA AND BACKFILL MATERIAL CRITERIA

Removal of tailings/impacted soils will require the placement of backfill material in order to meet CFR Reach A, Phases 15 and 16 design objectives. Coarse materials, including alluvial and vegetative backfill will be required. Vegetative backfill requirements are presented in the ROD, and coarse material specifications are based on site specific requirements for floodplain stability.

3.6.1 Vegetative Backfill

Vegetative backfill is relatively fine grained material that is suitable for plant growth including grasses, forbs, shrubs and trees. Table 3-6 presents the chemical and physical requirements for vegetative backfill on the CFROU.

Table 3-6. Chemical and Physical Criteria for Vegetative Backfill

Suitability Criteria For Floodplain Backfill Materials Reach A, Phases 15 and 16 – CFR OU Remedial Design	
Parameter	**Suitability Criteria**
Texture	Sandy loam or finer
Particle Size Distribution	Particles > 0.079 inches (2mm) will constitute <45 percent (by volume)
Rock Fragments	Maximum Rock Size is 6 inches (150mm)
pH	>6.5 and <8.5 standard units
Specific Conductivity	< 4. 0 dS/m
Organic Matter	>1.5 percent (by weight) in upper 6 inches
Element Arsenic Cadmium Copper Lead Zinc	Total Concentration <30 mg/kg <4 mg/kg <100 mg/kg <100 mg/kg <250 mg/kg
ppm – parts per million dS/m – deciSiemens per meter cm – centimeter mm – millimeter *mg/kg – milligrams per kilogram*	

No nutrient requirements are set for vegetative backfill as soil may be amended to provide necessary nutrient content. The vegetative backfill borrow material will provide appropriate growth media for the reconstruction of the Reach A, Phases 15 and 16 floodplain. Vegetative backfill material will be required in most locations where tailings/impacted soils are removed and will be required to have an appropriate texture and particle size distribution to be suitable as growth media. Floodplain backfill for Reach A, Phases 15 and 16 will require approximately 145,700 bank cubic yards (bcy) of vegetative backfill material.

The required vegetative backfill material will be excavated from the Beck Ranch Borrow Area located approximately 3 miles south-southwest of Deer Lodge, Montana. The Transportation Plan, Sheet, C19 displays the borrow area location.

3.6.2 Alluvium Material

Alluvial materials are generally sands, gravels, and cobbles that can be transported by water. The remedial action for Reach A, Phases 15 and 16 will require alluvial material that will be utilized for general floodplain backfill, side-channel bed material, and bank toe material.

The following design criteria apply to alluvial gravel:

- The soil portion of the alluvial material shall meet metals criteria for vegetative backfill.
- Gravel and cobble fractions shall be rounded and not crushed.
- The D_{50} of the bank toe material shall not be mobilized at flows less than the 10-year recurrence event in the river channel.
- The floodplain material shall have sufficient soil fraction to allow compaction.

Remedial action for Reach A, Phases 15 and 16 will require approximately 50,000 bcy of alluvial material. A direct material source has not been specifically identified; however, several material sources in the immediate area of this remedial action have been identified and are being explored.

3.6.2.1 Montana Correctional Enterprises Ranch

Several gravel sources have been previously utilized at the Montana Correctional Enterprises Ranch (Prison Ranch). The gravel sources at the Prison Ranch are an ideal source for materials due to the Prison Ranch's close proximity to the CFR Reach A, Phases 15 and 16 project areas. The fact that it is a Montana State agency may also be advantageous for the DEQ for contracting and purchasing purposes. Tetra Tech is currently exploring the availability, quality, and quantity of alluvial material from this location.

3.6.2.2 Deer Lodge Asphalt

Deer Lodge Asphalt currently operates a gravel pit on the northeast corner of the Deer Lodge Airport facility. This alluvial materials source has several advantages including the fact that the current pit location is less than one mile from Reach A, Phases 15 and 16 project area. Utilizing this alluvial material source could significantly reduce the costs associated with the transportation of material and greatly reduce potential public interaction with haul traffic. Previous inquiries into this source suggest that the pricing structure for materials would be very advantageous as well. Tetra Tech is currently exploring the availability, quality, and quantity and the costs associated with this alluvial material source.

3.6.3 Design Components

Initial staking of the borrow limits and clearing and grubbing in the borrow area shall be limited to the area detailed on Sheet C20, Borrow Area Plan. Field adjustments or changes to the borrow area limits may be determined by DEQ. After the borrow area is cleared and grubbed, the top 12 inches of topsoil will be stockpiled for reclamation purposes.

The following criteria describes the borrow area design and construction:

- The top 12 inches of topsoil shall be stripped and stockpiled due to arsenic concentrations and borrow source reclamation;
- Maintain a maximum 2H:1V slope during construction;
- Re-contour side slopes to a maximum of 4H:1V at reclamation; and
- Maintain existing drainage ways and promote positive drainage.

Once the topsoil is stockpiled, the borrow material shall be excavated to the elevations shown on Sheet C20, Borrow Area Plan. The final excavation surface will have slopes no steeper than 4H:1V. The construction contractor shall implement an excavation approach that limits ponding of surface water and erosion. Excavation cut faces where equipment is not working shall be immediately sloped back to a 2H:1V slope or less. Side slopes will be monitored for stability and potential safety concerns.

There will likely remain small zones within each characterized borrow area that do not meet all of the required criteria and that were not delineated by the sampling density employed. If these zones are sufficiently small such that mixing during excavation produces material meeting the criteria, no attempt will be made to segregate these zones. If zones are encountered where mixing will not be sufficient to allow compliance with criteria, the materials will not be used. Borrow materials will be excavated and stockpiles tested to ensure backfill meets specifications. The owners representative will determine the suitability of all material. Samples will be analyzed in the field by the owners representative to determine rock content, soil texture, and pH. In addition, hand texturing and pH will be determined on a continuous basis during excavation.

3.7 FLOODPLAIN VEGETATION DESIGN

This section describes the vegetation design criteria for Phases 15 and 16 in Reach A of the CFROU and also includes detailed descriptions of each of these cover types, restoration strategies and treatments for each cover type, and descriptions of each revegetation treatment assigned to the cover types.

3.7.1 Basis of Revegetation Plan Design

Because the GKR is a NPS site, it is particularly important that plants species used on the site are native, and that the reclaimed floodplain be able to sustain natural processes and associated plant communities that occur on the site. Because of this site's historical and ecological importance, many vegetation studies have been completed on the GKR. These studies are summarized in Section 2, and information from those studies was considered during development of this plan.

Specifically, the ROD describes the ecological potential of the GKR in terms of riparian vegetation habitat types that would be expected to occupy the site based on hydrology and soil type (as determined by land form, substrate and climate) (Hansen et al., 1995 and EPA, 2004b). To accomplish the intent of the ROD, the vegetation design emphasizes creating a self-sustaining mosaic of riparian and wetland plant communities on a floodplain surface that is hydrologically connected to the CFR. The monitoring plan developed for the GKR will establish performance targets for short- and long- term time frames.

Riparian vegetation varies among geomorphic features in an alluvial floodplain such as the CFR floodplain, and plant community development is also linked to how geomorphic features develop. Riparian areas are highly productive due to their location between terrestrial and aquatic ecosystems. They are critical links between water bodies and adjacent uplands through surface and subsurface water flow. A hydrologically connected floodplain is at an elevation where both ground and surface water converge to promote the cycling of nutrients, which is important to both the productivity of rivers and associated riparian areas. Nutrient cycling is defined as the process where nutrients such as organic carbon, nitrogen, phosphorous, magnesium, and calcium are temporarily stored and then released further downstream as they cycle from organic to inorganic form and then back again (Mitsch and Gosselink, 2000).

Soils in riparian areas consist of sediments with different textures that are subjected to fluctuating water levels. Riparian soils tend to be rich with nutrients and contain increased organic matter, which allows them to retain moisture. Riparian vegetation may consist of herbaceous, shrub, or tree cover and can provide several important functions including: trapping sediments, stabilizing creek banks, promoting organic matter, helping to regulate stream temperatures through shading, contributing food for microorganisms and aquatic insects, and providing important wildlife habitat. In addition, riparian plants reduce erosive energy and increase the time for water to infiltrate the soil and be stored for slow release back into the stream. Riparian areas that are hydrologically disconnected from streams lose these important ecological functions.

At the project-wide scale, this design aims at correcting a geomorphic imbalance by re-exposing a floodplain that was buried under a layer of tailings/impacted soils, and thus was hydrologically disconnected from the CFR. In order to link vegetation and geomorphology as a diverse mosaic within the project area, a set of vegetation cover types were developed that correspond to different geomorphic features. Each cover type represents a starting point for the development of a dynamic riparian system that has the ability to respond to interconnected factors at both the local and watershed scale. Local factors that influence vegetation community development and succession in the floodplain include: groundwater, woody debris accumulation, sediment distribution, and accumulation of organic matter or litter. Landscape-scale factors that influence vegetation development include: flood regimes, climate patterns, valley type, and surface water-groundwater interactions. These communities are not meant to be static, but are intended to develop and change over time in response to natural floodplain processes. Figure 3-8 shows an example floodplain cross-section with the existing condition including tailings/impacted soils, the immediate post-reclamation condition, and the desired future condition once riparian vegetation has become established.

Because several plant communities can occur on similar geomorphic features, plant communities are lumped into seven broader floodplain cover types for purposes of developing vegetation design criteria and treatments. These cover types include: Exposed Depositional (non-vegetated), Colonizing Depositional (vegetated), Riparian Wetland; Floodplain Riparian Shrub, Outer Bank Riparian Shrub, Emergent Wetland, and Upland Transition. Each cover type represents a range of ecological site potentials that can be expressed in terms of habitat types and community types (Hansen et. al, 1995 and EPA, 2004b). The relationships between cover types and habitat/community types that may develop within these cover types are shown in Table 3-7, Figure 3-9, and Figure 3-10.

Figure 3-9 and Figure 3-10 show the distribution of design cover types, in addition to planting areas and other features discussed in this section for Phases 15 and 16, respectively.

Table 3-7. Cover Types and Hansen Ecological Types (Hansen et al., 1995)

Exposed Depositional	Floodplain Riparian Shrub
• NA	• Alnus incana CT
Colonizing Depositional	• Betula occidentalis CT
• Eleocharis palustris HT	• Populus trichocarpa/Calamagrostis canadensis CT
• Populus trichocarpa/Cornus stolonifera CT	• Populus trichocarpa/Cornus stolonifera CT
• Salix exigua CT	• Salix exigua CT
Emergent Wetland	• Salix geyeriana/Calamagrostis canadensis HT
• Carex aquatilis HT	• Symphoricarpos occidentalis CT
• Calamagrostis canadensis HT	**Outer Bank Riparian Shrub**
• Carex rostrata HT	• Alnus incana CT
• Eleocharis palustris HT	• Betula occidentalis CT
• Typha latifolia HT	• Populus trichocarpa/Calamagrostis canadensis CT
Riparian Wetland	• Populus trichocarpa/Cornus stolonifera CT
• Alnus incana CT	• Salix geyeriana/Calamagrostis canadensis HT
• Salix exigua CT	• Rosa Woodsii CT
• Salix geyeriana/Carex rostrata HT	• Symphoricarpos occidentalis CT
	Upland Transition
	• Agropyron smithii HT
	• Rosa Woodsii CT
	• Symphoricarpos occidentalis CT

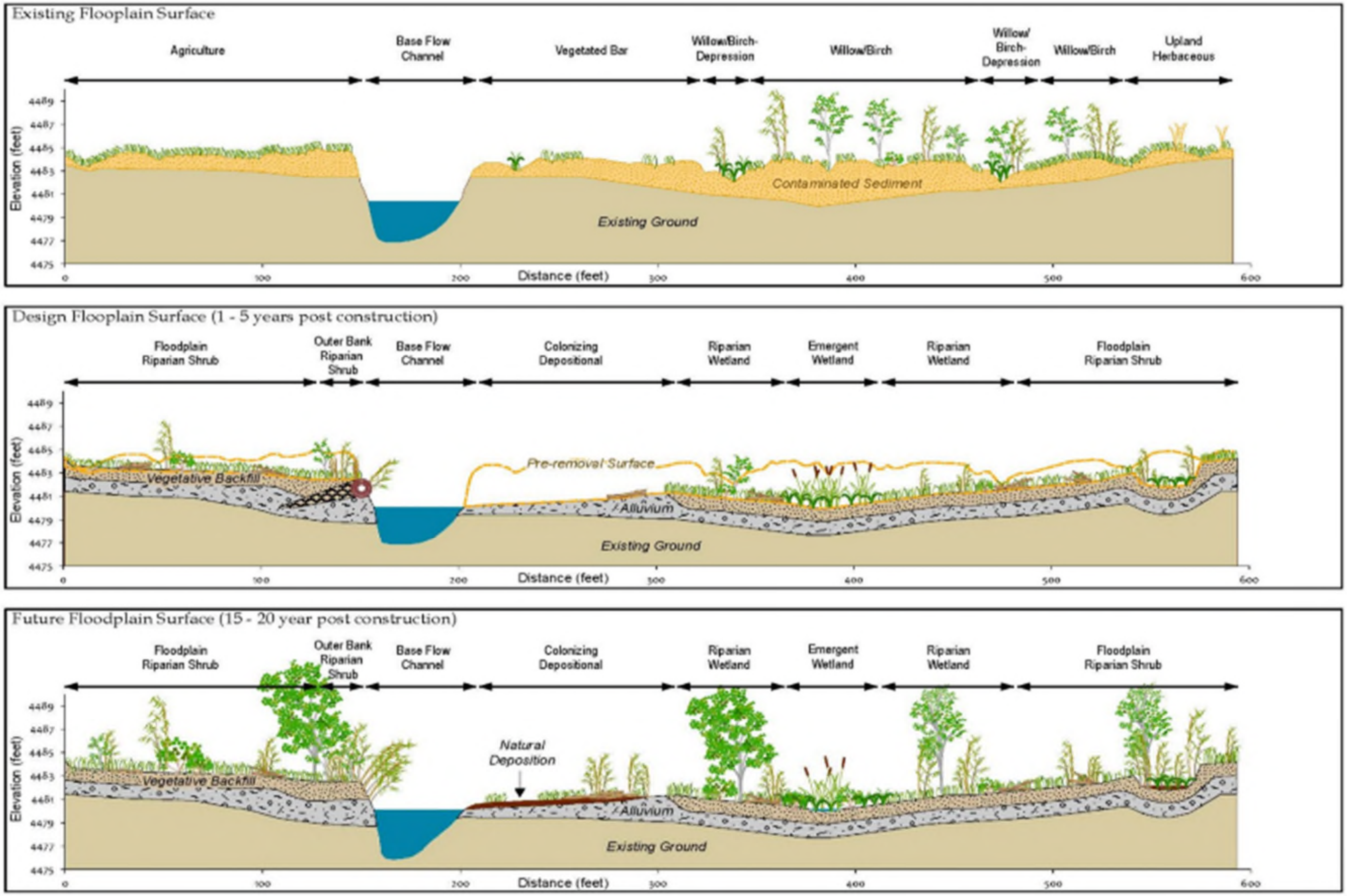


Figure 3-8. Example Cross-Section of the Existing Floodplain Surface with Tailings/Impacted Soils Deposits, the Immediate Post-Remediation Floodplain Surface, and the Desired Future Condition of the Floodplain Once Vegetation Has

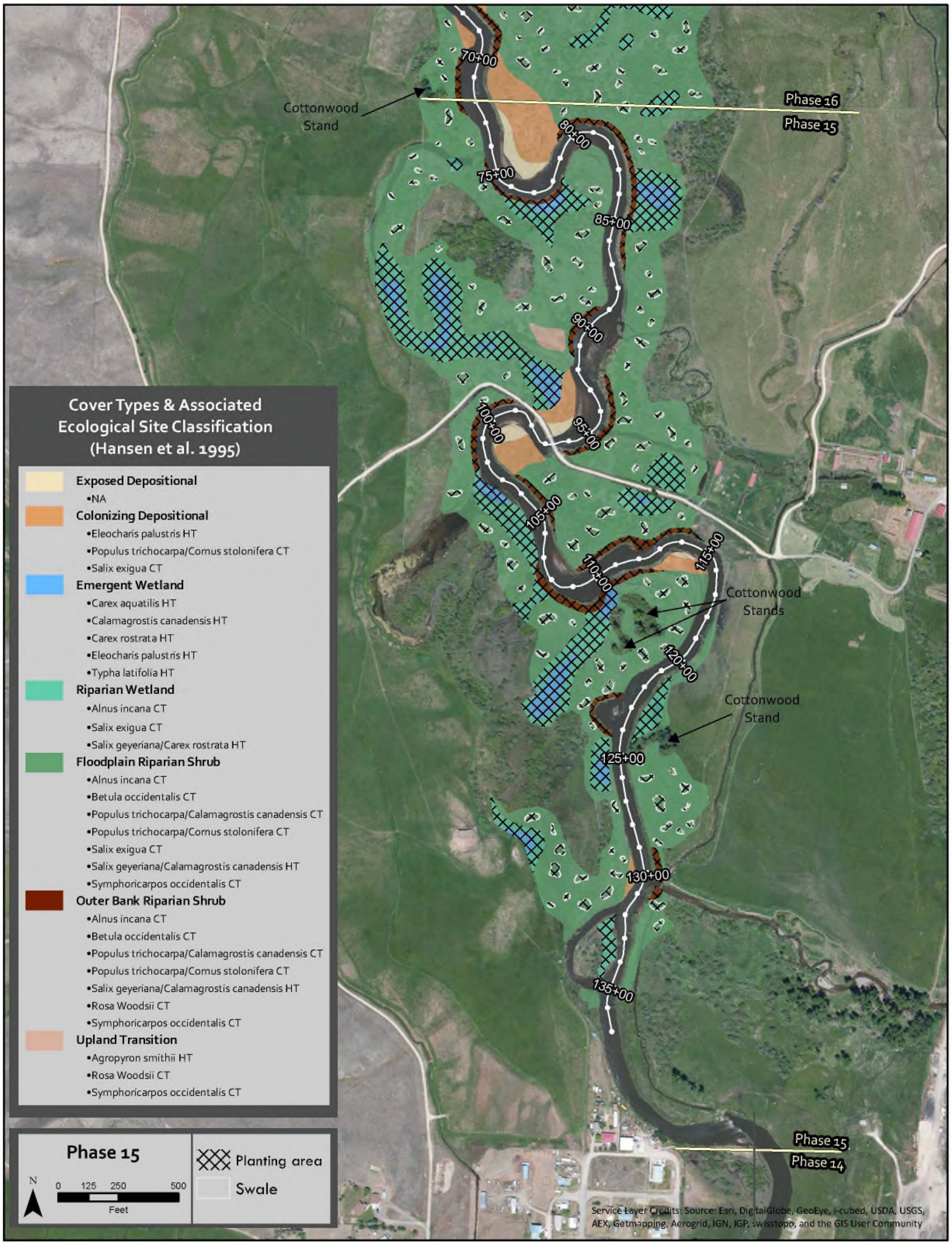


Figure 3-9. Phase 15 Design Cover Types, Planting Areas, Swale Features, and Cottonwood Stands to be Preserved

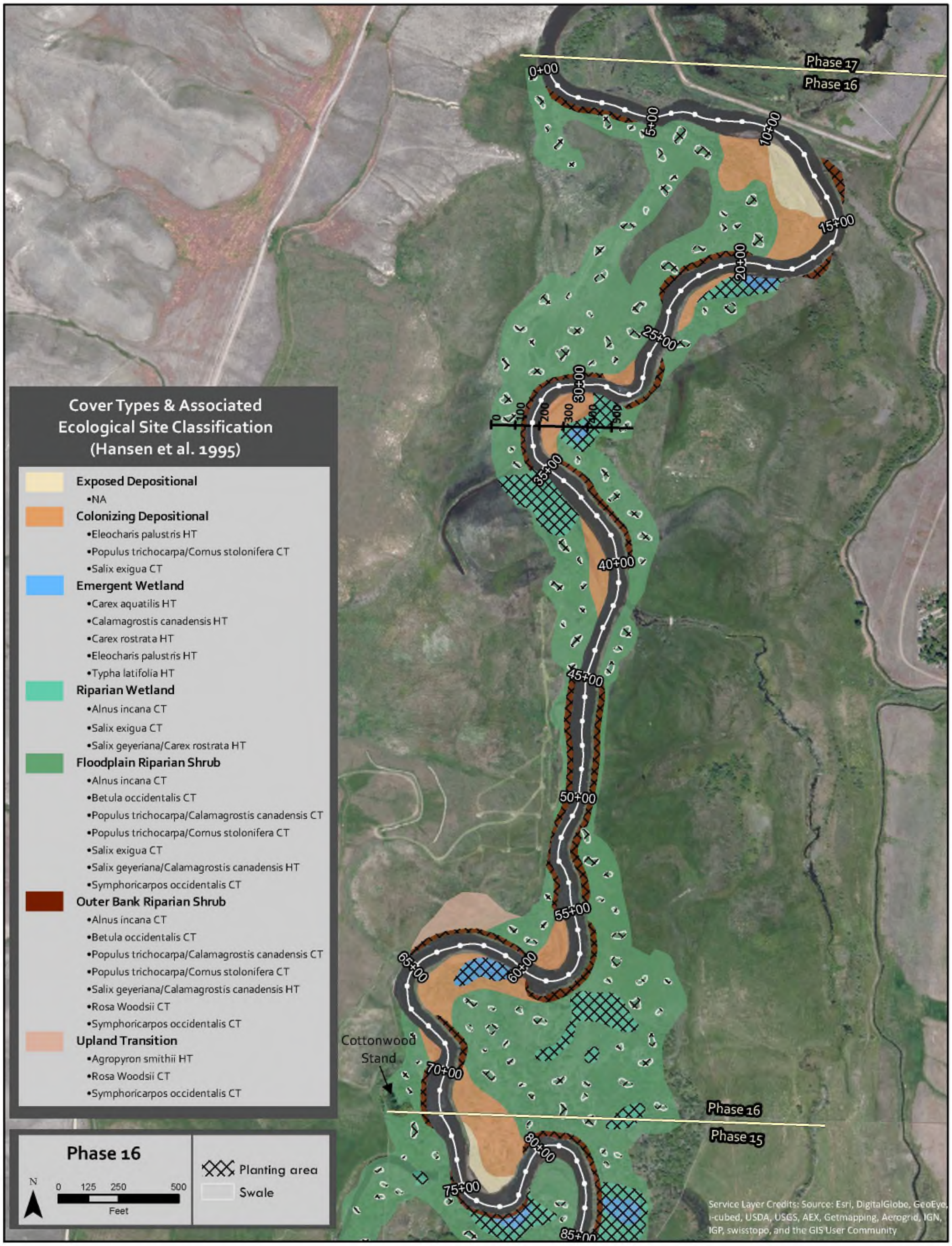


Figure 3-10. Phase 16 Design Cover Types, Planting Areas, Swale Features, Example Valley Cross-Section Location, and Cottonwood Stands to be Preserved

Design criteria for each floodplain cover type include the following physical factors that influence the development of plant communities:

- Geomorphic feature: the location of the cover type within the floodplain;
- Flood dynamic: the anticipated return interval for overbank flooding within the cover type;
- Estimated distance to groundwater;
- Elevation relative to the 2-year WSE;
- Soil texture: Range of soil textures that can support development of desired plant communities within the cover type; and
- Soil depth: Depth of vegetative backfill needed above the sub-grade material.

Table 3-8 provides ranges for each of these criteria by floodplain cover type. Design criteria for vegetation are closely tied to floodplain design criteria (Section 3.4.4), streambank reconstruction design criteria (Section 0), and design criteria for backfill (Section 3.6). The following discussion explains some of the rationale for vegetation design criteria within the Phases 15 and 16 project area.

As described above, creating hydrologic connectivity between the channel and floodplain is necessary for floodplain cover types and related plant communities to develop so they can provide a wide range of floodplain functions and processes. For purposes of this project, a connected floodplain is defined as one where surface water can access some features within the floodplain every year, and at least 40 percent of the total reconstructed floodplain area is inundated during an average 2-year flood event, represented by the 2-year WSE.

Reconstructing the floodplain at the range of elevations represented in this design will result in hydrologic connectivity between the floodplain and channel. As a result, flows exceeding the 2-year return flow will deposit nutrients, sediment and seeds on the floodplain, thereby creating and sustaining riparian vegetation. Floodplain topography will also result in connection between surface water and groundwater that supports nutrient transport to floodplain vegetation and develops complex food webs below ground (Brinson et al., 2005). Diverse topography will also support diverse plant species and communities in the floodplain.

Gage data can be used to estimate the typical duration as well as frequency of anticipated floodplain inundation in the project reach (Figure 3-11). At the Deer Lodge USGS gage, the measured mean daily discharge exceeded the 2-year flow a total of 302 days between 1979 and 2012, or 2.4 percent of the time. So floodplain inundation in the project reach, to a depth equal to the 2-year water surface elevation, should be expected to occur approximately 2.4% of the time. The duration of the 2-year mean daily flow exceedence in any given year ranged from zero days (17 years of the 34-year record) to 1 day (1983, 1989, 1991, and 2007) to a maximum of 56 days (2011).

Table 3-8. Design Criteria for Floodplain Cover Types

Floodplain Cover Types	Geomorphic Design Feature(s)	Flood Dynamic (flood return interval)	Distance to Ground-water (feet)	Elevation Relative to 2-Year WSE (feet)	Soil Texture	Vegetative backfill (inches to alluvium)
Exposed Depositional (Non-vegetated)	Non-vegetated portion of point bars	< 1 year	0 to 3	-2.5 to -1.0	Sand, fine to coarse gravel or cobble, (alluvium)	0
Colonizing Depositional (Vegetated)	Vegetated portion of point bars	1 to 2 years	0 to 3	-1.0 to 0	Sand, fine to coarse gravel or cobble, (alluvium)	0
Emergent Wetland	Passive margins along channel; wetlands, oxbows and backwater areas	< 1 year	0 to 3	-2.5 to -1.0	Silt to sandy loam (vegetative backfill) overlaying floodplain alluvium or other general fill	12
Riparian Wetland	Bankfull floodplain in backwater areas; edge of emergent wetlands and oxbows	1 to 2 years	0 to 3	-1.0 to 0	Silt to sandy loam (vegetative backfill) overlying floodplain alluvium or other general fill	12
Floodplain Riparian Shrub	Bankfull floodplain; low terrace	2 to 50 years	2 to 4	-0.5 to 2.5	Silt loam to sandy loam (vegetative backfill) overlying floodplain alluvium or other general fill	12
Outer Bank Riparian Shrub	Streambanks along outer meanders	1 to 10 years	2 to 4	0 to 2.0	Silt loam to sandy loam (vegetative backfill)	12
Upland Transition	Slope transitions to higher terraces; high inclusions within Channel Migration Zone	10+ years	3 +	2.0 +	Silt loam to sandy loam (vegetative backfill) overlaying floodplain alluvium or other general fill	12

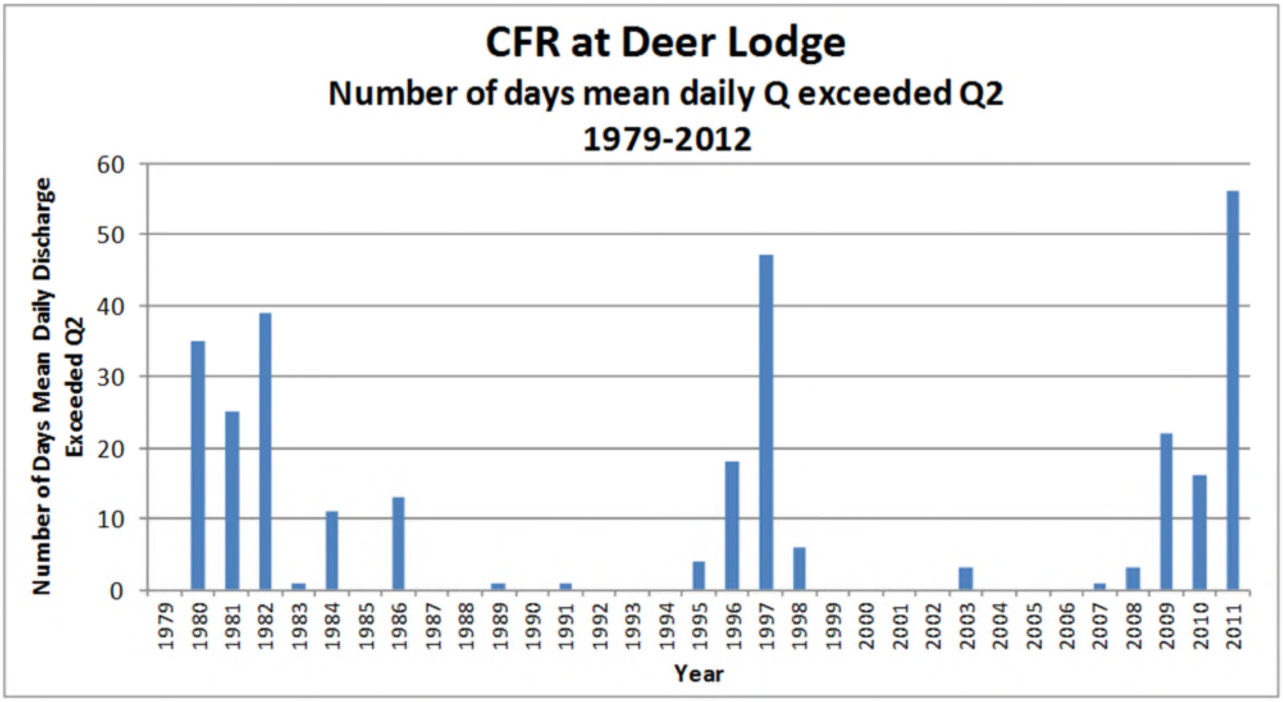


Figure 3-11. Mean Daily Discharge Exceedance

As with other natural floodplain processes, riparian soil development and related nutrient exchange also depends on the floodplain and channel being hydrologically connected. Riparian systems generally receive nutrients from allochthonous sources such as dead leaves and woody debris brought from upstream (Vannote et al., 1980). Topographic diversity in the form of oxbows, connected side channels, wetlands and smaller depressions provides pathways and sinks for allochthonous inputs of organic matter and promotes soil development. A significant portion of organic matter and nutrients is also delivered to the floodplain during flood events (Tabacchi et al., 1998). A high proportion of fine sediment in floodplain soils is soil particles or mineral sediments originating from the stream channel where they were coated with organics (Gregory et al., 1991). Because these are the dominant nutrient and organic matter input pathways in floodplain systems, the vegetation design calls for minimal organic matter additions in the form of imported compost.

The appropriate substrate to support vegetation development includes cobble, gravel and sand (alluvium) on exposed depositional and colonizing surfaces; and silt to sandy loam (vegetative backfill) on higher elevation floodplain surfaces and within wetlands. Vegetative backfill depth will be 12 inches within most cover types, which reflects the typically shallow soils found on western Montana alluvial floodplains where most fine-textured soil is made up of sediment deposits that accumulated on alluvium after woody vegetation established and trapped fine sediment. The organic component of these soils is typically low (1.5 to 2.5 percent) as most organics are derived from either litter that has accumulated over a relatively short time frame or organics that have moved in through the water column and coated soil particles (as described above).

Deeper vegetative growth media may be placed in wetland depressions because depressions with no outlets trap more sediment, resulting in a deeper mineral soil layer. Anaerobic conditions within these constantly-saturated features also result in relatively rapid accumulation of organic matter in soils because the organics do not decompose rapidly. Within designed wetlands, organic matter content in soils will likely trend toward 5 percent or greater.

3.7.2 Design Criteria and Components by Cover Type

3.7.2.1 Exposed Depositional

Description

Within the project area, the Exposed Depositional cover type is located at low elevations along the inside of meander bends between base flow and approximately 1.5 feet above base flow. These areas typically do not support vegetation due to frequent scour, but they have the potential to recruit sediment and eventually become vegetated as they aggrade. This type of feature forms naturally as a result of the sediment transport process, so it is composed entirely of exposed alluvial substrate such as cobble, gravel and sand; and supports mostly scattered annual vegetation.

Because these surfaces are subject to frequent disturbance, over the long-term they tend to change shape and may be eliminated altogether. In some locations, once these features have matured, they may be colonized with willows (Salix species) or herbaceous vegetation that will trap fine sediments thus creating more niches for other plant species to colonize. These areas may become higher over time as they trap sediment and aggrade, causing them to encroach on the channel, forming defined banks. Because these areas are so dynamic and unpredictable, no active revegetation treatments are proposed.

Strategy

The revegetation strategy for the Exposed Depositional cover type includes:

- Grading associated with floodplain construction to create surfaces with gradual slopes extending from the baseflow channel to approximately one foot below the 2-year WSE elevation.
- Construction using floodplain alluvium consisting of fine to coarse gravel or cobble.

Table 3-9 summarizes the revegetation criteria and treatments for the Exposed Depositional cover type.

Table 3-9. Exposed Depositional Cover Type Criteria and Revegetation Treatments

Exposed Depositional Cover Type	Total Area = 1.5 acres Percent of Total Area = 1.5%	
Treatment	**Criteria/Description**	**Treatment Area**
Grading	-2.5 to -1.0 feet relative to 2-year WSE	1.5 acres
Soil Texture	Sand, fine to coarse gravel or cobble, (alluvium)	1.5 acres
Vegetative Backfill Depth	0 inches to alluvium	Not applicable

3.7.2.2 Colonizing Depositional

Description

The Colonizing Depositional cover type occupies areas on point bars between the Exposed Depositional cover type and the 2 year WSE. These surfaces are partially vegetated, so they trap finer material than in the Exposed Depositional cover type. Typically, they are composed of recently deposited sediments; patches of sand and silt over gravel and cobble. Successful natural recruitment of willows requires bare, moist mineral surfaces that are protected from scour so seedlings can survive beyond the first growing season. In addition to willows and other riparian trees and shrubs, annual and perennial herbaceous vegetation will develop on these surfaces.

The bare patches created by scour and re-shaping also provide places for additional recruitment, resulting in a variety of age classes and diverse plant community structure. The Colonizing Depositional cover type is a transition between the Exposed Depositional surfaces that experience frequent re-sorting and the more stable Floodplain Riparian Shrub or Riparian Wetland cover type surfaces that experience lower magnitude and lower frequency floods. Over time, some areas within this cover type will continue to be re-shaped by the river. Other areas will become more stable and may transition to one of the other cover types such as Floodplain Riparian Shrub or Riparian Wetland.

Strategy

The revegetation strategy for the Colonizing Depositional cover type includes:

- Grading associated with floodplain construction to create surfaces at a higher elevation and further away from the channel than the Exposed Depositional cover type.
- Construction using floodplain alluvium consisting of fine to coarse gravel or cobble.
- Placement of woody debris on the surface (microtopography) to provide safe sites where existing cottonwood and willow seedlings can survive frequent flooding, and to trap sediment and debris floating downstream, creating additional microsites where seeds can germinate and survive.
- Planting containerized trees and shrubs, and herbaceous wetland plugs to encourage development of desired plant communities along the channel margins.
- Seeding with a two-stage seed mix. The seed mix will include a quick germinating sterile cover crop to limit weed infestations, and a mix of native grasses and forbs which are generally slower to germinate but are longer-lived.

Table 3-10 summarizes the revegetation criteria and techniques for the Colonizing Depositional cover type.

Table 3-10. Colonizing Depositional Cover Type Criteria and Revegetation Treatments

Colonizing Depositional Cover Type	Total Area: 7.9 acres Percent of Total Area: 7.9 percent	
Treatments	**Criteria/Description**	**Treatment Area**
Grading	-1 to 0 feet relative to 2-year WSE	7.9 acres
Soil Texture	Sand, fine to coarse gravel or cobble, (alluvium)	7.9 acres
Vegetative Backfill Depth	0 inches to alluvium	7.9 acres
Microtopography	Partially buried coarse woody debris	7.9 acres
Containerized Planting: Shrubs and Trees	Shrubs and trees will be installed in all areas of this cover type	7.9 acres
Containerized Planting: Herbaceous Plugs	Herbaceous wetland plugs will be installed in all areas of this cover type to promote establishment of desired plant communities	7.9 acres
Seeding	Seed with two-stage seed mix for early germination cover crop and long term diverse native mix of grasses and forbs	7.9 acres

3.7.2.3 Emergent Wetland

Description

The Emergent Wetland cover type will occur primarily within off-channel wetland features and connected wetland complexes throughout the floodplain. It will occupy a zone adjacent to the Riparian Wetland cover type. This cover type will consist of herbaceous wetland plants such as sedges (Carex species), bulrushes (Scirpus and/or Schoenoplectus species), cattails (Typha species), rushes (Juncus species) and some wetland grasses. These areas have deeper soils than adjacent cover types, more stable hydroperiods (less groundwater fluctuation within the rooting zone than would be present in the Riparian Wetland cover type), and would likely be submerged during flows above the 2-year return flow. The Emergent Wetland cover type will support several floodplain functions including floodwater retention and energy dissipation, sediment storage, food web support, aquatic and terrestrial habitat, aquifer recharge, and nutrient cycling.

Strategy

The revegetation strategy for Emergent Wetland cover type includes:

- Grading and substrate placement in association with floodplain shaping to create suitable growing conditions for native wetland vegetation.
- Placing large and coarse woody debris (microtopography) within connected wetland complexes to mimic floodplain and wetland features that are created and maintained by beaver.
- Planting herbaceous plugs within wetlands according to hydrologic zones preferred by various wetland species.
- Seeding with a two-stage seed mix to provide short- and long-term vegetative cover, and to promote a diverse, native seed bank.

Table 3-11 summarizes revegetation criteria and treatments for the Emergent Wetland cover type.

Table 3-11. Emergent Wetland Cover Type Criteria and Revegetation Treatments

Emergent Wetland Cover Type	Total Area = 3.2 acres / Percent of Total Area = 3.2 percent	
Treatments	**Criteria/Description**	**Treatment Area**
Grading	-2.5 to -1.0 feet relative to 2-year WSE	3.2 acres
Soil Texture	Silt to sandy loam (vegetative backfill) overlying floodplain alluvium or other general fill	3.2 acres
Vegetative Backfill Depth	12 inches (to alluvium)	3.2 acres
Microtopography	Large and coarse woody debris installed within wetland features	3.2 acres
Containerized Planting: Herbaceous Plugs	Herbaceous plugs installed according to appropriate hydrologic zones	3.2 acres
Seeding	Seed with two-stage seed mix for early germination cover crop and long term diverse native mix of grasses and forbs	3.2 acres

3.7.2.4 Riparian Wetland

Description

The Riparian Wetland cover type aims to mimic the floodplain landscape features that would have been created and maintained by beavers or natural abandoned channel meanders (oxbows) over time in this type of floodplain system. Plant communities in this cover type would include a shrubby overstory of willows, birch (Betula species), and dogwood (Cornus species) with a diverse understory composed of various bulrush, sedges, rushes, wetland grasses, and wetland forbs. Understory species composition will develop at a local-scale in response to elevation, depth to groundwater and other hydrologic factors that influence vegetation development into distinct “zones”.

The Riparian Wetland cover type will contribute to primary production, nutrient cycling and aquatic and terrestrial habitat in addition to other floodplain functions. This cover type will occupy floodplain areas that are 0 to 1.0 feet below the 2-year WSE. Soils within this cover type are expected to remain saturated or inundated throughout much of the growing season, and therefore would support various riparian and wetland plant communities. Over time, this community could shift to the Floodplain Riparian Shrub cover type depending on floodplain processes and plant community succession.

Strategy

The revegetation strategy for the Riparian Wetland cover type includes:

- Grading associated with floodplain construction to create connected off-channel wetland complexes, connected wetlands, and secondary channels where floodplain elevations and depth to groundwater will support a wide range of riparian and wetland plant species.
- Substrate variation and microtopographic enhancements to provide suitable growth media and microsites for better germination and plant survival.
- Installation of large and coarse woody debris to create niches and microsites for vegetation development as well as add organic matter to the soil.
- Installation of containerized plant material to promote establishment of the vegetation community and provide a long term seed source.
- Installation of browse protection to protect containerized plants from deer and beaver browse.
- Seeding with a two-stage seed mix to provide immediate cover for erosion protection, establish perennial vegetation, and establish a native seed bank in the soil.

Table 3-12 summarizes the revegetation criteria and treatments for the Riparian Wetland cover type.

Table 3-12. Riparian Wetland Cover Type Criteria and Revegetation Treatments

Riparian Wetland Cover Type	Total Area = 11.0 acres /Percent of Total Area = 11.0 percent	
Treatments	**Criteria/Description**	**Treatment Area**
Grading	-1.0 to 0 feet relative to 2-year WSE	11.0 acres
Soil Texture	Silt to sandy loam (vegetative backfill) overlying floodplain alluvium or other general fill	11.0 acres
Vegetative Backfill Depth	12 inches (to alluvium)	11.0 acres
Microtopography	Large and coarse woody debris will be partially buried and scattered throughout floodplain and within connected wetland complexes as grade control features	11.0 acres
Containerized Planting: Shrubs and Trees	Shrubs and trees will be installed in all areas of this cover type. Features include: swales, off-channel wetlands and along secondary channels	11.0 acres
Containerized Planting: Herbaceous Plugs	Herbaceous wetland plants will be installed in select areas of this cover type including along the edges of and in between Emergent Wetland features of connected wetland complexes	11.0 acres
Browse Protection	Exclosures or individual browse protectors depending on shape of these areas	TBD
Seeding	Seed with two-stage seed mix for early germination cover crop and long term diverse native mix of grasses and forbs	11.0 acres

3.7.2.5 Floodplain Riparian Shrub

Description

The Floodplain Riparian Shrub cover type will occupy the largest percentage of floodplain area within the Phases 15 and 16 project areas. It will occur mostly at the 2-year WSE, but include areas slightly below and slightly higher. Soils are expected to be saturated for long enough during the growing season to support riparian plant communities with some wetland characteristics.

Plant communities will consist of a variety of shrubs including those species that are components of the Riparian Wetland cover type described above. The Floodplain Riparian Shrub cover type will also have an overstory component consisting of patches of quaking aspen (Populus tremuloides) and black cottonwood (Populus balsamifera ssp. trichocarpa). Understory species will include some wetland graminoids, but drier species such as Rocky Mountain juniper (Juniperus scopulorum) will also be present, particularly where it is necessary to keep floodplain elevations higher to limit risk of a channel avulsion. This cover type will provide structural diversity in the floodplain, diverse terrestrial habitat, and long-term floodplain stability.

Strategy

The revegetation strategy for the Floodplain Riparian Shrub cover type includes:

- Grading and substrate placement associated with floodplain construction. This cover type will occupy the floodplain that is connected at the 2-year WSE, and lower elevation swales will be incorporated into this surface.
- Substrate variation and microtopographic enhancements to provide suitable growth media and microsites for better germination and plant survival.

- Installation of large and coarse woody debris to create niches and microsites for vegetation development as well as add organic matter to the soil.
- Installation of containerized plant material within swale features and potential meander cut-offs to "jump start" the vegetation community and provide a long-term seed source.
- Installation of browse protection to protect containerized plants from ungulate and beaver browse.
- Seeding with a two-stage seed mix to provide immediate cover for erosion protection, establish perennial vegetation, and establish a native seed bank in the soil.

Table 3-13 summarizes revegetation criteria and treatments for the Floodplain Riparian Shrub cover type.

Table 3-13. Floodplain Riparian Shrub Cover Type Criteria and Revegetation Treatments

Floodplain Riparian Shrub Cover Type	Total Area = 69.5 acres Percent of Total Area = 69.7 percent	
Treatments	**Criteria/Description**	**Treatment Area**
Grading	-0.5 to 2.5 feet relative to 2-year WSE	69.5 acres
Soil Texture	Silt loam to sandy loam	69.5 acres
Vegetative Backfill Depth	12 inches (to alluvium)	69.5 acres
Microtopography	Partially buried large and coarse woody debris scattered throughout floodplain	69.5 acres
Containerized Planting	Shrubs and trees installed in swales	4.3 acres
Browse Protection	Exclosures around groups of plantings within swales	TBD
Seeding	Seed with two-stage seed mix for early germination cover crop and long term diverse native mix of grasses and forbs	69.5 acres

3.7.2.6 Outer Bank Riparian Shrub

Description

The Outer Bank Riparian Shrub cover type includes areas where the desired long-term vegetation community is dense, deeply rooted riparian trees and shrubs on outer meander bends where the objective is streambank stability. This cover type will be concentrated along outer meander bends to enhance streambank stability, provide overhanging bank vegetation, and create roughness along the channel margins.

Native woody shrub and tree species will dominate the overstory and mid-canopy layers while a mix of native forbs and grasses would occupy the understory. Deep-rooted shrubs such as willow, birch and dogwood provide streambank stability especially when they are incorporated into streambank bioengineering treatments. Plant communities developing in this cover type will contribute organic material to the stream through leaf litter and as banks erode over time; vegetation will fall into the channel supporting aquatic habitat by creating roughness along the channel margins. This cover type differs from the Floodplain Riparian Shrub cover type because it has a denser distribution of native woody shrubs.

Strategy

The revegetation strategy for the Outer Bank Riparian Shrub cover type includes:

- Grading and substrate placement in association with streambank treatments and floodplain shaping to create suitable growing conditions for native vegetation.

- Installation of large and coarse woody debris to create niches and microsites for vegetation development and promote soil development.
- Installation of containerized plant material in conjunction with streambank treatments.
- Installation of individual browse protection or large browse exclosures around plantings to protect containerized plants from ungulate and beaver browse.
- Seeding with a two-stage seed mix to provide immediate cover for erosion protection, establish perennial vegetation, and establish a native seed bank in the soil.

Table 3-14 summarizes revegetation criteria and treatments for the Outer Bank Riparian Shrub cover type.

Table 3-14. Outer Bank Riparian Shrub Cover Type Criteria and Revegetation Treatments

Outer Bank Riparian Shrub Cover Type	Total Area = 5.4 acres Percent of Total Area = 5.4 percent	
Treatments	**Criteria/Description**	**Treatment Area**
Grading	0 to 2.0 feet relative to 2-year WSE	5.4 acres
Soil Texture	Silt loam to sandy loam (vegetative backfill) overlying bank backfill and floodplain alluvium	5.4 acres
Vegetative Backfill Depth	12 inches (to alluvium)	5.4 acres
Microtopography	Partially buried large and coarse woody debris scattered throughout floodplain	5.4 acres
Containerized Planting: Trees and Shrubs	Planted in all areas throughout the cover type	5.4 acres
Browse Protection	Exclosures or individual protectors depending on proximity to channel and size of planting area	TBD
Seeding	Seed with two-stage seed mix for early germination cover crop and long term diverse native mix of grasses and forbs	5.4 acres

3.7.2.7 Upland Transition

Description

The Upland Transition cover type occurs at two isolated areas along the edge of the newly constructed floodplain where the floodplain transitions to significantly higher ground. This serves as a transitional cover type between the riparian and floodplain vegetation communities to surrounding drier, upland vegetation communities.

The Upland Transition cover type will consist primarily of herbaceous grasses and forb species that are typically adapted for drier growing conditions. However, some species adapted to a wider range of hydrologic conditions will be included to occupy slightly wetter microsites and limit weed invasion. The depth to groundwater is deeper than other cover types and soils will likely be dry throughout most of the growing season. The Upland Transition cover type will primarily serve as an intermediate zone between the floodplain and adjacent uplands, but also supports some floodplain functions such as providing terrestrial habitat, filtering sediment and nutrients associated with agricultural runoff, flood storage during large flood events, and food web support.

Strategy

The revegetation strategy for the Upland Transition cover type includes:

- Grading and substrate placement in association with floodplain shaping to create suitable growing conditions for native upland vegetation.
- Seeding with a two-stage seed mix to promote a diverse, native seed bank.

Table 3-15 summarizes revegetation criteria and treatments for the Emergent Wetland cover type.

Table 3-15. Upland Transition Cover Type Criteria and Revegetation Treatments

Upland Transition Cover Type	Total Area = 1.3 acres / Percent of Total Area = 1.3 percent	
Treatments	**Criteria/Description**	**Treatment Area**
Grading	2.0+ feet relative to 2-year WSE	1.3 acres
Soil Texture	Silt loam to sandy loam (vegetative backfill) overlying floodplain alluvium or other general fill	1.3 acres
Vegetative Backfill Depth	12+ inches (to alluvium)	1.3 acres
Seeding	Drill seed with two-stage seed mix for early germination cover crop and long term diverse native mix of grasses and forbs	1.3 acres

3.7.3 Revegetation Treatments

Table 3-16 summarizes revegetation treatments proposed for the Phases 15 and 16 project area and the general locations where each treatment is proposed for application. Each treatment is described in more detail in the following sections.

Table 3-16. Summary of Revegetation Treatments and General Locations for the Phases 15 and 16 Project Area

Revegetation Treatment	Treatment Location
Floodplain Grading	
Geomorphic Features	All areas within grading limits.
Substrate	All areas within grading limits
Floodplain swales	Within the Floodplain Riparian Shrub cover type
Microtopography	All areas within grading limits except the Exposed Depositional and Upland Transition cover types
Bank Structure Revegetation	Install dormant cuttings within bank treatments according to bank designs

Planting	
Containerized Trees and Shrubs	All vegetation cover types except Upland Transition and Exposed Deposition; only swales within Floodplain Riparian Shrub cover type
Herbaceous Plugs	Areas within Colonizing Depositional, in select areas of the Riparian Wetland cover type, and according to hydrologic zones in the Emergent Wetland cover type
Browse Protection	All areas where containerized trees and shrubs are installed
Seeding	
Two-Stage Seed Mix – Drill Seeding	All areas within grading limits where equipment access is feasible, except the Exposed Depositional cover type
Two-Stage Seed Mix – Broadcast	All areas within grading limits where equipment access is not feasible, except the Exposed Depositional cover type

3.7.3.1 Floodplain Grading

Geomorphic Features

The grading plan includes details for removing contaminated sediments from the floodplain and creating a new floodplain surface. As described above, floodplain cover types are the basis for applying revegetation treatments in the project area according to geomorphic position. Table 3-17 summarizes the grading criteria for each floodplain cover type, and summarizes the total area of each floodplain cover type within the grading limits.

Table 3-17. Relationship of Floodplain Cover Type to Geomorphic Features, Elevation Relative to the 2-Year WSE, and Total Area Based on the Preliminary Design Grading Surface

Floodplain Cover Type	Geomorphic Floodplain Feature	Elevation Relative to 2-Year WSE (feet)	Area (acres)
Exposed Depositional (Non-vegetated)	Non-vegetated portion of point bars	-2.5 to -1.0	1.5
Colonizing Depositional (Vegetated)	Vegetated portion of point bars	-1.0 to 0	7.9
Emergent Wetland	Passive margins along channel; wetlands, oxbows and backwater areas	-2.5 to -1.0	3.2
Riparian Wetland	Bankfull floodplain in backwater areas; edge of emergent wetlands and oxbows	-1.0 to 0	11.0
Floodplain Riparian Shrub	Bankfull floodplain; low terrace	-0.5 to 2.5	69.5
Outer Bank Riparian Shrub	Streambanks along outer meanders	0 to 2.0	5.4
Upland Transition	Slope transitions to higher terraces; high inclusions within Channel Migration Zone	2.0 +	1.3

Substrate Variation

Plant community development within the floodplain requires varied substrate and soil textures, depending on geomorphic position. Two types of surface substrates are specified: bare alluvium in Exposed Depositional and Colonizing Depositional cover types; and Vegetative Backfill (silt to sandy loam in other cover types). Table 3-18 summarizes the desired substrate for each floodplain cover type, and distinguishes among cover types where alluvium should underlie vegetative backfill, and cover types where vegetative backfill can be placed on a wider range of material, depending on what subgrade material is available.

Table 3-18. Substrate Criteria and Volumes for Floodplain Cover Types

Floodplain Cover Type	Soil/Substrate Texture	Vegetative Backfill Depth (inches)	Volume of Vegetative Backfill (cubic yards)
Exposed Depositional (Non-vegetated)	Sand, fine to coarse gravel or cobble, (alluvium)	0	0
Colonizing Depositional (Vegetated)	Sand, fine to coarse gravel or cobble, (alluvium)	0	0
Emergent Wetland	Silt to sandy loam (vegetative backfill)	12	5,093
Riparian Wetland	Silt to sandy loam (vegetative backfill) overlying alluvium	12	17,747
Floodplain Riparian Shrub	Silt loam to sandy loam (vegetative backfill) overlying alluvium	12	112,126
Outer Bank Riparian Shrub	Silt loam to sandy loam (vegetative backfill) overlying alluvium	12	8,712
Upland Transition	Silt loam to sandy loam (vegetative backfill)	12	2,021

Floodplain Swales

Floodplain swales are small depression features incorporated into the Floodplain Riparian Shrub cover type that provide microsites where floodplain vegetation can establish at slightly lower elevations—closer to the water table—than adjacent floodplain surfaces. Floodplain swales also provide flood water and sediment storage at variable flows, in addition to broadening the range of ecological niches available on the floodplain surface to support different life stages (and behaviors) of plant, bird, amphibian and terrestrial wildlife species. To maximize diversity, floodplain swales should vary in size and depth. Dimensions should vary and range from 15 to 30 feet wide and 20 to 50 feet long. Swale depth should be at least one foot below the adjacent surface. For larger swales, depth can be up to 2.5 feet below the adjacent surface. The side slopes of swales should be no steeper than 3:1. Where avulsion risks are a concern, swales should be oriented perpendicular to the channel. Figure 3-12 shows examples of constructed floodplain swales.

Figure 3-12. Examples of Constructed Floodplain Swale Features

Microtopography

This treatment creates complexity and microsites on newly constructed floodplain surfaces to trap and protect seed and other plant propagules, and to provide resistance to erosion by limiting rill formation. Microtopography is created using equipment to roughen the floodplain surface, and partially bury woody debris in the soil (Figure 3-13). Roughness or microtopography creates variation in the constructed floodplain surface (+/- 0.5 feet relative to the design floodplain surface). The woody debris increases soil moisture retention, creates protective microsites for establishing seed and plants, and promotes soil development by introducing organic material. Microtopography should be placed in all floodplain cover types except Exposed Depositional and Upland Transition.

Figure 3-13. Microtopography Placed on a Constructed Floodplain Surface

Two types of woody debris, large and coarse, are included as part of the microtopography treatment. Large woody debris should consist of 8-inch pieces of wood that are at least 10 feet in length and these pieces should be placed at a rate of approximately 50 per acre. Large woody debris should be partially buried within the floodplain surface, leaving no more than half of the log exposed. Smaller, coarse woody debris can be highly variable in size (salvaged material from floodplain clearing within the removal boundary is suitable) and should be placed at a rate of approximately 100 to 150 pieces per acre. Coarse woody debris does not need to be buried but should be scattered within swales or piled around planted shrubs and trees. Coarse woody debris can also function as a deterrent to browse by wildlife.

3.7.3.2 Bank Structure Revegetation

Dormant cuttings from native shrub and tree species are the primary plant material incorporated in bank treatments. Cuttings are collected from plants that root easily, such as willows (*Salix* species) and cottonwoods (*Populus* species). The best species to use for willow cuttings for the Phases 15 and 16 project area, in order of preference are: sandbar willow (*Salix exigua*), Geyer willow (*Salix geyeriana*), Booth's willow (*Salix boothii*), Bebb willow (*Salix bebbiana*), yellow willow (*Salix lutea*), and Pacific willow (*Salix lasiandra*). All species should be used as part of a multi-species collection. In addition to willows, black cottonwood (*Populus balsamifera ssp. trichocarpa*) cuttings can be used in some areas. Red-osier dogwood (*Cornus sericea*) and thin-leafed alder (*Alnus incana*) may also be used as cuttings, but should only be used as part of a mix consisting primarily of willow species. Table 3-19 lists the bank treatment groups that require dormant cuttings and approximate quantities of cuttings needed for each treatment. The bank treatment groups are shown in Sheets D2 and D3.

Table 3-19. Summary of Dormant Willow Cutting Needs for Streambank Treatments

Treatment Group	Treatment Length (feet)	Cuttings per Foot	Total
1	600	10	6,000
2	11,900	5	59,500
3	7,700	5	38,500

3.7.3.3 Planting

Containerized plants will be installed within the following floodplain cover types: Colonizing Depositional, Emergent Wetland, Riparian Wetland, Outer Bank Riparian Shrub, and in swales within the Floodplain Riparian Shrub cover type (Table 3-20). Containerized plant installation locations are shown in Figure 3-9 and Figure 3-10. In general, plant mixes include a mix of riparian tree and shrub species, such as cottonwoods, aspen, willows, currant (*Ribes* species), birch, and alder that may be better suited for the minimal shade conditions and lack of developed soils that will be present on the newly constructed floodplain surface.

In the Floodplain Riparian Shrub cover type, planting will be concentrated within excavated swale features. Shrubs will be installed throughout the Outer Bank Riparian Shrub and Riparian Wetland cover types. Herbaceous plugs, consisting of sedges and rushes, will be installed within the Emergent Wetland and Colonizing Depositional cover types and in select areas of the Riparian Wetland cover type. Table 3-21 through

Table 3-26 provide the species included in each plant mix and

Table 3-27 summarizes the total plant needs by species and container size for the Phases 15 and 16 project area.

Table 3-20. Floodplain Cover Type Planting Locations, Plant Material and Plant Spacing

Floodplain Cover Type	Planting Locations	Type of Plant Materials	Approx. Spacing (feet on center)
Exposed Depositional	None	None	N/A
Colonizing Depositional	All Areas	10t herbaceous 10t shrubs	6 6
Emergent Wetland	All Areas	10t herbaceous	3
Riparian Wetland	All Areas	1 gallon shrubs	8
Floodplain Riparian Shrub	Swales	1 gallon shrubs and trees	8 (shrubs) 15 (trees)
Outer Bank Riparian Shrub	All Areas	1 gallon shrubs and trees	8 (shrubs) 15 (trees)
Upland	None	None	N/A

PLANT MIXES

Final plant lists are being developed in cooperation with the Grant-Kohrs Ranch to meet revegetation objectives consistent with Appendix E of the ROD. This decision process will be documented in a separate report. Any changes or updates to the revegetation plan will be addressed during the final design process.

The following tables include preliminary lists of species for plant mixes to be used for the Phases 15 and 16 project area. These species lists will be modified during final design, based on ongoing coordination with the Grant-Kohrs Ranch.

Table 3-21. Colonizing Depositional - Herbaceous Plant Mix

Scientific Name	Common Name	Percent of Mix
Carex aquatilis	water sedge	20
Carex nebrascensis	Nebraska sedge	10
Carex pellita (syn. C. lanuginosa)	woolly sedge	10
Carex utriculata	Northwest Territory sedge	20
Eleocharis palustris	common spikerush	10
Juncus arcticus	arctic rush	10
Scirpus microcarpus	panicled bulrush	20
	Total	**100**

Table 3-22. Colonizing Depositional - Shrub Plant Mix

Scientific Name	Common Name	Percent of Mix
Alnus incana	gray alder	5
Betula occidentalis	water birch	20
Salix bebbiana	Bebb willow	5
Salix boothi	Booth's willow	20
Salix exigua	sandbar willow	45
Salix geyeriana	Geyer willow	5
	Total	**100**

Table 3-23. Emergent Wetland – Herbaceous Plant Mix

Scientific Name	Common Name	Percent of Mix
Carex aquatilis	water sedge	15
Carex microptera	small winged sedge	5
Carex nebrascensis	Nebraska sedge	5
Carex pellita (syn. C. lanuginosa)	woolly sedge	5
Carex utriculata	Northwest Territory sedge	10
Carex vesicaria	inflated sedge	20
Eleocharis palustris	common spikerush	10
Juncus arcticus	arctic rush	10
Schoenoplectus acutus	hardstem bulrush	10
Scirpus microcarpus	panicled bulrush	10
	Total	**100**

Table 3-24. Riparian Wetland – Shrub Plant Mix

Scientific Name	Common Name	Percent of Mix
Alnus incana	gray alder	10
Betula occidentalis	water birch	15
Cornus sericea	red-osier dogwood	10
Ribes setosum	inland gooseberry	10
Salix bebbiana	Bebb willow	10
Salix boothii	Booth's willow	10
Salix exigua	sandbar willow	20
Salix geyeriana	Geyer willow	5
Salix lutea	yellow willow	5
Salix planifolia	plane-leaf willow	5
	Total	**100**

Table 3-25. Floodplain Riparian Shrub Swales – Tree and Shrub Plant Mix

Scientific Name	Common Name	Percent of Mix
Trees		
Populus balsamifera ssp. trichocarpa	black cottonwood	85
Populus tremuloides	quaking aspen	15
	Total	**100**
Shrubs		
Alnus incana	gray alder	10
Betula occidentalis	water birch	10
Cornus sericea	red osier dogwood	10
Ribes setosum	inland gooseberry	10
Salix bebbiana	Bebb willow	10
Salix boothii	Booth's willow	5
Salix exigua	sandbar willow	10
Salix geyeriana	Geyer willow	5
Salix lutea	yellow willow	5
Salix planifolia	plane-leaf willow	5
Sheperdia argentea	silver buffaloberry	10
Symphoricarpos occidentalis	western snowberry	10
	Total	**100**

Table 3-26. Outer Bank Riparian Shrub – Tree and Shrub Plant Mix

Scientific Name	Common Name	Percent of Mix
Trees		
Populus balsamifera ssp. trichocarpa	black cottonwood	85
Populus tremuloides	quaking aspen	15
	Total	**100**
Shrubs		
Alnus incana	gray alder	5
Betula occidentalis	water birch	15
Cornus sericea	red-osier dogwood	10
Dasiphora floribunda	shrubby cinquefoil	5
Ribes aureum	golden currant	5
Ribes setosum	inland gooseberry	5
Rosa woodsii	Woods' rose	5
Salix bebbiana	Bebb willow	10
Salix boothii	Booth's willow	10
Salix exigua	sandbar willow	5
Salix lutea	yellow willow	5
Sheperdia argentea	silver buffaloberry	15
Symphoricarpos occidentalis	western snowberry	5
	Total	**100**

Table 3-27. Total Plants for Phases 15 and 16 Project Area by Species

Scientific Name	Common Name	Container Size
Graminoids		
Carex aquatilis	water sedge	10t
Carex microptera	small winged sedge	10t
Carex nebrascensis	Nebraska sedge	10t
Carex pellita (syn. C. lanuginosa)	woolly sedge	10t
Carex utriculata	Northwest Territory sedge	10t
Carex vesicaria	inflated sedge	10t
Eleocharis palustris	common spikerush	10t
Juncus arcticus	arctic rush	10t
Schoenoplectus acutus	hardstem bulrush	10t
Scirpus microcarpus	panicled bulrush	10t
Shrubs		
Alnus incana	gray alder	1 gallon
		10t
Betula occidentalis	water birch	1 gallon
		10t
Cornus sericea	red-osier dogwood	1 gallon
Dasiphora floribunda	shrubby cinquefoil	1 gallon
Ribes aureum	golden currant	1 gallon
Ribes setosum	inland gooseberry	1 gallon
Rosa woodsii	Woods' rose	1 gallon
Salix bebbiana	Bebb willow	1 gallon
		10t
Salix boothii	Booth's willow	1 gallon
		10t
Salix exigua	sandbar willow	1 gallon
		10t
Salix geyeriana	Geyer willow	1 gallon
		10t
Salix lutea	yellow willow	1 gallon
Salix planifolia	plane-leaf willow	1 gallon
Sheperdia argentea	silver buffalo berry	1 gallon
Symphoricarpos occidentalis	western snowberry	1 gallon
Trees		
Populus balsamifera ssp. trichocarpa	black cottonwood	1 gallon
Populus tremuloides	quaking aspen	1 gallon

3.7.3.4 Browse Protection

Browse protection measures are intended to protect planted shrubs and trees from browse and other damage caused by wildlife. Two types of browse protection may be used for the Phases 15 and 16 project area: fenced exclosures and individual plant protectors. Exclosures are the preferred method of protection because they require less maintenance than individual protectors and can protect plantings over a longer period of time. Exclosures will target groups of plants installed in constructed floodplain swale and wetland features. Individual protectors will be needed in areas where the feasibility of exclosure fencing installation is difficult; for example, linear planting units immediately adjacent to the channel.

A variety of fencing options are available to construct browse exclosures. The preferred fence option for floodplain swales includes 12-foot long, 4-inch diameter untreated wooden posts installed vertically at least 3 feet deep along the perimeter of a swale with a sturdy plastic mesh fencing material, such as Deer-D-Fence (Figure 3-14, left). The fencing material is secured to the posts using releasable cable ties or other fastenings that would allow removal of fencing during high flows. Individual browse protectors consist of a 4-foot wide by 4-foot tall piece of black polyethylene (UV-stabilized), extruded

Figure 3-14. Examples of Browse Protection Measures: Wildlife Exclosure Fence (left) and Individual Browse Protectors (right).

mesh rounded into a 16-inch diameter cylinder (Figure 3-14, right). The individual browse protector encloses a plant and is secured to two, 2-inch square wooden stakes with releasable cable ties. The browse protector should be installed so its base is in contact with the ground surface to discourage rodents from girdling plants.

3.7.3.5 Seeding

Establishing native vegetative cover on the newly created floodplain is essential for maintaining soil stability and preventing weed infestations. Planting will establish native vegetation in portions of the floodplain, but seeding is the primary mechanism for stabilizing soil within the new floodplain. To ensure quick, long-lasting vegetation establishment a two-stage seed mix will be used. The two-stage seed mix includes two components: a mix of quick germinating species (nurse crop or cover crop) that will provide immediate cover to limit colonization by invasive species and a mix of long-term desired species that may not germinate immediately after construction because they require a stratification period. Seed mixes consist of a range of herbaceous species including grasses, forbs, sedges and/or rushes. Woody species may also be seeded in select areas within most of the floodplain cover types.

Several seed mixes will be used throughout the floodplain to support establishment of desired plant communities. Seed mixes are linked to specific floodplain cover types. Table 3-28 summarizes seed mixes by floodplain cover type. Table 3-29 through Table 3-32 provide the species for each seed mix.

Various methods for seeding may be required due to ground conditions or because the variety of seeds within the seed mixes need to be planted at different depths and/or during different seasons. Hand broadcast seeding will be required in most areas where microtopography treatment is installed. The roughness created by the microtopography treatment makes equipment access difficult or impossible. Broadcast seed should be either hand raked or harrowed into the soil after application, depending on the size and sensitivity of the seeded areas. Drill seeding should be possible in the Upland Transition cover type where the microtopography treatment will not be applied.

Table 3-28. Summary of Seed Mixes for Floodplain Cover Types

Floodplain Cover Type	Seed Mix
Colonizing Depositional (Vegetated)	Wet Floodplain
Emergent Wetland	Wetland
Riparian Wetland	Wet Floodplain
Floodplain Riparian Shrub	Floodplain
Outer Bank Riparian Shrub	Floodplain
Upland Transition	Upland

Table 3-29. Wetland Floodplain Seed Mix

Scientific Name	Common Name
Grasses	
Deschampsia caespitosa	tufted hairgrass
Elymus canadensis	Canada wildrye
Elymus trachycaulus	slender wheatgrass
Leymus (Elymus) cinereus	great basin wildrye
Pascopyrum smithii	western wheatgrass
Poa compressa	Canada bluegrass
Sporobolus airoides	alkali sacaton
Forbs	
Achillea millefolium	common yarrow
Argentina anserina	silverweed cinquefoil
Artemisia ludoviciana	white sage
Aster occidentalis	western aster
Astragalus canadensis	Canadian milkvetch
Cleome serrulata	Rocky Mountain bee plant
Linum lewisii	Lewis flax
Verbena hastata	swamp verbena

Table 3-30. Floodplain Seed Mix

Scientific Name	Common Name
Grasses	
Sterile cover crop	(To be determined)
Agropyron riparium	streambank wheatgrass
Elymus canadensis	Canada wildrye
Elymus lanceolatus	thickspike wheatgrass
Elymus trachycaulus	slender wheatgrass
Leymus (Elymus) cinereus	great basin wildrye
Forbs	
Achillea millefolium	common yarrow
Artemisia ludoviciana	White sage
Astragalus canadensis	Canadian milkvetch
Cleome serrulata	Rocky Mountain bee plant
Gaillardia spp.	blanketflower
Linum lewisii	Lewis flax
Verbena hastata	swamp verbena
Shrubs	
Cornus sericea	red-osier dogwood
Dasiphora floribunda	shrubby cinquefoil
Ribes setosum	inland gooseberry
Shepherdia argentea	silver buffaloberry

Table 3-31. Wetland Seed Mix

Scientific Name	Common Name
Grasses	
Beckmannia syzigachne	American sloughgrass
Carex aquatilis	water sedge
Carex pellita (syn. *C. lanuginosa*)	woolly sedge
Carex microptera	small winged sedge
Carex utriculata	beaked sedge
Deschampsia cespitosa	tufted hairgrass
Eleocharis palustris	creeping spikerush
Elymus trachycaulus	slender wheatgrass
Glyceria striata	fowl mannagrass
Juncus arcticus	arctic rush
Schoenoplectus acutus	hardstem bulrush
Scirpus microcarpus	panicled bulrush
Forbs	
Argentina anserina	silverweed cinquefoil
Iris missouriensis	Rocky Mountain Iris
Mimulus gutattus	seep monkey flower

Table 3-32. Upland Seed Mix

Scientific Name	Common Name
Grasses	
Sterile cover crop	(To be determined)
Bromus marginatus	mountain brome
Leymus (Elymus) cinereus	great basin wildrye
Elymus trachycaulus	slender wheatgrass
Elymus lanceolatus	thickspike wheatgrass
Festuca idahoensis	Idaho fescue
Pascopyrum smithii	western wheatgrass
Poa secunda	Sandberg bluegrass
Stipa viridula	green needlegrass
Forbs	
Achillea millefolium	common yarrow
Artemisia ludoviciana	white sage
Gaillardia spp.	blanketflower
Shrubs	
Artemisia cana	silver sagebrush
Artemisia frigida	prairie sagewort
Dasiphora floribunda	shrubby cinquefoil
Ericameria nauseosa	rubber rabbitbrush
Ribes setosum	inland gooseberry
Shepherdia argentea	silver buffaloberry

3.7.4 Preservation Areas within Removal Boundary

The following types of preservation areas occur in the Phases 15 and 16 project area:

- Areas within the CMZ where contaminated sediments are not present,
- Hydrologically connected native wetland and riparian vegetation, and
- Cottonwood stands

Some areas within the extents of soil sampling were found to have clusters of soil pits with no contamination, and these areas are shown as receiving no grading or revegetation treatments in the PDP drawings. These clean areas occur within a mix of existing vegetation communities described in Section 2, and the boundaries do not correspond with existing vegetation community boundaries.

Mature cottonwoods are rare within Phases 15 and 16 of the CFROU and include the Cottonwood Stand and Willow/Birch – Cottonwood Overstory existing vegetation communities described in Section 2 and Appendix C. These communities comprise approximately 1.1 acres (Figure 3-9 and Figure 3-10). Because cottonwood stands are uncommon and provide important habitat and seed sources within the CFROU, they will be preserved regardless of their location and the depth of contaminated sediments.

All preservation areas will be clearly marked in the field prior to the start of construction. Floodplain grading will work up to the edges of the preservation area, grading to the necessary depth to remove contaminants from the surrounding area. Alluvium and vegetative backfill will be placed to the necessary depths as specified for the assigned floodplain cover types. Final grading will result in gentle slopes of no steeper than 3H:1V between the vegetation preservation areas and the constructed floodplain.

3.7.5 Weed Management and Long Term Maintenance

Weed management will occur prior to, in conjunction with, and after the revegetation activities described above. During construction the following practices should be followed to avoid the introduction and spread of noxious weeds:

- All vehicles and equipment should arrive free of weeds and weed seeds.
- Vehicle and equipment traffic should remain within designated construction limits and on designated access routes.
- Driving through existing weed infestations should be avoided to the greatest extent possible.
- Noxious weed infestations adjacent to construction limits should be treated according to relevant weed management plans in order to prohibit the spread of infestations within construction limits.
- All vegetative backfill used during revegetation should be weed and weed seed free.

Vegetation mapping conducted in 2012 identified the state-listed noxious weed species within the project area (Table 3-33). Other noxious weeds may be present at the site that were not recorded within the vegetation sampling plots. Noxious weeds identified at the site are listed as Priority 2a, 2b, and 3 by the State of Montana (Montana Department of Agriculture, 2010). Priority 2a weeds are common in isolated areas in Montana and management criteria require eradication or containment where less abundant. Priority 2b weeds are abundant in Montana and widespread in many counties, and management criteria require eradication or containment where less abundant. Priority 3 weeds are regulated plants, but are not Montana listed noxious weeds. Regulated plants have the potential for significant negative impacts; they may not be intentionally spread or sold; and the State recommends research, education, and prevention to minimize the spread of the plant (Montana Department of Agriculture, 2013).

A long-term weed management plan will be necessary to control weed infestations at the site post-construction and to ensure project goals and objectives are met. Weed management will be most successful if it is coordinated with local weed management experts and authorities. Development of a long-term vegetation management plan for the site and post-construction weed mapping should be coordinated with the Anaconda/Deer Lodge Weed Coordinator, adjacent private landowners and watershed groups such as the Upper Clark Fork River Vegetation Working Group.

Table 3-33. Noxious Weed Species Found in Phases 15 and 16 and Listing Priority

Scientific Name	Common Name	Priority
Bromus tectorum	cheatgrass	3
Cirsium arvense	Canada thistle	2b
Euphorbia esula	leafy spurge	2b
Ranunculus acris	tall buttercup	2a

3.8 SUPPORTING DESIGN ELEMENTS

This section describes supporting design elements that enable the construction of the project but do not directly affect the goals of tailings removal, floodplain and bank reconstruction, and revegetation. These supporting design elements are groundwater dewatering, transportation, and project landowners.

3.8.1 Groundwater Dewatering

To mitigate the problems associated with excavation, transport, and disposal of saturated tailings/impacted soils, the groundwater level in the floodplain will be lowered through groundwater dewatering. The groundwater dewatering system consists of a series of collector trenches from which water will be pumped into sediment detention ponds before being discharged to the CFR.

3.8.1.1 Objectives

The objective of groundwater dewatering is to permit handling of relatively dry tailings/impacted soils removal activities. It is difficult to keep clean and contaminated materials from mixing when they are saturated. In addition, wet tailings/impacted soils would otherwise have to be stockpiled and allowed to drain prior to hauling, which would require double handling by the construction contractor. Dewatering tailings/impacted soils will ease handling and will lower the moisture content for direct placement in the B2.12 Cell at Opportunity Ponds.

3.8.1.2 Design Criteria

Based on construction experience gained from past floodplain dewatering projects, the following design criteria will serve as guidelines for locating the groundwater dewatering trenches:

1. Locate the centerline of outer trenches within 40 feet of the outer extent of the impacted soils saturated by groundwater.

2. Groundwater must be detained for a sufficient amount of time to reduce turbidity prior to release to the CFR. Sediment detention ponds shall be sized based on the project flow in the trenches and guidelines outlined in Montana Sediment and Erosion Control Manual (DEQ, 1996).

<u>Design Components</u>

The groundwater dewatering system consists of three design components: 1) dewatering trenches designed to lower the groundwater in the floodplain; 2) sediment detention ponds designed to capture sediment from the dewatering trenches; and 3) collection sumps, pumps, and piping to transmit the water to and from the sediment detention basins.

Construction of the dewatering trenches will begin with excavation of the sumps at the downgradient end of the trenches. A typical groundwater dewatering cross-section is shown on Sheet D1, Dewatering Details. The base of the sumps shall be at least 2 feet below the grade of the dewatering trench. The sumps will be packed with gravel to filter sediment. The pump system must operate continuously with a backup pumping system available onsite consisting of a spare pump and generator or compressor.

The approximate locations of the groundwater dewatering trenches were determined using the design criteria mentioned above. A typical groundwater dewatering cross-section is shown on Drawing D1, Dewatering Details. After the construction of each trench is complete the pumped discharge is clear, the discharge from that trench will be rerouted directly to the river. Construction of the dewatering trenches should be completed at least two weeks prior to the initiation of the tailings/impacted soils removal.

The tailings/impacted soils excavated from the groundwater dewatering trenches will be disposed in the B2.12 Cell at Opportunity Ponds. Saturated tailings/impacted soils must be stockpiled to drain water prior to hauling to the B2.12 Cell.

Drawing D1, Dewatering Details, shows a cross section and plan of a typical sediment detention pond. Approximate pond locations are shown on Drawings C4 through C6, Dewatering Plan. Most ponds will require excavation of tailings/impacted soils in the pond footprint before pond construction. Pond embankments will be constructed from clean local material or imported borrow material. The depth of the ponds shall be 3.5 feet from the top of the embankment to the bottom of the basin.

The sediment detention pond embankments shall be constructed in 12-inch maximum lifts and compacted to at least 95 percent of maximum standard Proctor density. To minimize the size of the sediment ponds, the trenches should be constructed sequentially and connected one trench at a time. After the construction of each trench is completed and the discharge is visibly free from sediment, the dewatering discharge will be routed directly from the trench to the CFR. The inlet area of the sediment detention ponds shall be protected from erosion with filter fabric covered by stone. The discharge areas from the ponds into the stream channel shall be similarly protected. Ponds will be removed after they are no longer needed.

3.8.2 Haul Roads

Haul routes will be necessary to transport waste materials and borrow to and from the Reach A, Phases 15 and 16 project area. The borrow source for Reach A, Phases 15 and 16 is located approximately 4.5 miles to the south at the former Beck Ranch. The waste materials will be transported to the B2.12 Cell at Opportunity Ponds, located approximately 19 miles to the south. Both routes will be along existing local road infrastructure.

Haul Roads located within the Reach A, Phases 15 and 16 remedial action area will be designed as part of the Construction Bid Package where the specific haul road alignment will be determined. The construction contractor will be responsible to design and construct the haul roads, approaches and crossings for the anticipated loads and sizes of the trucks utilized for hauling waste materials and borrow material. Adequate drainage measures will be required, including culverts at drainage crossings, irrigation ditches, creeks, and road ditches.

3.8.2.1 Objectives

Haul routes will be established for safe and efficient materials handling from the Beck Ranch borrow source and to the B2.12 Cell at Opportunity Ponds. Haul roads within Reach A, Phases 15 and 16 will be developed in order to facilitate movement of both waste and borrow materials. Development of haul routes will allow over-the-road (OTR) vehicles to both directly deliver to, and remove materials from, the construction areas. During construction activities related to the Reach A, Phases 15 and 16 remedial action, haul routes and crossings (public roads, railways, and utilities) will be maintained and appropriate traffic control will be instituted to sustain safe traffic flows.

3.8.2.2 Design Criteria

Waste materials in Reach A, Phases 15 and 16 will be transported to the B2.12 Cell at Opportunity Ponds. Approximately 387,500 cy of waste material will be transported an average distance of 21.5 road miles. For floodplain reconstruction, approximately 161,700 cy of borrow material will be transported from the Beck Ranch borrow source an average distance of 6.5 road miles. OTR type vehicles will be utilized to transfer materials from the borrow source area. The planned haul routes will require crossing the Burlington Northern Santa Fe (BNSF) Railway, public road intersections, and utilities while transporting both waste and borrow source materials.

The following design criteria were developed for the design of construction haul routes/roads for Reach A, Phases 15 and 16 remedial action:

- Minimize haul lengths;
- Minimize the disturbance of non-contaminated areas;
- Minimize disruption to GKR activities;
- Minimize the effects on the public;
- Maximize safety; and
- Utilize a cost effective design.

3.8.2.3 Design Components

Haul routes have been selected for the transport of materials based on the design criteria. Specific road routes have been determined for both the Beck Ranch borrow source and Mine Waste Relocation Repository Route. Only general design parameters have been developed as design and construction of both primary and secondary haul roads will be the responsibility of the construction contractor.

All ingress/egress traffic for the CFROU Reach A, Phases 15 and 16 project area will be limited to the Washington Street entrance. Construction traffic across the Cattle Driver Road Bridge crossing the CFR will also be prohibited. It is anticipated that the construction contractor will build internal river crossings utilizing temporary bridges. Coordination with GKR personnel will be completed prior to construction of temporary bridges.

3.8.2.4 Beck Ranch Borrow Source Haul Route

Alternative haul routes for the Beck Borrow source are being evaluated for consistency with project goals including safety and cost effectiveness. Although a preliminary haul route has been selected, alternatives will continue to be evaluated.

The preliminary route will start at the Beck Ranch borrow source location and proceed 0.5 miles to Lake Hill Road. The route will then proceed northeast 0.4 miles where it will intersect Greenhouse Road, then northerly along Greenhouse Road approximately 3.3 miles to the intersection with West Peterson Ave. Both Lake Hill and Green House Roads are secondary county roads consisting of gravels and some degrading pavements.

Some road improvements were made to both Lake Hill and Green House Roads during prior CFR Phases 15, and 16 remedial actions; however, additional road improvements may be warranted to accommodate the CFR Phases 15 and 16 OTR traffic. The route will then proceed west along West Peterson Ave for 0.75 miles to the intersection of Airport Road, then north 0.5 miles to the intersection of Airport Road and West Milwaukee Ave. The route will then proceed east on West Milwaukee Ave for 0.6 miles to the intersection of Washington Street, then north on Washington street to the GKR. The haul route from the Beck Ranch to the Reach A, Phases 15 and 16 project area is displayed on Sheet C19, Transportation Plan.

3.8.2.5 Mine Waste Relocation Repository Route

Mine wastes will be removed during Reach A, Phases 15 and 16 remedial action and will be deposited at the B2.12 Cell at Opportunity Ponds. The route to the mine waste repository will begin at the Reach A, Phases 15 and 16 project area and proceed south along Washington Street to the intersection of West Milwaukee Ave, then west for 0.6 miles to the intersection of West Milwaukee Road and Airport Road. The route will then proceed south 0.5 mile on Airport Road to West Peterson Ave, then east for 0.75 mile to the intersection of Greenhouse Road, then southerly on Greenhouse Road for 1.2 miles to the intersection of an unnamed cross road (cross road-1) connecting Greenhouse Road to the Frontage Road. The route will cross the BNSF Railway near the I-90 Frontage Road on cross road-1. The route will then head south along the I-90 Frontage Road 14.3 miles to the intersection of Montana Highway 48 (MT 48). Proceeding westerly along MT 48, the route will cross the BNSF Railway approximately 275 feet from the intersection and proceed along MT 48 approximately 3.75 miles to the B2.12 Cell at Opportunity Ponds. The haul route from the Reach A, Phases 15 and 16 project area to the B2.12 Cell at Opportunity Ponds is displayed on Sheet C19, Transportation Plan.

An alternative haul route option utilizing the BNSF Railway to transport mine waste to the B2.12 Cell at Opportunity Ponds is currently being explored for feasibility.

3.8.2.6 Alluvial Material Haul Route

Alluvial material haul routes will generally follow the existing materials haul routes described above, depending on the source location. Currently, at least two alluvial material sources have been identified in close proximity to the CFROU Reach A, Phases 15 and 16 project area.

River, Stream, Diversion Channel, and Utility Crossings

The construction of the Reach A, Phases 15 and 16 remedial action internal haul roads system will require river and limited utility crossings during the transport of both waste and borrow materials. Water crossings in Reach A, Phases 15 and 16 will be designed and constructed by the construction contractor with approval from DEQ, GKR, and Engineer and will be placed only in areas where stream bank preservation efforts are not being conducted. Irrigation ditch crossings will be coordinated with GKR and other applicable ditch owners prior to construction. The road fill over the flow structures will be adequate to provide minimum structure cover requirements and maintain maximum road grades, but shall be designed as small as possible to create minimal flow restriction. Crossings shall include erosion protection for the flow structures and fill embankments. Road approaches to the crossings will be constructed at or below the floodplain surface grades to allow passage of flood flows with minimal backwater accumulation.

Utility crossings will be constructed in accordance with the appropriate utility requirements and will be inspected by individual utility representatives prior to use by construction equipment. Utility crossings for the haul roads will be required to contain measures to prevent damage to existing structures including both underground and overhead utilities. All known utilities have been identified on Sheets C1 through C3, Existing Conditions.

Other utilities may exist that are not shown on the drawings. The construction contractor will be responsible for coordination with the appropriate utility representatives to determine locations and crossing requirements. The construction contractor will be required to have all utilities located at the exact crossing locations prior to excavation or heavy equipment mobilization, determine their depths below ground surface, obtain soil engineering properties of the overburden material, and conduct an engineering analysis to design an appropriate crossing structure. The design and installation procedures shall be submitted to the appropriate utility, DEQ, GKR, and Engineer prior to implementation and installation. Public road crossings will be constructed to maximize vehicle visibility and stopping distances.

3.8.3 Landowner

Land in the CFROU Reach A, Phases 15 and 16 project area is under control of the NPS and operates as the GKR. The GKR is a National Park generally open to the public and operates as a working cattle ranch with irrigated and non-irrigated pastures, grazing lands, hay ground, and historical tours. The GKR currently utilizes some of the floodplain for cattle grazing, although cattle have been explicitly excluded from grazing in the 127-acre fenced (Sheets C1 through C3, Existing Conditions) riparian corridor since spring 1994. Cattle are currently rotated through upland and irrigated pastures. (USDI, 2007)

The construction contractor will be required to work closely with GKR personnel in order to minimize disruption of GKR ranching and visitor activities. GKR personnel will require access along routes that will also be utilized by the construction contractor for this remedial action. Proper coordination between GKR personnel and the construction contractor will be imperative in order to ensure a safe and efficient project worksite.

3.8.4 Traffic Control

Traffic control will be required and appropriate for the size and type of haul equipment used. It is anticipated that the primary haul vehicle for waste materials and borrow material will be OTR haul trucks; however, scrapers and other excavation equipment may be used during construction activities.

The construction contractor will be required to submit a Traffic Control Plan outlining controls, signing, barricades and access control stations in accordance with Part VI of the Manual on Uniform Traffic Control Devices (MUTCD) and Montana Department of Transportation (MDT) Detailed Drawing. The Traffic Control Plan shall be submitted to DEQ, GKR, and Engineer for their approval.

Traffic control will also include control of the two crossings of the BNSF Railway. Railroad crossings and other uncontrolled intersections are considered “areas of concern” and will require enhanced traffic control measures. The construction contractor shall coordinate the required crossing system with BNSF Railway. It is anticipated that both the cross road-1 and the MT 48 crossings of the BNSF Railway will require flaggers during the potential operational hours of the railway. Areas of concern requiring enhanced traffic control measures have been identified on Sheet C19, Transportation Plan.

3.8.5 Irrigation

Current and historic GKR activities include flood irrigation of hay fields and grazing areas. GKR personnel have evaluated this PDP for conflicts with current irrigation ditch use. None of the presently used arterial ditches are located within the construction boundary for this remedial action; however, a small portion of the Kohrs-Manning ditch south of Cottonwood Creek is located in the removal boundary. Some of the ditches may need to be modified/removed temporarily in order to meet access and haul traffic requirements. Changes or impacts to the Kohrs-Manning ditch or other ditches need approval by all ditch owners prior to implementation.

The construction contractor will be required to consult with GKR personnel prior to any modifications of irrigation ditches. Any modifications or alterations will be removed immediately upon construction completion and pre-construction ditch conditions restored.

Approximately 250 feet of the Kohr-Manning irrigation ditch is located within the preliminary design removal boundary. An analysis of the data indicates the depth of contamination in soils surrounding the irrigation ditch may be greater than the depth of the bottom of the ditch. Tailings/impacted soils will be removed from the surrounding edges of the ditch while maintaining a 3H:1V slope to protect the channel from erosion or other damage. Work will be conducted during periods in which the Kohrs-Manning ditch is not flowing water so that irrigation needs of downstream users is not interrupted.

3.8.6 Mine Waste Repository

This section describes the design for the B2.12 Cell at Opportunity Ponds, which will be used for relocation of all tailings/impacted soils excavated during the Reach A, Phases 15 and 16 construction. More specifically, the repository will be constructed in the eastern portion of the B2.12 Cell at Opportunity Ponds, as displayed on Sheet C21, Repository Plan.

3.8.6.1 Site Characteristics

The B2.12 Cell is situated in the northwest portion of the Opportunity Ponds complex. The cell is approximately 200 acres in size and is surrounded by earthen berms. A railroad spur and load out structure are located near the cell's southwest corner and is currently used for placement of mine waste materials from the Streamside Tailings Operable Unit projects. The pond complex is located in a semiarid region and average annual precipitation is expected to be within the range of 10 to 14 inches per year, based on rainfall data for Butte, Montana.

Tailings waste material was placed in the cell during past operation of the nearby Anaconda Company Smelter. Initial depth of tailings material was estimated at 10 to 20 feet, based on comparison of elevation contours for B2.12 Cell to adjacent areas which were undisturbed. Characteristics of the smelter tailings was not determined but is expected to consist of mostly silt and sand size material. The cell's foundation material likely consists of sand and gravel similar to that exposed along the margins of the Opportunity Ponds complex. Depth to groundwater is estimated at 10 to 20 feet below the contact between smelter tailings and foundation soil.

3.8.6.2 Repository Placement

The repository for the Reach A, Phases 15 and 16 tailings/impacted soils will be in the eastern portion of the B2.12 Cell as displayed on Sheet C21, Repository Plan. Selection of this location was based on access into the B2.12 Cell from MT 48 and to separate the Reach A, Phases 15 and 16 placement activity from other ongoing construction activities within the cell.

The layout for the repository provides for placement of 387,500 cy of waste with side slopes at 4H:1V. Tailings/impacted soils will be placed in maximum 2-foot lifts and compacted by running haul traffic uniformly over the waste surface. If the Anaconda Smelter tailings are too soft to allow equipment operation and proper compaction, an alternate method of waste disposal will include placement of an initial lift 4 to 5 feet thick that is graded and compacted to provide a surface on which equipment can then work, followed by placement of 2-foot lifts of tailings/impacted soils.

3.8.7 Construction Sequencing

Construction could be accomplished in one construction season, provided construction begins in early April. Contract award will need to be made in March to allow submittal and approval of required plans. Certain activities (i.e bank treatment work) will need to be performed at certain times of year due to seasonal high water, weather conditions and planting requirements. Most floodplain planting will be accomplished in spring and fall of the following construction year, but bank planting will occur during the construction year as the banks are built up until July 31, and can resume again after October 1. Given these construction and planting constraints, the following construction sequence is anticipated for Phases 15 and 16.

- March: Construction bidding and submittal review and approval.
- April: Develop staging area and mobilize equipment to site. Install fencing and BMPs for erosion control. Begin clearing and grubbing and construct haul roads.
- April – May: Develop borrow areas and build haul roads.
- May – November: Dewatering, tailings/impacted soils excavation, and floodplain backfill. Floodplain excavation and backfilling shall proceed generally from upstream to downstream. These activities will be ongoing during most of the project and usually constitute the critical path.
- July – November: Low flow period for bank treatment construction. Vegetation components of bank treatments will be phased so they occur prior to July 31 or after October 1.

Seeding should occur at the first opportune time after completion of final grading, including microtopography and incorporation of coarse wood. This will likely be late fall if the above schedule is maintained. Seeding and planting can also occur in the spring if portions of the floodplain are not finished in late fall.

Floodplain excavation and construction should proceed generally from upstream to downstream; however, groundwater levels at the time of construction may dictate the initial work areas. Work may proceed on opposite sides of the river simultaneously or the contractor may choose to work on one side and then the other. No more than 10 acres of floodplain shall be under construction at one time including dewatering, excavation, and backfill to final grade.

3.9 SUPPORTING PLANS

This section describes supporting plans for the Phases 15 and 16 remedial action. These plans are prepared to guide aspects of construction such as quality assurance (QA) and environmental protection that are outside the primary design objectives. Four plans are described here:

1. Construction Quality Assurance/Quality Control Plan;
2. Construction Stormwater Best Management Practices Plan;
3. Dust Control Plan, and
4. Weed Control Plan.

In some cases DEQ has prepared a generic plan to address an activity for the entire CFROU; in other cases, a specific plan needs to be prepared by the construction contractor to address the activity. The section provides a summary of what is required by each plan and how responsibilities for items in the plan are apportioned.

3.9.1 Construction Quality Control and Quality Assurance

Construction quality control (QC) will be the responsibility of the construction contractor. QC responsibilities are identified in the Special Provisions and Technical Specification of the remedial action construction documents. The DEQ and the EPA have responsibility to implement and maintain a QA program that ensures the overall quality of the project. DEQ will prepare a site-specific Phases 15 and 16 Construction Quality Assurance Plan (CQAP) prior to construction.

The main purpose of the CQAP is to outline QA procedures for confirming that the remedial action for the CFROU meets all performance standards presented in the Property Specific Remedial Action Work Plans/Bid Packages, plans, specifications and other Remedial Design/Remedial Action documents. The specific objectives of the CQAP are:

- Define the QA team organization and responsibilities;
- Define the interaction between the QA program and the contractor’s QC plan;
- Describe project communication, documentation and record keeping protocols, on-site communications, progress meetings and preparation of progress reports and construction files; and
- Detail the role of the QA team in reviewing and approving certification and calibration submittals; surveying and verifying construction grade and alignment; conducting verification testing, sampling and analysis; and monitoring during Remedial Action construction activities.

These QA efforts are in addition to the contractor QC program testing and analysis. The site-specific CQAP will account for activities to be implemented in Phases 15 and 16 construction.

3.9.2 Construction Stormwater Best Management Practices

The Construction Stormwater Best Management Practices Plan (CSWBMPP) provides information necessary to ensure that the substantive requirements of the Montana General Permit for Storm Water Discharges Associated with Construction Activity are met. DEQ has prepared a draft of this plan that addresses the entire CFROU. The CSWBMPP (DEQ,2009) identifies types of actions where construction activities will require the use of erosion control best management practices (BMPs) and the best type of BMP suitable for each location. Erosion control BMPs are expected to be implemented at locations where tailings/impacted soils will be removed; construction roads; borrow areas, construction staging areas, streambanks, and areas where soils will be lime-amended, if any. In addition, the CSWBMPP will outline the necessary requirements for monitoring and documenting erosion control activities. This plan will be updated during final design to address all storm water BMPs expected to be used in Phases 15 and 16 construction.

The specifications require that the construction contractor prepare an erosion control plan that reflects implementation of the CSWBMPP on the Phases 15 and 16 sites. The Erosion Control Plan will detail the locations and types of BMPs to be used during construction activities.

3.9.3 Dust Control Plan

The Dust Control Plan will be the responsibility of the construction contractor. The plan will include a description of the processes that will be implemented to address fugitive dust during construction activities. The plan will identify potential fugitive dust sources and activities at the construction site and applicable procedures to monitor and minimize dust generation.

3.9.4 Weed Control

Weed control takes place before, during and after the Reach A, Phases 15 and 16 remedial action and; therefore, is primarily the responsibility of the Agencies. The draft Weed Control Plan for the CFR Operable Unit (the “Weed Control Plan”; DEQ, 2008) describes the general approach to weed control for remediation/restoration activities to ensure that remedial actions are achieving performance standards and remedial goals. The goal is to achieve healthy, diverse, self-sustaining native vegetation with minimal noxious weeds. The Weed Control Plan describes measures that can be implemented to minimize spreading of noxious weeds by controlling weeds before they arrive on site, controlling weeds prior and during remediation activities and ensuring the landowners control noxious weeds on their properties in compliance with state weed laws and county weed plans. The draft Weed Control Plan will be updated by DEQ prior to initiation of the Reach A, Phases 15 and 16 Remedial Action.

Design specifications will require the construction contractor to prepare a site-specific weed control plan specific to construction activities for Phases 15 and 16. This plan will describe specific methods and procedures to be used by the contractor to prevent and/or minimize spread of noxious weeds. It will include designation of washing and decontamination areas.

3.9.5 Performance Targets

This section describes performance targets established in two monitoring plans that have been developed for the CFROU. These plans are as follows:

- <u>Interim Comprehensive Long-Term Monitoring Plan for the Clark Fork River Operable Unit—2013 (Atkins, 2011).</u> This plan addresses surface water, groundwater, in-stream sediments, and aquatic biota, including macroinvertebrates and fish. This plan provides a framework for monitoring the CFROU as remedial activities are implemented, and to evaluate the environmental effectiveness of these remedial actions. Specific performance targets have been developed for surface water and groundwater, but not for sediments and aquatic biota. Performance targets are described in detail in Atkins (2013).

- CFR Reach A, Phase 1 Geomorphology and Vegetation Monitoring Plan (Monitoring Plan) (DEQ, 2012): This plan provides a framework to evaluate physical- and vegetation-related components of the CFR and its floodplain that will be influenced directly by remedial and restoration actions. Effectiveness monitoring described in this plan will evaluate progress toward achieving project goals and objectives related to geomorphology and vegetation. The focus will be on collecting data that can be used to calculate metrics to measure performance targets for remedial and restoration activities.

Performance targets are values that indicate if the project is accomplishing goals and objectives. Performance targets are presented in terms of monitoring metrics that have target ranges or values. Monitoring metrics were selected for their ability to measure, consistently and objectively, whether desired ecological processes and functions are being achieved. Monitoring locations, schedule, and methods will be established in a site-specific monitoring plan that will be developed for CFROU Reach A, Phases 15 and 16 but will be similar to those in the CFR Reach A, Phase I Geomorphology and Vegetation Monitoring Plan (DEQ, 2012). The following sections describe performance targets and monitoring metrics for geomorphology and vegetation.

3.9.5.1 Geomorphology Performance Targets

The two timeframes used to evaluate geomorphology-related performance targets are:

- Short-term (0 to 15 years): The short-term time frame for channel and floodplain adjustments during the period of vegetation establishment. The objectives for this timeframe focus on overall channel and floodplain stability.
- Long-term (after 15 years): The long-term time frame reflects natural channel process within a revegetated, lowered floodplain condition that may include a higher level of dynamism typical of non-entrenched, unarmored river systems.

Specific performance target values and associated monitoring metrics are shown in Table 3-34. The Monitoring Plan provides an in-depth discussion on how geomorphology performance targets were developed (DEQ, 2012).

Table 3-34. Geomorphology Monitoring Metrics and Associated Performance Targets

Objective	Monitoring Metrics	Performance Target Values
Channel Dimensions	Cross section area Bankful width and Bankfull depth	Short-term: Change in average channel cross-section area will not exceed 20 percent of design dimensions.
	Width/depth Ratio	Long-term: Change in average channel cross-section area will not exceed 25 percent of design conditions.
Slope and Sinuosity	Sinuosity Slope	Short-term: Changes in sinuosity and slope will not exceed 5 percent of pre-project condition as channel course and profile is maintained and vegetation is established. Long-term: Changes in sinuosity and slope may reach 20 percent as bendway cutoffs or avulsions occur.
Bank Erosion and Channel Migration	Bank erosion rate Channel migration rate	Short-term: Average rates of movement will reflect typical rates of movement in Phases 15 and 16 which is 1.1 ft/yr. If flows greater than the 10-year recurrence interval occur, average bendway migration rates will not exceed the 90th percentile historic migration rate of 1.7 ft/yr. Long-term: Channel migration rates will reflect typical rates of movement of moderately vegetated banklines (Griffin and Smith, 2001). Average bendway migration rates will not exceed 0.6 ft/yr.
Floodplain Connectivity	Bankfull discharge Bankfull / bank height ratio Floodplain inundation extent	Short-term: Area of inundated floodplain exceeds design criteria or is within 10 percent of design criteria.
Floodplain Stability	Floodplain channel morphology (cross section area, width depth, slope, continuity)	Short-term: Floodplain erosion does not create new continuous channel segments that develop connectivity with main channel at the 2-year flow. Long-term: Erosion of floodplain channels is variable and may create continuous threads that are active at all flows

ft/yr – feet per year

3.9.5.2 Vegetation Performance Targets

The Vegetation Monitoring Plan (DEQ, 2012) describes how vegetation performance targets were determined. Vegetation performance targets were developed based on four vegetation-related objectives, including: streambank vegetation, floodplain vegetation, noxious weeds, and wetlands. The timeframes used to evaluate vegetation performance targets are:

- Short-term (0 to 5 years): The short-term target is the post-construction period when floodplain vegetation is immature and the site is being colonized by pioneer species.
- Mid-term (5 to 15 years): The mid-term target is the period of time when vegetation installed during project implementation has developed functioning root systems such that maintenance irrigation is no longer required. In addition, the site is beginning to be colonized by plants originating from seed or other propagules coming from established plants, either on or off site. Mature vegetation

is present but sparsely distributed throughout the site. Vegetation is becoming a primary factor in floodplain stability during this timeframe.

- Long-term (after 15 years): The long-term target is the period when areas of mature vegetation are well distributed and self-sustaining on the floodplain and the channel can migrate and change at natural rates without compromising project objectives.

Specific vegetation monitoring metrics and associated performance targets are shown in Table 3-35.

Table 3-35. Vegetation Monitoring Metrics and Associated Performance Targets

Objective	Monitoring Metrics	Performance Target Values
Streambank Vegetation	Woody canopy cover	Short-term: 40 percent canopy cover on treated streambanks by year 5. Mid-term: 60 percent or greater canopy cover on treated streambanks by year 10. Long-term: Canopy cover varies with natural channel migration rates but is greater than 80 percent.
Floodplain Vegetation	Plant survival and density Woody canopy cover Native canopy cover	Short-term: Native species comprise greater than 80 percent of the total vegetative cover. Total cover is greater than 20 percent by Year 1, 50 percent by Year 3, and 80 percent by Year 5. Average canopy cover of woody vegetation in the floodplain is 30 percent by Year 5. Planted woody species have 80 percent or greater survival after the first growing season and woody plant density is not decreasing in subsequent years. Mid-term: Native species comprise greater than 80 percent of the total vegetative cover. Total canopy cover is 80 percent, allowing for some bare patches of non-contaminated substrate deposition, and open water. Canopy cover of woody vegetation in the floodplain is 50 percent by Year 10. Long-term: The floodplain is composed of a mosaic of native riparian and wetland ecological types, non-contaminated depositional features and open water that support a full range of ecological functions and processes.
Noxious Weeds Wetlands	Weed canopy cover Wetland delineation Function Effective Wetland Area (FEWA)	Short-, mid-, and long-term: Less than 5 percent canopy cover of noxious weeds is present. Short-, mid-, and long-term: There is no net loss of wetlands meeting Army Corps of Engineers criteria from pre-project conditions. After 5 years, the site meets the reference wetland FEWA score of 2.3 developed for the CFROU.

4.0 REFERENCES

Andrews, E.D., 1984. Bed material entrainment and hydraulic geometry of gravel-bed rivers in Colorado. Geological Society of America Bulletin 95, March, pp. 371-378.

Atkins, 2011. Interim Comprehensive Long-Term Monitoring Plan for the Clark Fork River Operable Unit - 2011. Prepared for Montana DEQ and Montana Natural Resource Damage Program, Helena, Montana. Atkins, 2013. Interim Comprehensive Long-Term Monitoring Plan for the Clark Fork River Operable Unit—2013. Prepared for Montana DEQ and Montana Natural Resource Damage Program, Helena, Montana.

Bedunah, Don and Jones, Thad. 2001. Flood Plain Vegetation Change on the Grant- Kohrs Ranch National Historic Site Between 1993 and 2000. Prepared for the National Park Service.

Berg, R.B, 2004. Geologic Map of the Deer Lodge and Conleys Lake 7.5 Minute Quadrangles Powell County, Southwestern Montana, Montana Bureau of Mines and Geology Open File Report MBMG 509, 14p.

Bitterroot Restoration, Inc. and Reclamation Research Unit, Montana State University, 2004. Clark Fork River Riparian Evaluation System: A Remediation Design Tool. Prepared for CH2MHill and the U.S. Environmental Protection Agency, pp. 1-60.

Brinson, M.M., R.D. Rheinhardt, F.R. Hauer, L.C. Lee, W.L. Nutter, and D. Smith, 2005. A Guidebook for Application of Hydrogeomorphic Assessments to Riverine Wetlands. Wetlands Research Program Technical Report WRP-DE-11. U.S. Army Corps of Engineers.

Bureau of Land Management (BLM), U.S. Department of the Interior, 2012. General Land Office Records Automation Website located at http://www.glorecords.blm.gov/.

CDM, 2012. Derkey, R.E., S.M. Watson, M.J. Bartholomew, M.C. Stickney, and P.J. Downey, Montana Bureau of Mines and Geology Open-File Report MBMF 271, 26p.

CH2MHill, Montana State Reclamation Research Unit, and Bitterroot Restoration, 2004. Remedial Design Principles and Criteria for the Clark Fork River Operable Unit of the Milltown Reservoir NPL Site, prepared for USEPA.

CH2MHill, 2008. Grant-Kohrs Ranch Property National Park Service – Historic Site. Landowner Notebook Riparian Evaluation System (RipES). Prepared for the U.S. EPA,

Cowardin, L. M., V. Carter, F.C. Golet, and E.T. LaRoe, 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. U.S.D.I. Fish and Wildlife Service. Washington, D.C.

Derkey, R.E., Watson, M., Bartholomew, M.J., Stickney, M.C., Downey, P., 1993. Preliminary geologic map of the Deer Lodge area, southwestern Montana, Revised May 2004, Montana Bureau of Mines and Geology Open File Report 271, 1:48000.

ESRI. 2011. ArcGIS Desktop, Release 10. Environmental Systems Research Institute, Redlands, California.

Evermann, B.W. 1892. A reconnaissance for the streams and lakes of western Montana and northwestern Wyoming. Bulletin of the U.S. Fish Commission 11: 1-59.

Federal Emergency Managent Agency (FEMA), 1980. Flood Insurance Study, City of Deer Lodge and Powell County, Montana Community Number 300060.

Federal Geographic Data Committee (FGDC). 2008. National Vegetation Classification Standard, Version 2. Document number FGDC-STD-005-2008 (Version 2). http://usnvc.org/wp-content/uploads/2011/02/NVCS_V2_FINAL_2008-02.pdf

Gannon, J. E. and M. Rillig. 2002. Relationship of Heavy Metal Contamination to Soil Respiration, Grant-Kohrs Ranch, Montana. Technical Data Report submitted to the USDOI, National Park Service.

Gaulke, L. S., C. L. Henry, and S. L. Brown, 2006. Nitrogen Fixation and Growth Response of Alnus rubra Amended with Low and High Metal Content Biosolids. Sci. Agric. (Piracicaba, Braz.), v.63, n.4, p.351-360.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins, 1991. An Ecosystem Perspective of Riparian Zones: Focus on Links between Land and Water. BioScience, 41(8), 540-551.

Griffin, E.R. and Smith, J.D., 2001. Analysis of vegetation controls on bank erosion rates, Clark Fork of the Columbia River, Deer Lodge valley, Montana: U.S. Geological Survey Water-Resources Investigations Report 01-4115, 8 p.

Griffin E.R. and J.D Smith, 2002. State of Floodplain Vegetation within the Meander Belt of the Clark Fork of the Columbia River Deer Lodge Valley, Montana. WRIR 02-4109. USDI Geological Survey, Boulder, Colorado. 20pp.

Hansen, P. L., Pfister, R. D., Boggs, K., Cook, B. J., Joy, J., and Hinckley, D. K. 1995. Classification and management of Montana's riparian and wetland sites. Forest and Conservation Experiment Station. The University of Montana, Missoula. Publ. No. 54. 646 p.

Hooke, J.M., 1997. Styles of Channel Change, IN: Applied Fluvial Geomorphology for River Engineering Management: C. Thorne, R. Hey, and M. Newson, eds, John Wiley and Sons, 376p.

Horizons, 2011. LiDAR data is the result of private and government entities working together under the guidance of DJ&A. Horizons Inc. acquired LiDAR with the FLIMAP Sensor for areas of the Clark Fork River area August 6, 2011 - August 11, 2011.

John Milner Associates, Inc., 2004. Cultural Landscape Report, Grant-Kohrs Ranch National Historic Site, Deer Lodge, Montana. Prepared by John Milner associates, Inc. of Charlottesville, Virginia.

Kapustka, L.A., J.A. Lipton, H. Galbraith, D. Cacela, and K. LeJeune, 1995. Metal and arsenic impacts to soils, vegetation communities and wildlife habitat in southwest Montana uplands contaminated by smelter emissions: II. Laboratory phytotoxicity studies. Environmental Toxicology and Chemistry, 14: 1905-1912.

Kapustka, L.A., 2002a. Natural Resource Injury Report on Riparian and Upland Areas of Grant-Kohrs Ranch National Historic Site, Clark Fork River Basin, Montana: Final Report prepared for The University of Montana, Missoula Montana, under contract to the National Park Service, 77p.

Kapustka, L.A., 2002b. Phytotoxicity Tests on Soils from the Grant-Kohrs Ranch National Historic Site, Clark Fork River Basin, Montana: Final Report prepared for The University of Montana, Missoula Montana, under contract to the National Park Service, 37p.

Meyer-Peter, E. and Müller (MPM), R., 1948. Formulas for bed load transport. In Proceedings of the 2nd Congress of the International Association for Hydraulic Research, Stockholm, 2: Paper No. 2, pp. 39-64.

Mitsch and Gosselink, 2000. Wetlands, 3rd ed. John Wiley & Sons, New York. 920 pp.

Microsoft, 2012. Bing Maps aerial imagery in ArcGIS 10.1, imagery courtesy of the U.S. Geological Survey.

Montana Department of Agriculture, 2013. http://agr.mt.gov/agr/Programs/Weeds/

Montana Department of Environmental Quality, 1996. Montana Sediment and Erosion Control Manual, Prepared by Roxann Lincoln, NPDES Storm Water Program, Revised May 1996.

Montana Department of Environmental Quality (DEQ), 2008. Weed Control Plan for the Clark Fork River Operable Unit. Draft

Montana Department of Environmental Quality (DEQ), 2009. Construction Storm Water Best Management Practices Plan Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site. Missoula County, Montana. Prepared by CDM. February.

Montana Department of Environmental Quality (DEQ), 2012. CFR Reach A Phase 1, Geomorphology and Vegetation Monitoring Plan. Prepared by Geum Environmental Consulting, Inc. and Applied Geomorphology, Inc. Prepared for Montana Department of Environmental Quality, Helena, Montana.

National Park Service (NPS), 2011. Northern Rocky Mountains Invasive Plant Management Plan. National Park Service, Pacific West and Intermountain Regions. http://parkplanning.nps.gov/gosp.

Neill, C.R. 1968. Note on initial movement of coarse uniform bed material. Journal of Hydraulic Research. 6:2, pp. 173-176.

Parrett, C. and Johnson, D.R., 2004. Methods for Estimating Flood Frequency in Montana Based on Data through Water Year 1998. Water-Resources Investigations Report 03-4308. U.S. Geological Society, February.

PBS&J, 2008. Beck Ranch Cover Soil Borrow Investigation, Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site; for Montana Department of Environmental Quality. October 15, 2008.

Pioneer Technical Services (PTS), 2003. Milltown Reservoir Sediments NPL Site, Clark Fork Operable Unit. Draft Charlie Beck Borrow Site Investigation Technical Memorandum; for Atlantic Richfield Company.

Quivik, F.R., 1998. Smoke and tailings: An environmental history of copper smelting technologies in Montana, 1880-1930. PhD Dissertation, University of Pennsylvania, Philadelphia, PA, 544p.

Rice, P.M., 2002. Toxic metals-pH impact on riparian plant community structure at Grant-Kohrs Ranch. Deer Lodge, MT: NPS Grant-Kohrs NHS. 16 p.

Rice, P.M and J. Hardin, 2002. Riparian plant community structure at Grant Kohrs Ranch. DBS, U of M, Missoula. Downloaded

Rice, P.M., E.W. Schweiger, W. Gustafson, C. Lea, D. Manier, D. Shorrock, B. Frakes, and L. O'Gan, 2012. Vegetation classification and mapping project report Grant-Kohrs Ranch National Historic Site. Natural Resource Technical Report NPS/ROMN/NRR – 2012. National Park Service, Fort Collins, Colorado. Available on line: http://www1.gov/vip/grko/grkorpt.pdf

Rosgen, D., 1996. Applied river morphology. Wildlife Hydrology, Pagosa Springs, CO.

Shields, A., 1936. Application of similarity principles and turbulence research to bed load movement. California Institute of Technology, Pasadena; Translation from German Original; Report 167.

Smith, J.D, J.H. Lambing, D.A. Nimick, D.A., C. Parrett, M. Ramey, and W. Schaefer, 1988. Geomorphology, flood-plain tailings, and metal transport in the Upper Clark Fork Valley, Montana. U.S. Geological Survey Water Resources Investigations Report 98-4170.

Smith, J.D., J.H. Lambing, D.A. Nimick, C. Parrett, M. Ramey, and W. Schafer, 1998. Geomorphology, flood-plain tailings, and metal transport in the Upper Clark Fork Valley, Montana: USGS Water Resources Investigations Report 98-4170, 56p.

Smith, J.D. and E.R. Griffin, 2002. Relation between geomorphic stability and the density of large shrubs on the flood plain of the Clark Fork River of the Columbia River in the Deer Lodge Valley, Montana. WRIR 02-4070. USDI Geological Survey, Boulder, Colorado. 25 pp.

Swanson, B., 2002. Bank Erosion and Metal Loading in a Contaminated Floodplain System, Upper Clark Fork River Valley, Montana: MS Thesis, University of Montana, 195p.

Tabacchi, E., D.L. Correll, R. Hauer, G. Pinay, and A.M Planty-Tabacchi, 1998. Development, Maintenance and Role of Riparian Vegetation in the River Landscape. Freshwater Biology, 40, 497-516.

Tetra Tech, 2012a. Clark Fork River at Grant-Kohrs Ranch Conceptual Bank Stabilization Design Report, prepared for Montana Department of Environmental Quality.

Tetra Tech, 2012b. FINAL Clark Fork River Operable Unit, Milltown Reservoir / Clark Fork River NPL Site, Powell, Deer Lodge, and Granite Counties, Montana Data Summary Report Reach A, Phases 15 and 16, prepared for Montana Department of Environmental Quality.

Thompson, B., B. Ehrhart, and P. Hansen, 1995. Vegetation mapping and analysis of the Grant-Kohrs Ranch National Historic Site. Deer Lodge, MT: NPS Grant-Kohts NHS. 205 p.

U.S. Army Corps of Engineers (USACE), 2010a. HEC-SSP Statistical Software Package, User's Manual, Version 2.0, Hydrologic Engineering Center, Davis, California.

U.S. Army Corps of Engineers (USACE), 2010b. HEC-RAS, River Analysis System, User's Manual, Version 4.1, Hydrologic Engineering Center, Davis, California.

U.S. Department of Agriculture Farm Service Agency (USDA FSA), 2009. Montana 2009 Color National Agriculture Imagery Program Digital Orthoimagery.

U.S. Department of Agriculture Natural Resource Conservation Service (USDA NRCS), 2012. Soil Survey Geographic (SSURGO) database for Powell County Area, Montana. http://www.ftw.nrcs.usda.gov/ssur_data.html

U.S. Department of Interior (USDI), 2007. Federal Restoration Plan. Clark Fork River Operable Unit, Milltown Reservoir/Clark Fork River National Priorities List Site.

U.S. Environmental Protection Agency (EPA), 2004a. Record of Decision, Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund site. U.S. Environmental Protection Agency, Helena, Montana, with concurrence of Montana Department of Environmental Quality, Helena, Montana. April.

U.S. Environmental Protection Agency (EPA), 2004b. Record of Decision: Appendix E Grant Kohrs Ranch National Historic Site. Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund site. U.S. Environmental Protection Agency, Helena, Montana, with concurrence of Montana Department of Environmental Quality, Helena, Montana. April.

U.S. Fish and Wildlife Service (USFWS), 2005. National Wetlands Inventory website. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Upper Clark Fork Watershed, 2005 false color infrared, orthorectified photography. http://www.fws.gov/wetlands/

U.S. Water Resources Council (WRC), 1981. Guidelines for Determining Flood Flow Frequency. Bulletin No. 17B of the Hydrology Committee, U.S. Geological Survey, September.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing, 1980. The River Continuum Concept. Canadian Journal of Fisheries and Aquatic Sciences, 37, 130-137.

Woessner, W. W. and M. M. Johnson. 2002. Water Resource Characterization Report, 2000-2001. Field Seasons at Grant-Kohrs Ranch National Historical Site. Technical Data Report submitted to the USDOI, NPS.

APPENDIX A – RESULTS FROM HEC-RAS MODELS

Profile Output Table - Standard Table 1

HEC-RAS Plan: Range   River: Clark Fork   Reach: Grant-Kohrs

Rivers = 1
Hydraulic Reaches = 1
River Stations = 66
Plans = 1
Profiles = 6

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Grant-Kohrs	13668	2	922.00	4501.50	4503.70		4504.27	0.004059	6.09	151.51	72.46	0.74
Grant-Kohrs	13668	5	1566.00	4501.50	4505.00		4505.63	0.002389	6.33	247.79	79.40	0.61
Grant-Kohrs	13668	10	2009.00	4501.50	4505.39		4506.21	0.002729	7.27	278.88	93.04	0.66
Grant-Kohrs	13668	20	2753.00	4501.50	4505.88	4505.17	4507.07	0.003382	8.79	322.40	110.78	0.75
Grant-Kohrs	13668	50	3024.00	4501.50	4505.95	4505.41	4507.34	0.003848	9.48	329.35	113.57	0.81
Grant-Kohrs	13668	100	3465.00	4501.50	4505.99	4505.78	4507.78	0.004894	10.76	333.23	115.10	0.91
Grant-Kohrs	13531	2	922.00	4500.91	4503.53		4503.86	0.001652	4.62	212.88	126.57	0.55
Grant-Kohrs	13531	5	1566.00	4500.91	4505.05		4505.36	0.000797	4.51	418.83	210.69	0.41
Grant-Kohrs	13531	10	2009.00	4500.91	4505.53		4505.88	0.000821	4.96	521.21	233.93	0.43
Grant-Kohrs	13531	20	2753.00	4500.91	4506.20		4506.63	0.000855	5.59	691.26	311.82	0.45
Grant-Kohrs	13531	50	3024.00	4500.91	4506.38		4506.84	0.000889	5.83	747.22	325.96	0.46
Grant-Kohrs	13531	100	3465.00	4500.91	4506.63		4507.15	0.000948	6.22	832.85	349.24	0.48
Grant-Kohrs	13383	2	922.00	4498.00	4503.15		4503.46	0.005026	4.50	204.89	71.30	0.47
Grant-Kohrs	13383	5	1566.00	4498.00	4504.83		4505.06	0.007917	3.89	406.18	271.31	0.55
Grant-Kohrs	13383	10	2009.00	4498.00	4505.39		4505.60	0.004567	3.63	562.95	303.98	

												0.44
Grant-Kohrs	13383	20	2753.00	4498.00	4506.14		4506.35	0.003083	3.65	787.16	351.40	0.38
Grant-Kohrs	13383	50	3024.00	4498.00	4506.33		4506.54	0.002943	3.72	855.19	359.44	0.37
Grant-Kohrs	13383	100	3465.00	4498.00	4506.61		4506.83	0.002837	3.87	955.68	374.78	0.37
Grant-Kohrs	13094	2	922.00	4498.50	4502.37		4502.61	0.001856	3.89	237.30	71.42	0.38
Grant-Kohrs	13094	5	1566.00	4498.50	4503.82		4504.13	0.001706	4.53	346.94	88.82	0.38
Grant-Kohrs	13094	10	2009.00	4498.50	4504.39		4504.79	0.001820	5.08	430.70	232.11	0.40
Grant-Kohrs	13094	20	2753.00	4498.50	4505.06		4505.58	0.002107	5.93	590.67	398.85	0.44
Grant-Kohrs	13094	50	3024.00	4498.50	4505.23		4505.77	0.002173	6.14	660.98	417.21	0.45
Grant-Kohrs	13094	100	3465.00	4498.50	4505.45		4506.04	0.002337	6.52	753.87	443.71	0.47
Grant-Kohrs	12730	2	922.00	4496.50	4501.51		4501.70	0.003414	3.52	262.25	65.24	0.31
Grant-Kohrs	12730	5	1566.00	4496.50	4502.97		4503.26	0.003569	4.34	370.69	148.69	0.33
Grant-Kohrs	12730	10	2009.00	4496.50	4503.65		4503.91	0.002975	4.29	598.31	346.62	0.31
Grant-Kohrs	12730	20	2753.00	4496.50	4504.51		4504.69	0.002175	4.01	954.77	464.00	0.27
Grant-Kohrs	12730	50	3024.00	4496.50	4504.70		4504.88	0.002107	4.02	1043.58	464.00	0.26
Grant-Kohrs	12730	100	3465.00	4496.50	4504.87		4505.07	0.002278	4.24	1124.91	464.00	0.28
Grant-Kohrs	12502	2	922.00	4495.00	4500.68		4500.91	0.003461	3.85	239.34	58.64	0.34
Grant-Kohrs	12502	5	1566.00	4495.00	4502.00		4502.38	0.004130	4.92	318.61	62.25	0.38
Grant-Kohrs	12502	10	2009.00	4495.00	4502.50	4499.88	4503.01	0.005078	5.75	352.59	300.82	0.43
Grant-Kohrs	12502	20	2753.00	4495.00	4503.01	4500.67	4503.81	0.007114	7.21	405.96	496.98	0.51
Grant-Kohrs	12502	50	3024.00	4495.00	4503.23	4500.96	4504.02	0.007002	7.32	514.67	496.98	0.51
Grant-Kohrs	12502	100	3465.00	4495.00								

					4503.67	4501.37	4504.27	0.005504	6.79	733.31	496.98	0.46
Grant-Kohrs	12323	2	922.00	4494.50	4500.64		4500.69	0.000409	1.80	512.12	192.00	0.17
Grant-Kohrs	12323	5	1566.00	4494.50	4502.05		4502.12	0.000395	2.13	739.93	295.64	0.18
Grant-Kohrs	12323	10	2009.00	4494.50	4502.60		4502.69	0.000467	2.38	892.59	365.86	0.20
Grant-Kohrs	12323	20	2753.00	4494.50	4503.25		4503.37	0.000527	2.77	1128.45	453.22	0.21
Grant-Kohrs	12323	50	3024.00	4494.50	4503.45		4503.57	0.000546	2.88	1217.41	453.22	0.22
Grant-Kohrs	12323	100	3465.00	4494.50	4503.75		4503.89	0.000570	3.05	1353.95	453.22	0.22
Grant-Kohrs	12202	2	922.00	4496.00	4500.48		4500.61	0.001122	2.86	322.70	105.08	0.29
Grant-Kohrs	12202	5	1566.00	4496.00	4501.86		4502.04	0.000962	3.34	471.41	264.16	0.28
Grant-Kohrs	12202	10	2009.00	4496.00	4502.38		4502.59	0.001029	3.72	628.44	388.79	0.30
Grant-Kohrs	12202	20	2753.00	4496.00	4503.03		4503.26	0.001060	4.10	902.43	433.04	0.31
Grant-Kohrs	12202	50	3024.00	4496.00	4503.23		4503.47	0.001066	4.21	987.64	433.04	0.31
Grant-Kohrs	12202	100	3465.00	4496.00	4503.53		4503.78	0.001068	4.36	1118.53	433.04	0.31
Grant-Kohrs	11939	2	922.00	4495.00	4500.22		4500.36	0.000804	2.98	309.65	83.12	0.26
Grant-Kohrs	11939	5	1566.00	4495.00	4501.60		4501.80	0.000853	3.61	522.49	337.11	0.27
Grant-Kohrs	11939	10	2009.00	4495.00	4502.12		4502.34	0.000908	3.96	675.96	379.01	0.29
Grant-Kohrs	11939	20	2753.00	4495.00	4502.75		4502.99	0.000981	4.40	914.69	379.01	0.30
Grant-Kohrs	11939	50	3024.00	4495.00	4502.93		4503.19	0.001010	4.55	985.39	379.01	0.31
Grant-Kohrs	11939	100	3465.00	4495.00	4503.22		4503.49	0.001045	4.76	1095.32	379.01	0.31
Grant-Kohrs	11816	2	922.00	4494.59	4500.07		4500.24	0.001096	3.30	279.65	88.29	0.29
Grant-Kohrs	11816	5	1566.00	4494.59								

					4501.42	4501.67	0.001178	4.08	432.23	304.50	0.31
Grant-Kohrs	11816	10	2009.00	4494.59	4501.89	4502.19	0.001329	4.59	540.33	361.47	0.34
Grant-Kohrs	11816	20	2753.00	4494.59	4502.48	4502.84	0.001472	5.16	759.47	369.42	0.36
Grant-Kohrs	11816	50	3024.00	4494.59	4502.66	4503.03	0.001511	5.33	826.03	369.42	0.37
Grant-Kohrs	11816	100	3465.00	4494.59	4502.95	4503.33	0.001548	5.55	931.01	369.42	0.38
Grant-Kohrs	11687	2	922.00	4495.50	4499.73	4500.00	0.003332	4.17	221.09	67.19	0.40
Grant-Kohrs	11687	5	1566.00	4495.50	4501.07	4501.43	0.002999	4.88	380.59	382.60	0.40
Grant-Kohrs	11687	10	2009.00	4495.50	4501.69	4501.96	0.002242	4.60	633.85	410.25	0.36
Grant-Kohrs	11687	20	2753.00	4495.50	4502.36	4502.59	0.001875	4.55	905.68	410.25	0.33
Grant-Kohrs	11687	50	3024.00	4495.50	4502.55	4502.77	0.001829	4.59	984.01	410.25	0.33
Grant-Kohrs	11687	100	3465.00	4495.50	4502.84	4503.07	0.001759	4.65	1105.80	410.25	0.33
Grant-Kohrs	11563	2	922.00	4493.50	4499.36	4499.56	0.003482	3.56	258.63	74.86	0.34
Grant-Kohrs	11563	5	1566.00	4493.50	4500.79	4501.03	0.002916	4.01	427.93	251.71	0.33
Grant-Kohrs	11563	10	2009.00	4493.50	4501.43	4501.66	0.002611	4.13	635.71	420.61	0.31
Grant-Kohrs	11563	20	2753.00	4493.50	4502.16	4502.34	0.002021	3.96	967.83	467.86	0.28
Grant-Kohrs	11563	50	3024.00	4493.50	4502.36	4502.53	0.001932	3.95	1061.95	467.86	0.28
Grant-Kohrs	11563	100	3465.00	4493.50	4502.67	4502.84	0.001800	3.94	1208.16	467.86	0.27
Grant-Kohrs	11408	2	922.00	4493.00	4498.88	4499.06	0.002942	3.40	271.04	118.09	0.30
Grant-Kohrs	11408	5	1566.00	4493.00	4500.31	4500.57	0.002998	4.14	398.71	274.44	0.32
Grant-Kohrs	11408	10	2009.00	4493.00	4500.92	4501.22	0.003105	4.53	499.82	397.14	0.33
Grant-Kohrs	11408	20	2753.00	4493.00	4501.75	4502.00	0.002514	4.46	859.02	459.03	0.30

Grant-Kohrs	11408	50	3024.00	4493.00	4501.99	4502.22	0.002314	4.38	968.62	459.03	0.29
Grant-Kohrs	11408	100	3465.00	4493.00	4502.35	4502.55	0.002062	4.28	1133.13	459.03	0.28
Grant-Kohrs	11299	2	922.00	4492.50	4498.65	4498.82	0.001622	3.37	273.91	81.70	0.29
Grant-Kohrs	11299	5	1566.00	4492.50	4500.03	4500.31	0.001865	4.29	372.06	338.68	0.32
Grant-Kohrs	11299	10	2009.00	4492.50	4500.64	4500.96	0.001915	4.66	527.68	411.37	0.33
Grant-Kohrs	11299	20	2753.00	4492.50	4501.49	4501.77	0.001656	4.72	849.91	438.24	0.32
Grant-Kohrs	11299	50	3024.00	4492.50	4501.74	4502.00	0.001570	4.71	958.40	438.24	0.31
Grant-Kohrs	11299	100	3465.00	4492.50	4502.11	4502.36	0.001449	4.68	1122.74	438.24	0.30
Grant-Kohrs	11178	2	922.00	4494.37	4498.51	4498.63	0.001402	2.71	340.70	103.20	0.26
Grant-Kohrs	11178	5	1566.00	4494.37	4499.94	4500.09	0.001273	3.18	494.51	150.69	0.26
Grant-Kohrs	11178	10	2009.00	4494.37	4500.55	4500.73	0.001239	3.41	688.08	343.88	0.27
Grant-Kohrs	11178	20	2753.00	4494.37	4501.40	4501.57	0.001092	3.55	1000.40	387.79	0.26
Grant-Kohrs	11178	50	3024.00	4494.37	4501.65	4501.81	0.001066	3.60	1094.51	387.79	0.25
Grant-Kohrs	11178	100	3465.00	4494.37	4502.01	4502.18	0.001030	3.68	1237.47	387.79	0.25
Grant-Kohrs	10925	2	922.00	4493.44	4498.35	4498.42	0.000472	2.14	431.80	115.23	0.19
Grant-Kohrs	10925	5	1566.00	4493.44	4499.79	4499.89	0.000473	2.60	608.34	138.23	0.20
Grant-Kohrs	10925	10	2009.00	4493.44	4500.39	4500.52	0.000521	2.94	742.14	278.61	0.22
Grant-Kohrs	10925	20	2753.00	4493.44	4501.21	4501.37	0.000556	3.32	1002.51	371.06	0.23
Grant-Kohrs	10925	50	3024.00	4493.44	4501.45	4501.62	0.000570	3.45	1089.66	371.06	0.23
Grant-Kohrs	10925	100	3465.00	4493.44	4501.80	4501.99	0.000588	3.63	1221.20	371.06	0.24

Grant-Kohrs	10648	2	922.00	4493.42	4497.98	4498.18	0.001704	3.64	253.25	78.06	0.36
Grant-Kohrs	10648	5	1566.00	4493.42	4499.42	4499.67	0.001348	4.08	465.04	315.70	0.33
Grant-Kohrs	10648	10	2009.00	4493.42	4500.08	4500.31	0.001148	4.11	682.54	365.82	0.32
Grant-Kohrs	10648	20	2753.00	4493.42	4500.99	4501.18	0.000886	4.02	1017.81	365.82	0.28
Grant-Kohrs	10648	50	3024.00	4493.42	4501.24	4501.43	0.000864	4.08	1107.48	365.82	0.28
Grant-Kohrs	10648	100	3465.00	4493.42	4501.60	4501.80	0.000841	4.17	1241.27	365.82	0.28
Grant-Kohrs	10379	2	922.00	4492.00	4497.43	4497.68	0.001986	4.01	229.72	67.54	0.38
Grant-Kohrs	10379	5	1566.00	4492.00	4498.97	4499.25	0.001775	4.37	384.90	131.20	0.38
Grant-Kohrs	10379	10	2009.00	4492.00	4499.65	4499.95	0.001550	4.52	550.34	247.45	0.36
Grant-Kohrs	10379	20	2753.00	4492.00	4500.63	4500.90	0.001239	4.56	791.63	247.45	0.33
Grant-Kohrs	10379	50	3024.00	4492.00	4500.87	4501.15	0.001240	4.69	850.71	247.45	0.34
Grant-Kohrs	10379	100	3465.00	4492.00	4501.22	4501.52	0.001255	4.89	937.47	247.45	0.34
Grant-Kohrs	10103	2	922.00	4490.50	4496.99	4497.17	0.001605	3.45	267.30	59.80	0.29
Grant-Kohrs	10103	5	1566.00	4490.50	4498.55	4498.79	0.001530	4.05	483.91	391.43	0.29
Grant-Kohrs	10103	10	2009.00	4490.50	4499.38	4499.55	0.001119	3.78	782.72	427.96	0.25
Grant-Kohrs	10103	20	2753.00	4490.50	4500.48	4500.60	0.000718	3.34	1256.65	427.96	0.21
Grant-Kohrs	10103	50	3024.00	4490.50	4500.74	4500.85	0.000698	3.37	1364.27	427.96	0.21
Grant-Kohrs	10103	100	3465.00	4490.50	4501.10	4501.22	0.000681	3.42	1520.79	427.96	0.21
Grant-Kohrs	9956	2	922.00	4490.12	4496.63	4496.85	0.003212	3.73	247.08	70.26	0.35
Grant-Kohrs	9956	5	1566.00	4490.12	4498.28	4498.51	0.002352	3.96	491.63	386.50	0.31
Grant-Kohrs	9956	10	2009.00	4490.12	4499.25	4499.38	0.001237	3.24	875.73	400.21	

0.24
Grant-Kohrs 9956 20 2753.00 4490.12
4500.41 4500.49 0.000742 2.83 1338.67 400.21
0.19
Grant-Kohrs 9956 50 3024.00 4490.12
4500.66 4500.75 0.000724 2.86 1439.70 400.21
0.19
Grant-Kohrs 9956 100 3465.00 4490.12
4501.03 4501.12 0.000713 2.93 1585.87 400.21
0.19

Grant-Kohrs 9836 2 922.00 4488.00
4496.26 4496.47 0.003007 3.73 247.48 66.24
0.34
Grant-Kohrs 9836 5 1566.00 4488.00
4497.95 4498.22 0.002583 4.18 388.65 105.75
0.33
Grant-Kohrs 9836 10 2009.00 4488.00
4499.04 4499.22 0.001575 3.71 699.55 468.94
0.27
Grant-Kohrs 9836 20 2753.00 4488.00
4500.31 4500.41 0.000827 3.05 1296.95 468.94
0.20
Grant-Kohrs 9836 50 3024.00 4488.00
4500.57 4500.67 0.000791 3.06 1418.53 468.94
0.19
Grant-Kohrs 9836 100 3465.00 4488.00
4500.94 4501.04 0.000760 3.09 1593.01 468.94
0.19

Grant-Kohrs 9793 2 922.00 4489.50
4496.16 4496.36 0.002239 3.59 257.06 59.42
0.30
Grant-Kohrs 9793 5 1566.00 4489.50
4497.82 4498.11 0.002346 4.32 368.74 83.22
0.32
Grant-Kohrs 9793 10 2009.00 4489.50
4498.92 4499.14 0.001683 4.04 629.17 282.17
0.28
Grant-Kohrs 9793 20 2753.00 4489.50
4500.25 4500.37 0.000866 3.29 1257.63 482.50
0.21
Grant-Kohrs 9793 50 3024.00 4489.50
4500.52 4500.63 0.000826 3.29 1384.62 482.50
0.20
Grant-Kohrs 9793 100 3465.00 4489.50
4500.89 4501.01 0.000788 3.31 1566.50 482.50
0.20

Grant-Kohrs 9732 2 922.00 4489.07
4496.08 4496.23 0.001651 3.10 297.51 66.64
0.25
Grant-Kohrs 9732 5 1566.00 4489.07
4497.73 4497.96 0.002007 3.90 401.97 136.53
0.28
Grant-Kohrs 9732 10 2009.00 4489.07
4498.81 4499.04 0.001768 3.94 584.86 207.42
0.27
Grant-Kohrs 9732 20 2753.00 4489.07
4500.18 4500.32 0.001014 3.38 1186.26 476.68
0.21
Grant-Kohrs 9732 50 3024.00 4489.07
4500.45 4500.58 0.000970 3.37 1313.34 476.68
0.20
Grant-Kohrs 9732 100 3465.00 4489.07

					4500.83		4500.96	0.000929	3.40	1494.89	476.68	0.20
Grant-Kohrs	9679	2	922.00	4488.00	4496.00	4491.99	4496.14	0.001409	3.00	307.33	56.83	0.23
Grant-Kohrs	9679	5	1566.00	4488.00	4497.62	4493.02	4497.86	0.001885	3.87	404.81	63.21	0.27
Grant-Kohrs	9679	10	2009.00	4488.00	4498.64	4493.63	4498.92	0.002024	4.26	472.95	105.16	0.28
Grant-Kohrs	9679	20	2753.00	4488.00	4499.99	4494.59	4500.22	0.001533	4.17	936.63	452.04	0.25
Grant-Kohrs	9679	50	3024.00	4488.00	4500.27	4494.89	4500.49	0.001459	4.16	1063.32	452.04	0.25
Grant-Kohrs	9679	100	3465.00	4488.00	4500.66	4495.36	4500.87	0.001380	4.17	1242.77	452.04	0.24
Grant-Kohrs	9668		Bridge									
Grant-Kohrs	9630	2	922.00	4489.00	4495.79		4495.96	0.001582	3.29	280.15	61.38	0.27
Grant-Kohrs	9630	5	1566.00	4489.00	4496.94		4497.24	0.002363	4.42	354.09	66.97	0.34
Grant-Kohrs	9630	10	2009.00	4489.00	4497.47		4497.88	0.002934	5.12	401.79	187.14	0.38
Grant-Kohrs	9630	20	2753.00	4489.00	4498.04	4495.08	4498.65	0.003953	6.30	482.59	363.97	0.45
Grant-Kohrs	9630	50	3024.00	4489.00	4498.19	4495.37	4498.85	0.004231	6.62	538.11	372.05	0.47
Grant-Kohrs	9630	100	3465.00	4489.00	4498.42	4495.84	4499.13	0.004556	7.04	624.65	386.31	0.49
Grant-Kohrs	9561	2	922.00	4490.50	4495.68		4495.83	0.001898	3.05	302.23	86.81	0.29
Grant-Kohrs	9561	5	1566.00	4490.50	4496.82		4497.04	0.002417	3.79	413.87	107.73	0.33
Grant-Kohrs	9561	10	2009.00	4490.50	4497.37		4497.62	0.002343	4.06	584.07	404.28	0.34
Grant-Kohrs	9561	20	2753.00	4490.50	4498.03		4498.27	0.002108	4.22	850.16	404.85	0.33
Grant-Kohrs	9561	50	3024.00	4490.50	4498.20		4498.44	0.002125	4.32	917.98	405.11	0.33
Grant-Kohrs	9561	100	3465.00	4490.50	4498.44		4498.69	0.002169	4.50	1016.35	405.60	0.33

Grant-Kohrs	9479	2	922.00	4490.50	4495.36	4495.59	0.004139	3.83	241.00	96.20	0.43
Grant-Kohrs	9479	5	1566.00	4490.50	4496.54	4496.79	0.003730	3.97	394.13	178.18	0.41
Grant-Kohrs	9479	10	2009.00	4490.50	4497.11	4497.39	0.003301	4.22	506.58	418.18	0.40
Grant-Kohrs	9479	20	2753.00	4490.50	4497.84	4498.08	0.002502	4.18	818.59	434.08	0.36
Grant-Kohrs	9479	50	3024.00	4490.50	4498.02	4498.26	0.002472	4.26	893.85	490.08	0.36
Grant-Kohrs	9479	100	3465.00	4490.50	4498.27	4498.52	0.002416	4.38	1016.85	490.08	0.36
Grant-Kohrs	9350	2	922.00	4490.00	4494.76	4495.03	0.004507	4.16	221.65	83.97	0.45
Grant-Kohrs	9350	5	1566.00	4490.00	4495.97	4496.26	0.004540	4.29	364.85	145.67	0.46
Grant-Kohrs	9350	10	2009.00	4490.00	4496.63	4496.93	0.003773	4.44	453.00	307.50	0.43
Grant-Kohrs	9350	20	2753.00	4490.00	4497.44	4497.75	0.003019	4.59	723.61	492.33	0.40
Grant-Kohrs	9350	50	3024.00	4490.00	4497.65	4497.94	0.002839	4.59	825.06	492.33	0.39
Grant-Kohrs	9350	100	3465.00	4490.00	4497.93	4498.22	0.002648	4.63	967.13	492.33	0.38
Grant-Kohrs	9074	2	922.00	4489.00	4494.34	4494.44	0.001090	2.49	370.27	145.99	0.28
Grant-Kohrs	9074	5	1566.00	4489.00	4495.64	4495.75	0.000836	2.69	582.23	167.61	0.25
Grant-Kohrs	9074	10	2009.00	4489.00	4496.35	4496.47	0.000782	2.85	717.81	277.60	0.25
Grant-Kohrs	9074	20	2753.00	4489.00	4497.18	4497.33	0.000756	3.18	945.10	422.76	0.26
Grant-Kohrs	9074	50	3024.00	4489.00	4497.37	4497.53	0.000781	3.31	1025.60	422.76	0.26
Grant-Kohrs	9074	100	3465.00	4489.00	4497.63	4497.82	0.000828	3.53	1137.49	422.76	0.27
Grant-Kohrs	8768	2	922.00	4488.00	4493.56	4493.88	0.003270	4.52	203.95	74.94	0.48
Grant-Kohrs	8768	5	1566.00	4488.00	4494.90	4495.31	0.002620	5.09	307.53	78.87	0.45
Grant-Kohrs	8768	10	2009.00	4488.00	4495.54	4496.03	0.002718	5.60	359.51	178.00	

0.47

Grant-Kohrs	8768	20	2753.00	4488.00	4496.27	4494.32	4496.88	0.002883	6.35	534.94	491.51	0.50
Grant-Kohrs	8768	50	3024.00	4488.00	4496.50	4494.56	4497.09	0.002745	6.38	645.58	491.51	0.49
Grant-Kohrs	8768	100	3465.00	4488.00	4496.83	4494.91	4497.37	0.002513	6.36	808.78	491.51	0.47
Grant-Kohrs	8551	2	922.00	4488.00	4493.24		4493.44	0.001218	3.55	259.69	63.86	0.31
Grant-Kohrs	8551	5	1566.00	4488.00	4494.55		4494.87	0.001455	4.55	344.41	82.23	0.35
Grant-Kohrs	8551	10	2009.00	4488.00	4495.13		4495.55	0.001704	5.23	407.11	357.40	0.38
Grant-Kohrs	8551	20	2753.00	4488.00	4495.85		4496.35	0.001872	5.93	591.67	375.62	0.41
Grant-Kohrs	8551	50	3024.00	4488.00	4496.03		4496.57	0.001961	6.18	643.63	389.25	0.42
Grant-Kohrs	8551	100	3465.00	4488.00	4496.30		4496.88	0.002067	6.52	749.11	389.25	0.43
Grant-Kohrs	8311	2	922.00	4486.30	4492.95		4493.15	0.001203	3.53	260.89	61.66	0.30
Grant-Kohrs	8311	5	1566.00	4486.30	4494.20		4494.51	0.001484	4.56	381.62	262.23	0.35
Grant-Kohrs	8311	10	2009.00	4486.30	4494.81		4495.15	0.001441	4.83	546.21	297.00	0.35
Grant-Kohrs	8311	20	2753.00	4486.30	4495.59		4495.92	0.001358	5.09	840.19	406.79	0.35
Grant-Kohrs	8311	50	3024.00	4486.30	4495.79		4496.12	0.001357	5.19	921.23	406.79	0.35
Grant-Kohrs	8311	100	3465.00	4486.30	4496.07		4496.40	0.001380	5.38	1034.65	406.79	0.35
Grant-Kohrs	8081	2	922.00	4485.00	4492.55		4492.79	0.001968	3.92	234.93	70.81	0.38
Grant-Kohrs	8081	5	1566.00	4485.00	4493.81		4494.13	0.001948	4.57	388.30	296.17	0.39
Grant-Kohrs	8081	10	2009.00	4485.00	4494.50		4494.79	0.001582	4.56	598.21	351.11	0.36
Grant-Kohrs	8081	20	2753.00	4485.00	4495.33		4495.59	0.001319	4.62	938.41	470.97	0.34
Grant-Kohrs	8081	50	3024.00	4485.00	4495.55		4495.80	0.001268	4.64	1038.21	470.97	0.34
Grant-Kohrs	8081	100	3465.00	4485.00								

					4495.83	4496.08	0.001242	4.74	1173.43	470.97	0.34
Grant-Kohrs	7868	2	922.00	4486.00	4492.17	4492.40	0.001728	3.82	241.46	70.00	0.36
Grant-Kohrs	7868	5	1566.00	4486.00	4493.36	4493.71	0.001915	4.80	330.05	123.81	0.40
Grant-Kohrs	7868	10	2009.00	4486.00	4493.95	4494.40	0.002049	5.39	393.93	226.79	0.42
Grant-Kohrs	7868	20	2753.00	4486.00	4494.68	4495.21	0.002190	6.08	606.50	406.67	0.44
Grant-Kohrs	7868	50	3024.00	4486.00	4494.90	4495.43	0.002140	6.16	698.12	416.49	0.44
Grant-Kohrs	7868	100	3465.00	4486.00	4495.18	4495.72	0.002163	6.38	817.86	439.16	0.45
Grant-Kohrs	7657	2	922.00	4487.50	4491.77	4492.00	0.001985	3.86	239.01	76.37	0.38
Grant-Kohrs	7657	5	1566.00	4487.50	4492.95	4493.30	0.002005	4.73	338.72	102.57	0.40
Grant-Kohrs	7657	10	2009.00	4487.50	4493.54	4493.95	0.002085	5.22	425.25	259.35	0.42
Grant-Kohrs	7657	20	2753.00	4487.50	4494.21	4494.73	0.002371	6.02	590.21	401.34	0.45
Grant-Kohrs	7657	50	3024.00	4487.50	4494.47	4494.97	0.002227	6.02	693.87	401.34	0.44
Grant-Kohrs	7657	100	3465.00	4487.50	4494.75	4495.26	0.002231	6.22	805.97	401.34	0.45
Grant-Kohrs	7424	2	922.00	4486.50	4491.44	4491.62	0.001281	3.41	283.04	112.29	0.32
Grant-Kohrs	7424	5	1566.00	4486.50	4492.66	4492.90	0.001254	4.07	438.62	147.06	0.33
Grant-Kohrs	7424	10	2009.00	4486.50	4493.25	4493.53	0.001313	4.50	544.41	242.52	0.34
Grant-Kohrs	7424	20	2753.00	4486.50	4493.90	4494.26	0.001468	5.14	706.51	364.01	0.37
Grant-Kohrs	7424	50	3024.00	4486.50	4494.08	4494.50	0.001677	5.60	766.53	405.56	0.40
Grant-Kohrs	7424	100	3465.00	4486.50	4494.35	4494.79	0.001729	5.84	874.85	405.56	0.40
Grant-Kohrs	7168	2	922.00	4487.50	4490.98	4491.15	0.002862	3.25	283.59	109.90	0.36
Grant-Kohrs	7168	5	1566.00	4487.50							

					4492.27		4492.47	0.002172	3.66	430.90	120.16	0.33
Grant-Kohrs	7168	10	2009.00	4487.50	4492.84		4493.09	0.002231	4.07	509.17	176.74	0.34
Grant-Kohrs	7168	20	2753.00	4487.50	4493.48		4493.77	0.002282	4.51	759.27	462.80	0.35
Grant-Kohrs	7168	50	3024.00	4487.50	4493.68		4493.97	0.002237	4.58	849.78	463.94	0.35
Grant-Kohrs	7168	100	3465.00	4487.50	4493.95		4494.25	0.002199	4.70	977.53	465.48	0.35
Grant-Kohrs	6934	2	922.00	4484.50	4490.48		4490.60	0.001856	2.84	328.48	91.07	0.24
Grant-Kohrs	6934	5	1566.00	4484.50	4491.78		4491.97	0.002083	3.53	476.00	230.42	0.26
Grant-Kohrs	6934	10	2009.00	4484.50	4492.31		4492.54	0.002417	4.03	587.73	274.72	0.28
Grant-Kohrs	6934	20	2753.00	4484.50	4492.93		4493.19	0.002625	4.47	767.38	305.40	0.30
Grant-Kohrs	6934	50	3024.00	4484.50	4493.10		4493.38	0.002742	4.65	824.34	335.39	0.31
Grant-Kohrs	6934	100	3465.00	4484.50	4493.36		4493.66	0.002859	4.86	910.43	337.62	0.32
Grant-Kohrs	6616	2	922.00	4483.86	4490.04		4490.13	0.001143	2.45	375.98	83.28	0.20
Grant-Kohrs	6616	5	1566.00	4483.86	4491.24		4491.39	0.001506	3.19	552.58	392.33	0.24
Grant-Kohrs	6616	10	2009.00	4483.86	4491.75		4491.90	0.001505	3.37	768.54	437.81	0.24
Grant-Kohrs	6616	20	2753.00	4483.86	4492.36		4492.52	0.001480	3.55	1039.55	438.31	0.24
Grant-Kohrs	6616	50	3024.00	4483.86	4492.52		4492.68	0.001524	3.65	1109.12	438.45	0.25
Grant-Kohrs	6616	100	3465.00	4483.86	4492.75		4492.92	0.001606	3.82	1208.90	438.63	0.26
Grant-Kohrs	6350	2	922.00	4486.00	4489.24		4489.53	0.004743	4.30	214.26	81.09	0.47
Grant-Kohrs	6350	5	1566.00	4486.00	4490.29		4490.69	0.004375	5.10	336.76	216.83	0.47
Grant-Kohrs	6350	10	2009.00	4486.00	4490.86		4491.24	0.003806	5.20	463.98	233.49	0.45
Grant-Kohrs	6350	20	2753.00	4486.00	4491.59		4491.93	0.003134	5.22	747.27	473.84	0.42

Grant-Kohrs	6350	50	3024.00	4486.00	4491.80		4492.12	0.002885	5.15	862.45	596.75	0.40
Grant-Kohrs	6350	100	3465.00	4486.00	4492.10		4492.38	0.002558	5.04	1047.32	629.96	0.38
Grant-Kohrs	6105	2	922.00	4484.51	4488.27		4488.60	0.003059	4.58	201.50	68.84	0.47
Grant-Kohrs	6105	5	1566.00	4484.51	4489.28		4489.76	0.003235	5.65	299.95	128.82	0.51
Grant-Kohrs	6105	10	2009.00	4484.51	4489.82		4490.38	0.003216	6.12	371.78	172.93	0.51
Grant-Kohrs	6105	20	2753.00	4484.51	4490.53	4489.33	4491.15	0.003145	6.68	549.40	302.45	0.52
Grant-Kohrs	6105	50	3024.00	4484.51	4490.73		4491.36	0.003156	6.86	609.55	327.89	0.52
Grant-Kohrs	6105	100	3465.00	4484.51	4491.00	4489.92	4491.66	0.003199	7.14	697.71	366.10	0.53
Grant-Kohrs	5794	2	922.00	4482.50	4487.58		4487.80	0.002022	3.74	246.66	85.06	0.39
Grant-Kohrs	5794	5	1566.00	4482.50	4488.62		4488.93	0.002000	4.52	387.82	179.76	0.40
Grant-Kohrs	5794	10	2009.00	4482.50	4489.24		4489.57	0.001840	4.75	524.15	323.09	0.39
Grant-Kohrs	5794	20	2753.00	4482.50	4490.06		4490.38	0.001614	4.95	801.51	501.59	0.38
Grant-Kohrs	5794	50	3024.00	4482.50	4490.30		4490.61	0.001521	4.95	927.27	540.10	0.37
Grant-Kohrs	5794	100	3465.00	4482.50	4490.62		4490.91	0.001438	5.00	1102.12	558.36	0.36
Grant-Kohrs	5562	2	922.00	4482.50	4486.90		4487.19	0.003446	4.32	213.37	87.54	0.49
Grant-Kohrs	5562	5	1566.00	4482.50	4488.13		4488.44	0.002316	4.58	378.62	144.35	0.42
Grant-Kohrs	5562	10	2009.00	4482.50	4488.81		4489.13	0.002014	4.75	475.57	156.03	0.41
Grant-Kohrs	5562	20	2753.00	4482.50	4489.69		4490.01	0.001689	4.94	789.75	460.52	0.38
Grant-Kohrs	5562	50	3024.00	4482.50	4489.93		4490.25	0.001636	5.01	904.14	474.12	0.38
Grant-Kohrs	5562	100	3465.00	4482.50	4490.29		4490.58	0.001492	4.99	1075.04	488.97	0.37

Grant-Kohrs	5299	2	922.00	4482.50	4486.43		4486.60	0.001435	3.29	280.12	89.31	0.33
Grant-Kohrs	5299	5	1566.00	4482.50	4487.72		4487.96	0.001354	3.95	396.62	91.89	0.33
Grant-Kohrs	5299	10	2009.00	4482.50	4488.38		4488.68	0.001384	4.39	459.67	145.31	0.35
Grant-Kohrs	5299	20	2753.00	4482.50	4489.15		4489.56	0.001602	5.19	569.66	317.42	0.38
Grant-Kohrs	5299	50	3024.00	4482.50	4489.35		4489.80	0.001674	5.43	634.78	322.13	0.39
Grant-Kohrs	5299	100	3465.00	4482.50	4489.64		4490.13	0.001776	5.77	729.36	329.10	0.41
Grant-Kohrs	5046	2	922.00	4480.00	4486.11		4486.28	0.001119	3.31	278.69	69.42	0.29
Grant-Kohrs	5046	5	1566.00	4480.00	4487.32		4487.61	0.001372	4.30	364.31	72.24	0.33
Grant-Kohrs	5046	10	2009.00	4480.00	4487.93		4488.30	0.001562	4.94	408.47	137.01	0.36
Grant-Kohrs	5046	20	2753.00	4480.00	4488.66		4489.13	0.001761	5.68	620.72	364.45	0.39
Grant-Kohrs	5046	50	3024.00	4480.00	4488.86		4489.36	0.001805	5.87	698.26	394.62	0.40
Grant-Kohrs	5046	100	3465.00	4480.00	4489.15		4489.67	0.001879	6.16	820.95	443.95	0.41
Grant-Kohrs	4772	2	922.00	4482.50	4485.68		4485.88	0.001898	3.62	255.04	87.58	0.37
Grant-Kohrs	4772	5	1566.00	4482.50	4486.90		4487.19	0.001769	4.31	363.71	93.15	0.38
Grant-Kohrs	4772	10	2009.00	4482.50	4487.47		4487.83	0.001854	4.82	423.30	267.47	0.40
Grant-Kohrs	4772	20	2753.00	4482.50	4488.04	4485.90	4488.57	0.002352	5.87	505.65	457.65	0.45
Grant-Kohrs	4772	50	3024.00	4482.50	4488.20	4486.10	4488.77	0.002481	6.15	578.28	457.65	0.47
Grant-Kohrs	4772	100	3465.00	4482.50	4488.44	4486.42	4489.06	0.002621	6.51	686.88	457.65	0.49
Grant-Kohrs	4529	2	922.00	4481.50	4485.17		4485.39	0.002148	3.81	242.25	84.58	0.40
Grant-Kohrs	4529	5	1566.00	4481.50	4486.43		4486.74	0.001896	4.47	350.92	87.85	0.39
Grant-Kohrs	4529	10	2009.00	4481.50	4486.95	4484.88	4487.35	0.002080	5.06	397.96	96.28	

												0.42
Grant-Kohrs	4529	20	2753.00	4481.50	4487.53		4487.99	0.002221	5.67	661.46	486.13	0.44
Grant-Kohrs	4529	50	3024.00	4481.50	4487.71		4488.17	0.002219	5.79	745.02	486.13	0.44
Grant-Kohrs	4529	100	3465.00	4481.50	4487.96		4488.43	0.002195	5.95	871.30	486.13	0.44
Grant-Kohrs	4273	2	922.00	4480.50	4484.67		4484.90	0.001724	3.85	239.56	68.16	0.36
Grant-Kohrs	4273	5	1566.00	4480.50	4485.88		4486.24	0.001934	4.84	324.86	176.48	0.40
Grant-Kohrs	4273	10	2009.00	4480.50	4486.49		4486.85	0.001755	5.01	567.55	484.36	0.39
Grant-Kohrs	4273	20	2753.00	4480.50	4487.19		4487.49	0.001464	4.98	907.77	493.00	0.36
Grant-Kohrs	4273	50	3024.00	4480.50	4487.37		4487.66	0.001445	5.04	996.60	493.00	0.36
Grant-Kohrs	4273	100	3465.00	4480.50	4487.64		4487.93	0.001429	5.16	1127.31	493.00	0.36
Grant-Kohrs	4032	2	922.00	4480.00	4484.28		4484.50	0.001570	3.73	247.46	76.33	0.35
Grant-Kohrs	4032	5	1566.00	4480.00	4485.45		4485.79	0.001786	4.71	347.77	280.68	0.39
Grant-Kohrs	4032	10	2009.00	4480.00	4485.96		4486.39	0.002011	5.33	415.47	404.66	0.42
Grant-Kohrs	4032	20	2753.00	4480.00	4486.69	4484.37	4487.09	0.001809	5.52	785.13	532.14	0.40
Grant-Kohrs	4032	50	3024.00	4480.00	4486.90	4484.60	4487.28	0.001702	5.49	901.53	532.14	0.39
Grant-Kohrs	4032	100	3465.00	4480.00	4487.21		4487.56	0.001603	5.50	1061.85	532.14	0.38
Grant-Kohrs	3777	2	922.00	4479.50	4483.77		4484.01	0.002350	3.96	232.99	82.26	0.41
Grant-Kohrs	3777	5	1566.00	4479.50	4484.95		4485.29	0.002157	4.67	349.62	167.52	0.42
Grant-Kohrs	3777	10	2009.00	4479.50	4485.41		4485.83	0.002399	5.27	414.47	379.55	0.45
Grant-Kohrs	3777	20	2753.00	4479.50	4485.84		4486.47	0.003189	6.47	502.57	445.61	0.52
Grant-Kohrs	3777	50	3024.00	4479.50	4485.98	4484.46	4486.66	0.003394	6.80	539.11	455.49	0.54
Grant-Kohrs	3777	100	3465.00	4479.50								

					4486.20	4484.84	4486.93	0.003584	7.19	639.18	473.33	0.56
Grant-Kohrs	3556	2	922.00	4479.49	4483.36		4483.57	0.001659	3.68	255.02	91.81	0.35
Grant-Kohrs	3556	5	1566.00	4479.49	4484.66		4484.89	0.001321	4.03	512.08	341.07	0.33
Grant-Kohrs	3556	10	2009.00	4479.49	4485.13		4485.39	0.001396	4.42	688.65	510.06	0.35
Grant-Kohrs	3556	20	2753.00	4479.49	4485.65		4485.91	0.001387	4.71	955.88	510.06	0.35
Grant-Kohrs	3556	50	3024.00	4479.49	4485.81		4486.07	0.001391	4.80	1038.32	510.06	0.35
Grant-Kohrs	3556	100	3465.00	4479.49	4486.06		4486.32	0.001390	4.94	1165.09	510.06	0.36
Grant-Kohrs	3269	2	922.00	4478.00	4482.77		4483.04	0.001944	4.24	218.76	76.93	0.39
Grant-Kohrs	3269	5	1566.00	4478.00	4483.96	4481.81	4484.39	0.002200	5.32	313.59	243.23	0.43
Grant-Kohrs	3269	10	2009.00	4478.00	4484.53		4484.91	0.001917	5.36	600.07	536.24	0.41
Grant-Kohrs	3269	20	2753.00	4478.00	4485.23		4485.51	0.001444	5.05	978.17	536.24	0.36
Grant-Kohrs	3269	50	3024.00	4478.00	4485.41		4485.68	0.001409	5.09	1073.47	536.24	0.36
Grant-Kohrs	3269	100	3465.00	4478.00	4485.68		4485.94	0.001368	5.15	1215.91	536.24	0.36
Grant-Kohrs	3002	2	922.00	4475.50	4482.42		4482.60	0.001269	3.50	271.98	97.33	0.31
Grant-Kohrs	3002	5	1566.00	4475.50	4483.70		4483.92	0.001120	3.97	547.78	388.51	0.31
Grant-Kohrs	3002	10	2009.00	4475.50	4484.28		4484.49	0.001060	4.14	812.61	579.51	0.30
Grant-Kohrs	3002	20	2753.00	4475.50	4485.04		4485.20	0.000801	3.91	1254.88	579.51	0.27
Grant-Kohrs	3002	50	3024.00	4475.50	4485.22		4485.37	0.000799	3.98	1357.03	579.51	0.27
Grant-Kohrs	3002	100	3465.00	4475.50	4485.48		4485.64	0.000801	4.09	1508.98	579.51	0.27
Grant-Kohrs	2786	2	922.00	4475.73	4482.05		4482.28	0.001697	3.85	242.06	120.98	0.36
Grant-Kohrs	2786	5	1566.00	4475.73								

4483.34 4483.63 0.001544 4.45 401.50 249.73
0.36
Grant-Kohrs 2786 10 2009.00 4475.73
4483.84 4484.19 0.001720 5.01 464.95 297.99
0.38
Grant-Kohrs 2786 20 2753.00 4475.73
4484.34 4482.52 4484.88 0.002376 6.26 631.45 440.42
0.46
Grant-Kohrs 2786 50 3024.00 4475.73
4484.50 4485.06 0.002409 6.42 705.55 455.64
0.46
Grant-Kohrs 2786 100 3465.00 4475.73
4484.78 4485.32 0.002363 6.55 836.08 484.27
0.46

Grant-Kohrs 2537 2 922.00 4477.50
4481.55 4481.80 0.002264 3.97 232.02 78.79
0.41
Grant-Kohrs 2537 5 1566.00 4477.50
4482.86 4483.19 0.002002 4.62 340.43 135.47
0.40
Grant-Kohrs 2537 10 2009.00 4477.50
4483.37 4483.73 0.002012 4.99 532.54 528.27
0.41
Grant-Kohrs 2537 20 2753.00 4477.50
4484.02 4484.32 0.001644 4.94 892.75 550.71
0.38
Grant-Kohrs 2537 50 3024.00 4477.50
4484.22 4484.50 0.001565 4.94 999.51 550.71
0.37
Grant-Kohrs 2537 100 3465.00 4477.50
4484.53 4484.79 0.001428 4.90 1172.14 550.71
0.36

Grant-Kohrs 2294 2 922.00 4474.50
4481.36 4481.48 0.000697 2.70 341.98 84.11
0.24
Grant-Kohrs 2294 5 1566.00 4474.50
4482.68 4482.86 0.000780 3.38 520.16 477.92
0.26
Grant-Kohrs 2294 10 2009.00 4474.50
4483.19 4483.38 0.000810 3.67 776.55 605.61
0.27
Grant-Kohrs 2294 20 2753.00 4474.50
4483.85 4484.02 0.000758 3.81 1173.99 605.61
0.27
Grant-Kohrs 2294 50 3024.00 4474.50
4484.04 4484.22 0.000751 3.87 1290.20 605.61
0.27
Grant-Kohrs 2294 100 3465.00 4474.50
4484.36 4484.53 0.000723 3.92 1482.11 605.61
0.26

Grant-Kohrs 2088 2 922.00 4476.50
4481.01 4481.25 0.001809 3.93 234.83 75.34
0.37
Grant-Kohrs 2088 5 1566.00 4476.50
4482.29 4482.61 0.001699 4.64 435.02 421.33
0.37
Grant-Kohrs 2088 10 2009.00 4476.50
4482.90 4483.16 0.001354 4.49 693.83 427.40
0.34
Grant-Kohrs 2088 20 2753.00 4476.50
4483.61 4483.83 0.001155 4.50 1010.33 477.30
0.32

Grant-Kohrs	2088	50	3024.00	4476.50	4483.80	4484.02	0.001140	4.57	1103.79	491.89	0.32
Grant-Kohrs	2088	100	3465.00	4476.50	4484.07	4484.32	0.001265	4.95	1245.72	607.43	0.34
Grant-Kohrs	1812	2	922.00	4476.00	4480.59	4480.78	0.001464	3.55	260.05	75.29	0.34
Grant-Kohrs	1812	5	1566.00	4476.00	4481.88	4482.17	0.001475	4.34	368.64	264.27	0.35
Grant-Kohrs	1812	10	2009.00	4476.00	4482.42	4482.76	0.001527	4.76	531.10	357.81	0.37
Grant-Kohrs	1812	20	2753.00	4476.00	4483.11	4483.46	0.001506	5.13	799.01	522.19	0.37
Grant-Kohrs	1812	50	3024.00	4476.00	4483.31	4483.65	0.001467	5.18	906.87	522.19	0.37
Grant-Kohrs	1812	100	3465.00	4476.00	4483.62	4483.95	0.001404	5.23	1068.52	522.19	0.36
Grant-Kohrs	1577	2	922.00	4474.37	4480.36	4480.50	0.000924	3.00	307.70	80.18	0.27
Grant-Kohrs	1577	5	1566.00	4474.37	4481.64	4481.85	0.001111	3.72	440.68	289.94	0.30
Grant-Kohrs	1577	10	2009.00	4474.37	4482.14	4482.41	0.001282	4.25	547.45	388.35	0.33
Grant-Kohrs	1577	20	2753.00	4474.37	4482.83	4483.12	0.001285	4.61	815.34	388.75	0.34
Grant-Kohrs	1577	50	3024.00	4474.37	4483.03	4483.33	0.001294	4.72	895.69	454.49	0.34
Grant-Kohrs	1577	100	3465.00	4474.37	4483.34	4483.64	0.001285	4.86	1039.16	481.22	0.34
Grant-Kohrs	1362	2	922.00	4475.00	4479.97	4480.20	0.002110	3.85	239.71	80.72	0.39
Grant-Kohrs	1362	5	1566.00	4475.00	4481.24	4481.52	0.002055	4.30	410.18	341.08	0.40
Grant-Kohrs	1362	10	2009.00	4475.00	4481.86	4482.10	0.001605	4.21	645.19	409.79	0.36
Grant-Kohrs	1362	20	2753.00	4475.00	4482.62	4482.83	0.001251	4.15	978.26	461.29	0.33
Grant-Kohrs	1362	50	3024.00	4475.00	4482.83	4483.04	0.001210	4.20	1077.09	478.27	0.33
Grant-Kohrs	1362	100	3465.00	4475.00	4483.15	4483.35	0.001164	4.29	1235.17	520.87	0.32

Grant-Kohrs	1107	2	922.00	4475.00	4479.44	4477.92	4479.67	0.002026	3.86	239.53	89.23	0.39
Grant-Kohrs	1107	5	1566.00	4475.00	4480.63	4478.67	4480.95	0.002426	4.60	348.37	202.04	0.43
Grant-Kohrs	1107	10	2009.00	4475.00	4481.24	4479.12	4481.61	0.002258	4.94	462.86	294.56	0.43
Grant-Kohrs	1107	20	2753.00	4475.00	4482.11	4479.81	4482.44	0.001751	4.94	723.96	302.40	0.39
Grant-Kohrs	1107	50	3024.00	4475.00	4482.32	4480.09	4482.66	0.001736	5.06	787.39	303.19	0.39
Grant-Kohrs	1107	100	3465.00	4475.00	4482.63	4480.58	4482.99	0.001726	5.24	881.72	304.36	0.39
Grant-Kohrs	855	2	922.00	4475.50	4479.00	4477.71	4479.17	0.001858	3.31	278.50	107.12	0.36
Grant-Kohrs	855	5	1566.00	4475.50	4480.23	4478.26	4480.45	0.001502	3.77	439.06	249.75	0.34
Grant-Kohrs	855	10	2009.00	4475.50	4480.95	4478.61	4481.15	0.001210	3.79	631.51	269.40	0.32
Grant-Kohrs	855	20	2753.00	4475.50	4481.89	4479.14	4482.09	0.000984	3.88	894.31	288.53	0.29
Grant-Kohrs	855	50	3024.00	4475.50	4482.09	4479.32	4482.30	0.001007	4.03	953.49	290.69	0.30
Grant-Kohrs	855	100	3465.00	4475.50	4482.39	4479.62	4482.63	0.001047	4.25	1041.36	291.66	0.31
Grant-Kohrs	603	2	922.00	4474.00	4478.43	4476.86	4478.72	0.001600	4.32	213.51	65.08	0.42
Grant-Kohrs	603	5	1566.00	4474.00	4479.58	4477.73	4480.02	0.001716	5.38	306.73	95.52	0.45
Grant-Kohrs	603	10	2009.00	4474.00	4480.22	4478.25	4480.76	0.001762	5.94	385.70	171.87	0.47
Grant-Kohrs	603	20	2753.00	4474.00	4481.16	4479.08	4481.74	0.001616	6.38	644.33	539.39	0.46
Grant-Kohrs	603	50	3024.00	4474.00	4481.46	4479.37	4481.97	0.001455	6.25	801.04	539.39	0.44
Grant-Kohrs	603	100	3465.00	4474.00	4481.88	4479.80	4482.32	0.001249	6.04	1028.59	539.39	0.41
Grant-Kohrs	343	2	922.00	4474.50	4478.01		4478.29	0.001681	4.26	216.31	69.00	0.42
Grant-Kohrs	343	5	1566.00	4474.50	4479.11		4479.55	0.001857	5.33	295.77	91.31	0.46
Grant-Kohrs	343	10	2009.00	4474.50	4479.76		4480.28	0.001856	5.84	367.41	134.33	

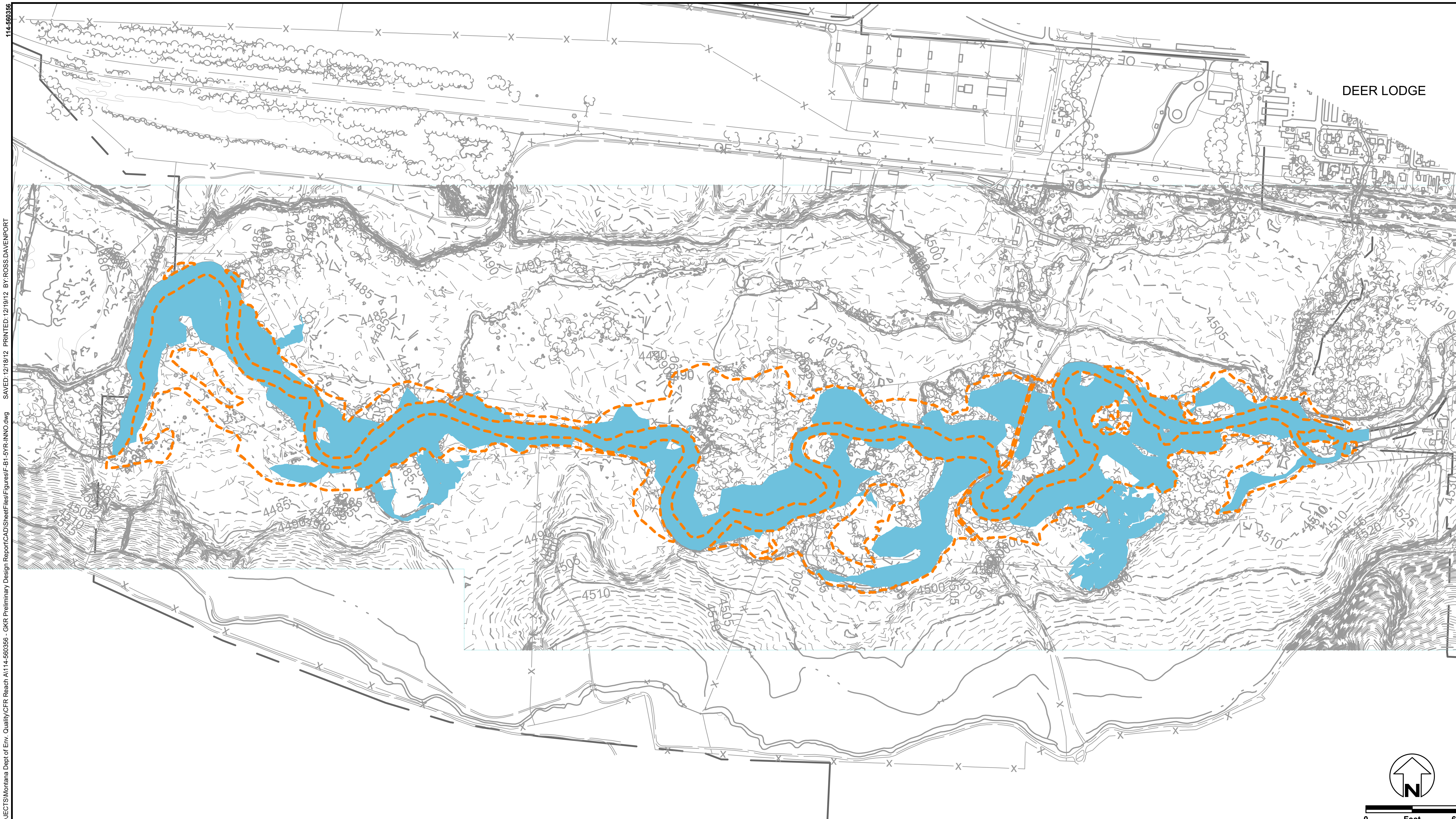
0.47

Grant-Kohrs	343	20	2753.00	4474.50	4480.67	4478.55	4481.29	0.001788	6.45	535.05	348.07	0.48
Grant-Kohrs	343	50	3024.00	4474.50	4480.93	4478.79	4481.55	0.001735	6.54	625.72	349.97	0.48
Grant-Kohrs	343	100	3465.00	4474.50	4481.26	4479.27	4481.91	0.001774	6.86	772.05	476.46	0.48

Grant-Kohrs	47	2	922.00	4473.50	4477.46	4476.23	4477.75	0.002001	4.34	212.44	76.31	0.46
Grant-Kohrs	47	5	1566.00	4473.50	4478.55	4477.00	4478.98	0.002003	5.25	298.04	79.80	0.48
Grant-Kohrs	47	10	2009.00	4473.50	4479.20	4477.44	4479.71	0.002000	5.73	350.60	85.31	0.49
Grant-Kohrs	47	20	2753.00	4473.50	4480.08	4478.13	4480.73	0.002000	6.49	451.70	345.10	0.50
Grant-Kohrs	47	50	3024.00	4473.50	4480.31	4478.34	4480.99	0.002002	6.69	534.57	353.34	0.51
Grant-Kohrs	47	100	3465.00	4473.50	4480.64	4478.69	4481.35	0.002002	6.96	652.20	364.71	0.51

APPENDIX B - INUNDATION BOUNDARIES AFTER REMEDIATION

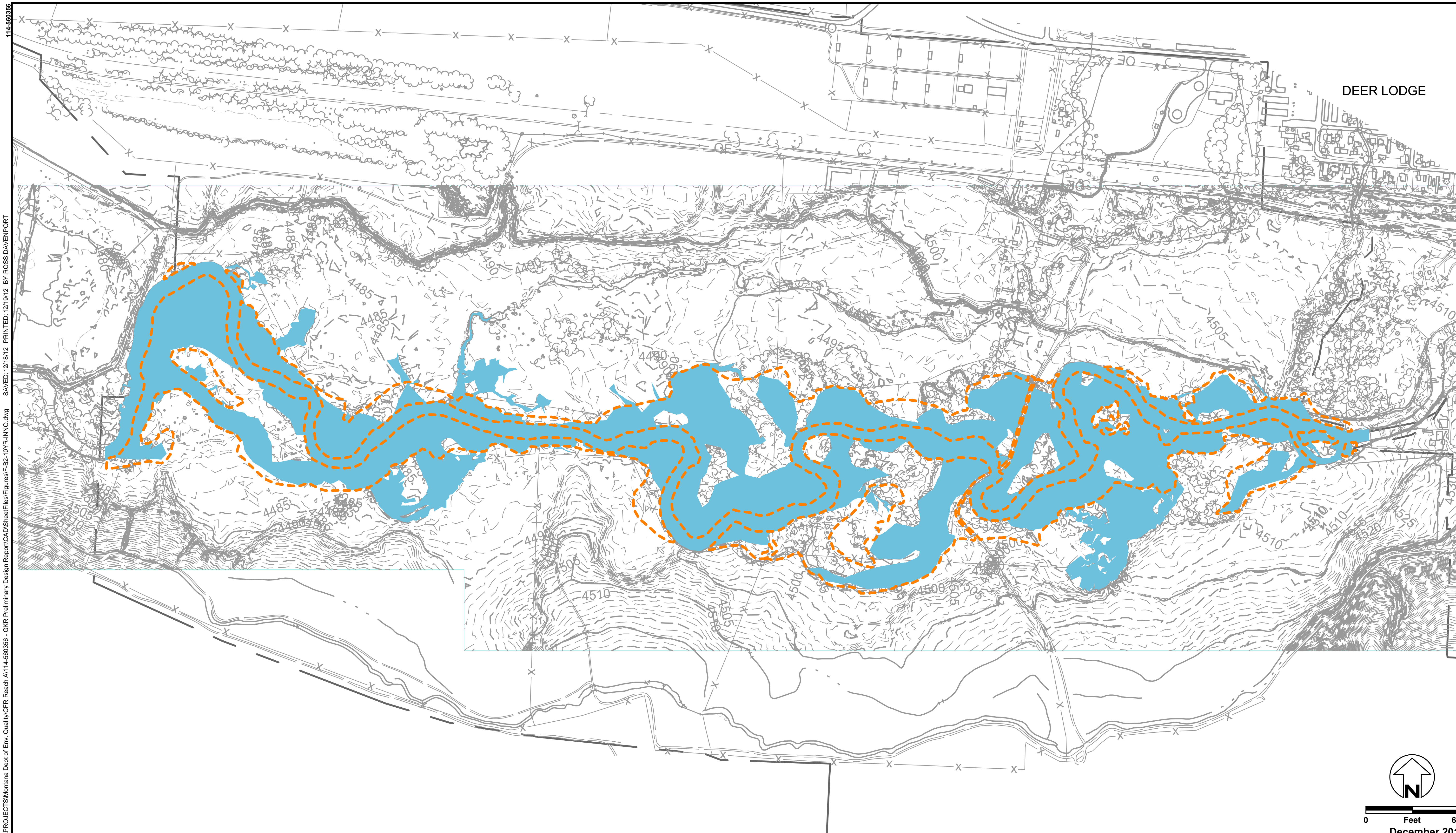
114-560356



PREDICTED INUNDATION AREA FOR 5 YEAR FLOOD — FOLLOWING FLOODPLAIN CONSTRUCTION

REMOVAL BOUNDARY

CLARK FORK RIVER
PHASES 15 & 16
5 YEAR INUNDATION
FIGURE B1



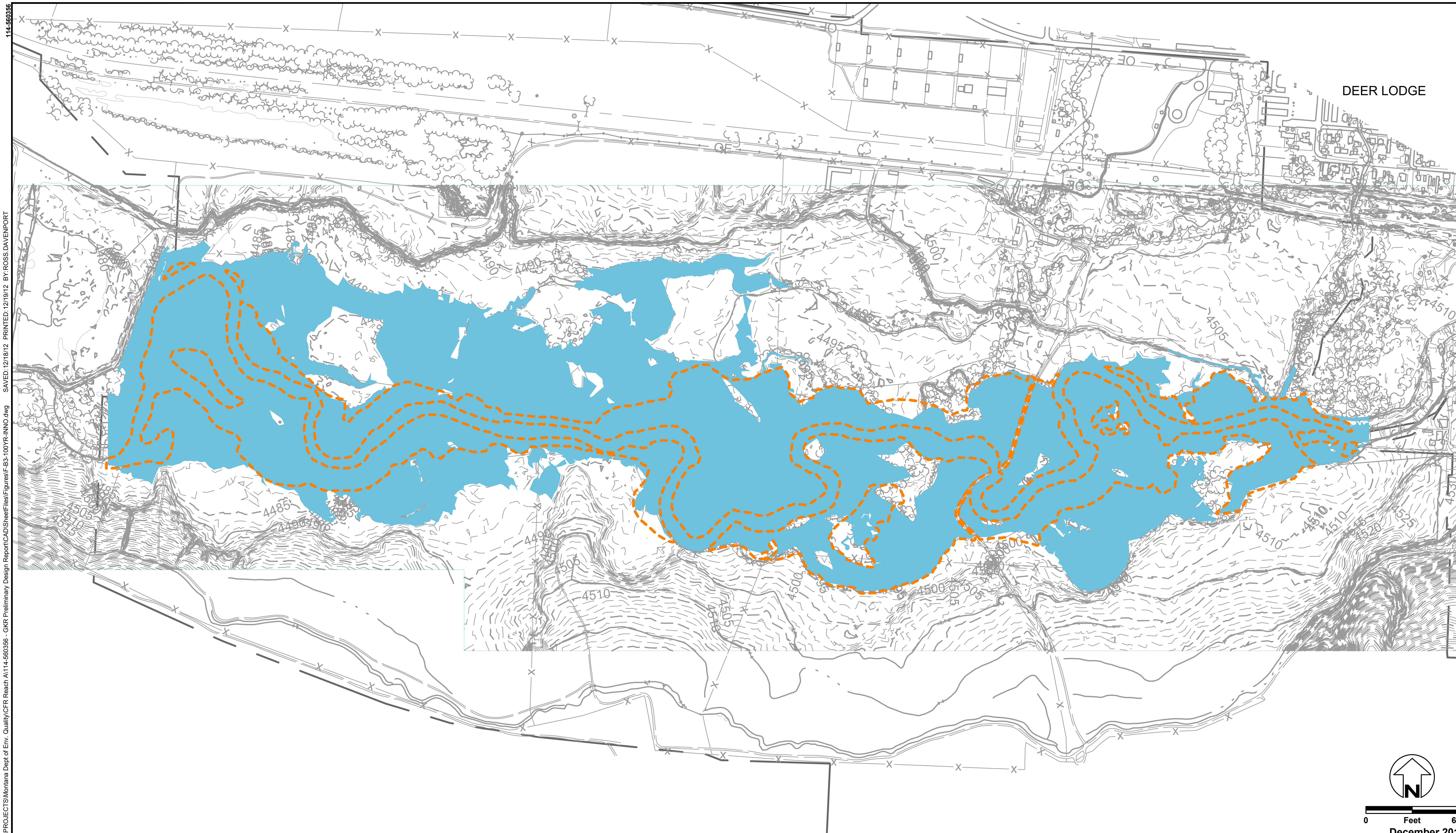
N:\PROJECTS\Montana Dept of Env. Quality\CFR Reach A\114-560356 - GKR Preliminary Design Report\CAD\SheetFiles\Figures\F-B2-10YR-INNO.dwg SAVED:12/18/12 PRINTED:12/19/12 BY:ROSS.DAVENPORT

114-560356

PREDICTED INUNDATION AREA FOR 10 YEAR FLOOD — FOLLOWING FLOODPLAIN CONSTRUCTION

REMOVAL BOUNDARY

CLARK FORK RIVER
PHASES 15 & 16
10 YEAR INUNDATION
FIGURE B2



CLARK FORK RIVER
PHASES 15 & 16
100 YEAR INUNDATION
FIGURE B3

PREDICTED INUNDATION AREA FOR 100 YEAR FLOOD — FOLLOWING FLOODPLAIN CONSTRUCTION

REMOVAL BOUNDARY

APPENDIX C - NATIONAL WETLANDS INVENTORY, SOIL SURVEY DATA, AND VEGETATION COMMUNITY DESCRIPTIONS

Appendix C

Vegetation Community Descriptions

Introduction

This Appendix summarizes the following information:

- Descriptions of existing vegetation communities mapped within Phases 15 and 16, photographs showing typical conditions, and plant species list collected within sample plots, and
- U.S. Fish and Wildlife Service, National Wetlands Inventory and U.S. Department of Agriculture, Natural Resources Conservation Service Soil Survey Data for Powell County within Phases 15 and 16.

For each vegetation community, summary tables include the percent canopy cover that was recorded for each observed plant species along with its life form (tree, shrub, forb, or graminoid) and its Wetland Indicator Status (WIS) according the National Wetlands Plant List (Lichvar, 2012) (Table 1). The WIS is a ranking of how frequently various species are found in either wetland or non-wetland environments.

Table 1. Wetland Indicator Status definitions according to the *National Wetland Plant List Indicator Rating Definitions* (Lichvar et al,. 2012).

Indicator Code	Indicator Name	Definition
OBL	Obligate Wetland Plants	Almost always occur in wetlands. With few exceptions, these plants (herbaceous or woody) are found in standing water or seasonally saturated soils (14 or more consecutive days) near the surface.
FACW	Facultative Wetland Plants	Usually occurs in wetlands, but may occur in non-wetlands. These plants predominantly occur with hydric soils, often in geomorphic setting where water saturates the soils or floods the soil surface at least seasonally.
FAC	Facultative Plant	Occur in wetlands and non-wetlands. These plants can grow in hydric, mesic, or xeric habitats. The occurrence of these plants in different habitats represents responses to a variety of environmental variables other than just hydrology, such as shade tolerance, soil pH, and elevation, and they have a wide tolerance of soil moisture conditions
FACU	Facultative Upland Plant	Usually occur in non-wetlands, but may occur in wetlands. These plants predominantly occur on drier or more mesic sites in geomorphic settings where water rarely saturates the soils or floods the soils surface seasonally
UPL	Upland Plants	Almost never occur in wetlands. These plants occupy mesic to xeric non-wetland habitats. They almost never occur in standing water or saturated soils. Typical growth forms include herbaceous, shrubs, woody vines, and trees.
--	--	Plant species not listed are considered UPL for wetland delineation purposes.

Upland Herbaceous

This Upland Herbaceous vegetation community occupies 46.2 acres of Phases 15 and 16. Dominant plant species include: redtop (*Agrostis gigantea*), smooth brome (*Bromus inermis*), tufted hairgrass (*Deschampsia cespitosa*), slender wheatgrass (*Elymus trachycaulus*), and timothy (*Phleum pratense*) (Table 2, Figure 1). Dominant forb species include: leafy spurge (*Euphorbia esula*), a noxious weed; common yarrow (*Achillea millefolium*); silverweed cinquefoil (*Argentina anserina*); and field pennycress (*Thlaspi arvense*). Upland Herbaceous vegetation communities are on average 1.8 feet above the 2-year flow water surface elevation. Contamination depths are on average 1.3 feet deep. In many cases, there is an obvious topography break between the Upland Herbaceous vegetation community on terraces and lower areas within the floodplain. Only 2.8 acres of Upland Herbaceous vegetation community is considered hydrologically connected to the river.

Figure 1. Examples of Upland Herbaceous vegetation communities A) bordering the Clark Fork River and B) looking east from channel with the Birch/Willow vegetation community in the distance.

Table 2. Species observed in the Upland Herbaceous vegetation community during the July 2012 vegetation survey.

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Plot 7				
Agrostis gigantea	redtop	graminoid	25	FAC
Bromus inermis	smooth brome	graminoid	20	FAC
Deschampsia cespitosa	tufted hairgrass	graminoid	15	FACW
Elymus trachycaulus	slender wheatgrass	graminoid	15	FAC
Phleum pratense	timothy	graminoid	15	FAC
Euphorbia esula	leafy spurge	forb	5	NI
Poa pratensis	Kentucky bluegrass	graminoid	5	FAC
Achillea millefolium	common yarrow	forb	2	FACU
Argentina anserina	silverweed cinquefoil	forb	2	OBL
Juncus arcticus	arctic rush	graminoid	2	FACW
Pascopyrum smithii	western wheatgrass	graminoid	2	FACU
Ribes americanum	American black currant	shrub	2	FAC
Thlaspi arvense	field pennycress	forb	2	FACU

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Brassica rapa	field mustard	forb	1	FACU
Urtica dioica	stinging nettle	forb	1	FAC

[1] Wetland Indicator Status (WIS) from 2012 National Wetlands Plant List (Lichvar, 2012). 'NI' are species not included on the list and are considered to be 'UPL' for wetland delineation purposes. 'N/A' are plants that were only identified to the genus level and therefore a WIS is not available.

Agriculture

The Agriculture vegetation community occupies approximately 45 acres and is managed for grazing and haying activities, and is often irrigated (Figure 2). Dominant vegetation consists primarily of non-native grasses and weedy forbs including: timothy, meadow foxtail (*Alopecurus pratensis*), smooth brome, common dandelion (*Taraxacum officinale*), and white clover (*Trifolium repens*) (Table 3). This vegetation community is located mostly outside of the channel migration zone on either side of the riparian corridor at an average elevation of 2.4 feet above the 2-year flow water surface elevation. One acre within this community is considered hydrologically connected to the river. The average contamination depth is 0.5 feet; however, few soil pits were evaluated in this vegetation community because it is generally located far from the channel.

Figure 2. Examples of the Agriculture vegetation community Phases 15 and 16 with A) showing recently grazed grasses and B) showing an irrigated pasture dominated by timothy and other pasture grasses.

Table 3. Species observed in the Agriculture vegetation community during the July 2012 vegetation survey.

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Plot 3				
Alopecurus pratensis	meadow foxtail	graminoid	60	FACW
Bromus inermis	smooth brome	graminoid	10	FAC
Taraxacum officinale	common dandelion	forb	10	FACU
Trifolium repens	white clover	forb	10	FAC
Cirsium arvense	Canada thistle	forb	2	FAC
Poa pratensis	Kentucky bluegrass	graminoid	2	FAC

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Ranunculus acris	tall buttercup	forb	2	FAC
Plot 11				
Juncus arcticus	arctic rush	graminoid	20	FACW
Poa pratensis	Kentucky bluegrass	graminoid	20	FAC
Carex aquatilis	water sedge	graminoid	15	OBL
Trifolium repens	white clover	forb	15	FACU
Alopecurus pratensis	meadow foxtail	graminoid	10	FACW
Bromus inermis	smooth brome	graminoid	10	FAC
Elymus trachycaulus	slender wheatgrass	graminoid	10	FAC
Phleum pratense	timothy	graminoid	10	FAC
Argentina anserina	silverweed cinquefoil	forb	2	OBL
Carex praegracilis	clustered field sedge	graminoid	2	FACW

[1] Wetland Indicator Status (WIS) from 2012 National Wetlands Plant List (Lichvar, 2012). 'NI' are species not included on the list and are considered to be 'UPL' for wetland delineation purposes. 'N/A' are plants that were only identified to the genus level and therefore a WIS is not available.

Willow/Birch

This shrub-dominated vegetation community occupies approximately 52.5 acres and is characterized by a dense canopy of water birch (*Betula occidentalis*) and/or willows (*Salix* spp.) in the overstory (Figure 3). It is generally found within the channel migration zone or along tributaries. The average relative elevation of this vegetation community is 1.7 feet above the 2-year flow water surface, with a range of 3.2 feet below and 9.1 feet above the 2-year flow water surface elevation. Due to the wide range of elevations, this vegetation community supports both wetland and upland vegetation in the understory. Dominant species in a Willow/Birch vegetation community with a drier understory include: redtop, Woods' rose (*Rosa woodsii*), smooth brome, and arctic rush (*Juncus arcticus*) (Table 4). Dominant species in a Willow/Birch vegetation community with a wetter understory include: arctic rush, panicled bulrush (*Scirpus microcarpus*), and meadow foxtail. Areas of bare ground occasionally occur within or adjacent to this vegetation community. Average depth of contamination is 1.6 feet. Approximately 2.6 acres of this vegetation community are considered hydrologically connected to the river.

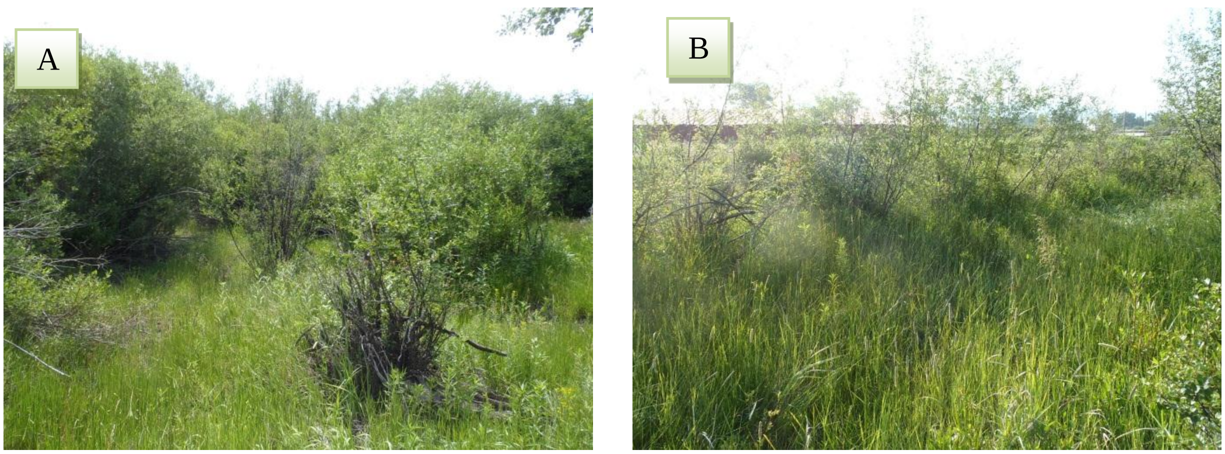


Figure 3. Examples of the Willow/Birch vegetation community in Phases 15 and 16 with A) showing a drier herbaceous understory dominated by redtop and B) showing a wetter understory dominated by arctic rush and sedges.

Table 4. Species observed in the Willow/Birch vegetation community during the July 2012 vegetation survey.

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Plot 13				
Agrostis gigantea	redtop	graminoid	45	FAC
Betula occidentalis	water birch	shrub	20	FACW
Juncus arcticus	arctic rush	graminoid	20	FACW
Rosa woodsii	Woods' Rose	shrub	15	FACU
Bromus inermis	smooth brome	graminoid	10	FAC
Euphorbia esula	leafy spurge	forb	10	NI
Salix geyeriana	Geyer willow	shrub	10	OBL
Salix boothii	Booth's willow	shrub	10	FACW
Deschampsia cespitosa	tufted hairgrass	graminoid	5	FACW
Trifolium repens	white clover	forb	2	FAC
Iris missouriensis	Rocky Mountain iris	forb	1	FACW

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Silene latifolia	bladder campion	forb	1	NI
Plot 8				
Carex aquatilis	water sedge	graminoid	65	OBL
Salix geyeriana	Geyer willow	shrub	45	OBL
Betula occidentalis	water birch	shrub	25	FACW
Elymus trachycaulus	slender wheatgrass	graminoid	25	FAC
Mentha arvensis	wild mint	forb	15	FACW
Poa pratensis	Kentucky bluegrass	graminoid	15	FAC
Agrostis gigantea	redtop	graminoid	10	FAC
Alopecurus pratensis	meadow foxtail	graminoid	10	FACW
Euphorbia esula	leafy spurge	forb	10	NI
Cirsium arvense	Canada thistle	forb	5	FAC
Deschampsia cespitosa	tufted hairgrass	graminoid	5	FACW
Juncus arcticus	arctic rush	graminoid	5	FACW
Ribes americanum	American black currant	shrub	5	FAC
Solidago canadensis var. lepida	Canada goldenrod	forb	5	FAC
Trifolium repens	white clover	forb	5	FACU
Equisetum arvense	field horsetail	forb	2	FAC
Plot 4				
Betula occidentalis	water birch	shrub	35	FACW
Juncus arcticus	arctic rush	graminoid	30	FACW
Alopecurus pratensis	meadow foxtail	graminoid	20	FACW
Scirpus microcarpus	panicled bulrush	graminoid	20	OBL
Agrostis gigantea	redtop	graminoid	10	FAC
Solidago canadensis var. lepida	Canada goldenrod	forb	10	FAC
Carex aquatilis	water sedge	graminoid	5	OBL
Carex utriculata	Northwest Territory sedge	graminoid	5	OBL
Cirsium arvense	Canada thistle	forb	5	FAC
Deschampsia cespitosa	tufted hairgrass	graminoid	5	FACW
Equisetum arvense	field horsetail	forb	5	FAC
Mentha arvensis	wild mint	forb	5	FACW
Salix boothii	Booth's willow	shrub	5	FACW
Sonchus arvensis	field sowthistle	forb	5	FACU
Poa pratensis	Kentucky bluegrass	graminoid	2	FAC
Triglochin palustris	marsh arrowgrass	graminoid	1	OBL

[1] Wetland Indicator Status (WIS) from 2012 National Wetlands Plant List (Lichvar, 2012). 'NI' are species not included on the list and are considered to be 'UPL' for wetland delineation purposes. 'N/A' are plants that were only identified to the genus level and therefore a WIS is not available.

Wet Meadow

The Wet Meadow vegetation community occupies approximately 24.4 acres and is characterized by herbaceous vegetation found in temporarily or seasonally flooded wetlands (Figure 4). Vegetation was recorded in a plot located within a mosaic of Wet Meadow and Willow/Birch vegetation communities; however the Wet Meadow community was not large enough to be an independent mappable unit and is therefore included as Willow/Birch. The herbaceous vegetation is representative of the wet meadow component in this area as well as other mapped Wet Meadow areas. Dominant vegetation includes: woolly sedge (*Carex pellita*), Northwest Territory sedge (*Carex utriculata*), fowl mannagrass (*Glyceria striata*), redtop, water sedge (*Carex aquatilis*), and Nebraska sedge (*Carex nebrascensis*) (Table 5). These areas have saturated soils or standing water during parts of the growing season and support a diverse community of wetland species. Noxious weeds are present but not dominant. This vegetation community is on average 1.9 feet above the 2-year flow water surface elevation with approximately 2.4 acres considered to be hydrologically connected to the river. Contamination depths average 0.7 feet.

Figure 4. Wet Meadow vegetation community example located east of the channel in Phase 16.

Table 5. Species observed in the Wet Meadow vegetation community during the July 2012 vegetation survey.

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Plot 2				
Carex pellita	woolly sedge	graminoid	20	OBL
Carex utriculata	Northwest Territory sedge	graminoid	20	OBL
Glyceria striata	fowl mannagrass	graminoid	15	OBL
Agrostis gigantea	redtop	graminoid	10	FAC
Carex aquatilis	water sedge	graminoid	10	OBL
Carex nebrascensis	Nebraska sedge	graminoid	10	OBL
Salix geyeriana	Geyer willow	shrub	10	OBL
Alopecurus pratensis	meadow foxtail	graminoid	2	FACW

Phleum pratense	timothy	graminoid	2	FAC
Polygonum amphibium	water knotweed	forb	2	NI

[1] Wetland Indicator Status (WIS) from 2012 National Wetlands Plant List (Lichvar, 2012). ‘NI’ are species not included on the list and are considered to be ‘UPL’ for wetland delineation purposes. ‘N/A’ are plants that were only identified to the genus level and therefore a WIS is not available.

Emergent Marsh

The Emergent Marsh vegetation community occupies approximately 17 acres and is characterized by hydrophytic herbaceous vegetation found in semi-permanently to permanently flooded wetlands (Figure 5). Dominant plant species include: clustered field sedge (*Carex praegracilis*), water sedge, softstem bulrush (*Schoenoplectus tabernaemontani*), broadleaf cattail (*Typha latifolia*), and arctic rush (Table 6). Emergent Marsh vegetation communities are commonly located in lower geomorphic features including oxbows and relic channels. A large area of Emergent Marsh is located in the southern portion of the Phases 15 and 16 west of the Clark Fork River. This area has likely developed in response to beaver activity and standing water, and saturated soils are likely present throughout much of the growing season in this vegetation community. The average elevation of this community is 1.5 feet above the 2-year flow water surface elevation with approximately 3.5 acres considered hydrologically connected to the river. Areas not presently connected to the river may have tailing deposits that raised the ground surface elevation relative to half a foot above the 2-year water surface elevation. The average depth of contamination is 1 foot.

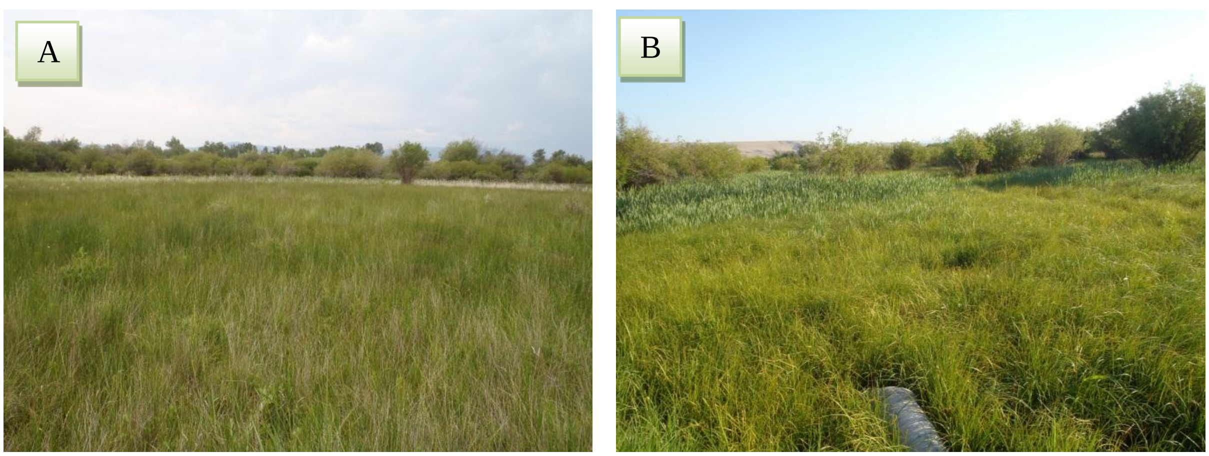


Figure 5. Examples of Emergent Marsh communities in A) Phase 16 east of the river and B) Phase 15 west of the river near a beaver impoundment.

Table 6. Species observed in the Emergent Marsh vegetation community during the July 2012 vegetation survey.

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Plot 9				
Carex praegracilis	clustered field sedge	graminoid	30	FACW
Carex aquatilis	water sedge	graminoid	20	OBL
Schoenoplectus tabernaemontani	softstem bulrush	graminoid	20	OBL
Juncus arcticus	arctic rush	graminoid	10	FACW

Pedicularis groenlandica	elephanthead lousewort	forb	10	OBL
Typha latifolia	broadleaf cattail	graminoid	10	OBL
Salix boothii	Booth's willow	shrub	5	FACW
Salix drummondiana	Drummond's willow	shrub	5	FACW
Zigadenus venenosus	meadow deathcamas	forb	5	NI
Argentina anserina	silverweed cinquefoil	forb	2	OBL
Carex nebrascensis	Nebraska sedge	graminoid	2	OBL
Mentha arvensis	wild mint	forb	2	FACW
Triglochin palustris	marsh arrowgrass	forb	2	OBL

[1] Wetland Indicator Status (WIS) from 2012 National Wetlands Plant List (Lichvar, 2012). 'NI' are species not included on the list and are considered to be 'UPL' for wetland delineation purposes. 'N/A' are plants that were only identified to the genus level and therefore a WIS is not available.

Willow/Birch – Depression

The Willow/Birch – Depression vegetation community occupies 7.4 acres. This vegetation community is similar to the Willow/Birch vegetation community but it is located in distinct topographic low areas such as swales, oxbows, or abandoned channels (Figure 6). The average elevation of this vegetation community is 0.7 feet above the 2-year flow water surface elevation and 2.5 acres are considered to be hydrologically connected to the river. The understory is dominated by wetland vegetation including fowl mannagrass, Kentucky bluegrass (*Poa pratensis*), meadow foxtail, water sedge, and wild mint (*Mentha arvensis*) (Table 7). Because these communities often occur in relic channel features, river derived sediments containing contaminants may have deposited in these areas as the channel features filled in over time. The average depth of contamination is 1 foot.

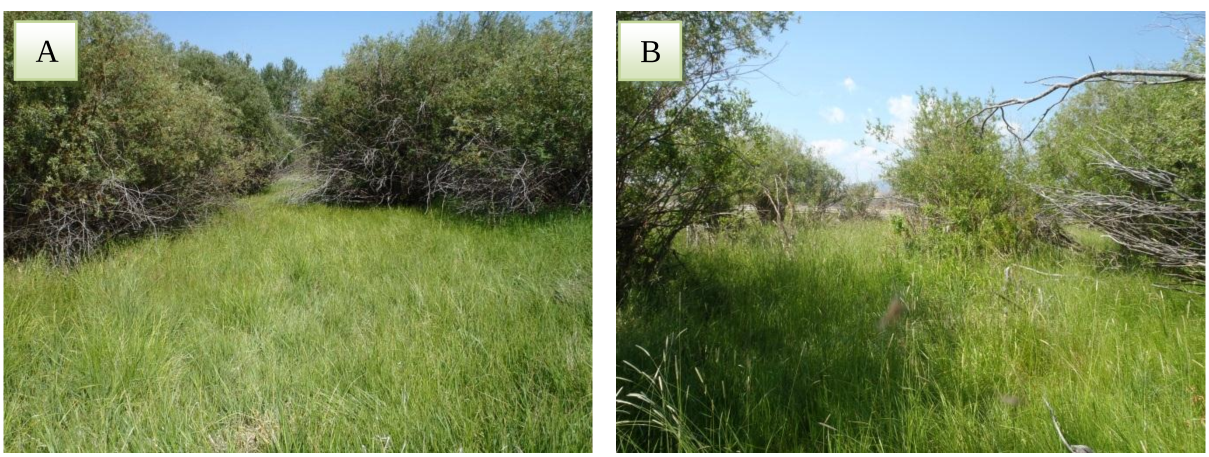


Figure 6. Examples of the Willow/Birch – Depression vegetation community with the understory dominated by A) sedges and B) wetland grasses.

Table 7. Species observed in the Willow/Birch - Depression vegetation community during the July 2012 vegetation survey.

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Plot 6				
Alopecurus pratensis	meadow foxtail	graminoid	65	FACW
Salix geyeriana	Geyer willow	shrub	50	OBL
Salix boothii	Booth's willow	shrub	30	FACW
Poa pratensis	Kentucky bluegrass	graminoid	15	FAC
Cirsium arvense	Canada thistle	forb	5	FAC
Glyceria striata	fowl mannagrass	graminoid	5	OBL
Carex aquatilis	water sedge	graminoid	2	OBL
Mentha arvensis	wild mint	forb	2	FACW
Trifolium repens	white clover	forb	2	FAC

[1] Wetland Indicator Status (WIS) from 2012 National Wetlands Plant List (Lichvar, 2012). 'NI' are species not included on the list and are considered to be 'UPL' for wetland delineation purposes. 'N/A' are plants that were only identified to the genus level and therefore a WIS is not available.

Vegetated Bar

The Vegetated Bar vegetation community occupies 3.8 acres and is dominated by: redtop, meadow foxtail, field horsetail (*Equisetum arvense*), sandbar willow (*Salix exigua*), common spikerush (*Eleocharis palustris*), dock species (*Rumex* spp.), panicled bulrush, field pennycress, tufted hairgrass, and reed canarygrass (*Phalaris arundinacea*) (Figure 7 and Table 8). It occurs on point bars along the river and experiences frequent flooding, scour, and deposition often resulting in sparse vegetative cover. On average this community occurs 0.3 feet above the 2-year flow water surface elevation and 2 acres of its area is considered hydrologically connected to the river. Those areas not connected to the river may have more deposition from higher magnitude flow events. The average depth of contamination is 1.7 feet.

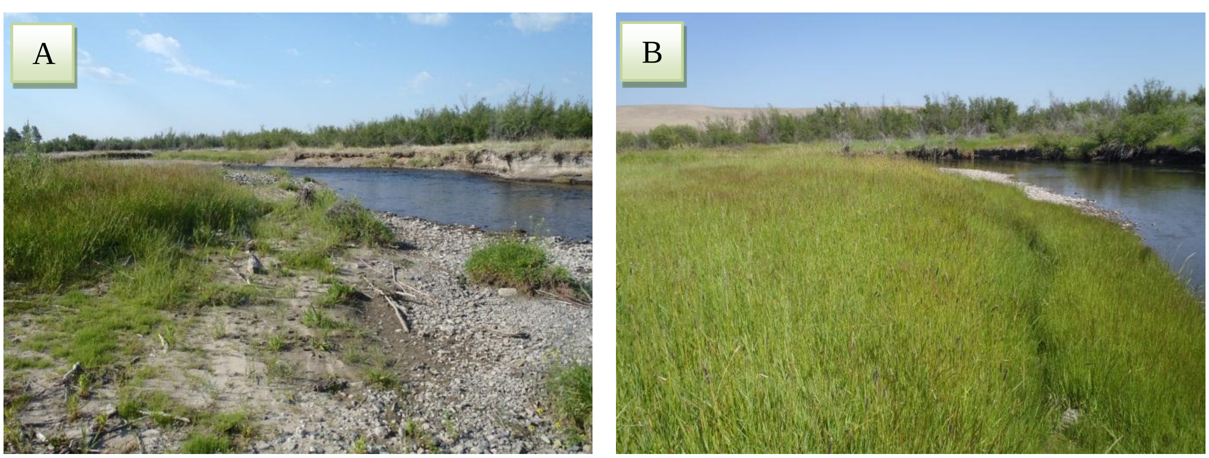


Figure 7. Examples of Vegetated Bar communities in Phases 15 and 16 with A) vegetation redeveloping following a scour event and B) dense vegetation including redtop and meadow foxtail.

Table 8. Species observed in the Vegetated Bar vegetation community during the July 2012 vegetation survey.

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Plot 5				
Agrostis gigantea	redtop	graminoid	5	FAC
Eleocharis palustris	common spikerush	graminoid	5	OBL
Equisetum arvense	field horsetail	forb	5	FAC
Rumex spp.	dock species	forb	5	N/A
Scirpus microcarpus	panicled bulrush	graminoid	5	OBL
Thlaspi arvense	field pennycress	forb	5	UPL
Brassica rapa	field mustard	forb	3	FACU
Silene latifolia	bladder campion	forb	3	NI
Alopecurus pratensis	meadow foxtail	graminoid	2	FACW
Pascopyrum smithii	western wheatgrass	graminoid	2	FACU
Taraxacum officinale	common dandelion	forb	2	FACU
Trifolium repens	white clover	forb	2	FAC
Alopecurus aequalis	shortawn foxtail	graminoid	1	OBL
Melilotus officinalis	sweetclover	forb	1	FACU
Veronica anagallis-aquatica	water speedwell	forb	1	OBL
Argentina anserina	silverweed cinquefoil	forb	<1	OBL
Bromus tectorum	cheatgrass	graminoid	<1	NI
Deschampsia cespitosa	tufted hairgrass	graminoid	<1	FACW
Epilobium ciliatum	fringed willowherb	forb	<1	FACW
Lactuca serriola	prickly lettuce	forb	<1	FACU
Mentha arvensis	wild mint	forb	<1	FACW
Polygonum aviculare	prostrate knotweed	forb	<1	FAC
Plot 12				
Alopecurus pratensis	meadow foxtail	graminoid	30	FACW
Agrostis gigantea	redtop	graminoid	10	FAC
Equisetum arvense	field horsetail	fern/allies	10	FACW
Salix exigua	sandbar willow	shrub	10	FACW
Deschampsia cespitosa	tufted hairgrass	graminoid	5	FACW
Phalaris arundinacea	reed canarygrass	graminoid	5	FACW
Brassica rapa	field mustard	forb	2	FACU
Elymus trachycaulus	slender wheatgrass	graminoid	2	FAC
Poa pratensis	Kentucky bluegrass	graminoid	2	FAC
Rumex spp.	dock species	forb	2	N/A
Scirpus microcarpus	panicled bulrush	graminoid	2	OBL
Melilotus officinalis	sweetclover	forb	1	FACU
Polygonum aviculare	prostrate knotweed	forb	1	FACU
Silene latifolia	bladder campion	forb	1	NI
Thlaspi arvense	field pennycress	forb	1	FACU

[1] Wetland Indicator Status (WIS) from 2012 National Wetlands Plant List (Lichvar, 2012). ‘NI’ are species not included on the list and are considered to be ‘UPL’ for wetland delineation purposes. ‘N/A’ are plants that were only identified to the genus level and therefore a WIS is not available.

Open Water

The Open Water community occupies 1.8 acres and is characterized by low elevation palustrine aquatic bed wetlands that have minimal emergent vegetation present. These areas are located in the central and northern portion of Phase 15 and consist of old oxbow features. The current elevation of these vegetation communities is an average 0.3 feet above the 2-year flow water surface elevation and 1.1 acres are considered hydrologically connected to the river. No soil pits were excavated in this area to provide an average depth of contamination. No vegetation data or photographs were collected.

Bare Ground

The Bare Ground vegetation community occupies 1.6 acres and is characterized by having little to no vegetation (Figure 8). These areas are located primarily within the channel migration zone, except for two areas east of the Clark Fork River at boundary between Phases 15 and 16. The average elevation of this vegetation community is 1.6 feet above the 2-year flow water surface elevation and approximately 0.1 acres of this community is considered hydrologically connected to the river. This vegetation community has the second largest average depth of contamination of 2.4 feet. Many of these areas have a green colored crust on the surface indicating the presence of copper salts (these areas closely correspond with slickens as described in the *Record of Decision*, USEPA/MDEQ, 2004). If vegetated, the dominant species are tufted hairgrass and redtop. Vegetation data were not collected for this vegetation community.

Figure 8. Example of a Bare Ground vegetation community in Phases 15 and 16.

Willow/Birch - Cottonwood Overstory

The Willow/Birch – Cottonwood Overstory vegetation community occupies 0.7 acres and is similar to the Willow/Birch vegetation community except that it includes an overstory canopy of black cottonwood (*Populus balsamifera spp. trichocarpa*) (Figure 9). Dominant vegetation in the understory includes: smooth brome, arctic rush, willows, redtop, and leafy spurge, American licorice (*Glycyrrhiza lepidota*), and western snowberry (*Symphoricarpos occidentalis*) (Table 9). This vegetation community occurs in several small patches on the west side of the Clark Fork River in Phase 15. It averages 0.9 feet above the 2-year flow water surface elevation and has an average depth of contamination of 1.3 feet. Approximately 0.1 acres of this community is considered to be hydrologically connected to the river.

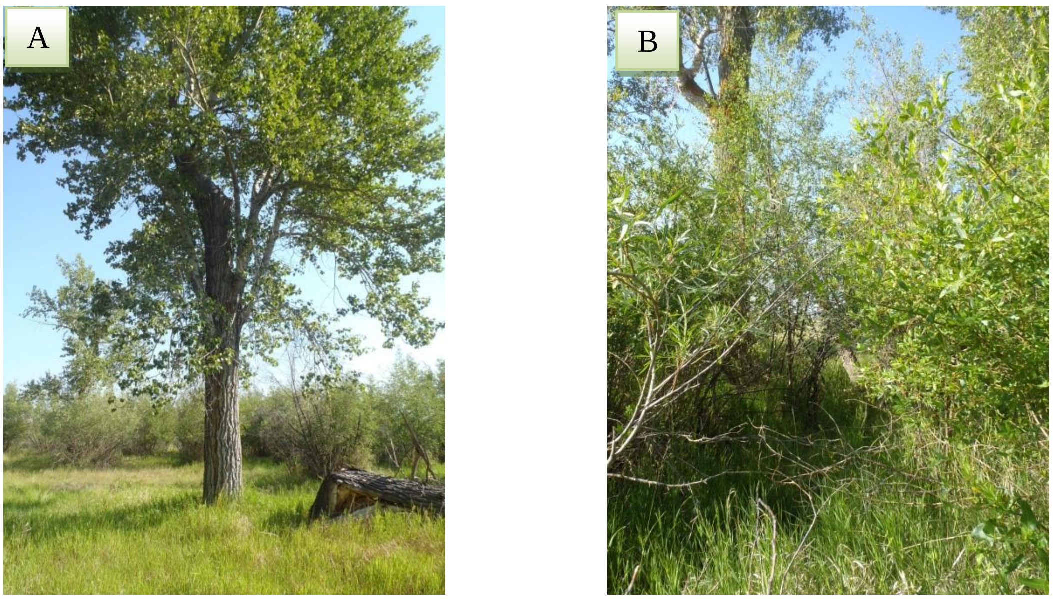


Figure 9. Examples of the Willow/Birch – Cottonwood Overstory vegetation community with A) black cottonwood in the overstory and B) dense willows in understory.

Table 9. Species observed in the Willow/Birch – Cottonwood Overstory vegetation community during the July 2012 vegetation survey.

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Plot 10				
Betula occidentalis	water birch	shrub	35	FACW
Populus balsamifera ssp. trichocarpa	black cottonwood	tree	30	FAC
Bromus inermis	smooth brome	graminoid	25	FAC
Juncus arcticus	arctic rush	graminoid	20	FACW
Salix boothii	Booth's willow	shrub	15	FAC
Salix geyeriana	Geyer willow	shrub	15	OBL
Agrostis gigantea	redtop	graminoid	10	FAC
Euphorbia esula	leafy spurge	forb	10	NI
Glycyrrhiza lepidota	American licorice	forb	5	FAC
Symphoricarpos occidentalis	western snowberry	shrub	5	FAC
Poa pratensis	Kentucky bluegrass	graminoid	2	FAC

Rosa woodsii	Woods' Rose	shrub	2	FACU
Juniperus communis	common juniper	shrub	1	FACU

[1] Wetland Indicator Status (WIS) from 2012 National Wetlands Plant List (Lichvar, 2012). 'NI' are species not included on the list and are considered to be 'UPL' for wetland delineation purposes. 'N/A' are plants that were only identified to the genus level and therefore a WIS is not available.

Cottonwood Stand

The Cottonwood Stand vegetation community occupies 0.5 acres and is characterized by a black cottonwood overstory with herbaceous species in the understory (Figure 10). Dominant vegetation in the understory includes: western snowberry, redtop, and smooth brome. This community is found in three locations in Phase 15: 1) along a tributary in the southeast portion of the site; 2) east of the Clark Fork River adjacent to pasture land; and 3) west of the channel crossing at the Phase 15 and Phase 16 reach break. The average elevation of this community is 1.7 feet above the 2-year flow water surface elevation and this vegetation community is not hydrologically connected to the river. The average depth of contamination is 1.3 feet. The elevation and current age class of the Cottonwood Stand vegetation community suggests these communities existed prior to the deposition of contaminated sediments. No new cottonwood recruitment was noted in the field visits in summer 2012. Plot data were not collected for this vegetation community.

Figure 10. Example of a Cottonwood Stand vegetation community in Phase 15.

Depositional

The Depositional vegetation community occupies 0.5 acres and consists of recently deposited sediment along the channel (Figure 11). Most of this vegetation community is unvegetated, but where sparse vegetation is present, plant species include: cheatgrass (*Bromus tectorum*), common mullein (*Verbascum thapsus*), and field pennycress. This vegetation community is located entirely within the channel migration zone. The average elevation of this vegetation community is 0.8 feet below the 2-year flow water surface elevation and 0.4 acres of this vegetation community are considered hydrologically connected to the river. The average depth of contamination is 1.9 feet. Plot data were not collected for this vegetation community.

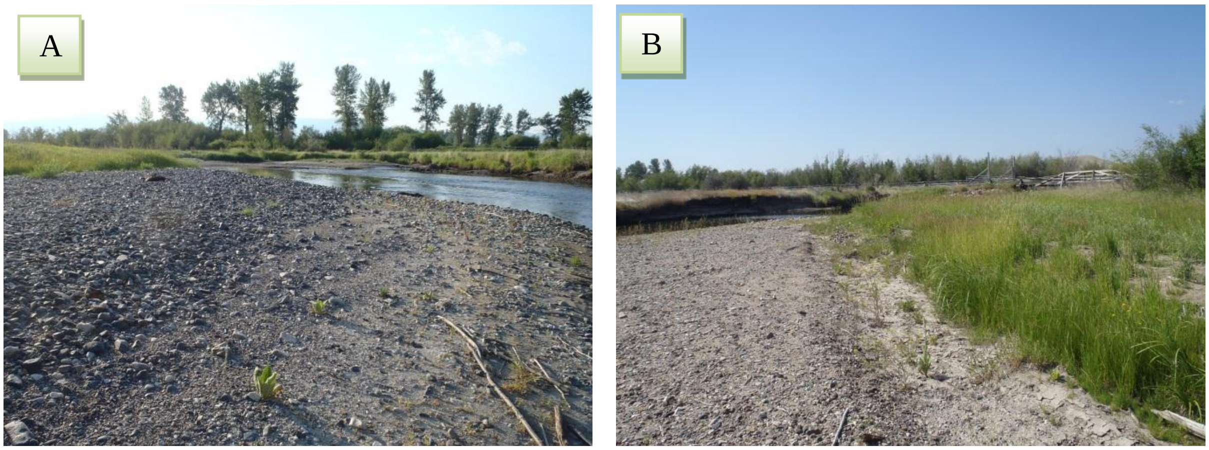


Figure 11. Examples of the Depositional vegetation community with A) minimal vegetative cover and B) a depositional bar leading up to a vegetated bar.

Low Shrub

The Low Shrub vegetation community occupies 0.2 acres and is characterized by a dominance of low shrub species, primarily western snowberry (Figure 12). Herbaceous species include: smooth brome, reed canarygrass, common cowparsnip (*Heracleum maximum*), and redtop (Table 10). The Low Shrub vegetation community is found within the channel migration zone as small isolated patches at elevations averaging 1.6 feet above the 2-year flow water surface elevation. This vegetation community is not hydrologically connected to the river. Contamination is on average 1.3 feet deep.

Figure 12. Low Shrub vegetation community in Phases 15 and 16 A) looking southwest from the channel and B) close up of the dominant shrub species, common snowberry.

Table 10. Species observed in the Low Shrub vegetation community during the July 2012 vegetation survey.

Scientific Name	Common Name	Life Form	Percent Cover	WIS [1]
Plot 1				
Symphoricarpos occidentalis	western snowberry	shrub	45	FAC
Bromus inermis	smooth brome	graminoid	20	FAC
Unidentified grasses	unidentified grasses	graminoid	20	N/A
Phalaris arundinacea	reed canarygrass	graminoid	15	FACW
Heracleum maximum	common cowparsnip	forb	10	FAC
Agrostis gigantea	redtop	graminoid	5	FAC
Cirsium arvense	Canada thistle	forb	5	FAC
Trifolium repens	white clover	forb	5	FAC
Carex utriculata	Northwest Territory sedge	graminoid	2	OBL
Poa pratensis	Kentucky bluegrass	graminoid	2	FAC
Taraxacum officinale	common dandelion	forb	2	FACU
Argentina anserina	silverweed cinquefoil	forb	<1	OBL
Galium spp.	bedstraw species	forb	<1	N/A
Ranunculus acris	tall buttercup	forb	<1	FAC

[1] Wetland Indicator Status (WIS) from 2012 National Wetlands Plant List (Lichvar, 2012). 'NI' are species not included on the list and are considered to be 'UPL' for wetland delineation purposes. 'N/A' are plants that were only identified to the genus level and therefore a WIS is not available.

Tufted Hairgrass

The Tufted Hairgrass vegetation community occupies 0.2 acres and is characterized by patches of tufted hairgrass interspersed with bare ground (Figure 13). This vegetation community is located on average 1.8 feet above the 2-year flow water surface elevation and is not considered hydrologically connected to the river. This vegetation community has the greatest accumulation of contamination with an average depth of 2.8 feet. Plot data were not collected for this vegetation community; however, tufted hairgrass is the dominant species with small amounts of redtop also present.

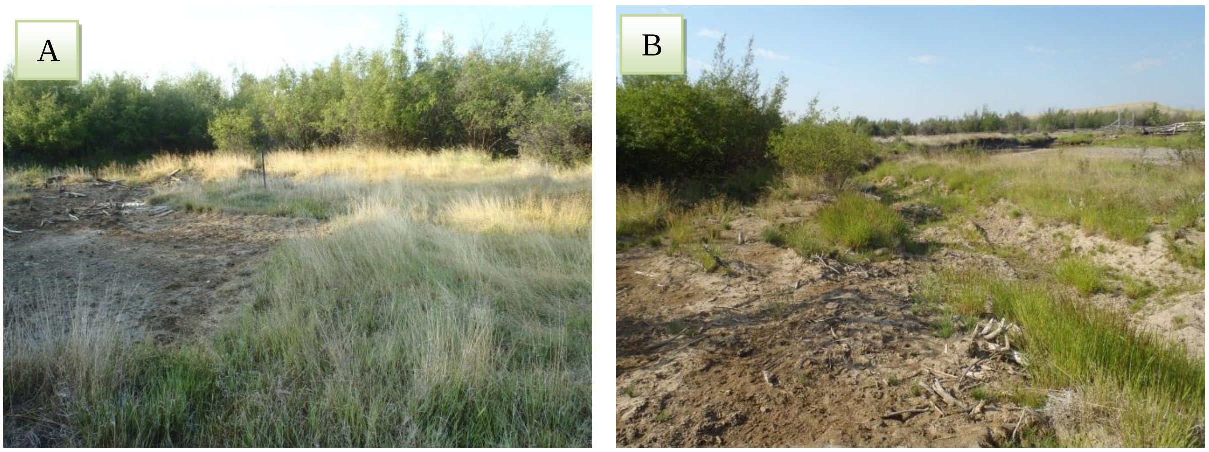


Figure 13. Examples of the Tufted Hairgrass vegetation community in Phases 15 and 16 with A) tufted hairgrass surrounding bare ground and B) redtop and tufted hairgrass interspersed with bare ground.

Colonizing Willow

The Colonizing Willow vegetation community occupies 0.15 acres and consists of recently deposited sediment along the channel that is being colonized by sandbar willow (Figure 14). This vegetation community is located entirely within the channel migration zone. The average elevation is 0.04 feet below the 2-year flow water surface elevation and 0.1 acres are considered hydrologically connected to the river. The average depth of contamination is 2 feet. Plot data were not collected for this vegetation community.

Figure 14. Example of the Colonizing Willow vegetation community in Phases 15 and 16.

Island

The Island vegetation community occupies 0.02 acres and consists of mid-channel bar features. Because of their geomorphic position, islands are often inundated and subject to frequent scouring and deposition. The average elevation of this vegetation community is 0.2 feet below the 2-year flow water surface elevation and the average depth of contamination is 1.6 feet. Plot data were not collected for this vegetation community.

Willow – Aspen Overstory

The Willow-Aspen Overstory vegetation community is located outside the soil sampling extent but is included as a vegetation community because it represents vegetative potential within the project area. This vegetation community occupies 0.3 acres and consists of a willow shrub canopy with an overstory of quaking aspen (*Populus tremuloides*). The understory is dominated by herbaceous vegetation including meadow foxtail and redtop. This vegetation community is located in the southern portion of Phase 15 east of the river. No soil pits were examined and plot data were not collected in this vegetation community.

Aspen Stand

The Aspen Stand vegetation community is located outside the soil sampling extent but is included as a vegetation community because it represents vegetative potential within the project area. It is characterized by a quaking aspen overstory with wetland herbaceous vegetation in the understory. The Aspen Stand vegetation community occupies 0.1 acres in Phase 15. No soil pits were examined and plot data were not collected for this vegetation community.

National Wetlands Inventory Mapping on the Grant-Kohrs Ranch

The National Wetlands Inventory data for Phases 15 and 16 are shown in Figure 15 and Figure 16 respectively (USFWS, 2005).

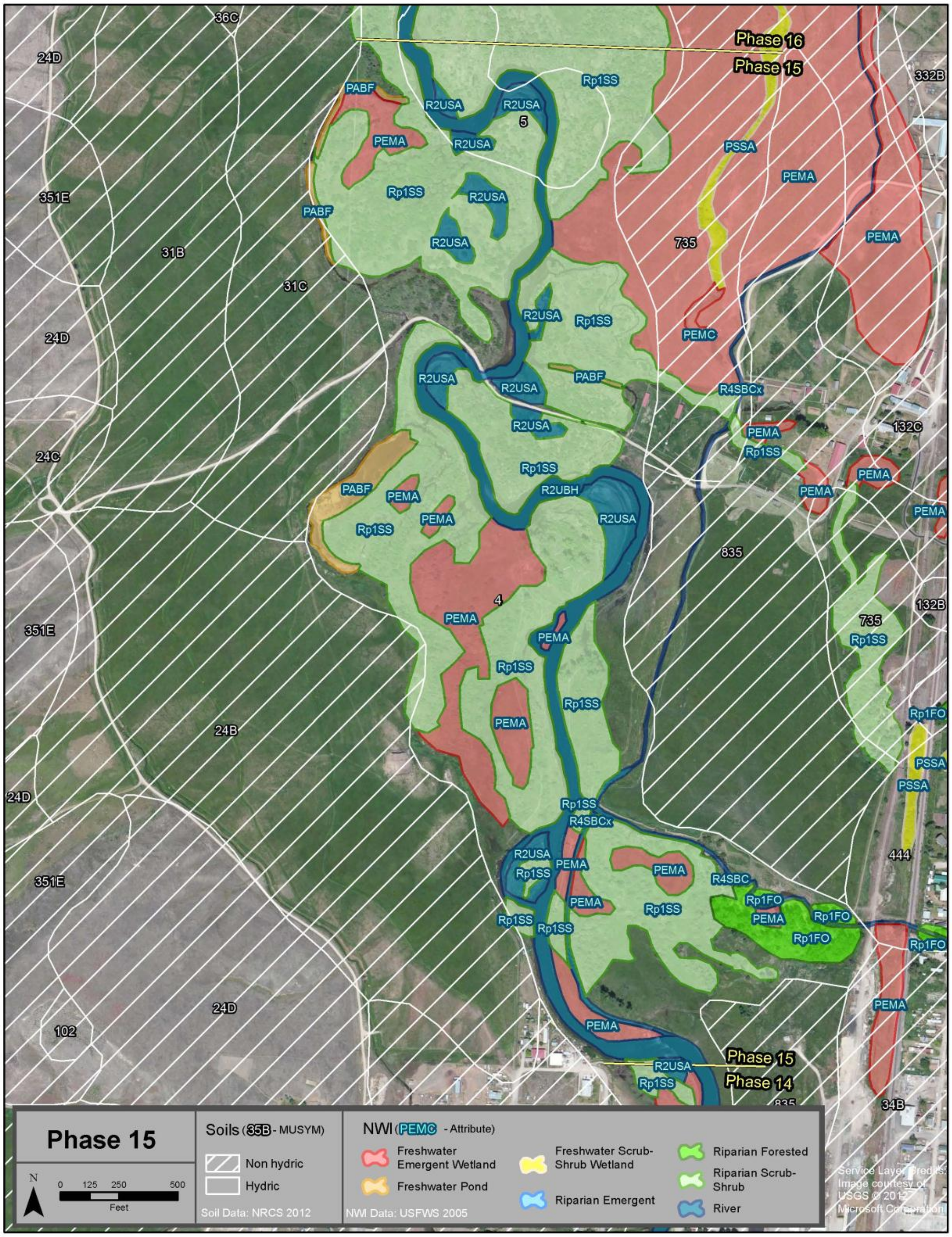


Figure 15. National Wetlands Inventory and Powell County soil survey data for Phase 15.

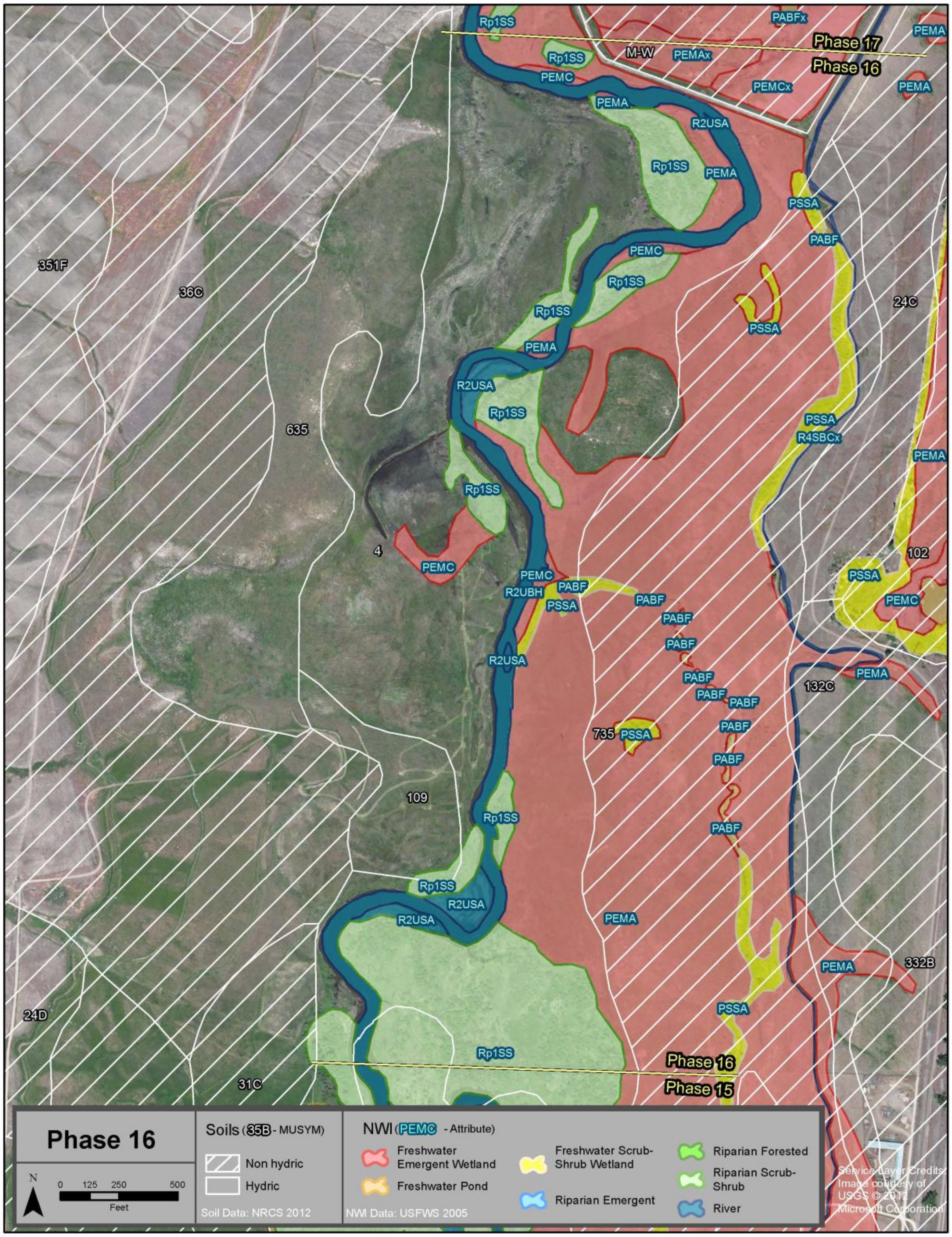


Figure 16. National Wetlands Inventory and Powell County soil survey data for Phase 16.

Table 11. National Wetlands Inventory wetland and riparian codes shown in Figure 15 and Figure 16 above.

Wetland and Riparian Codes	Wetland and Riparian Names [1]
Wetland Codes and Names	
PABF	Palustrine system (P), aquatic bed class (AB), semipermanently flooded water regime (F)
PEMA	Palustrine system (P), emergent class (EM), temporarily flooded water regime (A)
PEMC	Palustrine system (P), emergent class (EM), seasonally flooded water regime (C)
PSSA	Palustrine system (P), scrub shrub class (SS), temporarily flooded water regime (A)
R2UBH	Riverine system (R), lower perennial subsystem (2), unconsolidated bottom class (UB), permanently flooded water regime (H)
R2USA	Riverine system (R), lower perennial subsystem (2), unconsolidated shore class (US), temporarily flooded water regime (A)
R4SBC (x)	Riverine system (R), intermittent subsystem (4), streambed class (SB), seasonally flooded water regime (C), (special modifier – excavated (x))
Riparian Codes and Names	
Rp1SS	Riparian system (Rp), lotic subsystem (1), scrub shrub class (SS)
Rp1FO	Riparian system (Rp), lotic subsystem (1), forested class (FO)

[1] All wetland system, subsystem, class, water regime, and special modifier descriptions below are from the Cowardin Classification System (Cowardin et al., 1979). All riparian system, subsystem, and class descriptions are from *A System for Mapping Riparian Areas in the Western United States* (USFWS, 2009)

Wetland systems and subsystems:

- Riverine system: Wetland and deepwater habitats contained within a channel not dominated by trees, shrubs, persistent emergent, emergent mosses, or lichens.
    - Lower perennial subsystem: Low gradient, slow velocity water body with no tidal influence and some water flowing throughout the year.
    - Intermittent subsystem: Channels with flowing water for only part of the year; water may remain in isolated pools or be absent.
- Palustrine system: Nontidal wetlands dominated by trees, shrubs, persistent emergent, emergent mosses, or lichens; and unvegetated wetlands smaller than 20 acres, without wave-formed or bedrock shorelines, that are less than two meters deep at low water.

Wetland classes:

- Aquatic bed class: Wetlands and deep water habitats dominated by plants that grow primarily on or below the water surface for most of the growing season in most years.
- Emergent class: Wetlands with erect, rooted, herbaceous hydrophytes, excluding mosses and lichens, with this vegetation present for most of the growing season in most years.
- Scrub shrub class: Wetlands dominated by woody vegetation less than 20 feet tall including shrubs, young trees, and stunted trees or shrubs.

Wetland water regimes:

- Permanently flooded: Surface water is present throughout the year in all years.
- Semi-permanently flooded: Surface water is present throughout the growing season in most years and when absent, the water table is usually at or near the ground surface.
- Seasonally flooded: Surface water present for extended periods, especially early in the growing season and absent by the end of the growing season in most years; when surface water is absent the water table is usually near the ground surface.
- Temporarily flooded: Surface water is present for brief periods during the growing season and the water table is usually well below the ground surface for most of the growing season.

Wetland special modifiers:

- Excavated: Wetlands within a basin or channel that were dug, gouged, blasted, or suctioned through artificial means by man.

Riparian systems and subsystems:

- Riparian system: Plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainage ways) having one or both of the following: 1) distinctly different vegetative species than adjacent areas, and 2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms; usually transitional between wetland and upland.
    - Lotic subsystem: Related to or living in flowing water.

Riparian classes:

- Emergent class: Dominant life form is erect and rooted species with an herbaceous stem.
- Scrub shrub class: Dominant life form is woody vegetation less than 6 meter tall.

U.S. Department of Agriculture Natural Resources Conservation Service Soils Survey Data

The U.S. Department of Agriculture, Natural Resources Conservation Service maps soils throughout the nation, including the Phase 15 and 16 project area (Figure 15 and Figure 16; USDA NRCS, 2012). Attributes assigned to specific soil map units are also useful for characterizing a site and its vegetation. The hydric status of soil map units in the project area was used to identify areas that may support wetlands or riparian vegetation communities. Brief descriptions from the Powell County soil survey are included below for map units located in Phases 15 and 16.

Soil map unit descriptions below are quoted from the Powell County soil survey (USDA NRCS, 2012):

Aquents-Slickens complex, 0 to 2 percent slopes, occasionally flooded (4):

> *The Aquents component makes up 55 percent of the map unit. Slopes are 0 to 2 percent. This component is on flood plains. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is poorly drained. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is occasionally flooded. It is not ponded. A seasonal zone of water saturation is at 18 inches during April, May, June. This soil meets hydric criteria.*
>
> *Generated brief soil descriptions are created for major soil components. The Slickens is a miscellaneous area.* [The Slickens component makes up 30 percent of the map unit.]

Slickens-Aquents complex, 0 to 2 percent slopes, occasionally flooded (5):

> *Generated brief soil descriptions are created for major soil components. The Slickens is a miscellaneous area.* [The Slickens component makes up 45 percent of the map unit.]
>
> *The Aquents component makes up 40 percent of the map unit. Slopes are 0 to 2 percent. This component is on flood plains. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is poorly drained. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is occasionally flooded. It is not ponded. A seasonal zone of water saturation is at 18 inches during April, May, June. This soil meets hydric criteria.*

Conn loam, 0 to 4 percent slopes (24B):

The Conn component makes up 85 percent of the map unit. Slopes are 0 to 4 percent. This component is on alluvial fans, stream terraces. The parent material consists of calcareous alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R044XW125MT Silty (si) 10-14" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 28 percent.

Conn loam, 4 to 8 percent slopes (24C):

The Conn component makes up 85 percent of the map unit. Slopes are 4 to 8 percent. This component is on alluvial fans, stream terraces. The parent material consists of calcareous alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R044XW125MT Silty (si) 10-14" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 28 percent.

Conn loam, 8 to 15 percent slopes (24D):

The Conn component makes up 85 percent of the map unit. Slopes are 8 to 15 percent. This component is on alluvial fans, stream terraces. The parent material consists of calcareous alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R044XW125MT Silty (si) 10-14" P.z. ecological site. Nonirrigated land capability classification is 4e. Irrigated land capability classification is 4e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 28 percent.

Varney clay loam, 0 to 4 percent slopes (31B):

The Varney component makes up 85 percent of the map unit. Slopes are 0 to 4 percent. This component is on stream terraces, alluvial fans. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R044XW125MT Silty (si) 10-14" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 23 percent.

Varney clay loam, 4 to 8 percent slopes (31C):

The Varney component makes up 85 percent of the map unit. Slopes are 4 to 8 percent. This component is on stream terraces, alluvial fans. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R044XW125MT Silty (si) 10-14" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 23 percent.

Cetrack loam, 0 to 4 percent slopes (34B):

The Cetrack component makes up 85 percent of the map unit. Slopes are 0 to 4 percent. This component is on stream terraces, alluvial fans. The parent material consists of calcareous loamy alluvium over sandy and gravelly alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R044XW125MT Silty (si) 10-14" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 18 percent.

Varney-Conn loams, 4 to 8 percent slopes (36C):

The Varney component makes up 60 percent of the map unit. Slopes are 4 to 8 percent. This component is on alluvial fans, stream terraces. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R044XW125MT Silty (si) 10-14" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 23 percent.

The Conn component makes up 25 percent of the map unit. Slopes are 4 to 8 percent. This component is on alluvial fans, stream terraces. The parent material consists of calcareous alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R044XW125MT Silty (si) 10-14" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 28 percent.

Pits, gravel (102):

Generated brief soil descriptions are created for major soil components. The Pits, Gravel is a miscellaneous area.

Bohnly silt loam, 0 to 2 percent slopes (109):

The Bohnly component makes up 85 percent of the map unit. Slopes are 0 to 2 percent. This component is on stream terraces. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is poorly drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. A seasonal zone of water saturation is at 15 inches during April, May, June, July, August, September. Organic matter content in the surface horizon is about 50 percent. This component is in the R044XW188MT Wet Meadow (wm) 15-19" P.z. ecological site. Nonirrigated land capability classification is 5w. Irrigated land capability classification is 5w. This soil meets hydric criteria.

Beaverell cobbly loam, 0 to 4 percent slopes (132B):

The Beaverell component makes up 85 percent of the map unit. Slopes are 0 to 4 percent. This component is on stream terraces, alluvial fans. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R044XW136MT Shallow To Gravel (swgr) 10-14" P.z. ecological site. Nonirrigated land capability classification is 6s. Irrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 9 percent.

Beaverell cobbly loam, 4 to 8 percent slopes (132C):

The Beaverell component makes up 85 percent of the map unit. Slopes are 4 to 8 percent. This component is on alluvial fans, stream terraces. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R044XW136MT Shallow To Gravel (swgr) 10-14" P.z. ecological site. Nonirrigated land capability classification is 6s. Irrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 9 percent.

Beaverell loam, 0 to 4 percent slopes (332B):

The Beaverell component makes up 85 percent of the map unit. Slopes are 0 to 4 percent. This component is on alluvial fans, stream terraces. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R044XW136MT Shallow To Gravel (swgr) 10-14" P.z. ecological site. Nonirrigated land capability classification is 6s. Irrigated land capability classification is 6e.

This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 9 percent.

Roy-Shawmut-Danvers complex, 15 to 35 percent slopes (351E):

The Roy component makes up 35 percent of the map unit. Slopes are 15 to 35 percent. This component is on alluvial fans. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R043BM038MT Droughty Steep (drstp) Lru 43b-m ecological site. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 9 percent.

The Danvers component makes up 25 percent of the map unit. Slopes are 15 to 35 percent. This component is on alluvial fans. The parent material consists of calcareous clayey alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is high. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R043BM040MT Loamy Steep (lostp) Lru 43b-m ecological site. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 25 percent.

The Shawmut component makes up 25 percent of the map unit. Slopes are 15 to 35 percent. This component is on alluvial fans. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R043BM038MT Droughty Steep (drstp) Lru 43b-m ecological site. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 23 percent.

Gregson loam, 0 to 4 percent slopes, rarely flooded (444):

The Gregson component makes up 85 percent of the map unit. Slopes are 0 to 4 percent. This component is on flood plains. The parent material consists of loamy alluvium over sandy and gravelly alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is somewhat poorly drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is rarely flooded. It is not ponded. A seasonal zone of water saturation is at 33 inches during April, May, June. Organic matter content in the surface horizon is about 50 percent. This component is in the R044XW128MT Subirrigated (sb) 10-14" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria.

Tetonview loam, 0 to 4 percent slopes (635):

The Tetonview component makes up 85 percent of the map unit. Slopes are 0 to 4 percent. This component is on stream terraces. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is poorly drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. A seasonal zone of water saturation is *at 18 inches during April, May, June. Organic matter content in the surface horizon is about 4 percent. This component is in the R043BY082MT Meadow (m) Lru 43b-y ecological site. Nonirrigated land capability classification is 4w. Irrigated land capability classification is 4w. This soil meets hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 25 percent.*

Tetonview-Blossberg loams, 0 to 4 percent slopes, rarely flooded (735):

The Tetonview component makes up 45 percent of the map unit. Slopes are 0 to 4 percent. This component is on flood plains. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is poorly drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is moderate. This soil is rarely flooded. It is not ponded. A seasonal zone of water saturation is at 18 inches during April, May, June. Organic matter content in the surface horizon is about 4 percent. This component is in the R044XW127MT Wet Meadow (wm) 10-14" P.z. ecological site. Nonirrigated land capability classification is 5w. This soil meets hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 25 percent.

The Blossberg component makes up 40 percent of the map unit. Slopes are 0 to 4 percent. This component is on flood plains. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is poorly drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is rarely flooded. It is not ponded. A seasonal zone of water saturation is at 18 inches during April, May, June, July. Organic matter content in the surface horizon is about 5 percent. This component is in the R044XW127MT Wet Meadow (wm) 10-14" P.z. ecological site. Nonirrigated land capability classification is 5w. This soil meets hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 8 percent.

Tetonview loam, 0 to 4 percent slopes, rarely flooded (835):

The Tetonview component makes up 85 percent of the map unit. Slopes are 0 to 4 percent. This component is on flood plains. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is poorly drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is rarely flooded. It is not ponded. A seasonal zone of water saturation is at 18 inches during April, May, June. Organic matter content in the surface horizon is about 4 percent. This component is in the R044XW127MT Wet Meadow (wm) 10-14" P.z. ecological site. Nonirrigated land capability classification is 4w. Irrigated land capability classification is 4w. This soil meets hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 25 percent.

Miscellaneous water (M-W):

Generated brief soil descriptions are created for major soil components. The Miscellaneous Water is a miscellaneous area.

References

Cowardin, L. M., V. Carter, F.C. Golet, and E.T. LaRoe, 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. U.S.D.I. Fish and Wildlife Service. Washington, D.C.

Lichvar, R.W., 2012. The National Wetland Plant List. ERDC/CRREL TR-12-11. Hanover, NH: U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory. http://acwc.sdp.sirsi.net/client/search/asset:asset?t:ac=$N/1012381

Lichvar, R.W., N.C. Melvin, M.L. Butterwick, and W.N. Kirchner, 2012. National Wetland Plant List Indicator Rating Definitions. ERDC/CRREL TN-12-1. U.S. Army of Engineers, Cold Regions Research and Engineering Laboratory.

U.S. Department of Agriculture Natural Resource Conservation Service (USDA NRCS), 2012. Soil Survey Geographic (SSURGO) database for Powell County Area, Montana. http://www.ftw.nrcs.usda.gov/ssur_data.html

U.S. Environmental Protection Agency/Montana Department of Environmental Quality (USEPA/DEQ), 2004. Record of Decision, Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site. U.S. Environmental Protection Agency, Helena, Montana with concurrence of Montana Department of Environmental Quality, Helena, Montana. April.

U.S. Fish and Wildlife Service, 2009. A System for Mapping Riparian Areas in the Western United States. U.S. Fish and Wildlife Service, Division of Habitat and Resource Conservation, Branch of Resource and Mapping Support, Arlington, VA.

U.S. Fish and Wildlife Service (USFWS), 2005. National Wetlands Inventory website. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Upper Clark Fork Watershed, 2005 false color infrared, orthorectified photography. http://www.fws.gov/wetlands/

APPENDIX D - CLARK FORK SMOA, EXIBIT A; STREAMBANK GUIDELINES

Exhibit A – Streambank Guidelines

1. When designing streambank removal, in-situ treatment, and replanting techniques, geomorphic stability of the effected streambank during construction must be considered carefully. This does not mean removal should be minimized if removal is necessary to meet remediation or restoration standards, but it does mean that the potential for unraveling of the river during construction must be an important consideration in the remedial design process, and must be addressed during remedial design.

2. Streambank designs should use natural vegetation and inorganic materials endemic to the Clark Fork River floodplain as much as possible. Streambank designs should provide a natural appearance and provide for suitable conditions to support natural processes, such as the natural movement of the river across its floodplain, after five years following the implementation of the streambank design or after vegetation is effectively mature to control the natural processes.

3. The toe of the existing streambank should be maintained to the maximum extent practicable during construction.

4. If rock is needed in the streambank or streambed, material that is native to the river system shall be used and shall be similar in size and shape as rock comprising the bed of the Clark Fork River. The goal of this design guideline is that any rock added into the Clark Fork River system will function as aquatic and benthic habitat. This design guideline does not apply to areas where infrastructure protection is a factor.

5. All steambank stabilization treatments must be designed to withstand a 10-year return flow flood event from the time of installation. All coir, or other non-vegetative material used in streambank stabilization must have an effective lifespan of 5 years. Rooted shrubs (i.e., prevegetated coir, bagged willows and alders) and forbs should be used to the maximum extent practicable, to assist vegetative success within one year of planting.

6. Native, desirable woody vegetation should not be disturbed during remediation to the maximum extent practicable.

7. Construction activities must be performed in a manner designed to minimize discharges into the Clark Fork River to the maximum extent practicable. This includes the use of best management practices to minimize stormwater runoff during and after construction.

APPENDIX E – FEDERAL RESTORATION PLAN (TEXT ONLY)

FEDERAL RESTORATION PLAN

U.S. Department of the Interior

Part I: National Park Service

Part II: Bureau of Land Management

Clark Fork River Operable Unit,
Milltown Reservoir/Clark Fork River
National Priorities List Site

September 2007

THIS PAGE INTENTIONALLY LEFT BLANK

Part I: National Park Service

Federal Restoration Plan
for Grant-Kohrs Ranch National Historic Site

National Park Service
Grant-Kohrs Ranch National Historic Site
Deer Lodge, MT 59722

Clark Fork River Operable Unit,
Milltown Reservoir/Clark Fork River
National Priorities List Site

September 2007

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS – PART I

Section **Page**

LIST OF FIGURES vi

LIST OF TABLES vi

LIST OF ACRONYMS vii

1. INTRODUCTION 1-1
   - 1.1 Site Description 1-1
     - 1.1.1 GRKO Management Zone 1-2
   - 1.2 Ranch Operations 1-3
     - 1.2.1 Historic 1-3
     - 1.2.2 Current 1-3
     - 1.2.3 Summary of Previous Investigations 1-4
2. EXISTING CONDITIONS 2-1
   - 2.1 Climate and Weather 2-1
   - 2.2 Geology 2-1
   - 2.3 Surface Water 2-1
   - 2.4 Hydrogeology 2-2
   - 2.5 Vegetation 2-3
   - 2.6 Grazing Practices 2-3
   - 2.7 Natural Resource Injuries 2-4
3. REMEDIATION SUMMARY 3-1
   - 3.1 Summary of Selected Remedy for CFROU 3-1
   - 3.2 Summary of Remedy Implementation at GRKO 3-2
4. RESTORATION DESIGN AND IMPLEMENTATION 4-1
   - 4.1 Regulatory Framework 4-2
   - 4.2 Restoration Goals 4-2
   - 4.3 Restoration measures 4-3
     - 4.3.1 Stream Bank Stabilization 4-3
     - 4.3.2 Monitoring 4-3
     - 4.3.3 Re-establishment and Augmentation of Plant Community Diversity 4-4
     - 4.3.4 Phytotoxic Soil Removal along Irrigation Ditches 4-4
     - 4.3.5 Supplemental Activities 4-4
5. REFERENCES 5-1

APPENDICES

Appendix A. Hydraulic Calculations
Appendix B. Erosion Control
Appendix C. Revegetation
Appendix D. Compliance with Applicable Federal, State, and Tribal Laws

LIST OF FIGURES

Figure 1-1. Vicinity Map

Figure 1-2. Site Location Map

Figure 1-3. Site Layout Map

Figure 2-1. Existing Vegetative Communities

Figure 2-2. Slickens Locations

Figure 2-3. Fenced Riparian Corridor

Figure 2-4. Probability of Encountering Phytotoxic Soils

Figure 2-5. Probability of Encountering Soils Toxic to Microbes

Figure 6-1. Riverbank Stabilization Stations

Figure 6-2. Riverbank Stabilization Stations

Figure 6-3. Riverbank Stabilization Stations

Figure 6-4. Existing Vegetative Communities Compared to Montana Riparian and Wetland Association (MWRA) Reference Types

Figure 6-5. Riverbank Stabilization Detail for the Selected Remedy

LIST OF TABLES

Table 1-1. Previous Investigations and Studies of GRKO

Table 2-1. Plant Communities of GRKO

Table 6-1. Baseline Plant Communities Occurring at GRKO in 2000

Table 6-2. Comparison of Remedy and Restoration

Table 6-3. Soil Volumes for Removal or Treatment

Table 6-4. Erosion Control Design

Table 6-6. Erosion Control Design—GRKO Treatment 4

LIST OF ACRONYMS

°F	degrees Fahrenheit
AERL	ARCO Environmental Remediation, L.L.C.
ARAR	Applicable or Relevant and Appropriate Requirements
ARCO	Atlantic Richfield Company
BMP	best management practice
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
C.F.R.	Code of Federal Regulations
CFROU	Clark Fork River Operable Unit
cfs	cubic feet per second
COC	chemical of concern
cu yds	cubic yards
DC	direct current
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
EP&T	Ecological Planning and Toxicology, Inc.
FlowMaster	Haestad Methods Flowmaster
Foster Wheeler	Foster Wheeler Environmental Corporation
FS	Feasibility Study
ft	foot/feet
GRKO	Grant-Kohrs Ranch National Historic Site
IC	institutional control
mg/kg	milligrams per kilogram
NPS	National Park Service
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NRD	Natural Resource Damage
NRDA	Natural Resource Damage Assessment
Opportunity Ponds	Opportunity Ponds Waste Management Area
psf	pounds per square feet
RAO	Remedial Action Objective
RBC	risk-based concentration
RBZ	riparian buffer zone
ROA	Restoration Options Analysis
ROD	Record of Decision
RipES	Clark Fork River Riparian Evaluation System
TtFW	Tetra Tech FW, Inc.
USAEC	U.S. Army Environmental Center
U.S.C.	U.S. Code
USGS	U.S. Geological Survey
WSAHGP	Washington State Aquatic Habitat Guidelines Program

1. INTRODUCTION

Grant-Kohrs Ranch National Historic Site (GRKO), a unit of the National Park System located in Deer Lodge, Montana, is bisected by the Clark Fork River which was placed by the United States Environmental Protection Agency (USEPA) on the National Priorities List (NPL) in 1992 due to the release of mining-related hazardous substances. The Clark Fork River Operable Unit (CFROU) is part of the Milltown Reservoir/Clark Fork River NPL Site and constitutes a 120 mile segment within one of the largest Superfund complexes in the United States (Figure 1-1). In April 2004, with the concurrence of the National Park Service (NPS) and the State of Montana, the USEPA issued a Record of Decision (ROD) for the CFROU pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The ROD identifies the selected remedy to be implemented at the CFROU, including GRKO, to remedy the release or threat of release of hazardous substances (EPA 2004a).

NPS has complementary response action and natural resource trustee responsibilities for GRKO. NPS has identified injuries to natural resources at GRKO, assessed the resulting damages, and developed this Restoration Plan (Plan), the purpose of which is to describe the measures to be taken to restore injured natural resources at GRKO. This Plan describes the expected outcome of remedial action, identifies residual natural resource injury, and presents proposed measures to restore those injured resources. Additional detail will be developed as part of the design phase of the project.

Restoration measures will be distinguished from remedial action based on whether the activity is required to attain the performance standards of the ROD (and therefore constitutes remedial action) or is an additional measure necessary to achieve restoration objectives. Restoration measures will be complementary to, and implemented in concert with, the remedial action to reduce costs and resource impacts associated with contractor mobilization and soil disturbance.

This Plan is subject to public review, public comment, and finalization during the pendency of the approval process for the *Consent Decree for the Clark Fork River Operable Unit and for Remaining State of Montana Clark Fork Basin Natural Resource Damage Claims* (“Consent Decree”), and meets the substantive provisions of Restoration Planning as specified at 43 CFR 11.93.

1.1 Site Description

GRKO is located in Powell County, Montana, adjacent to the northern boundary of the City of Deer Lodge (Figure 1-2). An approximately 1,600-acre working cattle ranch, GRKO is located within the fertile Deer Lodge Valley and is drained by the Clark Fork River of the Columbia River Basin (Figure 1-3). The elevation of Deer Lodge is 4,500 feet (ft) above sea level (GRKO 1995).

GRKO's important cultural resources include 61 historic buildings, 27 other historic structures, and a large collection of artifacts, documents, and photographs related to ranch operations dating back to the 1860s. The furnishings of the main ranch house and bunkhouse (which are original and intact), along with a large assortment of horse-drawn farm and ranch vehicles and equipment, constitute a curatorial collection for exhibit and study of significant natural and cultural resources. The museum collection includes approximately 26,500 objects (GRKO 1995).

1.1.1 GRKO Management Zone

The following information is summarized from GRKO's *Statement for Management* (1995). The *Statement for Management* "documents the park's purpose, significance, management objectives, obstacles to achieving those objectives, owners of the obstacles, and actions that need to be taken to overcome the obstacles" (GRKO 1995, signature page).

The management zoning for GRKO provides a framework for decisions on use and development. The framework is based on three management zones—historic zone, development zone, and special use zone—with each divided into subzones to help focus on specific types of intended use and development.

The historic zone is the largest and most significant of the three zones and comprises about 81 percent of the lands within the park boundary. It is managed primarily to preserve cultural resources and historical land uses and to provide public appreciation of the cattle ranching heritage. Two subzones have been designated within the historic zone. The preservation/adaptive use subzone includes the home ranch area west of the railroad tracks as well as the mechanized feed operation to the east. The grazing/hay meadow subzone includes the grazing lands and meadows northwest of the main ranch complex. The historic zone is where the majority of visitor and worker activity occurs.

The development zone is an 11-acre parcel of land located near the southeast boundary and consists of an enlarged parking area, temporary visitor's center, and a curatorial facility.

The special use zone comprises about 18 percent of GRKO's acreage and includes improvements used by other interests. It includes three subzones: (1) a utility subzone in the northern part of GRKO, which contains easements for sewer lines and sewage lagoons owned and maintained by the City of Deer Lodge; (2) a scenic easement on adjacent ranch lands to maintain the visual integrity at the ranch's northern boundary; and (3) a transportation subzone for the Burlington Northern/Montana Western railroad right-of-way.

1.2 Ranch Operations

1.2.1 Historic

The following information regarding ranch operations is presented verbatim from the GRKO *Statement for Management* (1995).

> The first documented settler on the Grant-Kohrs Ranch site was John Francis Grant, whose fur trade upbringing led to trade with emigrants on the Oregon Trail at Fort Hall, Idaho. This led into the acquisition of livestock, which evolved into ranching. He established the ranch in 1862. In 1866 Grant sold the ranch and its assets to Carsten Conrad Kohrs. Kohrs and his half-brother, John Bielenberg, made it the operations base of a range cattle empire extending, by the 1890s, over several states, with land holdings of about 30,000 acres in the Deer Lodge Valley alone. He also owned nearly 1 million acres (in fee and by water rights) and grazed more than 10 million acres of public land, mainly in eastern Montana. Kohrs and Bielenberg, the Pioneer Cattle Company, were instrumental in upgrading the quality of range cattle, with the introduction of Shorthorn and Hereford bloodlines into the herds. Even the catastrophic losses of stock, which hit the industry in the unusually severe winter of 1886–1887, represented only a minor setback to their operation. Kohrs became prominent in the cattle industry and participated in territorial and state politics. In 1868 Conrad Kohrs married Augusta Kruse. After Conrad and Augusta Kohrs moved to Helena, Montana, in 1899–1900, Bielenberg continued ranching operations at Deer Lodge, but with homesteading encroaching on the open range and their fortunes made and secure, the partnership began winding down operations. When the two men died (Kohrs in 1920 and Bielenberg in 1922), Augusta Kohrs cared for the 1,000 or so remaining acres of the home ranch, which was officially operated and controlled by a corporation, the Kohrs Company. Augusta died in 1945.
>
> In 1932, Kohrs' grandson, Conrad Kohrs Warren, was employed as a foreman, and a new phase of expansion began. In 1934 Warren moved into the house, east of the railroad tracks, which had been a wedding gift to him and his wife, Nell Warren, from Augusta Kohrs. He bought the holdings of the Kohrs Company in 1940, and the ranch became known for its registered Hereford cattle and Belgian horses. In 1952, Warren moved the operations east of the railroad tracks to the upper bench of the ranch. The registered Herefords were dispersed in 1958, but ranching continued under Warren's direction with a commercial herd, even after purchase by the National Park Foundation in 1970. In 1980, Warren began leasing his remaining lands to local ranchers, until the 1988 purchase by the NPS. It was Warren and his wife who recognized the importance of the site, and through their efforts, it was preserved intact. When the NPS purchased the acreage and buildings at the center of the property from the National Park Foundation in 1972, they acquired a site changed only slightly from its origins as the headquarters for an open-range ranching operation.

1.2.2 Current

The purpose of GRKO is to preserve the historic integrity of the site, interpret the national values associated with the frontier cattle era, and provide for the benefit and inspiration of present and future generations (GRKO 1993). The ranch is a day-use site where visitors can take self-guided or guided tours. Summer activities include observing blacksmithing, chuck wagon cooking, and examples of 1890s cowboy life. GRKO receives approximately 20,000 visitors each year. Major attractions at GRKO are viewing the historic ranch house and ranch outbuildings, walking the nature trails, and observing cattle, horses, poultry and historic haying operations against a natural vista little changed in the past century. A prominent feature of GRKO's cultural landscape, and a significant reason for the establishment of ranch operations in this location beginning in 1859, is the Clark Fork River riparian corridor that today traverses the ranch for 3.5 river miles within the legislative boundary (2.44 miles under NPS management).

1.2.3 Summary of Previous Investigations

More than 25 previous investigations and studies have been undertaken to assess site conditions, including the evaluation of hazardous substance releases, identification of natural resource injuries, and the quantification of associated damages at GRKO. Table 1-1 lists the significant previous investigations and studies used to develop this document.

The NPS evaluated the Final Draft Feasibility Study (FS) (AERL 2002), Proposed Plan (EPA 2002), and ROD (EPA 2004a) to aid the development of this Plan. These documents provided a structured means to identify, develop, evaluate, and select remedial alternatives for the CFROU to eliminate, prevent, reduce, or control human health and/or environmental risks identified during the Remedial Investigation for the CFROU and otherwise comply with CERCLA, including compliance with "Applicable or Relevant and Appropriate Requirements" (ARARs).

The *Natural Resource Injury Report on Riparian and Upland Areas of Grant-Kohrs Ranch National Historic Site, Clark Fork River Basin, Montana* (Injury Report, EP&T 2002c) provided the determination and quantification of injury and damages upon which this Plan is based.[1] The Injury Report documented the magnitude of injury to natural resources at GRKO due to contamination from upstream mining activities. The Injury Report concluded that contaminant concentrations at GRKO are well above background concentrations and are sufficiently high to cause injury to natural resources. Injured soils result in direct toxicity to plants, restricted development of plant roots, loss of ecological functions mediated by microbes, loss of primary plant production, deviation of plant community composition, degradation of habitat, and alteration of the cultural landscape. The existing conditions and extent of natural resource injuries are described in Section 2 below.

[1] The Injury Report is available at the following web site: nps.gov/GRKO/naturalresourcemanagement/Superfund/Injury Report

2. EXISTING CONDITIONS

The climate and weather, geology, surface water, hydrogeology, vegetation, grazing practices, and natural resource injuries at GRKO are summarized below.

2.1 Climate and Weather

The climate along the Clark Fork River valley and GRKO is generally semi-arid. The ranch is sheltered from the worst effects of stormy weather by the surrounding mountains. The temperature is 90 degrees Fahrenheit (°F) or warmer an average of 9 days a year. The growing season (frost-free days) averages 95 days a year. On average, there are 21 days per year with maximum temperatures of 32°F or less. Annual precipitation averages 10.6 inches, with most of this falling in the form of rain during late spring and early summer. Winds are typically from the south or southwest and average about 5 to 7 miles per hour. River flow rates in the spring are determined by the amount of snowfall in the surrounding mountains and the rate at which it melts. The length of time between rainstorms can influence the amount of river water needed for irrigation purposes and can also influence the fate and transport of contaminants in soil (Schafer & Associates 1998).

2.2 Geology

Between the headwaters of the Clark Fork River and the northern end of the Deer Lodge Valley, the Clark Fork River basin is composed mainly of unconsolidated gravel, sand, silt, and clayey alluvium eroded from surrounding highlands and deposited in alluvial fans. Sediments in this area can be as thick as 5,000 feet (ft). Between Warm Springs Ponds and Deer Lodge, the river flows mainly north, but turns to the northwest between Deer Lodge and Garrison, following the trend of the underlying geology. Deposits of alluvium are generally thinner in this reach (less than 200 ft); the river down-cuts through exposed Cretaceous or Paleozoic sedimentary rocks. Beyond Bearmouth, the river flows mainly over older Precambrian and Proterozoic rock (Schafer & Associates 1998).

2.3 Surface Water

The upper Clark Fork River drains an area of approximately 3,650 square miles. Major tributaries to the Clark Fork River include Silver Bow Creek, Warm Springs Creek, Little Blackfoot River, Flint Creek, Rock Creek, and Blackfoot River. GRKO is located on the Clark Fork River between Warm Springs Creek and Little Blackfoot River. Flow rates in the Clark Fork River are highly variable depending on location and time of year. Average flows are around 250 to 300 cubic feet per second (cfs) at the headwaters and increase (because of the influx from tributaries) to around 2,000 cfs near the town of Milltown, Montana. Peak flow rates typically occur in late May or early June, and low flow usually occurs in the fall and winter. Most floods occur in the spring as the result of snowmelt, but winter and summer floods can also occur following major rainstorms. Under low flow conditions, the Clark Fork River is a gaining stream (groundwater discharges into the river) over most of its length. Water from the river is withdrawn at numerous points to irrigate agricultural land, most of which is used to grow hay for livestock.

The Clark Fork River serves multiple purposes, including stock water, irrigation, recreation, and aquatic habitat. The State of Montana has assigned use classifications for different segments of the Clark Fork River based on water quality conditions and surface water use goals. The first segment, from the headwaters to Cottonwood Creek at Deer Lodge, is classified as C-2. The C-2 classification indicates that the river is suitable for bathing, swimming, and recreation; growth and marginal propagation of salmonid fishes, aquatic life, waterfowl, and mammals; and agricultural and industrial water supply. The second segment lies between Cottonwood Creek to the Little Blackfoot River and is classified as C-1, which includes all of the same uses as C-2 except for full (rather than marginal) propagation of salmonid fishes and aquatic life. GRKO lies in this segment of the river. The third segment of the Clark Fork River, from the confluence with the Little Blackfoot River to the former Milltown Dam site, is classified as B-1, which includes all of the uses associated with the C-1 classification as well as drinking and culinary uses after conventional treatment. A small segment of the stream, from the confluence of the old Silver Bow Creek channel with the reconstructed bypass to the confluence with Warm Springs Creek, is also classified as B-1 (EPA 2001).

2.4 Hydrogeology

The principal source of groundwater used by humans living and ranching in the CFROU is an unconfined aquifer located in the unconsolidated and semi-consolidated alluvium. Depth to groundwater varies from near surface to more than 150 ft below ground surface. Groundwater flow generally follows surface water flow and topography. Locally, groundwater flows out of highland areas toward the river; regionally, it flows north-northwest down the river valley (EPA 2001).

Locally, groundwater at GRKO occurs near the surface at variable depths generally correlated to the proximity to the Clark Fork River. The water table is within about 5 ft or less of the land surface within the floodplain area, increasing to 10 to 20 ft below land surface under the gravel terraces to the east, and is 30 ft or more below the surface in the upper parts of the west side fields (Woessner and Johnson 2002). In general, Woessner and Johnson (2002) show that groundwater in the water table aquifer flows toward the Clark Fork River, where groundwater discharges to surface water flow in the river, flowing northwesterly toward the river on the east side of the river and northeasterly toward the river on the west side of the river.

The State of Montana has classified the groundwater in and near the ranch as potentially usable as drinking water. According to GRKO documents, multiple types of wells exist on GRKO: groundwater monitoring, domestic, irrigation, and stock (GRKO 1993). Currently the drinking water supply for humans and the majority of cattle at the ranch is not drawn from the ranch's groundwater resources, but obtained from the City of Deer Lodge's water supply system. One groundwater supply well is used infrequently for livestock watering (Foster Wheeler 2003a). In addition, numerous recent studies have been performed to characterize water resources at GRKO (Moore and Woessner 2001; Woessner and Johnson 2002). As part of these studies, a number of groundwater monitoring wells have been installed to characterize and monitor the groundwater quality and determine the hydrogeologic characteristics of the groundwater system.

2.5 Vegetation

A detailed vegetation study by Rice and Hardin (2002) concluded that there is a diverse riparian corridor at GRKO as well as irrigated fields and upland pastures. Within the riparian corridor, 23 plant communities were identified, including seral stage community types, grazing disclimaxes, and climax habitat types (Figure 2-1). Areas devoid of vegetation because of high metal concentrations or sparsely vegetated with metals-tolerant plants species (i.e., tufted hairgrass) were designated as slickens. Slickens covered approximately 8 acres of the GRKO floodplain (Figure 2-2) (EP&T 2002c). The dominant plant communities are water birch, geyer willow, smooth brome, and geyer willow/beaked sedge (Table 2-1) (Rice and Hardin 2002). Additional discussion on the effects of the chemicals of concern (COCs) on vegetation is presented in the Injury Report.

2.6 Grazing Practices

GRKO has been the headquarters for cattle ranching operations for more than 125 years. The mission of the park is to preserve and interpret the frontier cattle era of the nation's history, beginning in the 1860s. The majority of the ranch property has been used for forage and hay production and for livestock grazing. According to GRKO records, the fenced riparian corridor of GRKO was not a principal grazing area, but was used for winter calving. Because the land holdings were so extensive (including a 30,000 acre home ranch and grazing across approximately 10 million acres under the management of Conrad Kohrs and John Bielenberg), cattle were grazed at disparate locations. Cattle have been explicitly excluded from grazing in the 127-acre fenced riparian corridor since spring 1994. Cattle are currently rotated through upland and irrigated pastures. Hay is produced in the irrigated fields.

2.7 Natural Resource Injuries

NPS undertook a series of comprehensive studies to identify and quantify the natural resource injuries at GRKO, focusing on injuries to soils of the riparian areas and historically irrigated fields. The NPS injury assessment was multifaceted and included quantitative studies of contaminant levels in various affected media, as well as the collection of data related to other physical, chemical, and biological parameters that directly or indirectly measured injuries to the natural resources at GRKO. NPS conducted the following activities:

- Sampled and analyzed surface and subsurface soils, sediment, surface water, groundwater, soil pore water, and vegetation for COCs
- Measured physical and chemical parameters in the soil, the groundwater aquifer, and biological resources and collected data on the characteristics of the geologic, hydrologic, and geomorphological systems
- Collected and analyzed data on the riparian areas, various biological species, and other ecological systems at the park
- Collected and analyzed data on the baseline conditions that would be expected to exist at the park but for the presence of COCs

The major findings of the data collection and analysis effort were summarized and published in numerous individual reports on the various media or resources (Table 1-1). The results of those resource-specific reports were further compiled, evaluated, and synthesized in the Injury Report (EP&T 2002c). The following section is a synopsis of that report.

A major concern at GRKO is that soil has been injured, as defined in 43 C.F.R. 11.62(e), due to the release of hazardous substances associated with large-scale mining activities in the areas of Butte and Anaconda, Montana. Mining and smelting in these areas began in 1864 and continued until the closure of the Washoe Smelter near Anaconda in 1980 and the cessation of upstream mining activities in 1983. Contaminant sources include historical discharges of raw, untreated mining and mineral-processing wastes into Silver Bow Creek and Warm Springs Creek, smelting waste deposits and aerial deposition, waste rock deposits, and tailings deposits. Due to the vast quantity of mining-related waste now present in the Clark Fork River floodplain, hazardous substance releases are ongoing through the process of erosion, sedimentation, precipitation, and so on. The major COCs detected in soils, groundwater, surface water, and plant tissues at GRKO are arsenic, cadmium, copper, lead, and zinc.

According to the Injury Report, exposure to hazardous substances resulted in direct toxicity to plants, loss of critical ecological functions mediated by microbes, loss of primary production, deviation of plant community composition from that expected for the area, and restricted development of plant root systems. Specifically, the Injury Report concluded the following:

- Growth and survival of herbaceous and woody species in controlled laboratory tests decreased as COC levels increased.
- Root growth was among the most sensitive endpoints in all species tested.
- Above-ground herbaceous plant growth measured in field clip plots decreased as pH-adjusted arsenic, copper, and zinc levels increased.
- Patterns of plant cover on a small-scale differed in relation to levels of COCs. Known metals-tolerant species (e.g., tufted hairgrass, redtop bentgrass, booth willow, etc.) were more prominent as pH-adjusted arsenic, copper, and zinc levels increased.
- The riparian plant community structure on a macro-scale deviated from expected baseline conditions in 63 percent of GRKO riparian areas.
- The patterns of soil respiration differed in relation to concentrations of COCs, as did patterns of microbial community structure.

Furthermore, the presence of hazardous substances was determined to have long-lasting negative consequences on critical ecological functions carried out by soil microbes, resulting in the following:

- Loss of agricultural/livestock production potential
- Loss of recovery potential should other disturbances, such as fire or drought, occur
- Disruption or alteration of elemental cycles such as those exhibited by carbon and nitrogen
- Land degradation, such as soil erosion, with subsequent sediment deposition and desertification

A key conclusion of the Injury Report was that the concentrations of COCs at GRKO are well above background concentrations and are sufficiently high to have caused phytotoxic responses in several plant species, thereby causing injury to natural resources. The area of injured soil is approximately 122 acres of the 127-acre fenced riparian corridor (Figure 2-3), including approximately 8 acres of barren and tufted hairgrass slickens. As further discussed in the Injury Report, despite extensive data collection at GRKO, the spatial heterogeneity of contaminant distribution is such that an exact footprint of the areal extent of injured soils has not been drawn; to do so would require a concentration of geochemical data on a grid of less than 5 meter increments throughout GRKO. Such a sampling effort was deemed prohibitively costly. Data are sufficient, however, to prepare probabilistic plots that can be used to predict the likelihood of encountering injured soil at any particular location and depth (Figures 2-4 and 2-5). As shown in Figure 2-4, there is a 90-percent probability of encountering phytotoxic soil within the first 3 ft of the soil profile at any given location within the sampled area. In addition, there is a 90-percent probability of encountering soil horizons toxic to microbes in the first 3.5 ft of the soil profile, as shown in Figure 2-5.

For the purposes of this report, the 127-acre fenced riparian corridor is shown on many of the figures for reference. Figure 2-3 shows the 127-acre fenced riparian corridor that includes the 122 acres of injured soils identified in the Injury Report. The areas mapped in the Injury Report as slickens are depicted in Figure 2-2. Details of the extent of injured soils and the degree of impact to soils and other natural resources relative to baseline conditions are presented in Section 4, as is information on design criteria and assumptions for restoring injured natural resources to baseline conditions.

3. REMEDIATION SUMMARY

This Plan assumes that remedial action will be implemented as described in the ROD (USEPA, April 2004). The subsections below present a summary of anticipated activities for site-specific implementation of the remedy at GRKO.

3.1 Summary of Selected Remedy for CFROU

As described by the ROD, the Clark Fork River Riparian Evaluation System (RipES) will be used as an evaluation tool to identify the remedial action appropriate to a given site in the riparian buffer zone, floodplain, and historically irrigated fields. The RipES system identifies vegetation polygons on the ground through field observations and analytical testing. The polygons are divided into six categories—three classes of stream banks within the riparian buffer zone and three types of soils within the historical floodplain. Under remedial action, the three RipES-defined soil type categories in the floodplain are:

1. Slickens and exposed tailings—These areas will require removal of phytotoxic soil, replacement with clean soil where necessary to provide adequate clean growth medium and floodplain stability, and revegetation with native plant communities.

2. Impacted soils and vegetation areas—These areas will predominantly receive in situ treatment of phytotoxic soil, except in circumstances requiring selected removals where tailings and/or impacted soils extend below 2 ft or are too wet to treat in situ. Such locations include old oxbow channels and wetlands. At these locations, the phytotoxic soils will be removed and replaced. Treatment or removal will be followed by revegetation with native plant communities. Impacted soils and vegetation areas within GRKO at which in situ treatment failed to attain location-specific ARARs, or at which the determination is made to remove rather than treat impacted soils, will be revegetated with native plant communities following removal.

3. Slightly impacted soils and vegetation areas—These areas are characterized by relatively healthy mature woody vegetation that generally will be left undisturbed despite elevated COC concentrations in underlying soils.

Under the selected remedy, RipES places all stream banks into one of three categories ranging from least to most stable. The three stream bank classes are:

- Class 1—Contaminated, unvegetated, and actively eroding areas without deep, binding, woody vegetation. These areas would require removal of phytotoxic material, soft engineering treatments, and revegetation.

- Class 2—Contaminated, partially vegetated, and unstable and eroding areas that would respond to supplemental revegetation with bioengineering techniques. Reconfiguration of stream banks may be required.

- Class 3—Contaminated, but stable, vegetated areas where best management practices (BMPs) would meet remedial action objectives (RAOs).

3.2 Summary of Remedy Implementation at GRKO

Implementation of the remedial action at GRKO is expected to result in the removal from approximately 8 acres of slickens of an estimated 38,720 cubic yards (cu yds) of contaminated soil to an average depth of 3.0 ft. Excavated areas will be backfilled to consist of an estimated thickness of 9 to 12 inches of clean cover soil and a total uncontaminated rooting medium 18 inches deep (EPA 2004a; p. 2–113) for native plant community revegetation and to promote geomorphic stability.

Phytostabilization (i.e., in situ treatment) will be applied to 33 acres of impacted soils. While it is anticipated that in situ treatment will result in the successful re-establishment of woody vegetation, uncertainty remains due to the paucity of relevant data. Given this uncertainty, the ROD allows for up to three replanting attempts following in situ treatment; in the event location-specific ARARs are not attained after these attempts, removal of contaminated soils will be required. Consequently, the possibility exists that removal of impacted soils, using the soil removal techniques applied in the slickens areas, will be required to achieve the performance standards. This second phase of remedial action would result in the removal of an additional 159,720 cu yds of soil. The extent and timing of removal of impacted soils, if it is deemed necessary to meet the requirements of the ROD, will be determined by NPS, USEPA, and the State of Montana during remedial action at GRKO.

Fifty-three acres of slightly impacted soils within the floodplain will be left untreated to preserve existing woody vegetation and floodplain stability. As noted in the ROD (page 2-108), however, this area is not considered to be uninjured.

Riverbanks along 2.44 miles of the Clark Fork River will be stabilized with soft engineering techniques and plantings of herbaceous and shrubby vegetation. A 50-ft wide riparian buffer zone (RBZ) will be replanted (approximately 28 acres) to reduce bank erosion and the lateral transport of metals contamination to the river.

The 41 acres in the floodplain outside of the RBZ where slickens were removed (8 acres) and impacted soils treated or removed (33 acres) will be revegetated according to the plant community structure in the ROD to meet the performance criteria of the location-specific ARARs.

All excavated areas will be backfilled with cover soils to provide a suitable planting medium. The cover soils will be of sufficient thickness to achieve a minimum of 18 inches of hospitable root zone of nontoxic rooting media according to the ROD Section 13.8.2.1 (EPA 2004a). Final topography in excavated areas will be determined based on the optimum soil and hydrologic conditions needed within a given polygon for the plant community or communities desired in that area.

Arsenic-contaminated soil in the ditches and ditch berms will be addressed only where it exceeds the EPA action level of 620 mg/kg for the rancher/farmer population. Based on the current geochemical data, no additional soil removal in the ditches is expected using this arsenic action level.

Other components of the remedial action include development and implementation of plans for weed management and grazing management, as well as utilization of best management practices during Site work.

4. RESTORATION DESIGN AND IMPLEMENTATION

NPS has evaluated the residual injury to natural resources anticipated to remain after implementation of the remedial action. This evaluation is based primarily on information presented in the Injury Report (EP&T 2002c), FS (AERL 2002), Proposed Plan (EPA 2002), Ditch Report (Moore 2003), ROD (EPA 2004a), and input from NPS and DOI staff.

Injured soils result in direct toxicity to plants, loss of ecological functions associated with and mediated by microbial activity, loss of primary plant production, deviation from the expected plant community composition, degradation of habitat, alteration of the cultural landscape, restricted development of plant roots, and accelerated stream bank erosion. These natural resource injuries are documented to have occurred on at least 122 acres at GRKO. Natural resource injury is further quantified in the following:

- Slickens (described as soils with surficial tailings that are devoid of vegetation, with the margins supporting tufted hairgrass) comprise approximately 8 acres in GRKO floodplain and riparian corridor (Figure 2-2). The average depth of contamination in the CFROU slickens was 3.0 ft deep as determined by site-specific studies and summarized in the Injury Report.

- Approximately 114 acres of injured non-slickens floodplain soils. Figure 2-3 shows the 127-acre fenced area in the floodplain at GRKO that encompasses the floodplain and riparian corridors and contains the total 122 acres of injured soils (8 acres of slickens and 114 acres of non-slickens).

- There is a 90-percent probability of capturing phytotoxic soils with effective treatment or removal of injured soils to a depth of 3 ft (90 centimeters) (Figure 2-4).

- There is a 90-percent probability of capturing contaminated soils that inhibit soil microbial respiration with effective treatment or removal of injured soils to a depth of 3.5 ft (105 centimeters) (Figure 2-5).

Residual injury is expected after implementation of the selected remedy and, absent restoration measures, will prolong the rate of natural resource recovery, fail to achieve the restoration objectives, and increase the long term costs of ranch management for NPS. The restoration measures discussed below are intended to address residual injuries in a manner that complements, and can be implemented simultaneously with, the remedial action. Consistent with the CFROU Consent Decree and Superfund Memorandum of Agreement (SMOA), restoration measures will be implemented by the State of Montana under NPS oversight and subject to NPS review and approval.

4.1 Regulatory Framework

The U.S. Department of the Interior (DOI) is authorized to take appropriate actions necessary to protect and restore natural resources and the services provided by those resources, where such resources are injured by a release or substantial threat of release of hazardous substances. The following laws and regulations, *inter alia*, apply to restoration efforts and provide DOI with the legal authority to fulfill its responsibilities as a natural resource trustee:

- CERCLA, as amended (42 U.S.C. §§ 9601 to 9675), including but not limited to Sections 104, 107, 111(i), and 122
- Oil Pollution Act of 1990 (33 U.S.C. §§ 2701 to 2761), including but not limited to Sections 1006 and 1012
- Federal Water Pollution Control Act (or "Clean Water Act"), as amended (33 U.S.C. §§ 1251 to 1387), including but not limited to Section 311(f)
- National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. Part 300 *et seq*.
- Natural Resource Damage Assessment (NRDA) Regulations for CERCLA, 43 C.F.R. Part 11
- National Park Service Organic Act, 16 U.S.C. §§ 1-4
- General Authorities Act, 16 U.S.C. §§ 1a-1 to 1c

4.2 Restoration Goals

The restoration goals applicable to injured natural resources at GRKO are as follows:

- Re-establish the diverse, self-perpetuating baseline plant community conditions of the GRKO riparian area as it was in the mid-1860s, prior to the commencement of large-scale mining activities upstream
- Promote an ecologically stable riparian corridor along the Clark Fork River at GRKO
- Remove any contaminant-related constraints upon the injured areas to allow for full and unrestricted use of ranch resources for all park purposes, including interpretive, educational, and operational activities

4.3 Restoration measures

4.3.1 Stream Bank Stabilization

One component of injury determination at GRKO involved assessment of stream bank conditions and associated stabilization needs. Bank stabilization and erosion control techniques were conceptually designed using the *Integrated Stream Bank Protection Guidelines* (WSAHGP 2002), hydraulic parameters obtained from the Haestad Methods FlowMaster (FlowMaster) hydraulic modeling program (see Appendix A for hydraulic calculations), shear stress calculations (Appendix B), and various vegetative stabilization techniques, among other considerations. Figures 6-1, 6-2, and 6-3 illustrate features along the river corridor and show the stationing along the river centerline. Hydraulic parameters, shear stress, and scour depth were calculated (see Appendices A and B). NPS considered vegetation, pre-vegetated coir fiber rolls, biodegradable soil matting, and other stabilization methods as possible techniques to address soil erosion along the stream banks of GRKO. Calculations for erosion control are presented in Table 6-4.

This information will be factored into the remedial design process and a determination made as to the extent to which remedial action will address these stabilization needs. Those components of bank stabilization not captured under remedial action will be identified and performed as restoration. Potential restoration measures include utilization of additional tipped willows and prevegetated coir fiber rolls, in combination with other robust revegetation techniques.

4.3.2 Monitoring

Site-specific studies at GRKO indicate that elevated COC concentrations and visible tailings are present from the surface to the depth of groundwater (which varies from 3 to 5 feet in the GRKO floodplain). Residual contamination will remain in large areas of the GRKO floodplain after remedial action, particularly in the 53 acre slightly impacted area noted in the ROD (page 2-110). Considerable uncertainty exists as to the effectiveness of revegetation efforts if COCs remain in the subsoils. This is particularly true of woody species the root systems of which must penetrate the zones of residual contamination. To account for seasonal fluctuations in precipitation, current drought conditions, and the slower growth rate of woody species, GRKO restoration extends monitoring an additional 5 years beyond that required by the ROD, to a total of 15 years. The purpose of this extended monitoring period is to ascertain whether additional restoration actions are necessary to accelerate the rate of resource recover or to better realize the restoration objectives.

4.3.3 Re-establishment and Augmentation of Plant Community Diversity

Baseline plant communities are those that would have occurred in the absence of phytotoxic contaminant concentrations. By comparing the baseline to the existing conditions, the magnitude of resource injury can be quantified. Table 6-1 and Figure 6-4 present the baseline plant communities existing at GRKO in 2000. Rice (2003) identified 17 probable baseline plant communities encompassing 50.8 acres, or 40.1 percent of the riparian floodplain. Augmentation of species diversity and planting density will be a restoration measure implemented in conjunction with remedial action to ensure the realization of the baseline plant community mosaic in the GRKO floodplain.

Restoration measures will enhance the species mix within the 28-acre RBZ as well. Restoration measures will include, inter alia, planting a combination of willow cuttings, stakes, bags, prevegetated fiber coir rolls, and live transplants of shrubby and herbaceous species (to the extent that such measures are not required as part of remedial action). In addition to these planting and transplanting methods, mature willow transplants will be salvaged on-site, then anchored and tipped over the banks to deflect and reduce water flows immediately adjacent to the banks. Overall, revegetation would be directed to achieve the baseline plant community composition in the RBZ according to the restoration objectives. Augmentation planting may be applied in other areas if needed to achieve a more rapid recovery to baseline.

4.3.4 Phytotoxic Soil Removal along Irrigation Ditches

Indications of phytotoxicity have been noted in numerous locations along the historically irrigated ditches, particularly on the berms of Kohrs Ditch west of the Clark Fork River. GRKO restoration removes these phytotoxic materials and replaces the berms to eliminate further restrictions on the management and operation of these ditches as part of the historic landscape of the ranch. Removal of phytotoxic berm soils is estimated to be an additional 6,240 cu yds of material to be hauled to Opportunity Ponds for disposal (Table 6-3). Areas of excavation would be reconstructed with clean soil and revegetated to re-establish ditch stability and productivity, allowing the NPS to achieve full, unencumbered use of the irrigation ditches with historic practices and methods.

4.3.5 Supplemental Activities

- Remove test plot exclosures installed as part of damage assessment.

- Rehabilitate tensiometers, peizometers, and ground water monitoring wells as part of an expanded monitoring program.

- Provide for NPS oversight of restoration plan development and implementation, ensuring appropriate and efficient integration with remedial action consistent with the Consent Decree and the SMOA.

5. REFERENCES

AERL (ARCO Environmental Remediation, L.L.C.). 2002. *Public Review Draft Feasibility Study Report, Milltown Reservoir Sediments NPL Site, Clark Fork River Operable Unit*. March.

Blaylock, Michael J. 2000. Phytoremediation of Peconic River Sediments. Peconic River Remedial Alternatives Workshop, Brookhaven National Laboratory. December 12.

Brown and Associates. 2002. Hardcopy and electronic survey package submitted to Tetra Tech FW, Inc. Maintained in the Tetra Tech FW, Inc. Denver office project files.

Chaney, Rufus L., Minnie Malik, Yin-Ming Li, Sally L. Brown, Eric. P. Brewer, J. Scoot Angle, Alan J. M. Baker. 1997. Phytoremediation of Soil Metals. Current Opinions in Biotechnology 8:279-284. CH2M Hill, 2001. *Phytostabilization of the Clark Fork River Operable Unit Milltown Sediments Superfund Site*. December.

CH2M Hill. 2001. Responses to Issues Posed by the EPA National Remedy Review Board. *Phytostabilization of the Clark Fork River Operable Unit, Milltown Sediments Superfund Site.* December.

CH2M Hill. 2004. *Cost Estimate for the U.S. Environmental Protection Agency's Cleanup Plan for the Clark Fork Operable Unit.* Prepared for the U.S. Environmental Protection Agency. May.

CH2M Hill. 2004. *Cost Estimate for the U.S. Environmental Protection Agency's Cleanup Plan for the Clark Fork Operable Unit- Correction Report.* Prepared for the U.S. Environmental Protection Agency. August.

Cunningham, S. D. and W.R. Berti, J. W. Huang. 1995. Phytoremediation of Contaminated Soils. Trends In Biotechnology 13:393-397.

DOI (U.S. Department of the Interior). 2002. Letter from Robert F. Stewart, Regional Environmental Officer, U.S. Department of the Interior, to Scott Brown of the U.S. Environmental Protection Agency, Montana Office, regarding the U.S. Department of the Interior's comments on the Proposed Plan for the Clark Fork Operable Unit. December 5.

EP&T (ecological planning and toxicology, Inc.). 2002a. *Final Phytotoxicity Tests on Soils from the Grant-Kohrs Ranch National Historic Site, Deer Lodge, Montana.* January.

EP&T. 2002b. *Natural Resource Injury Report on Riparian and Upland Areas of the Bureau of Land Management within the Clark Fork River Basin, Montana.* Final Report. May.

EP&T. 2002c. *Natural Resource Injury Report on Riparian and Upland Areas of Grant-Kohrs Ranch National Historic Site, Clark Fork River Basin, Montana.* Final Report. May.

EPA (U.S. Environmental Protection Agency). 2001. *Clark Fork River Ecological Risk Assessment.* October.

EPA. 2002. *Superfund Program Clean-up Proposal, Clark Fork River Operable Unit of the Milltown/Clark Fork River Superfund Site.* August.

EPA. 2004a. *Record of Decision, Clark Fork Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site.* U.S. Environmental Protection Agency, Region 8, Helena, Montana. April.

EPA. 2004b. Telephone communication to M.Griswold of Tetra Tech FW, Inc. from a Project Engineer with U.S. Environmental Protection Agency, Region 8, Helena, Montana, on August 18, 2004, regarding the capacity of Opportunity Ponds, Clark Fork Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site.

Foster Wheeler (Foster Wheeler Environmental Corporation). 2003a. *Baseline Human Health Risk Assessment for Grant-Kohrs Historic Site.* Revised Final. September.

Gannon, James E. and Mathias Rillig. 2002. *Relationship of Heavy Metal Contamination to Soil Respiration.* March.

GRKO (Grant-Kohrs Ranch National Historic Site). 1993. *Environmental Impact Statement, General Management Plan, and Development Concept Plan*. March.

GRKO. 1995. *Statement for Management*. October.

Lasat, M.M. 2000a. *Phytoextraction of Metals from Contaminated Soil: A review of Plant/Soil/Metal Interaction and Assessment of Pertinent Agronomic Issues.* Journal of Hazardous Substance Research. Vol. 2(5): 1-25. Kansas State University.

Lasat, M.M. 2000b. *The Use of Plants for the Removal of Toxic Metals from Contaminated Soil.* Publication posted on the website www.epa.gov/tio/download/remed/lasat.pdf.

Moore, Johnnie N. 2003. C*hemical Concentrations in Surface Soils of the Irrigation Ditch Berms, Grant-Kohrs Ranch National Historic Park.* May.

Moore, Johnnie N., Benjamin Swanson, and Clara Wheeler. 2002. *Geochemistry and Fluvial Geomorphology Report—A Draft Report to the Grant-Kohrs Ranch National Historic Site.* January.

Moore, Johnnie N. and W. Woessner. 2001. *Geologic, Soil Water and Groundwater Report 2000, Grant-Kohrs Ranch National Historic Site.* February.

Munshower, Frank F., Dennis R. Neuman, and Stuart R. Jennings. 2003. Phytostabilization Permanence Within Montana's Clark Fork River Basin Superfund Sites. *National Meeting of the American Society of Mining and Reclamation and the 9th Billings Land Reclamation Symposium, Billings, Montana.* June. Published by American Society of Mining and Reclamation, Lexington, Kentucky.

NPS. 2004. Internet Web page (http://data2.itc.nps.gov/npspolicy/index.cfm): Office of Policy, Washington, DC. Retrieved June 21, 2004.

Rice, Peter M. 2003. *Baseline Vegetation Types for Grant-Kohrs Ranch.* July.

Rice, Peter M. 2002. *Toxic Metals-pH Impact on Riparian Plant Community Structure at Grant-Kohrs Ranch.* February.

Rice, Peter M. and Janet Hardin. 2002. *Riparian Plant Community Structure at Grant-Kohrs Ranch.* March.

Schafer & Associates. 1998. *Milltown Reservoir Sediments NPL Site Clark Fork River Operable Unit, Final Draft Remedial Investigation Report.* August.

Smith, J. D., J. H. Lambing, D.A. Nimick, C. Parrett, M. Ramey, and W. Schafer. 1998. *Geomorphology, Flood-Plain Tailings, and Metal Transport in the Upper Clark Fork Valley, Montana.* U. S. D. I. Geological Survey and Environmental Protection Agency. Water Resources Investigation Report 98-4170.

Swanson, Benjamin John. 2002. *Bank Erosion and Metal Loading in a Contaminated Floodplain System Upper Clark Fork River Valley, Montana.* University of Montana–Missoula. December.

University of Montana. 2002. Land Resources Internet Web page at http://landresources.montana.edu/lres560/clean%20water%20act%20and%20reclamation.htm.

USAEC (U.S. Army Environmental Center). 2000. *Final Report – In Situ Electrokinetic Remediation of Metal Contaminated Soils.* Report Number SFIM-AEC-ET-CR-99022. U.S. Army Environmental Center. Technology Status Report. July.

USDC (U.S. District Court for the District of Montana). 1998. Notice of Lodging of Consent Decree Pursuant to the Comprehensive Environmental Response, Compensation and Liability Act, United States v. ARCO, Civil Action No. 89-039-BU-PGH (D. Mont.) and Montana v. ARCO, Civil Action 83-317-HLN-PGH (D. Mont.). Retrieved from http://www.eswr.com/cd121098.txt on June 22, 2004.

USGS (U.S. Geological Survey). 2002. Internet Web page (www.usgs.gov): Peak Streamflow for Montana, USGS 12324200 Clark Fork at Deer Lodge, MT.

Woessner, William W. and Molly M. Johnson. 2002. *Water Resource Characterization Report 2000 and 2001 Field Seasons, Grant-Kohrs National Historic Site.* Department of Geology, The University of Montana, Missoula. Prepared for the National Park Service, Department of Interior. January.

WSAHGP (Washington State Aquatic Habitat Guidelines Program). 2002. *Integrated Stream bank Protection Guidelines*, WA