Natural Resource Damage Program

Symposium on Riparian Restoration in a Contaminated Environment

The Evolution of Channel and Floodplain Restoration Design Approaches Based on Lessons Learned Over the Past Few Decades

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Montana Department of Justice
Natural Resource Damage Program

River Design Group, Inc.

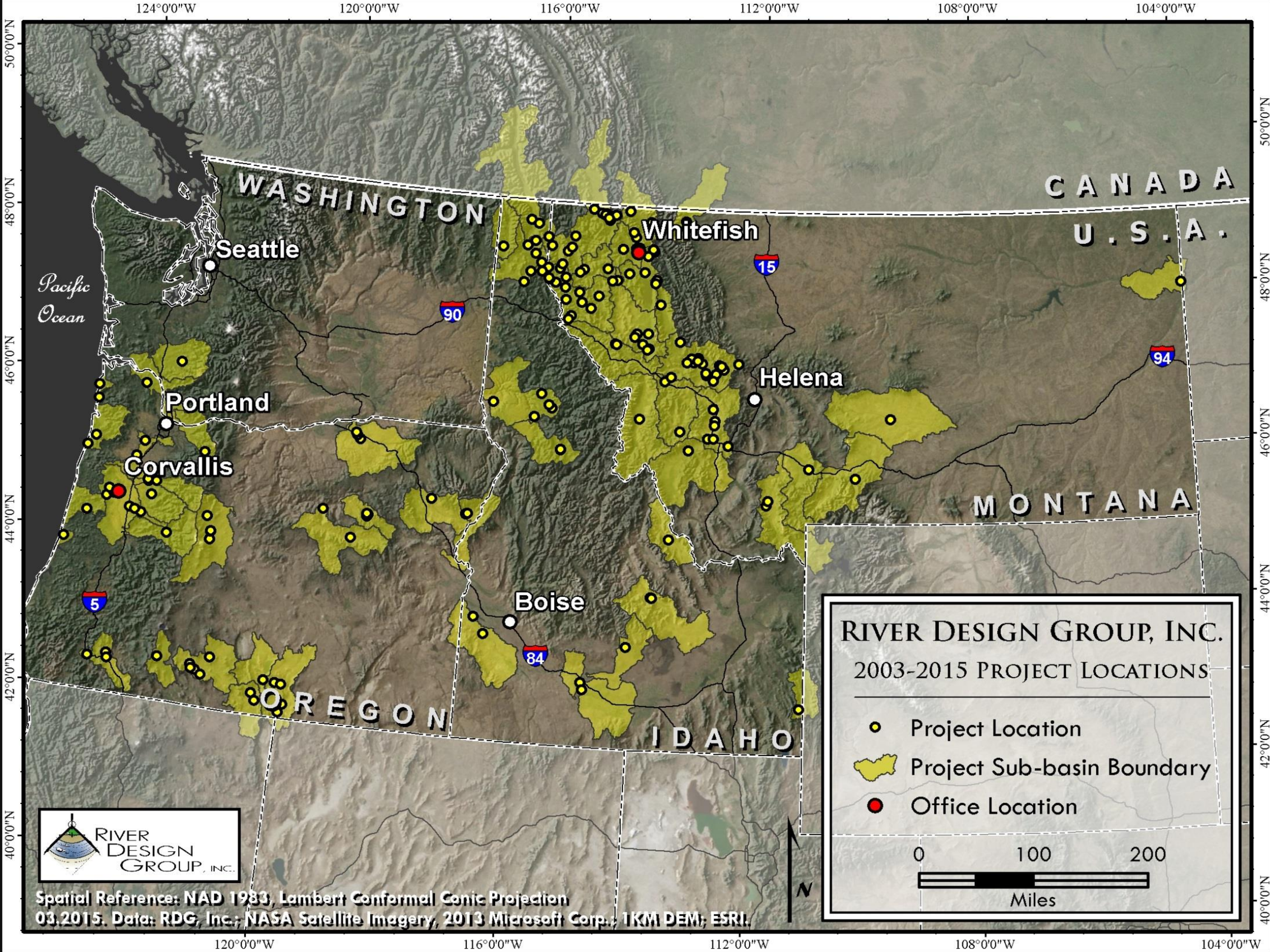
Presentation Outline

- Channel Design
- Floodplain Design
- Streambank Design

Approaches and Lessons Learned

- Grave Creek, Montana
- Granite Creek, Idaho
- Clark Fork River, Montana
- Whychus Creek, Oregon
- Middle Fork John Day, Oregon
- Jocko River, Montana

- Planning and Expectations



124°0'0"W
120°0'0"W
116°0'0"W
112°0'0"W
108°0'0"W
104°0'0"W
50°0'0"N
48°0'0"N
46°0'0"N
44°0'0"N
42°0'0"N
40°0'0"N
CANADA
U.S.A.
WASHINGTON
MONTANA
OREGON
IDAHO
Pacific Ocean
Seattle
Portland
Corvallis
Whitefish
Helena
Boise
90
15
94
5
84
RIVER DESIGN GROUP, INC.
2003-2015 PROJECT LOCATIONS
Project Location
Project Sub-basin Boundary
Office Location
0
100
200
Miles
N
RIVER DESIGN GROUP, INC.
Spatial Reference: NAD 1983, Lambert Conformal Conic Projection
03.2015. Data: RDG, Inc.; NASA Satellite Imagery, 2013 Microsoft Corp.; 1KM DEM; ESRI.

Channel Design and Lessons Learned

- Modeled Hydraulic Roughness vs. Field Conditions
- Loss of Streambed Armor Layer
- Need for Grade Control Structures
- Multiple Failure Mechanisms

Failure Modes and Geomorphic Response

Rock Displacement and Flanking

Channel Incision and Floodplain Disconnection

Deformable Grade Control Structures

“Graded” Tailout

Boulder Energy Dissipater Structures

Matrix Supported River Bed Construction

Matrix Supported Constructed River Bed

Clark Fork River at the Former Milltown Dam Site – Reach CFR 2

Matrix Supported Constructed River Bed

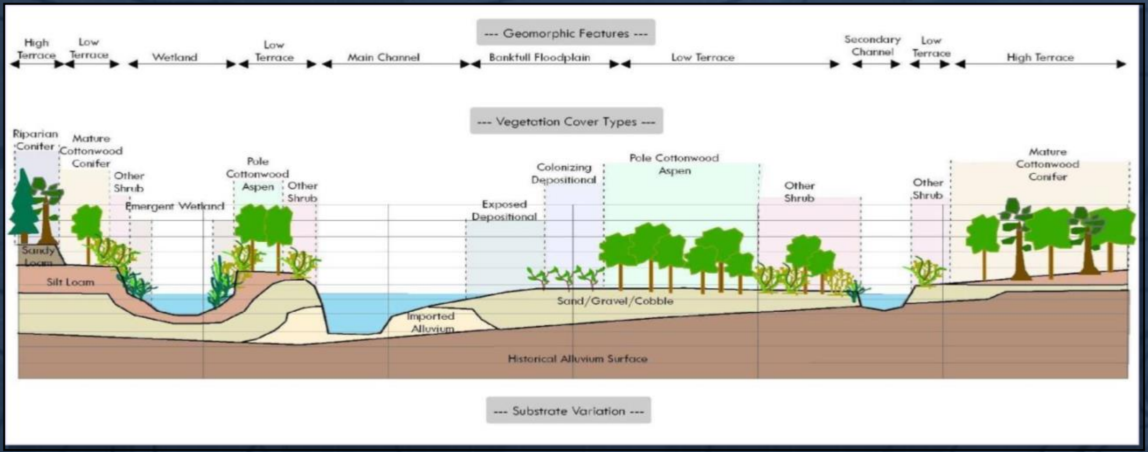
Pre Flow Activation - Whychus Creek, Oregon

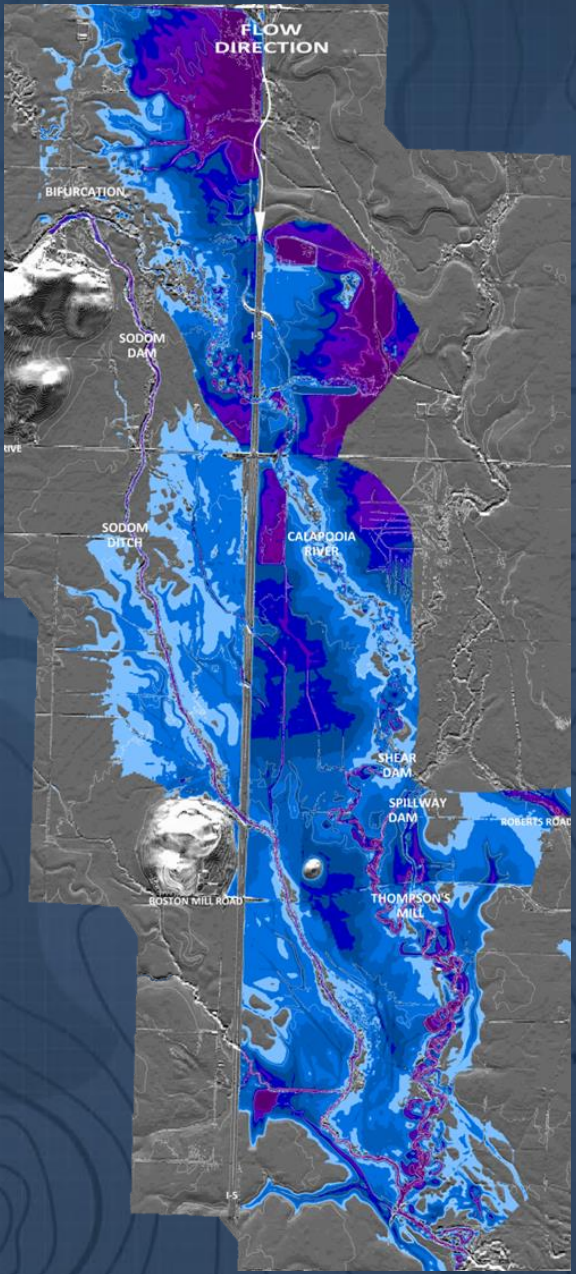
Matrix Supported Constructed River Bed

Post Flow Activation - Whychus Creek, Oregon

Floodplain Design and Lessons Learned

- Link vegetation community types to geomorphic features
- Promote recruitment rather than containerized planting
- Provide soil types to support vegetation types
- Include weed management in maintenance program





Floodplain Treatments

Grave Creek Near Eureka, Montana 2004

5-Years Later…..

Complex Floodplain Grading

Swales

Micro-topography

- Add roughness to raw floodplain surfaces
- Create micro-topography to promote natural recruitment
- Place coarse woody debris to augment organic content

Middle Fork John Day River Phase 1

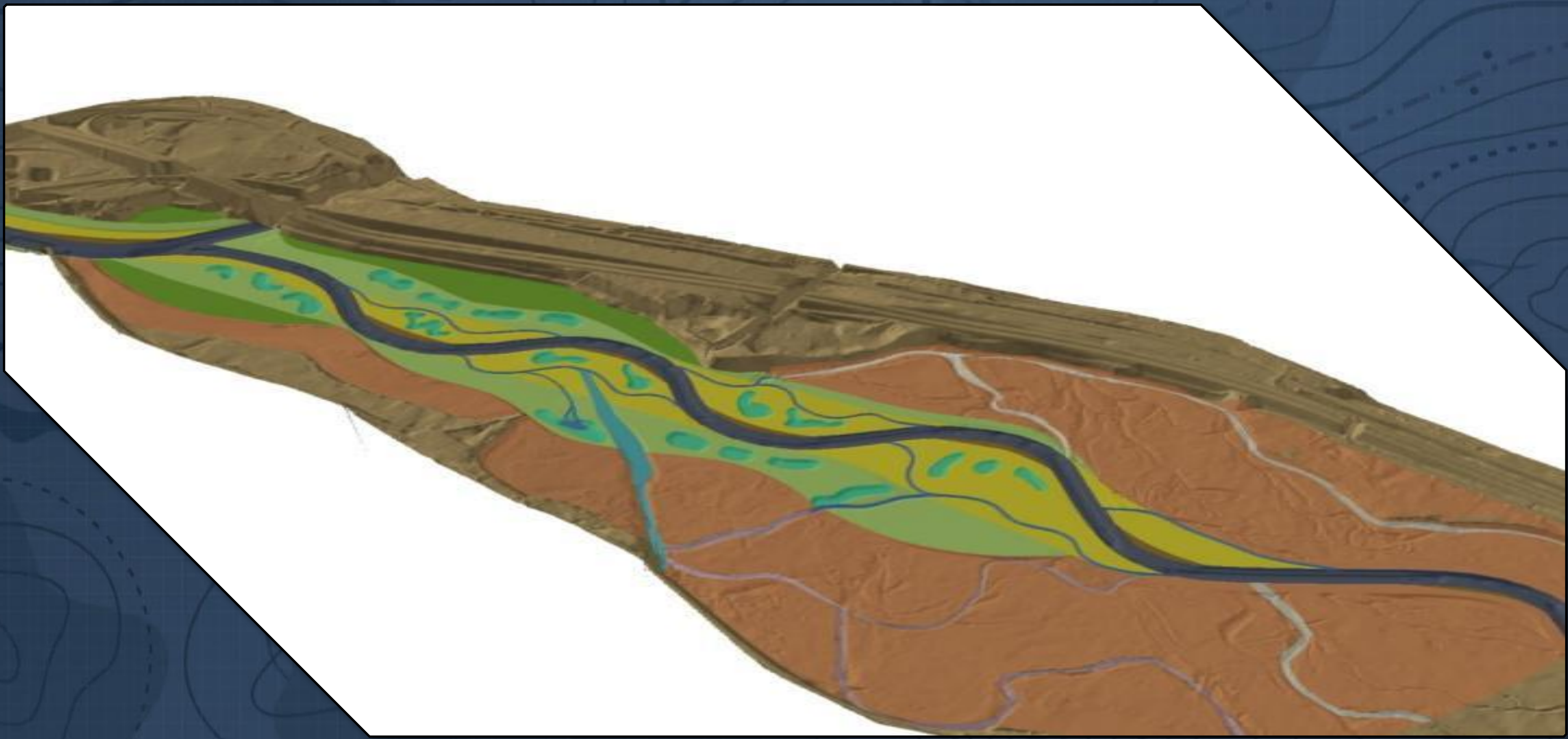
2011 100-Year R.I. Flood

Swales

Macro-topography

Terraces Where Appropriate…..

- Define channel migration zone
- Landform control between valley and stream type transitions
- Support upland vegetation and provide LWD recruitment



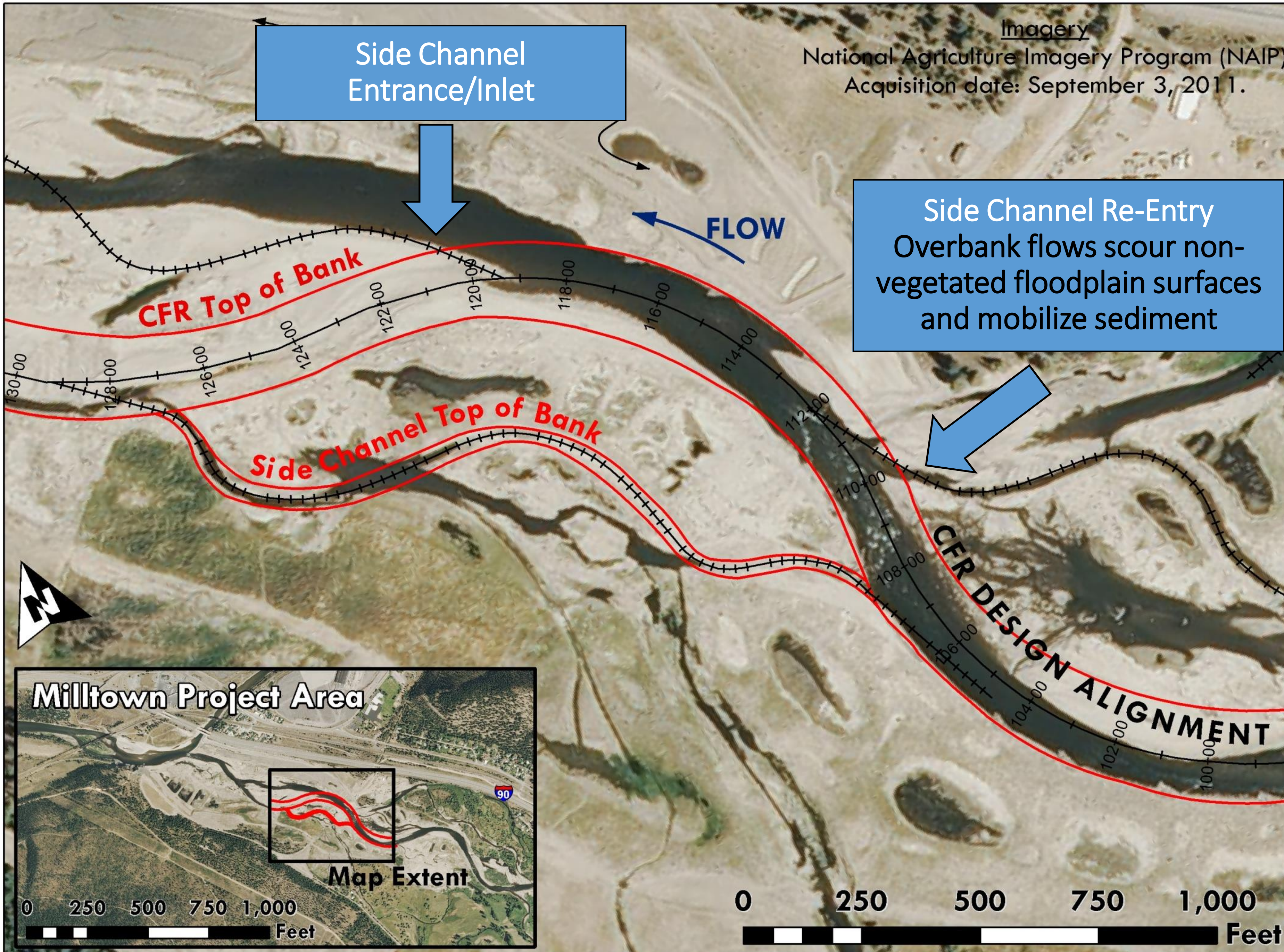
Side Channels Design and Lessons Learned

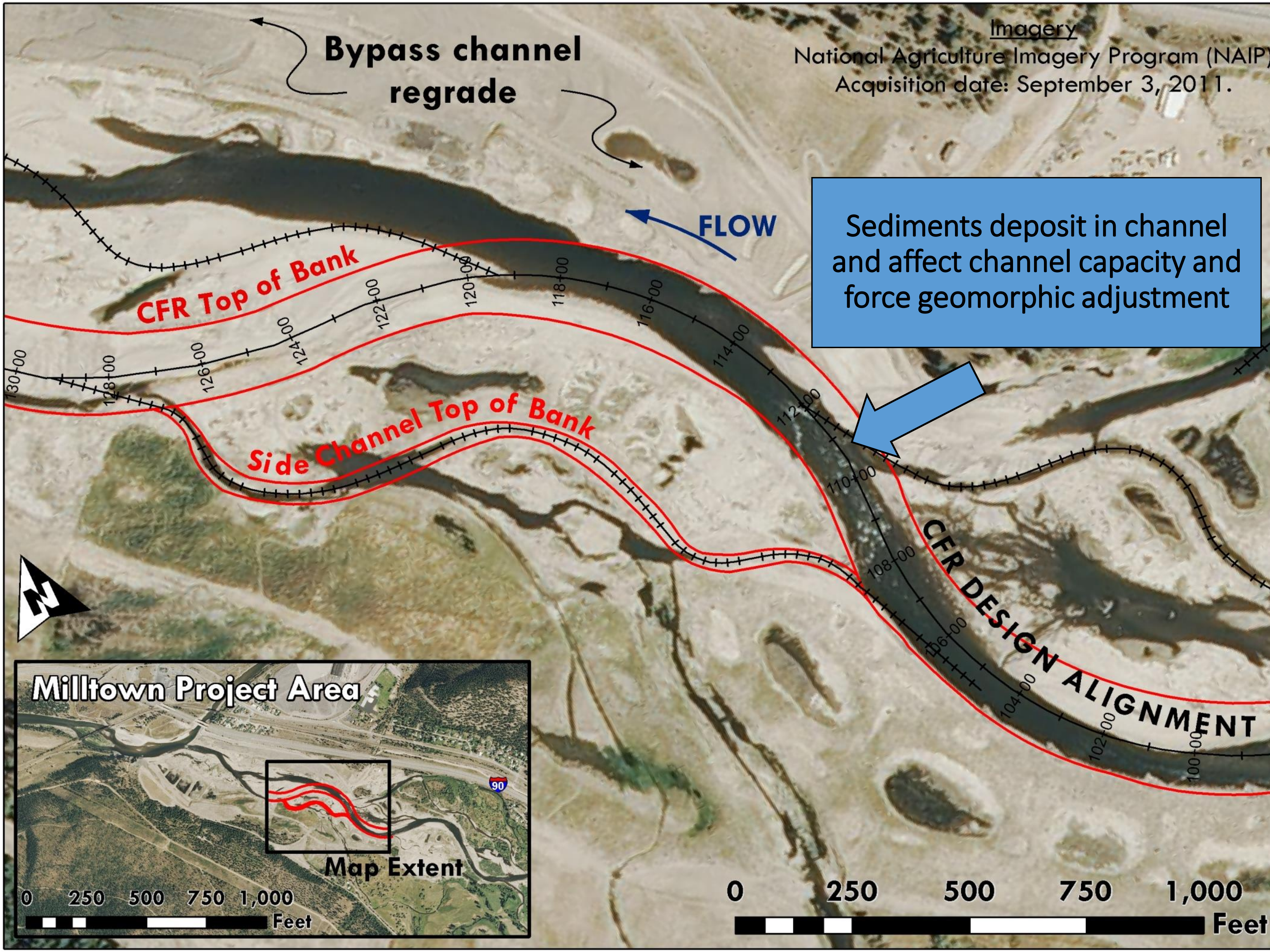
Clark Fork River 2011 38-Year R.I. Flood

Flood Stage

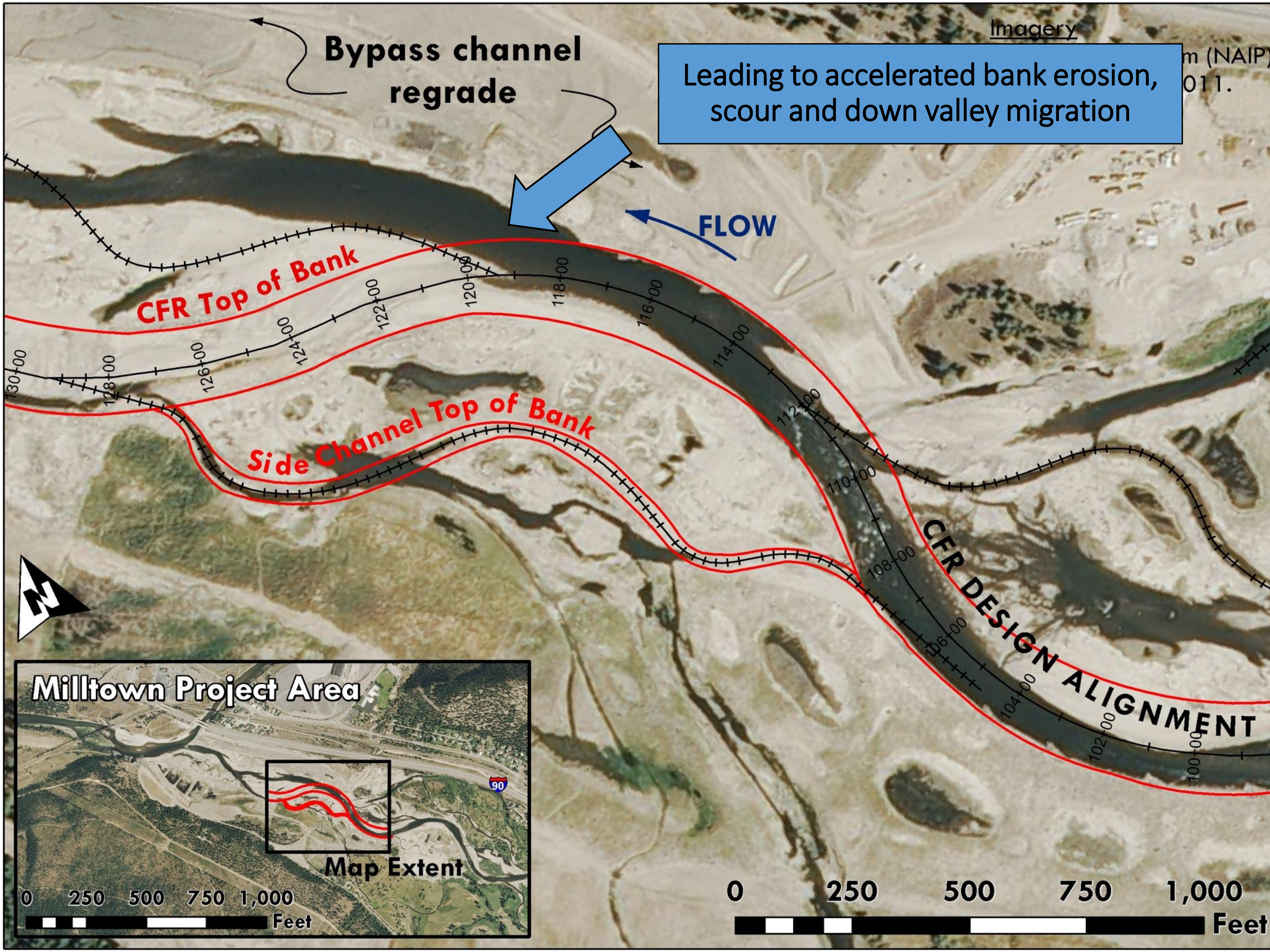
Post Flood

- Distribute flow, sediment and nutrients across floodplain surfaces
- Provide flood and ice jam relief
- Off-channel aquatic habitat during floods


Side Channel Entrance/Inlet
Imagery
National Agriculture Imagery Program (NAIP)
Acquisition date: September 3, 2011.
FLOW
Side Channel Re-Entry
Overbank flows scour non-vegetated floodplain surfaces and mobilize sediment
CFR Top of Bank
Side Channel Top of Bank
CFR DESIGN ALIGNMENT
130+00
128+00
126+00
124+00
122+00
120+00
118+00
116+00
114+00
112+00
110+00
108+00
106+00
104+00
102+00
100+00
N
Milltown Project Area
Map Extent
90
0 250 500 750 1,000 Feet
0 250 500 750 1,000 Feet



Bypass channel regrade
Imagery
National Agriculture Imagery Program (NAIP)
Acquisition date: September 3, 2011.
FLOW
Sediments deposit in channel and affect channel capacity and force geomorphic adjustment
CFR Top of Bank
Side Channel Top of Bank
CFR DESIGN ALIGNMENT
130+00
128+00
126+00
124+00
122+00
120+00
118+00
116+00
114+00
112+00
110+00
108+00
106+00
104+00
102+00
100+00
N
Milltown Project Area
90
Map Extent
0 250 500 750 1,000
Feet
0 250 500 750 1,000
Feet



Bypass channel regrade
Leading to accelerated bank erosion, scour and down valley migration
Imagery
FLOW
CFR Top of Bank
Side Channel Top of Bank
CFR DESIGN ALIGNMENT
130+00
128+00
126+00
124+00
122+00
120+00
118+00
116+00
114+00
112+00
110+00
108+00
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Feet
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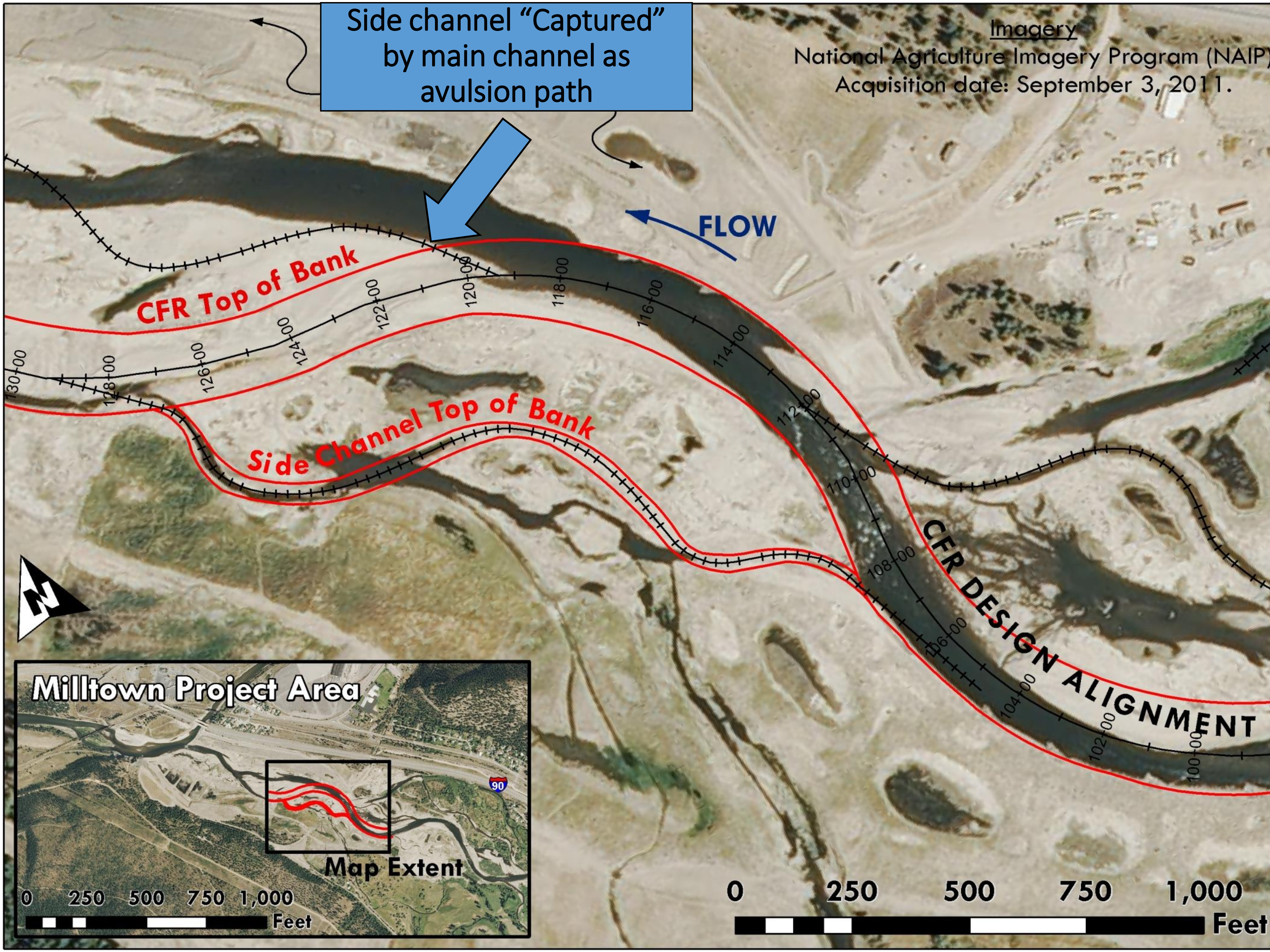
Feet



Side channel "Captured" by main channel as avulsion path
Imagery
National Agriculture Imagery Program (NAIP)
Acquisition date: September 3, 2011.
FLOW
CFR Top of Bank
Side Channel Top of Bank
CFR DESIGN ALIGNMENT
130+00
128+00
126+00
124+00
122+00
120+00
118+00
116+00
114+00
112+00
110+00
108+00
106+00
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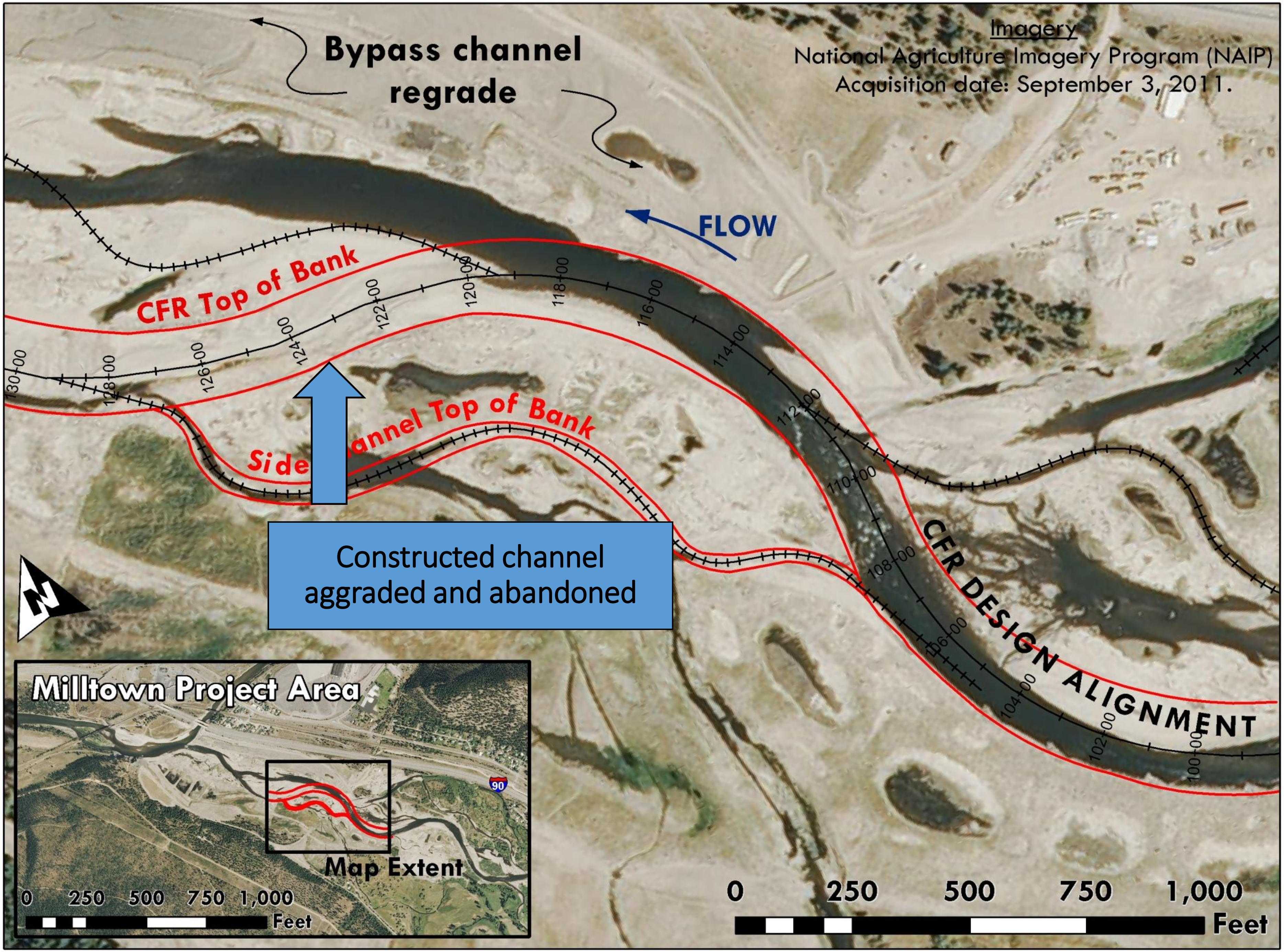
0 250 500 750 1,000
Feet
0 250 500 750 1,000
Feet



Bypass channel regrade
Imagery
National Agriculture Imagery Program (NAIP)
Acquisition date: September 3, 2011.
FLOW
CFR Top of Bank
Side Channel Top of Bank
Constructed channel aggraded and abandoned
CFR DESIGN ALIGNMENT
130+00
128+00
126+00
124+00
122+00
120+00
118+00
116+00
114+00
112+00
110+00
108+00
106+00
104+00
102+00
100+00
Milltown Project Area
90
Map Extent
0 250 500 750 1,000
Feet
0 250 500 750 1,000
Feet

Side Channel Performance and Lessons Learned

- Entrance angles critical in relation to higher stage flow paths

- Relation to upstream and downstream side channels and risk

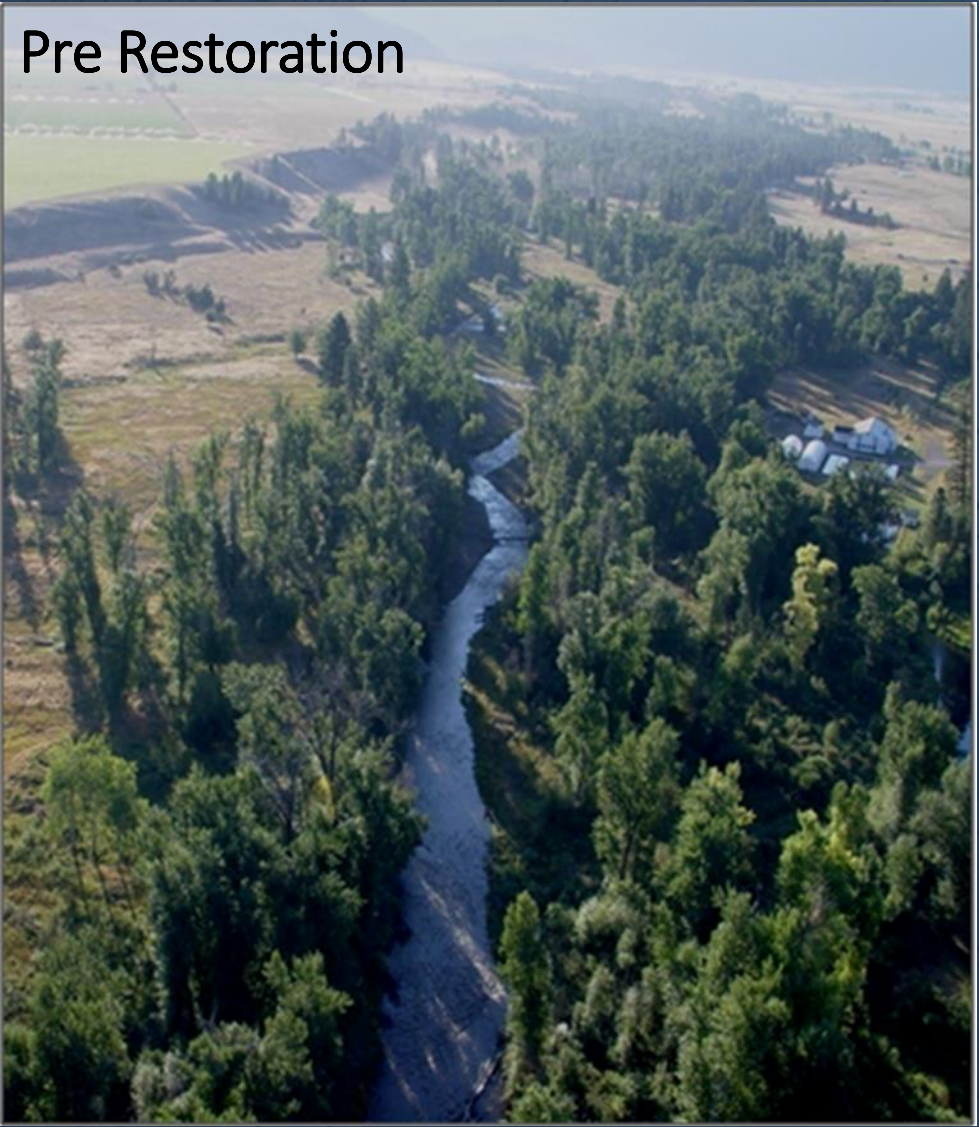
- Activated at less than bankfull flow

- Provided hydrologic recharge to floodplain surfaces during baseflow conditions

- Facilitated natural revegetation of raw floodplain surfaces

Jocko River near Arlee Phase 1 and 2

Confederated Salish and Kootenai Tribes



Jocko River Phase 1

June 2005 20-Year Flood

Phase 1 Project Area

Downstream (Untreated)

Jocko River Phase 1

Streambank Revegetation Structures

- Toe scour and settling of base lift → Toe Material Design (D84)
- Hydraulic "piping" of soil backfill → Coir Log
- Cutting Survival → Timing of collection and installation

Jocko River Phase 1

June 2005 25-Year Post Flood Observations

Large Wood Structure Flanking and Eddy Erosion

Grade Control Structure Compromised and Channel Response

Jocko River Phase 1

June 2005 25-Year Flood Post Flood Observations

- Planform - Lower radius meanders experienced deposition in the thalweg and scour across point bars

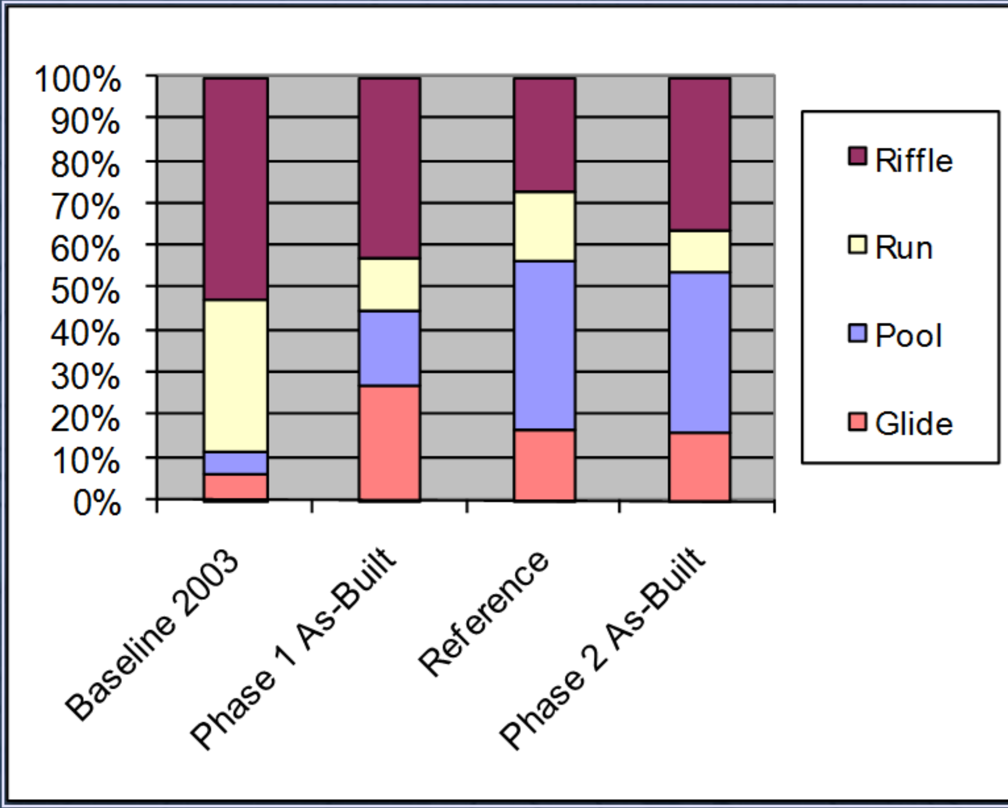
- Profile - Abrupt transitions between features caused features to adjust.

- Cross section - Average channel depth increased (slight incision)

- Structures - Channel vertical stability compromised as discrete grade control structures deformed (e.g. dislodged rock)

Jocko River Phase 2
Design Modifications

- Planform - Increased meander radius to at least 3.5 times channel width and increased meander arc length.
- Profile - Increased length of transitions between riffle and pool features. Glides increased to 2 times Wbkf.
- Cross section - Width:depth ratio increased from 25 to 30 to reduce shear stress



Jocko River Phase 2
Design Modifications

- Streambanks
  - Super elevated outer banks
  - Coarse wood in bank toes
- Floodplain
  - Side channels
  - Microtopography
  - Set surfaces below bankfull
- Grade Control
  - Eliminated vanes and weirs
  - Constructed riffles

Jocko River Phase 2

Jocko River Phase 2

Sequencing and Layout of Structures

- Geomorphic criteria drives structure spacing, length & depth
- Consider multi-stage hydraulic response (including flood paths)
- Short-term stability vs. long-term deformability

Vegetated Wood and Brush Fascine
Bank Restoration Structure
Passive Margins


Post Construction


Year 2 Post Construction


Year 5 Post Construction

Designing for 'Deformability Over Time'

- Select hydraulic criteria from flood events less than 100-yr
- Design bank toe protection at depths less than scour
- Use biodegradable fabrics, plant material and wood
- Specify round versus angular rock if appropriate
- Allow bed mobility up to D_{84} size class
- Integrate side channels
- Maintain floodplain connection at less than Q_2

Project Planning

- Establish Clear Goals and Objectives

  Goal 1 - restore a naturally functioning system that is appropriate for the geomorphic setting and site constraints.

  Objective - reconstruct a meandering channel and broad floodplain that gradually transitions to an confined channel with a narrow, sloping floodplain.

- Performance Criteria – Range of natural variability (+/- 20%)
- Design Criteria – Morphology is similar to reference conditions
- Uncertainty and Expectations – Short and long-term
- Integrate multiple disciplines

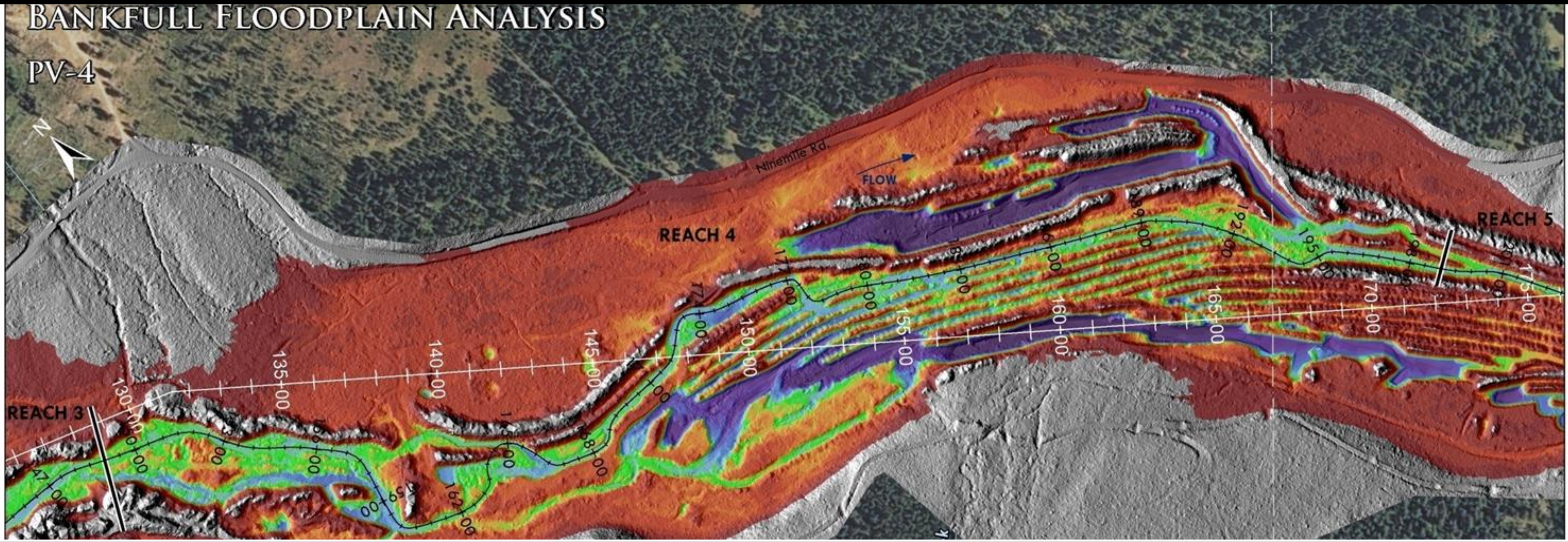
  Hydrologist → Geomorphologist → Engineer → Biologists → Contractor

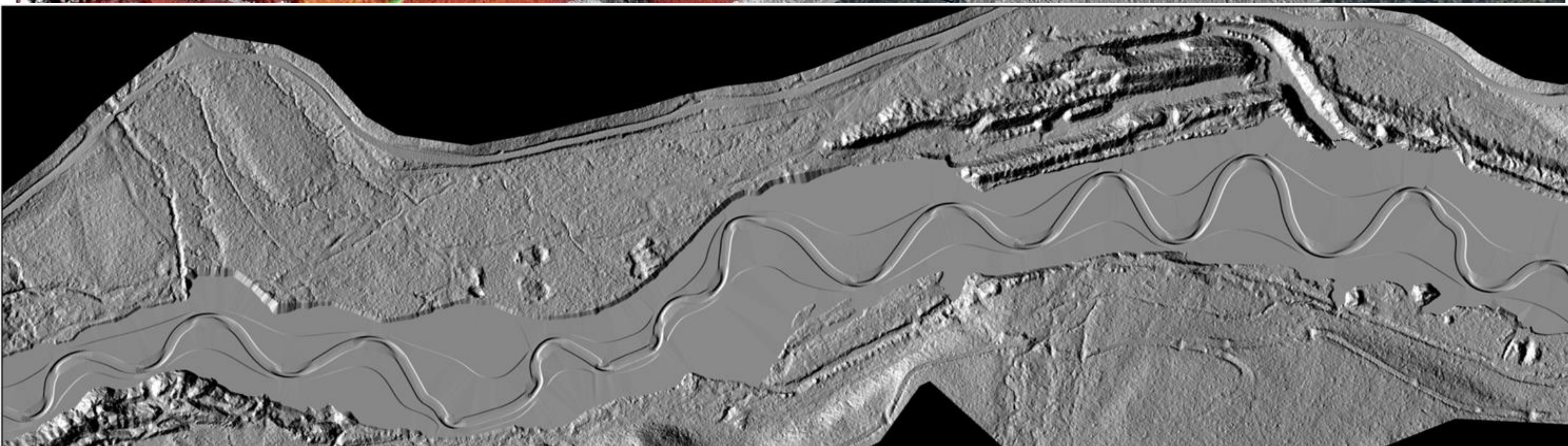
Set Timelines for Expectations

Short Term Expectations (0-15 Years)	*Long Term Expectations (15+ Years)*
Structures control channel form, which in turn, dictates lateral and vertical channel stability	Vegetation dictates lateral channel stability. Channel armoring processes dictate vertical stability
Vegetation provides stability on floodplain surface and along streambanks	Vegetation communities are established and provide habitat and other riparian/wetland functions
Structures are stable	Structures decompose & become buried
Habitat enhanced by bank stabilization and grade control structures	Habitat created by bedforms & vegetation
Bank erosion rates are low	Bank erosion rates are low
Natural processes are maintained	Natural processes govern

Technological Advancements

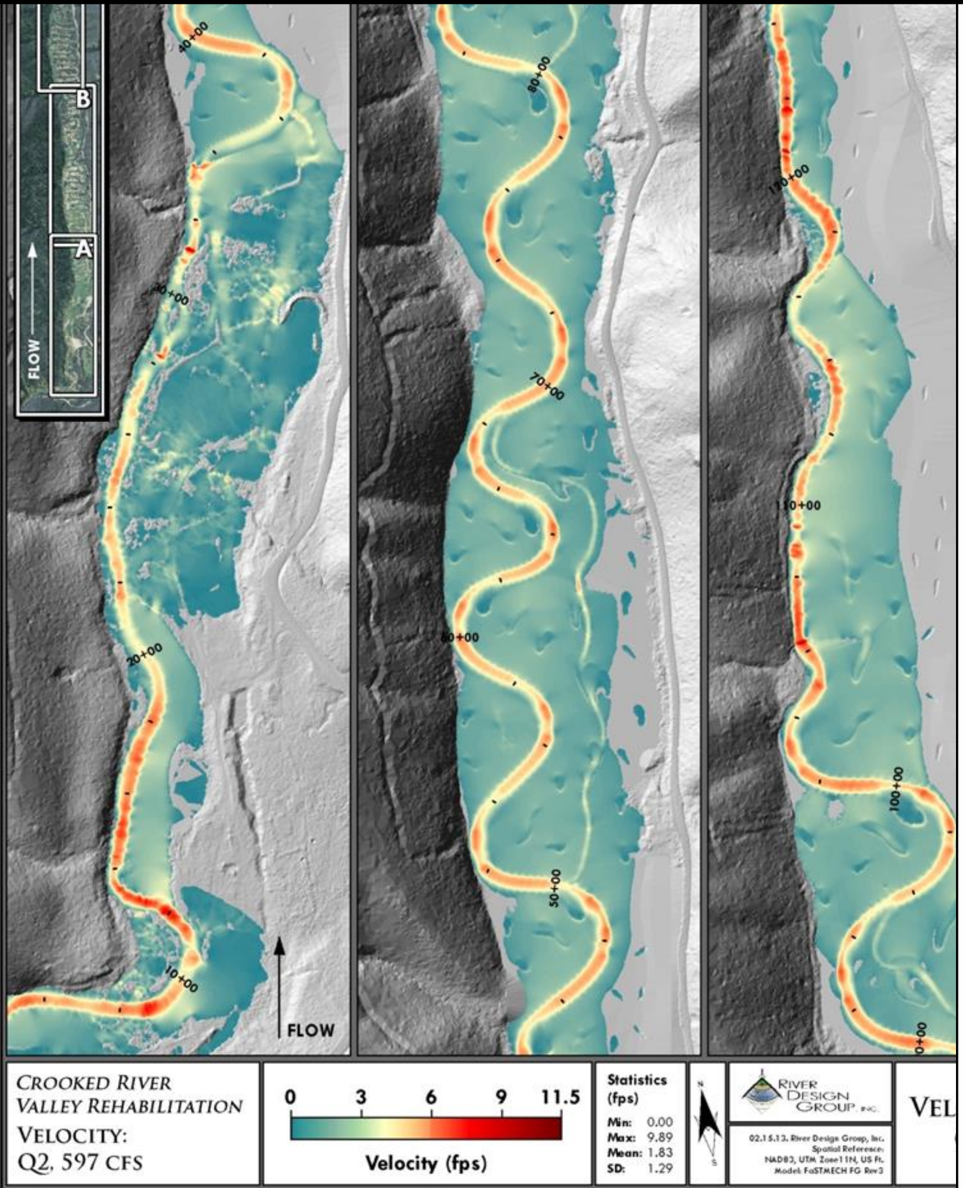
LiDAR data sets, 3-D Multi Dimensional Models

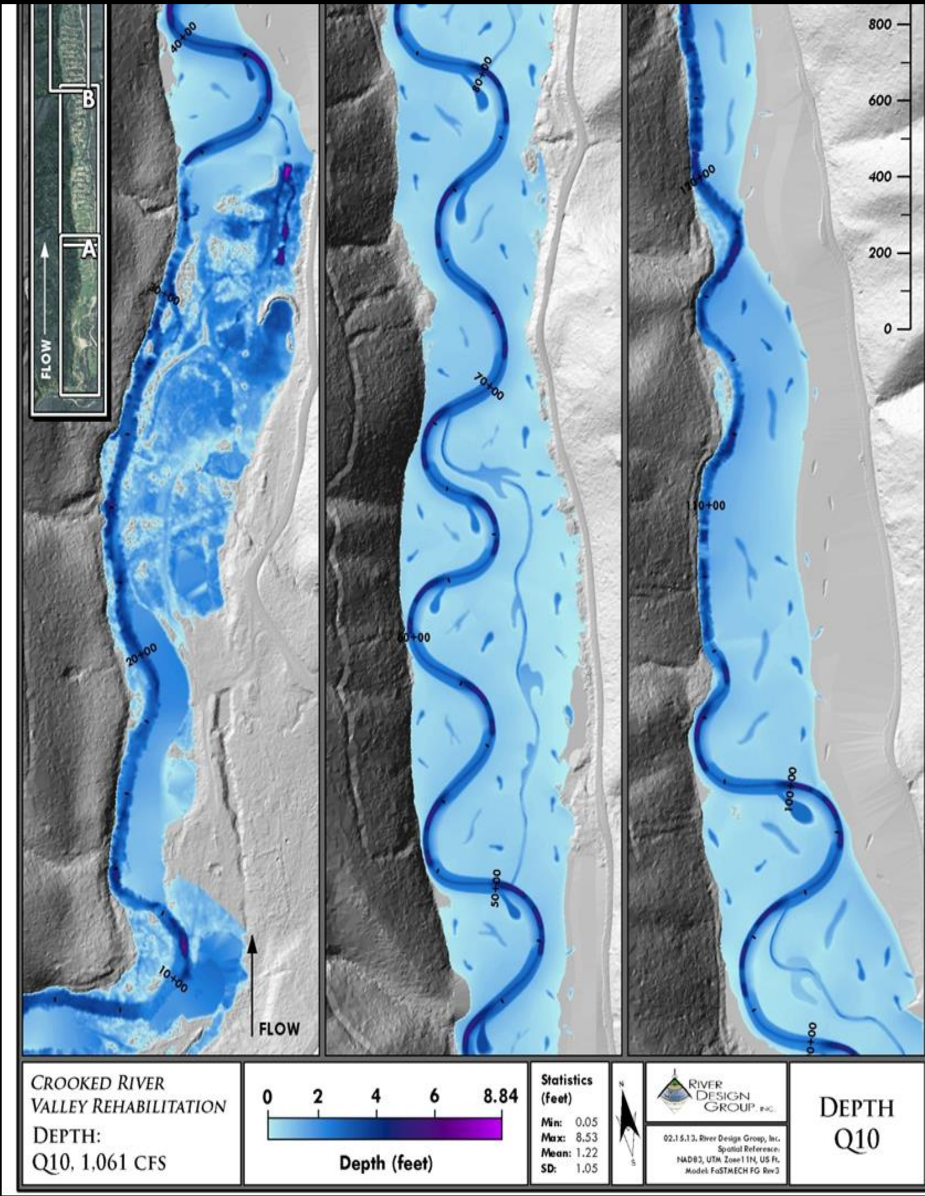




Technological Advancements

Hydraulic Modeling





Acknowledgements

Montana Department of Justice
Natural Resource Damage Program

The Confederated Salish and Kootenai Tribes of the Flathead Reservation

The Freshwater Trust® Changing the course of conservation.

Bonneville Power Administration

Montana Fish, Wildlife & Parks

Nez Perce Tribe Treaty of 1855

Kootenai River Network, Inc.
International Alliance for Water Quality and Aquatic Resources
British Columbia North Idaho Northwest Montana

Upper Deschutes Watershed Council

Forest Service U S Department of Agriculture

Avista Corp.

Geum Environmental Consulting, Inc.

Idaho Fish and Game
preserve • protect • perpetuate