



YELLOWSTONE RIVER PROJECT INVENTORY AND RANKING

January 2018

PREPARED FOR:



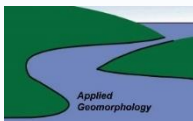
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Yellowstone River Project Inventories and Rankings for Large Woody Debris and Riverine Aquatic Habitat

Final Programmatic Damage Assessment and Restoration Plan and Final
Programmatic Environmental Assessment for the ExxonMobil Pipeline Company
July 1, 2011 Yellowstone River Oil Spill

Prepared for:

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Glossary and Abbreviations

Accretion – A natural process of gradual sediment accumulation on channel features, especially channel bed and banks or bottomland surfaces including the floodplain and low-lying terraces, through the deposition of fine fluvial sediment.

Aggradation – A geologic process where sediment deposition results in the progressive buildup or rise in elevation of the channel bed and floodplain.

Aquatic – Relating to living, being or growing in water.

Aquatic Complexity—Refers to side channels. A higher number and greater hydrologic connectedness of side channels within a defined area represents greater aquatic complexity.

Avulsion – The rapid abandonment of a river channel and formation of a new channel. Avulsions typically occur when floodwaters flow across a floodplain surface at a steeper grade than the main channel, carving a new channel along that steeper, higher energy path. As such, avulsions typically occur during floods.

Backwater Area – Areas along the main channel or within tributaries with stagnant water or little to no current flow obstruction.

Bank Armoring – Structural treatments designed to stabilize channel banks.

Channel Migration – The process of a river or stream moving laterally (side to side) across its floodplain. Channel migration is a natural riverine process that is critical for floodplain turnover and regeneration of riparian vegetation on newly created bar deposits such as point bars. Migration rates can vary greatly though time and between different river systems; rates are driven by factors such as flows, bank materials, geology, riparian vegetation density, and channel slope.

Channel Migration Zone (CMZ) – A delineated river corridor that is anticipated to accommodate natural channel migration rates over a given period of time. The CMZ typically accommodates both channel migration and areas prone to avulsion. The result is a mapped “footprint” that defines the natural river corridor that would be active over some time frame, which is commonly 100 years.

Connectivity —In reference to whether or not an area (floodplain, side channel, etc.) receives water from the main channel. If a floodplain area floods, or a side channel fills, it is considered connected. Often levees/dikes, or blockages prevent water access.

Erosion— The process by which water or wind removes soil or rock.

Floodplain- An area of low-lying ground adjacent to a river, formed mainly of river sediments and subject to flooding.

Geomorphology - The study of landforms on the Earth’s surface, and the processes that create those landforms. “Fluvial Geomorphology” refers more specifically to how river processes shape the Earth’s surface.

GIS – Geographic Information System: A system of hardware and software used for storage, retrieval, mapping, and analysis of spatial data.

Herbaceous – Plants that do not have wood and above ground parts generally do not persist outside of the growing season.

Historic Migration Zone (HMZ) – The historic channel footprint that forms the core of the channel migration zone (CMZ). The HMZ is defined by mapped historic channel locations, typically using historic air photos and maps.

Hydrology – The study of properties, movement, distribution, and effects of water on the Earth's surface.

Interested Owners – Landowners who have contacted NRDP or FWP and expressed interest in an easement or selling land.

Lacustrine - Relating to lakes or standing bodies of water.

Large Woody Debris (LWD) – Large pieces of wood that fall into streams, typically trees and shrubs that are undermined when banks erode.

Meander -- One of a series of regular freely developing sinuous curves, bends, loops, turns, or windings in the course of a stream.

Native -- Normally found as part of a particular ecosystem; a species that was present in a defined area prior to European settlement.

Natural Recovery — The process by which a river and floodplain ecosystem regains appropriate channel morphology, native vegetation and natural processes without human intervention.

NAIP – National Agriculture Imagery Program – A United States Department of Agriculture program that acquires aerial imagery during the agricultural growing seasons in the continental U.S.

Perennial – Occurring for or lasting for several years. Perennial streams flow continuously during both wet and dry times.

Process – The dynamic aspects of an ecosystem resulting in change including floods, sedimentation, erosion, freeze-thaw cycles, seed dispersal, plant growth, nutrient cycling and many other instances of energy interacting with matter.

Restricted Migration Area (RMA) – Those areas of the CMZ that are isolated from active river migration due to bank armor or other infrastructure.

Riparian – Of, relating to or situated on the banks of a river. Riparian zones are the interface between land and a river or stream.

Riprap – A type of bank armor made up of rocks placed on a streambank to stop bank erosion. Riprap may be composed of quarried rock, river cobble, or manmade rubble such as concrete slabs.

Riverine System – A wetland system generally described as aquatic habitat contained within a channel.

Terrace – On river systems, terraces are land surfaces with a consistent elevation that flank the sides of floodplains. They represent historic floodplain surfaces that have become perched due to stream downcutting.

Terrestrial – Relating to living, being or growing on land.

Wetland – Land areas that are either seasonally or permanently saturated with water, which gives them characteristics of a distinct ecosystem.

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Introduction

This document describes an inventory and ranking framework for certain restoration projects identified to implement the Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Assessment for the ExxonMobil Pipeline Company July 1, 2011 Yellowstone River Oil Spill (State of Montana and USDOI 2017) (restoration plan). Injuries from the oil spill are split into five categories: terrestrial/riparian habitat and supported biota; large woody debris piles; riverine aquatic habitat and supported biota; injuries to American white pelican; and recreational human use. This inventory and ranking of projects is related to large woody debris piles and riverine aquatic habitat and supported biota. Where additional information is readily available, the inventory and ranking identifies opportunities where terrestrial/riparian habitat injuries or recreational human use injuries can be additionally addressed as part of multiple resource benefits. Injuries to terrestrial/riparian habitat, birds and recreational human use are being addressed through other prioritization processes.

Each of the two injury categories addressed in this report has associated project types.

1) Large Woody Debris Pile Injury Category

These projects are designed to recruit large woody debris to the river and restore natural river function to re-establish large woody debris piles in areas where they were dismantled or disturbed by response actions, and include:

- Obtain easements/fee title land acquisitions on upstream cottonwood bottomlands or use other land management methods to produce a quantity of large woody debris to compensate for that removed by response actions and
- Further enhance the naturally functioning river system by removing unnatural or man-made restrictions to natural fluvial processes and/or channel migration and function.

2) Riverine Aquatic Habitat Injury Category

Riverine habitat project types (enhance aquatic habitat for fish production and other aquatic organisms) include:

- Increase fish production by improving fish passage on the main stem and tributaries;
- Improve aquatic habitat by using soft, bioengineered bank stabilization techniques; and
- Increase aquatic habitat by opening blocked side channels, and reactivating old oxbows and backwater channels.

The overall goal of this inventory and ranking framework is to identify, characterize, and rank potential projects for each injury category that will most effectively address the respective injury category. The projects presented will likely further evolve upon more intensive project development based on feasibility, detailed costs, and other new information. To support that future effort, this initial project identification phase has concentrated on identifying projects in terms of their meeting certain prioritization parameters, while building an objective methodology for assessing those parameters. The process will support continued evaluation of any additional or modified projects so that restoration plan goals can be most cost-effectively met.

This document is organized as follows:

- Description of the inventory and ranking process;
- Methods to evaluate prioritization parameters; and
- Results of applying ranking criteria and prioritization parameters to representative projects identified in the inventory.

Project Inventory and Ranking

This section describes a process for setting priorities among potential projects along the Yellowstone River between Reed Point and Custer (river mile [RM] 435 to RM 303).

Between Reed Point and Billings, the inventory includes projects that may meet restoration plan large woody debris project goals to recruit large woody debris to the river and to restore natural river function through potential fee title acquisitions, easements, or other land conservation or restoration methods. Between Reed Point and Custer, the inventory includes projects for riverine habitat restoration including: removal of blocks on side channels, reactivation of old oxbows and back channels, removal of bank armor that is currently on the bank or has been flanked by the river, or other opportunities for removing unnatural or man-made restrictions to natural fluvial processes and/or channel migration function and to restore riverine habitat.

From the restoration plan (State of Montana and USDOJ 2017), the

...core principle for selection of terrestrial/riparian, large woody debris, and riverine projects will be to base decisions in sound scientific information that will lead to achievement of the goals for each injury category...In general, the [Natural Resource Damage Program] NRDP will consult with local resource managers and other resource specialists to help identify, evaluate, and prioritize potential restoration projects that will have the greatest ability to achieve the goals of the restoration plan. Each identified project will be evaluated using the six criteria required by the Oil Pollution Act, as well as other legal and Montana policy criteria where pertinent.

Oil Pollution Act criteria are listed below, in addition to information about how they are addressed as part of this Inventory and Ranking process:

- **Project cost and cost-effectiveness.** Cost and cost effectiveness is evaluated qualitatively. Projects are ranked as having low, medium, or high cost, as described in the Prioritization Parameters section below. Once projects are selected for further development, feasibility-level cost estimates will be developed as part of conceptual planning and preliminary design, and more formal cost/benefit analyses will be completed.
- **Project goals and objectives.** Only projects that directly address injured resources and services are included in the inventory. For example, projects support future large wood recruitment, result in improved aquatic habitat, or protect and enhance riparian habitats.
- **Likelihood of project success.** Likelihood of project success is evaluated qualitatively. Projects are ranked as having low, medium, or high likelihood of success, as described in the Prioritization Parameters section below. Once projects are selected for further development,

project feasibility will be evaluated during conceptual and preliminary design stages as part of normal project development.

- **Avoidance of adverse impact.** Only projects that appear to have limited negative side effects and that limit continued impacts from injury are included in the inventory. In addition, the framework includes a specific parameter where projects are evaluated as low, medium, or high for risk of adverse effects. Potential adverse impacts, including risks associated with potential liability, would be further evaluated during later project development and feasibility assessment phases.
- **Multiple resources and service benefits.** This is one of the primary criteria evaluated by the inventory and ranking process. The scoring framework described in the Prioritization Parameters section below results in higher ranking reflecting additive benefits from additional river functions and processes being addressed by a project. In addition, the framework includes a specific parameter where projects are evaluated as low, medium, or high for supporting multiple resource benefits.
- **Public health and safety.** Public health and safety is considered by excluding potential projects that appear to put the public at risk. Once projects are selected for further development, public health and safety will be evaluated during conceptual and preliminary design stages as part of normal project development and feasibility assessment.

In addition to the Oil Pollution Act criteria described above, projects are generally evaluated in terms of natural recovery potential, compliance with laws and regulations, and with respect to whether a project might be replacing normal government function, as indicated in the restoration plan. Specifically, no project is included in the inventory that does not comply with laws and regulations, or that would replace normal government function.

Property purchases or easements with riparian habitat or large woody debris purposes are also generally evaluated in terms of the following parameters, as appropriate: price, habitat size, connectivity to public or conserved land, vegetation quality and diversity, wildlife values and diversity, multiple resource benefits, recreation benefits and public access, and cavity nesting bird habitat.

Project Inventory

As described in the restoration plan,

NRDP will work with project partners such as [Montana Fish, Wildlife, and Parks] FWP and nonprofit organizations and with area landowners to help identify properties suitable to meet the project goals of conservation or restoration of cottonwood bottomland, or altered terrestrial riparian land and for large woody debris recruitment. NRDP may work with nonprofit land conservation organizations to secure the properties or easements. Acquisition may only be approved when the price to be paid for the property is equal to or less than the fair market value. An independent appraisal by a qualified appraiser which complies with the Uniform Standards of Professional Appraisal Practice will be required to verify the property's value...For terrestrial/riparian restoration projects, NRDP will work with state, federal, local and private project partners to help identify potential sites for terrestrial/riparian restoration. For invasive woody plant removal, NRDP will work with project partners such as FWP, DNRC, and the

Yellowstone County Weed District to help identify areas on State-owned lands. NRDP will work with FWP and the local conservation districts to help identify projects to restore river function. NRDP will work with FWP and the local conservation districts or irrigation companies to help identify locations in tributaries to restore fish passage. NRDP will work with FWP and the local conservation districts or private entities to help identify locations to restore or create aquatic habitat.

In April 2017, NRDP released a Request for Quotes (RFQ) to support inventory and ranking of projects related to the restoration plan. A consultant team (consultant team) including Geum Environmental Consulting, Inc.; Applied Geomorphology, Inc.; DTM Consulting, Inc.; Montana Aquatic Resource Services (MARS); and Pioneer Technical, Inc. was retained to develop aspects of the inventory and ranking related to the two injury categories described above.

The consultant team developed an initial list of projects and visited a subset of projects in the field on June 5-6, 2017. Initial projects included potential channel migration easements (CMEs), side channel reconnection and enhancement projects, flanked armor, and other potential aquatic habitat projects. Karin Boyd of Applied Geomorphology, Inc. made the initial project selections based on her familiarity with the project area. After completion of the June 5-6 site visits, the consultant team identified a draft inventory of restoration projects and used these projects to provide context for developing prioritization parameters to support project ranking, and to identify thresholds for each parameter. Guidelines used to delineate project boundaries are described below followed by the prioritization parameters developed to evaluate and rank projects individually.

[Project Boundary Delineation](#)

The general approach to project delineation was to develop broad, geomorphically inclusive sites to increase the potential for long-term riverine function and addressing of injury. Project areas were identified by reviewing 2015 aerial photos and identifying areas with concentrations of riparian forest where dynamic river processes are evident, and areas with off-channel aquatic habitat with potential to be reconnected. In addition, areas with interested landowners, conservation easements, and public ownership were included where potential for large wood or aquatic habitat projects is present. Lands with public ownership or conservation status were included because they would not need to be purchased or protected using restoration funds. Consultant team knowledge and information gained during the June 5-6 site visit were also considered. Once project areas were identified, the following factors were considered when delineating project boundaries:

- Encompass zones of optimal similar function—project areas may extend across the river to develop functional “nodes”;
- Encompass zones of broad major impact such as contiguous floodplain areas separated from the channel by dikes;
- Expand beyond areas with high inherent river function to include areas behind bank armor to include restoration opportunities as part of projects;
- Conservation easement boundaries may be considered when delineating projects;
- The boundaries shown in Figures 5 through 44 follow the perimeter of each project; however, for purposes of assigning values to parameters, the main river channel is excluded from analyses;

- Include adjacent erosion polygons where erosion is moving in the direction of the project in order to capture the dynamic nature of the project area;
- Use the historic migration zone (HMZ) as an outer boundary where possible (expanding beyond the HMZ to include areas showing riparian vegetation on 2015 aerial photography);
- Minimize Infrastructure/public safety complications (e.g. bridge approaches);
- Exclude uplands; and
- Use cadastral as guidance, but not as primary criteria. For example, exclude small parcels along the edge of a large parcel if they are not adding value in terms of river function or restoration opportunity.

Prioritization Parameters

Two overriding themes in the restoration plan for the large woody debris pile and riverine aquatic habitat injury categories are supporting river function and identifying projects that provide multiple benefits. In addition (from the restoration plan), “[t]o achieve restoration plan goals for each injury category, the NRDP proposes to address the factor(s) that most limit the injured resources first, then implement projects that reduce or eliminate the next most limiting factor(s).” To capture these themes and also to address the core principal from above, “base decisions in sound scientific information,” the consultant team developed a list of prioritization parameters that can be linked directly to Yellowstone River data that has been developed since the Cumulative Effects Analysis (CEA) (U.S. Army Corps of Engineers and Yellowstone River Conservation District Council 2015) was initiated in 2001. The purpose of the CEA was to determine the cumulative hydrologic, biological, and socioeconomic impacts of human activity on the Yellowstone River, in response to increased bank stabilization permits on the Yellowstone River during the mid-1990’s. Specific data from the CEA and other sources are described in the Methods section below.

Prioritization parameters used in this inventory and ranking are organized into three groups under each injury category: inherent river function and process parameters; limiting factors (restoration opportunity) parameters; and other parameters. These groups are described below.

Inherent River Function and Process Parameters

This group includes parameters that describe the existing condition of a potential project site in terms of natural river function and process. High ranking for these parameters indicates a project area’s natural recovery potential, suggest a relatively high likelihood of success for implemented projects, and similarly suggest a relatively high benefit to cost ratio for projects. For example, a large woody debris project with abundant riparian forest and a high channel migration rate will more quickly achieve large woody debris goals than a site with sparse riparian forest and a slow channel migration rate. Similarly, a plugged side channel located in riparian forest at a frequently connected floodplain elevation within the historic migration zone (HMZ) would have a greater chance of enhancing aquatic habitat, upon removal of the plug, than a side channel running through agricultural land further from the active channel migration zone. Identifying a set of parameters that characterize river function and process emphasizes the importance of river movement, hydrologic connectivity, riparian forest development processes, and overall diversity as key components of a self-sustaining, highly functioning river and floodplain ecosystem.

Limiting Factors (Restoration Opportunity) Parameters

This group includes parameters that capture factors limiting river function and present the opportunity to restore damaged resources. For purposes of this document, limiting factors are defined as things that limit natural river function and processes that can be fixed by applying management actions. In the case of a channel migration easement project, one example might be non-functional bank armor that is no longer needed to protect infrastructure, but if removed, could allow restoration of natural channel migration into an area previously cut off from natural channel processes. Similarly, removing a side channel plug that is limiting connectivity could restore aquatic habitat in a side channel during flows that cannot currently overtop the channel plug.

Other Parameters

This group includes important criteria from the restoration plan such as proximity to injury, estimated cost, public versus private ownership, and likelihood of success. These administrative and feasibility-level criteria provide direct links to the restoration plan, and some would be further evaluated during later planning stages once projects are selected for further development.

Specific prioritization parameters for each injury category are described below and summarized in Table 1.

Large Woody Debris Piles Injury Category Parameters

Inherent river function and process parameters:

- **Short-term wood recruitment.** This parameter is evaluated based on the amount of erosion that has occurred between 2001 and 2015 (representative of recent migration rates under more recent infrastructure, climate and erosion patterns, and also includes the 2011, 35-year flood event), and it is expressed in terms of acres per year. Higher values indicate a dynamic site location where natural river processes are relatively unimpeded and near term large wood recruitment is likely. Higher values also indicate larger areas, and this is supported by the restoration plan where habitat size is a criterion for acquisition or easement projects.
- **Long-term wood recruitment.** This parameter is evaluated based on the total acres of woody vegetation present within a project area. This represents the idea that, over the long-term, most floodplain surfaces within the channel migration zone will be reworked by natural river processes. As with short-term wood recruitment, this also accounts for habitat size being a selection criteria in the restoration plan.
- **Short-term expansion of riparian forest.** This parameter is evaluated based on the amount of vegetated floodplain accreted between 2001 and 2015. Expressed in terms of acres per year, this captures the replacement rate of riparian forest at any given project site and represents the potential for woody vegetation to mature and become large wood in the future. As with short-term and long-term wood recruitment, this also accounts for habitat size being a selection criteria in the restoration plan.
- **Bank length (shoreline).** The parameter is evaluated based on the total amount of bank length in a project area relative to the total project area in acres. For large wood recruitment, more bank length per acre indicates a faster relative wood recruitment rate because relatively more riparian forest is exposed to erosion forces.
- **Lateral connectivity.** This parameter is evaluated based on the percent of a project area within the HMZ, which indicates that it is likely to provide a source for large wood recruitment within the core area of active channel processes.

- **Natural recovery potential.** This parameter is evaluated based on other parameters such as short-term wood recruitment, and is expressed as low, medium, or high potential for natural recovery.

Limiting factors:

- **Armor present.** This parameter is evaluated based on the length of bank armor or floodplain dikes present relative to the total bank length. Higher ranking indicates a higher relative proportion of bank armor which limits erosion, but also reflects greater opportunity for restoration through removal of bank armor.
- **Russian olive present.** This parameter is evaluated based on the area within a project occupied by Russian olive. Higher ranking indicates a higher area of Russian olive, but also reflects greater opportunity for restoration through weed management to achieve multiple resource benefits. There were no available spatial data for salt cedar, but this may be further identified as a restoration opportunity after project selection.
- **Agricultural land present.** This parameter is evaluated based on the percent of land currently managed for agriculture, and it represents a limiting factor in terms of present potential for wood recruitment, but it also reflects potential to convert the area to native riparian forest as part of restoration and management actions.

Other parameters:

- **Proximity to injury.** This parameter is evaluated based on proximity of the project to the injured area.
- **Ownership.** This parameter is evaluated based on the percent of a project area in either public or conservation ownership, and captures the idea that public lands or private lands protected by conservation easements have a greater chance of long-term project success because management, monitoring and/or long-term protection mechanisms are in place. This supports the restoration plan selection criteria of connectivity to public or conservation land.
- **Likelihood of success.** This parameter is evaluated based on the ratio of inherent river function to limiting factor scores, and is expressed as low, medium, or high potential for success.
- **Cost.** This parameter is evaluated based on average acreage values in addition to average costs to establish and manage an easement or public property. It is expressed as low, medium, or high potential cost. This supports the restoration plan selection criteria of price for easement or acquisition projects. Higher cost results in a higher score and this is subtracted from the total score.
- **Cost effectiveness:** This parameter is evaluated based on the total benefit of a project in terms of the sum of all parameter scores relative to the estimated project cost. It is expressed as low, medium, or high potential for cost-effectiveness.
- **Risk of adverse effects.** This parameter is evaluated based on proximity to infrastructure (bridges, powerlines, permanent irrigation pumps, diversions or dams, buildings, and railroads), and is expressed as low, medium, or high potential for adverse effects. Higher risk of adverse effects receives a higher score, and this is subtracted from the total score.
- **Public health and safety.** This parameter is evaluated based on presence of residential or recreational infrastructure, and is expressed as low, medium, or high potential for effects on public health and safety. Higher potential for effects on public health and safety receive a higher score, and this is subtracted from the total score. This parameter includes the potential for a project to cause liability concerns.
- **Potential for multiple resource benefits.** This parameter is evaluated based on whether a project addresses more than one injury category, an evaluation of aquatic complexity (number

and connectedness of channels), and potential for recreational/terrestrial habitat resource benefits (parcels identified for potential acquisition to address terrestrial habitat). It is expressed as low, medium, or high potential to achieve multiple resource benefits.

Riverine Aquatic Habitat and Supported Biota Injury Category Parameters

Inherent river function and process parameters:

- **Off channel aquatic habitat length.** This parameter is evaluated based on the total length of side channels, backwater features, and oxbows with potential to be reconnected in a project area, where greater length suggests more potential for aquatic habitat reconnection.
- **Perennial surface water in off channel aquatic habitat features.** This parameter is evaluated based on the likelihood of a side channel supporting sustainable perennial flow if it is included as part of a restoration project, based on the percent of a side channel where surface water is visible in aerial photographs during a drier year (2015). Based on conversations with fisheries biologists from FWP on June 3, 2017, available water for refuge is one of the most important parameters for fish habitat, particularly in side channels.
- **Vertical connectivity.** This parameter is evaluated based on the relative percent of areas connected at the 2-year flow interval which includes the floodplain and side channels. More connectivity would result in a higher ranking because wetter areas support better aquatic habitat via nutrient exchange between the floodplain and channel and natural processes that may form side channels or areas for fish refugia.
- **Lateral connectivity.** This parameter is evaluated based on the percent of a project area (or side channel if that is the entire project) within the HMZ, which indicates that it is likely to provide long-term function within the core area of active channel processes.
- **Natural cover.** This parameter is evaluated based on the percent of a project area that includes natural riparian vegetation (not agriculture or developed land). A higher proportion of natural riparian cover indicates the riparian/terrestrial contribution to sustaining aquatic habitat. This supports the restoration plan selection criteria of vegetation quality and diversity.
- **Natural recovery potential.** This parameter is evaluated based on other parameters such as lateral connectivity and side channel length and is expressed as low, medium, or high potential for natural recovery.

Limiting factors:

- **Side channel blockages present.** This parameter is evaluated based on the nature of side channel blockages present which limit connectivity. Higher ranking reflects more substantial or longer blockages, but also indicates opportunity to restore connectivity by removing blockages.
- **Armor present.** This parameter is evaluated based on the length of bank armor or floodplain levees/dikes present relative to the total bank length. Higher ranking indicates a higher relative proportion of bank armor, but also reflects greater opportunity for restoration through removal of bank armor.
- **Russian olive present.** This parameter is evaluated based on the percent of woody vegetation polygons occupied by Russian olive. Higher ranking indicates a higher area of Russian olive, but also reflects greater opportunity for restoration through weed management to achieve multiple resource benefits. There were no available spatial data for salt cedar, but this may be further identified as a restoration opportunity after project selection.
- **Agricultural land present.** This parameter is evaluated based on the percent of land currently managed for agriculture, and it represents a limiting factor in terms of present habitat, but also

reflects potential to convert the area to native riparian vegetation as part of restoration and management actions.

Other parameters:

- **Proximity to injury.** This parameter is evaluated based on proximity of the project to the injured area.
- **Ownership.** This parameter is evaluated based on the percent of a project area in either public or conservation ownership, and captures the idea that public lands or private lands protected by conservation easements have a greater chance of long-term project success because management, monitoring and/or long-term protection mechanisms are in place. This supports the restoration plan selection criteria of connectivity to public or conservation land.
- **Likelihood of success.** This parameter is evaluated based on the ratio of inherent river function to limiting factor scores, and is expressed as low, medium, or high potential for success.
- **Cost.** This parameter is evaluated based on average acreage values in addition to average costs to establish and manage an easement or public property. It is expressed as low, medium, or high potential cost. This supports the restoration plan selection criteria of price for easement or acquisition projects. Higher cost results in a higher score and this is subtracted from the total score.
- **Cost effectiveness:** This parameter is evaluated based on the total benefit of a project in terms of the sum of all parameter scores relative to the estimated project cost. It is expressed as low, medium, or high potential for cost-effectiveness.
- **Risk of adverse effects.** This parameter is evaluated based on proximity to infrastructure (bridges, powerlines, permanent irrigation pumps, diversions or dams, buildings, and railroads), and is expressed as low, medium, or high potential for adverse effects. Higher risk of adverse effects receives a higher score, and this is subtracted from the total score.
- **Public health and safety.** This parameter is evaluated based on presence of residential or recreational infrastructure, and is expressed as low, medium, or high potential for effects on public health and safety. Higher potential for effects on public health and safety receive a higher score, and this is subtracted from the total score. This parameter includes the potential for a project to cause liability concerns.
- **Potential for multiple resource benefits.** This parameter is evaluated based on whether a project addresses more than one injury category, an evaluation of aquatic complexity (number and connectedness of channels), and potential for recreational/terrestrial habitat resource benefits (parcels identified for potential acquisition to address terrestrial habitat). It is expressed as low, medium, or high potential to achieve multiple resource benefits.

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Table 1. Yellowstone Inventory and Ranking: Prioritization framework for meeting project goals and objectives.

Prioritization parameter	Supporting data	Ranking metrics	+/-	Weight	Scoring thresholds
Damage Category: Large woody debris piles					
Inherent River Function and Process Parameters					
Short-term wood recruitment	Erosion polygons developed by comparing 2001 and 2015 bank lines	Acres erosion per year	+	1	<u>Area likely to be eroded in the short-term:</u> 1 = Migration rate < 0.3 acres per year 2 = Migration rate 0.3 to 1.1 acres per year 3 = Migration rate > 1.1 acres per year
Long-term wood recruitment	Forested and shrub polygons mapped by Montana Natural Heritage Program and the National Wetland Inventory with accretion areas between 2001 and 2015	Total acres supporting woody vegetation and potential for woody vegetation	+	0.75	<u>Area supporting woody vegetation</u> 1 = Area < 71.1 acres 2 = Area 71.1 to 170.1 acres 3 = Area > 170.1 acres
Short-term expansion of riparian forest	Accretion polygons developed by comparing 2001 and 2015 bank lines	Acres accretion per year	+	0.75	<u>New riparian forest likely to be added in the short-term:</u> 1 = Accretion rate < 0.4 acre per year 2 = Accretion rate 0.4 to 2.4 acres per year 3 = Accretion rate > 2.4 acres per year
Bank length (shoreline)	2015 bank lines from NAIP imagery, and project area	Feet/acre	+	0.5	<u>Bank length per area:</u> 1 = Bank length < 73.2 ft/acre 2 = Bank length 73.2 to 129.1 ft/acre 3 = Bank length > 129.1 ft/acre
Lateral connectivity	Historic migration zone (HMZ), restricted historic migration zone, and 2001 channel from channel migration zone	Percent of project area within historic migration zone	+	0.5	<u>Percent of project area within HMZ:</u> 1 = < 60% 2 = 60 to 90% 3 = > 90%
Natural recovery potential	Short-term wood recruitment score	High/medium/low	+	0.25	<u>Likelihood of short-term natural recovery potential equivalent to short-term wood recruitment score:</u> 1 = 1 2 = 2 3 = 3
Limiting Factors (Restoration Opportunities)					
Armor present	2015 physical feature data that includes several types of bank armor compared to total 2015 bank length	Percent of bank length with armor	+	1	<u>Percent of bank with armor:</u> 1 = <1% 2 = 1 to 10% 3 = >10%
Russian olive present	2011 Russian olive mapping square feet	Square feet of Russian olive in project area	+	0.25	<u>Total square feet of Russian olive:</u> 1 = < 1453 2 = 1,453 to 9,074 3 = > 9074
Agricultural land present	Agricultural land without mixed use polygons from 2011 land use mapping compared to project area	Percent of land area in agriculture	+	0.25	<u>Percent of total land area in agricultural land use:</u> 1 = < 5% 2 = 5 to 10% 3 = > 10%

Prioritization parameter	Supporting data	Ranking metrics	+/-	Weight	Scoring thresholds
Other Parameters					
Proximity to injury	River miles	Distance in miles	+	0.75	Distance to Laurel (RM 385), closer is better: 1 = > 31.7 miles from RM 385 2 = 13.3 to 31.7 miles from RM 385 3 = < 31.7 miles from RM 385
Ownership	Cadastral and conservation easement layer from the Montana State Library and project area	Percent of land in public ownership or conservation easement	+	1	Percent in public or conservation ownership: 1= < 26.5% 2= 26.5 to 61.3% 3= > 61.3%
Likelihood of success	Inherent river function score and limiting factor score	Inherent river function to limiting factor ratio	+	0.25	Likelihood of success based on ratio of inherent river function score to limiting factor score: 1 = < 3.3 2 = 3.3 to 4.5 3 = > 4.5
Cost	Estimates of land costs, easement costs, management costs	Implementation, long-term maintenance and monitoring	-	0.25	Estimated cost per acre based on acquisition, easement costs, future management: 1 = <\$2,742 2 = \$2,742 to \$3,637 3 = >\$3,637
Cost effectiveness	Cadastral and conservation easement layer from the Montana State Library and project area	Ratio of total score to cost, to achieve greatest and longest-lasting benefit	+	0.5	Benefit to cost based on ratio of total score to cost multiplied by 1,000: 1 = < 3.1 2 = 3.1 to 4.8 3 = > 4.8
Risk of adverse effects	2015 physical feature data (lines and points), channel plugs, and aerial imagery	High/medium/low	-	0.25	Proximity and number of infrastructure features based on reviewing physical features and 2015 aerial imagery, more infrastructure is a higher score: 1 = No infrastructure 2 = 1 infrastructure item identified 3 = 2 or more infrastructure items identified
Public health and safety	2015 aerial imagery, fishing access points from FWP, and cadastral from the Montana State Library	High/medium/low	-	0.25	Proximity and number of residential or recreational infrastructure features based reviewing physical features and 2015 aerial imagery, more infrastructure is a higher score: 1 = No public access or residences 2 = 1 public access point or residence 3 = 2 or more public access points or residences
Potential for multiple resource benefits	Cadastral from the Montana State Library and project rank percentile	High/medium/low	+	1	Amount of additional potential multiple resource benefits: 0 = No apparent additional resource benefits 1 = Few additional resource benefits 2 = Some additional resource benefits 3 = High additional resource benefits

Prioritization parameter	Supporting data	Ranking metrics	+/-	Weight	Scoring thresholds
Damage Category: Riverine aquatic habitat and supported biota					
Inherent River Function and Process Parameters					
Off channel aquatic habitat length	Side channel developed from 2015 NAIP aerial imagery	Length in feet	+	1	Side channel, backwater feature and oxbow total length in project area: 1 = < 6,251 ft 2 = 6,251 to 10,256 ft 3 = > 10,256 ft
Perennial surface water present in side channel	Interpretation of 2015 NAIP aerial imagery to identify areas in off channel aquatic habitat with surface water	Percent of side channel with visible surface water	+	1	Side channel surface water percentage: 1 = < 82% 2 = 82-88% 3 = >88%
Vertical Connectivity	2-year inundation and project area	Proportion of area within the project area	+	0.75	Proportion of project area inundated at 2 year return flow elevation: 1 = < 25% 2 = 25-39% 3 = > 39%
Lateral Connectivity	Historic migration zone, restricted historic migration zone, and 2001 channel from channel migration zone	Percent of project area within historic migration zone	+	0.5	Percent of project area within HMZ: 1 = < 58% 2 = 58 to 93% 3 = > 93%
Natural cover	All areas mapped by the Montana Natural Heritage Program and the National Wetland Inventory except riverine and lacustrine. Includes accreted areas, excludes eroded areas	Percent of project area with natural cover. Captures land use and quality of habitat relative to project area	+	0.5	Relative percent of natural cover: 1 = < 68% 2 = 68 to 76% 3 = > 76%
Natural recovery potential	Side channel blockage and lateral connectivity score	High/medium/low	+	0.25	Likelihood of natural recovery potential based on side channel blockage and lateral connectivity: 1 = Side channel blockage score = 3 and lateral connectivity score = 1 2 = Not a score of 1 or 3 3 = Side channel blockage score = 1 and lateral connectivity score >1
Limiting Factors (Restoration Opportunities)					
Side channel blockage	Length of side channel blockage measured in GIS	Length of disconnecting features	+	1	Length of disconnecting feature: 1 = <174 ft 2= 174-351 ft 3= >351 ft
Armor present	2015 physical feature data includes several types of bank armor, relative to total 2015 bank length	Percent of bank length with armor	+	0.5	Percent of bank with armor: 1 =<1% 2 = 1-10% 3 = >10%
Russian olive present	2011 Russian olive mapping compared to project area	Square feet of Russian olive in project area	+	0.25	Total square feet of Russian olive: 1 = < 1,453 2 = 1,453 to 9,074 3 = > 9,074

Prioritization parameter	Supporting data	Ranking metrics	+/-	Weight	Scoring thresholds
Agricultural land present	Agricultural land without mixed use polygons from 2011 land use mapping compared to the area within 100ft buffer around side channel	Land area in agriculture	+	0.25	Percent of land within a 100ft of the side channel in agricultural land use: 1 = < 5% 2 = 5 to 10% 3 = < 10%
Other Parameters					
Proximity to injury	River miles	Distance in miles	+	0.75	Distance to Laurel (RM 385), closer is better: 1 = > 31.7 miles from RM 385 2 = 13.3 to 31.7 miles from RM 385 3 = < 31.7 miles from RM 385
Ownership	Cadastral and conservation easement layer from the Montana State Library and project area	Percent of land in public ownership or conservation easement	+	1	Percent in public or conservation ownership: 1= < 26.4% 2= 26.4 to 62.3% 3=> 62.3%
Likelihood of success	Inherent river function score and limiting factor score	Inherent river function to limiting factor ratio	+	0.25	Likelihood of success based on ratio of inherent river function score to limiting factor score: 1 = Low 2 = Medium 3 = High
Cost	Estimates of land costs, easement costs, management costs	Implementation, long-term maintenance and monitoring	-	0.25	Estimated cost per acre based on acquisition, easement costs, future management: 1 = <\$5,000 2 = \$5,000 to \$15,000 3 = >\$15,000
Cost effectiveness	Cadastral and conservation easement layer from the Montana State Library and project area	Ratio of total score to cost, to achieve greatest and longest-lasting benefit	+	0.5	Ratio of cost to total score * 1,000: 1 = < 0.71 2 = 0.71 to 3.6 3 = > 3.6
Risk of adverse effects	2015 physical feature data (lines and points), channel plugs, and aerial imagery	High/medium/low	-	0.25	Proximity and number of infrastructure features based reviewing physical features and aerial imagery, more infrastructure is a higher score: 1 = No infrastructure 2 = 1 infrastructure item identified 3 = 2 or more infrastructure items identified
Public health and safety	Risk of adverse effects score	High/medium/low	-	0.25	Proximity and number of residential or recreational infrastructure features based reviewing physical features and aerial imagery, more infrastructure is a higher score: 1 = No infrastructure 2 = 1 infrastructure item identified 3 = 2 or more infrastructure items identified
Potential for multiple resource benefits	Cadastral from the Montana State Library and project rank percentile	High/medium/low/none	+	1	Amount of additional potential multiple resource benefit: 0 = No apparent additional resource benefits 1 = Few additional resource benefits 2 = Some additional resource benefits 3 = High additional resource benefits

Methods and Data Sources

This section describes data used to evaluate prioritization parameters and how the data were analyzed to arrive at a value for parameters where they can be quantified. Results of analyses were used to assign a score of high, medium or low. The remaining parameters were assessed qualitatively by the consultant team using available GIS data, data from previously published documents such as the CEA, internal knowledge, and professional expertise.

For all quantitative data, base GIS layers were prepared that spanned the entire reach addressed by this inventory and ranking project. These layers were then *intersected* with the project area layer to isolate the GIS data to the project area extents. Attribute data from all parameters were then exported and organized by project polygon to produce parameter values for a project area (such as percent of armored banks). Results were entered into a ranking spreadsheet, and data for each parameter were used to identify 33 and 66 percentile breaks. These percentile breaks resulted in empirically generated thresholds to support low, medium, and high assignments for each quantifiable parameter. For bank armor and agricultural land in both injury categories, and cost in the riverine aquatic habitat category, percentiles were generated manually using professional knowledge of the parameter because the data distributions were strongly skewed and did not produce discrete thresholds using percentile breaks (ie. two or more bins reported essentially the same percent). Project ranks were generated by summing the inherent river function values, subtracting the limiting factor values, and adding or subtracting the other parameter values according to Table 1.

Data are discussed below by injury category and prioritization parameter group with a brief description of the data source, what the data represents, and how the data were used. Words in italics are specific tools in ArcGIS software used to combine or analyze data.

Large Woody Debris Piles Injury Category Parameters

Inherent river function and process parameters:

- **Short-term wood recruitment.** Banklines, including islands, were digitized using 2015 NAIP imagery by the consultant team as polygons. The 2001 banklines produced for the CEA were then *unioned* with the 2015 banklines. This created a layer with four categories, areas accreted since 2001, areas eroded since 2001, areas that remained land since 2001, and areas that remained channel since 2001. Short-term wood recruitment was determined by dividing the total acres of eroded area in a project area by 14, the number of years between 2001 and 2015.
- **Long-term wood recruitment.** Woody vegetation polygons from the Montana Natural Heritage Program's wetland and riparian mapping were exported as a stand-alone layer. Woody vegetation polygons were identified by the "NWI" attribute and included Rp1SS, Rp2SS, PSS and Rp1Fo and Rp2FO. Accreted areas from the accretion and erosion layer (created by *unioning* 2015 and 2001 banklines) were then added resulting in a layer that represented all areas within a project area with the potential to support wood recruitment.
- **Short-term expansion of riparian forest.** Banklines, including islands, were digitized using 2015 NAIP imagery as polygons. The 2001 banklines produced for the CEA were then *intersected* with the 2015 banklines. This created a layer with four categories: areas that accreted since 2001, areas that eroded since 2001, areas that remained land since 2001, and areas that remained channel since 2001. Short-term expansion of riparian forest was determined by dividing the total acres of accreted area in a project area by 14, the number of years between 2001 and 2015.

- **Bank length (shoreline).** Banklines, including islands, were digitized using 2015 NAIP imagery by the consultant team as polygons. The total linear feet of bank within a project area was summed.
- **Lateral connectivity.** The historic migration zone (HMZ), restricted HMZ, and 2001 channel polygons were exported as a stand-alone layer from the channel migration zone layer produced for the CEA. This area was then compared to the project area to determine the percent of the project area within the HMZ.
- **Natural recovery potential.** This parameter requires no GIS analysis and is expressed as low, medium, or high potential for natural recovery that is correlated with short-term wood recruitment.

Limiting factors:

- **Armor present.** Bank armor lines produced for the CEA in 2011 were updated by the consultant team based on 2015 NAIP aerial imagery. The bank armor was compared to the 2015 bank lines to determine the percent of armored bank.
- **Russian olive present.** Russian olive polygons (2008) generated by the Natural Resources Conservation Service (NRCS) were summed by square feet.
- **Agricultural land present.** Agricultural land was exported as a stand-alone layer from the 2011 land use layer produced for the CEA. Agricultural land was defined by the “LU2” attribute populated with agricultural land and the “LU4” attribute populated with pivot, sprinkler, flood and hayland/pasture. This area was compared to the total project area to determine the percent of the project area with agricultural land.

Other parameters:

- **Proximity to injury.** This parameter is evaluated based on proximity of the project to the origin of injury in river miles.
- **Ownership.** Cadastral and easement layers from the State Library were *unioned*. An attribute was then added to identify whether a polygon was private, public or an easement. The total acres of public and easement land were then compared to the project area to determine the percent of the project area with public land.
- **Likelihood of success.** This parameter is calculated by dividing the inherent river function score by the limiting factor score.
- **Cost.** This parameter is evaluated based on average costs of implementation, long-term maintenance and monitoring.
- **Cost effectiveness.** This parameter is evaluated by dividing the total project score by the estimated project cost and multiplying by 1,000 so results are in an intuitive range.
- **Risk of adverse effects.** This parameter is evaluated by counting the number of infrastructure features in the vicinity of a project.
- **Public health and safety.** This parameter is evaluated by counting the number of residential or recreational infrastructure features in the vicinity of a project.
- **Potential for multiple resource benefits.** This parameter is evaluated based on whether a project addresses more than one injury category, an evaluation of aquatic complexity (number and connectedness of channels), and potential for recreational/terrestrial habitat resource benefits (parcels identified for potential acquisition to address terrestrial habitat). It is expressed as low, medium, or high potential to achieve multiple resource benefits.

Riverine Aquatic Habitat and Supported Biota Injury Category Parameters

Inherent river function and process parameters:

- **Off channel aquatic habitat length.** Side channels, backwater features, and oxbows were digitized using 2015 NAIP imagery by the consultant team. The total linear feet of side channel were summed.
- **Perennial surface water in off-channel aquatic habitat features.** Using side channels digitized by the consultant team, a new line layer representing linear feet with visible surface water was created and compared to the total side channel length to determine the percent of the side channel that has perennial surface water.
- **Vertical connectivity.** Two-year inundation depth rasters were produced for the CEA from hydraulic models. These rasters were converted to GIS layers and acres of inundation were compared to the project area to determine the percent of the project area that is connected at the 2-year flow.
- **Lateral connectivity.** The historic migration zone (HMZ), restricted HMZ, and 2001 channel polygons were exported as a stand-alone layer from the channel migration zone layer produced for the CEA. This area was then compared to the project area to determine the percent of the project area within the HMZ.
- **Natural cover.** All polygons excluding lacustrine and riverine polygons from the Montana Natural Heritage Program's wetland and riparian mapping were exported as a stand-alone layer. Riverine and lacustrine polygons were identified by the attribute "wetland type" populated by riverine or lacustrine. Accreted areas were added representing surfaces that could recruit natural vegetation. Eroded areas were *clipped* out. Accreted and eroded areas were determined by *unioning* 2001 and 2015 bank lines. This area was then compared to the project area to determine the percent of the project area with natural cover.
- **Natural recovery potential.** This parameter has no GIS analysis and is expressed as low, medium, or high potential for natural recovery that is correlated with short-term wood recruitment.

Limiting factors:

- **Side channel blockages present.** Using 2015 NAIP aerial imagery, the distance between the main channel and the beginning of a blocked side channel was measured representing the length of blockage.
- **Armor present.** Bank armor lines produced for the CEA in 2011 were updated by the consultant team based on 2015 NAIP aerial imagery. The bank armor was compared to the 2015 bank lines to determine the percent of armored bank.
- **Russian olive present.** Russian olive polygons (2008) generated by the Natural Resources Conservation Service (NRCS) were summed by square feet.
- **Agricultural land present.** Agricultural land was exported as a stand-alone layer from the 2011 land use layer produced for the CEA. Agricultural land was defined by the "LU2" attribute populated with agricultural land and the "LU4" attribute populated with pivot, sprinkler, flood and hayland/pasture. This area was compared to the total area within a 100ft buffer of the side channel to determine the percent of the project area with agricultural land.

Other parameters:

- **Proximity to injury.** This parameter is evaluated based on proximity of the project to the origin of injury in river miles.
- **Ownership.** Cadastral and easement layers from the State Library were *unioned*. An attribute was then added to identify whether a polygon was private, public or an easement. The total

acres of public and easement land were then compared to the project area to determine the percent of the project area with public land.

- **Likelihood of success.** This parameter is calculated by dividing the inherent river function score by the limiting factor score.
- **Cost.** This parameter is evaluated based on average costs of implementation, long-term maintenance and monitoring.
- **Cost effectiveness.** This parameter is evaluated by dividing the total project score by the estimated project cost and multiplying by 1,000 so results are in an intuitive range.
- **Risk of adverse effects.** This parameter is evaluated by counting the number of infrastructure features in the vicinity of a project.
- **Public health and safety.** This parameter is evaluated by counting the number of residential or recreational infrastructure features in the vicinity of a project.
- **Potential for multiple resource benefits.** This parameter is evaluated based on whether a project addresses more than one injury category, an evaluation of aquatic complexity (number and connectedness of channels), and potential for recreational/terrestrial habitat resource benefits (parcels identified for potential acquisition to address terrestrial habitat). It is expressed as low, medium, or high potential to achieve multiple resource benefits.

Results

Results of the inventory and ranking are presented in this section, organized by injury category in order of river mile (RM), beginning at the downstream end near Custer, Montana and extending up river to approximately Reed Point, Montana. Figure 3 and Figure 4 shows the geographic extent of this inventory and ranking effort, and the distribution of projects along the Yellowstone River. For each project, a narrative description is provided, in addition to a figure showing its location along with important spatial data used to determine its ranking. While project ranks and parameter scores are reported in Appendix A, the exact rank of a project is less meaningful than whether it is ranked near the top, in the middle, or near the bottom, in terms of selecting projects to pursue and fund. Therefore, projects within each injury category are grouped into three tiers: upper, middle and lower.

The upper tier represents projects that clearly stand out as providing the greatest benefit relative to restoration plan goals and objectives, and these projects should be pursued first given available funding. The middle tier represents projects with clear but more modest benefits relative to restoration plan goals and objectives, and these projects should be pursued if top tier projects prove not to be feasible. The lower tier represents projects that would support some restoration plan goals and objectives, and these could be pursued if additional funding becomes available. Some middle or lower tier projects may also be pursued if the project receives funding related to another injury category (e.g., terrestrial/recreational use), or there is an appropriate funding match from an outside source. Among the 24 large woody debris projects, those ranked between 1 and 6 are in the top tier, 7 to 16 are in the middle tier, and 17 to 24 are in the lower tier (Figure 1). Among the 16 riverine habitat projects, those ranked between 1 and 4 are in the top tier, 5 to 10 are in the middle tier, and 11 to 16 are in the lower tier (Figure 2).

For each project, a brief narrative describes its location along the river, position relative to river features, ownership patterns, and other information to provide context that can help interpret its scores relative to prioritization parameters. In some cases, the channel migration zone (CMZ) is referenced to describe broader river patterns. The CMZ refers to the area where the channel has migrated in the past

(the historic migration zone, [HMZ]), as well as areas at risk of future erosion and avulsion based on a geomorphic analysis incorporating reach scale river characteristics. Following the narrative, bullets summarize results for overall ranking, inherent river function, limiting factors, and other parameters that contribute to a project's scoring and ranking.

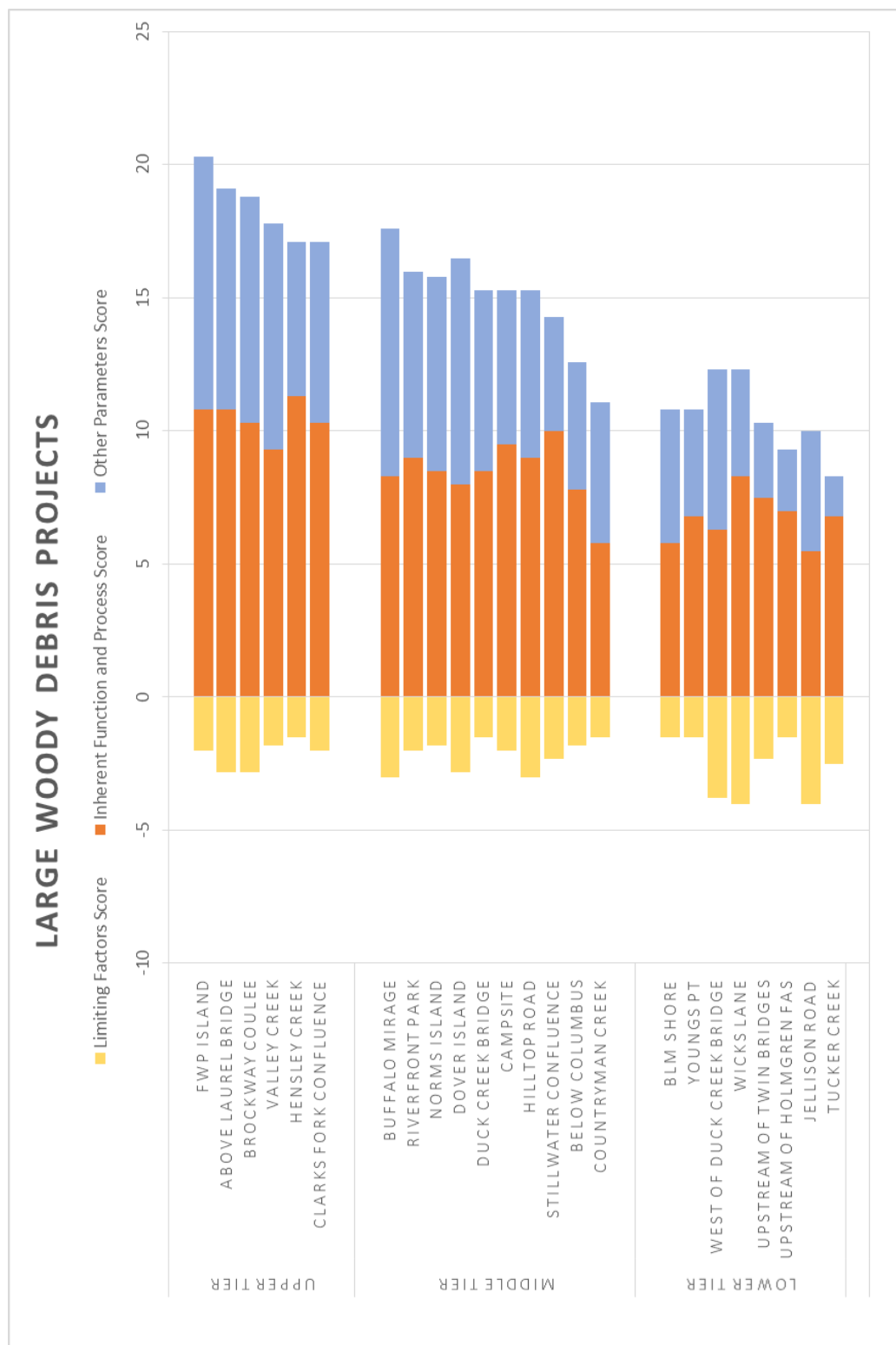


Figure 1. Upper, middle and lower tier projects addressing the large woody debris piles injury category. Bars represent relative contribution of limiting factors (-), inherent river function (+) and other parameters (+) to a project's score. See Appendix A for project and parameter scoring details.

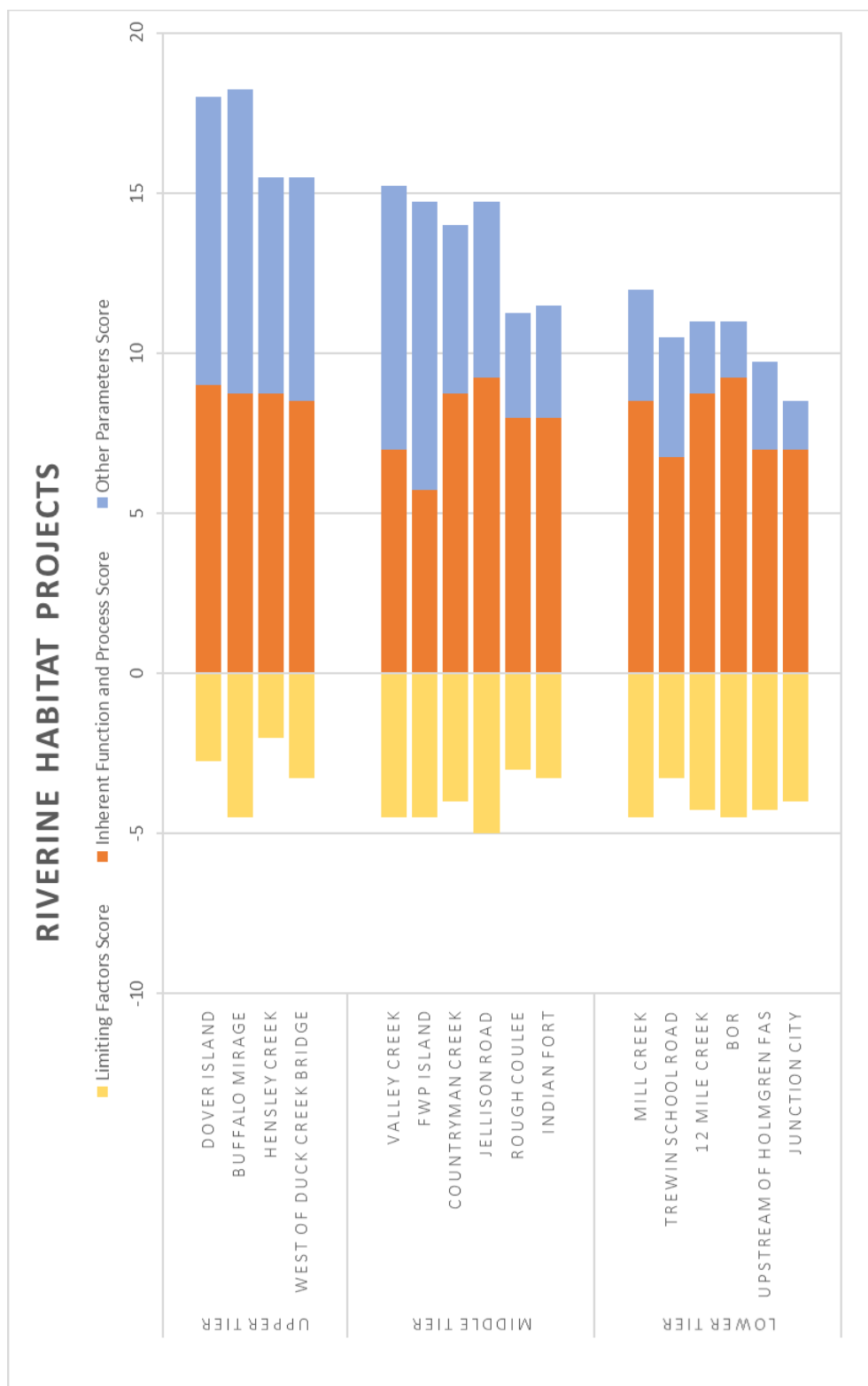


Figure 2. Upper, middle and lower tier projects addressing the riverine habitat injury category. Bars represent relative contribution of limiting factors (-), inherent river function (+) and other parameters (+) to a project's score. See Appendix A for project and parameter scoring details.

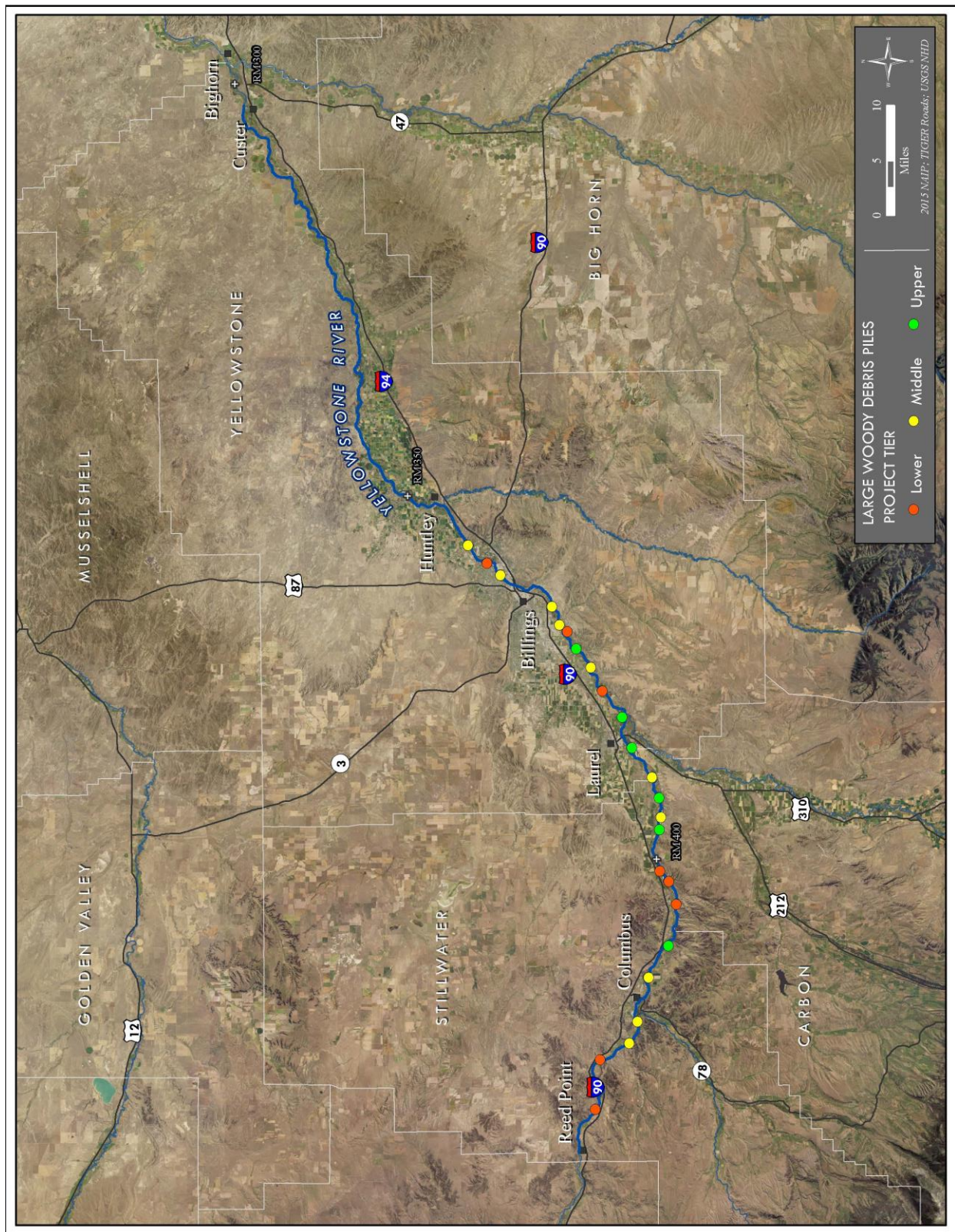


Figure 3. Distribution of Large Woody Debris Pile projects along the Yellowstone River color coded by tier.

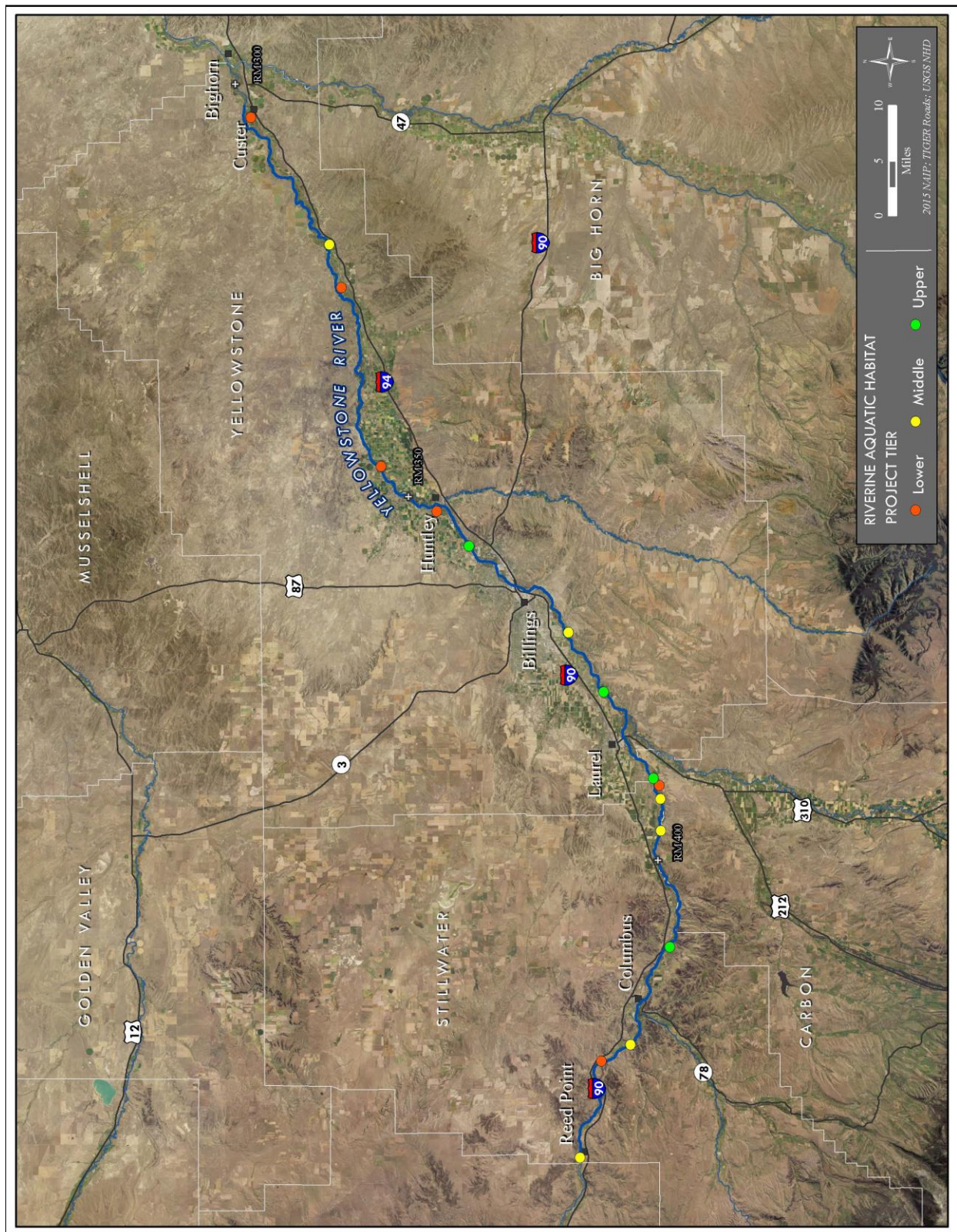


Figure 4. Distribution of Riverine Aquatic Habitat and Supported Biota projects along the Yellowstone River color coded by tier.

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Large Woody Debris Projects

DOVER ISLAND

PROJECT TYPE	TIER
Large woody debris potential	middle

Project Summary

Dover Island is located at RM 359, downstream of Billings, on the Yellowstone River left bank. It is 26 miles downriver of the oil spill origin. The project consists of a series of established riparian bottoms and actively vegetating islands in an area where the CMZ narrows dramatically as the river approaches the Huntley Diversion structure downstream. On the opposite bank the rail line runs along the valley wall against the channel and the bank is heavily armored. The project is located in Reach B3 of the CEA, an approximately 4 mile-long channel segment where over 30% of the total bankline has been armored by rock riprap, flow deflectors, and concrete rubble. The project area is 125.7 acres, and the majority is owned by a single landowner and is under a conservation easement. There are three other landowners who own small percentages of the project area, and there are some areas where ownership is uncertain. There is no infrastructure within close proximity to the *Dover Island* project.

Project Highlights

- This project ranks in the middle tier among all large woody debris projects. While banklength and public ownership are high, most inherent river functions and limiting factors are moderate. Bank armor, while not as high as other projects, covers nine percent of the total bankline.
- The project boundary includes parcels of two interested land owners and extends beyond the HMZ on the upstream end to include dense riparian forest protected by bank armor under the premise that the bank armor could be removed. The boundary excludes agricultural land within a conservation easement because this land does not provide either a potential large woody debris source or riverine habitat. The boundary also includes two islands protected by a conservation easement or of unknown ownership with long-term wood recruitment potential.
- Erosion and accretion are moderate (0.4 and 2.4 acres per year respectively), indicating this is a less dynamic project than other, higher ranking projects, and 97.3 acres of woody vegetation are present. Over 50 acres of the surfaces supporting woody vegetation were established before 1950. Most (86%) of the project area is within the HMZ and the project has a high bank length score because it includes islands.
- 1,926 feet of bank armor/dikes are present, and most of this consists of a partially armored floodplain dike on the upstream portion of the project. This dike isolates about 17 acres of the CMZ in the project area, most of which is mature woody vegetation. No agricultural land is present within the project area and Russian olive is present.
- The project includes 94% public or conservation land, has some aquatic complexity in the form of multiple active channels, and has high potential for multiple resource benefits in terms of terrestrial habitat and recreation. The project is also evaluated as a riverine habitat project.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.4	2.4	97.3	86	9

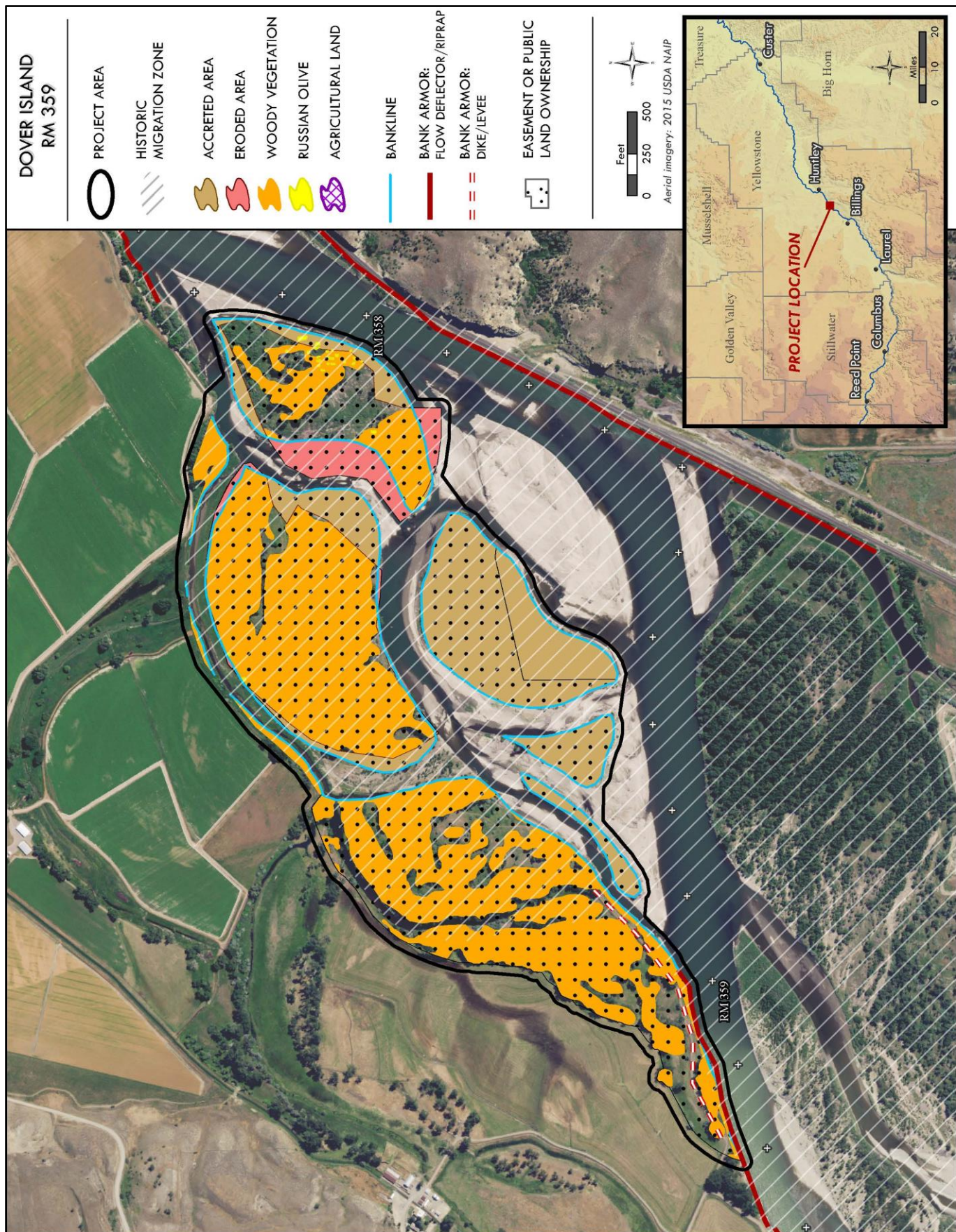


Figure 5. Dover Island RM 359, large woody debris project.

PROJECT TYPE	TIER
Large woody debris potential	lower

Project Summary

Wicks Lane is located at RM 361, in Billings, on the left bank of the Yellowstone River. It is 24 miles downriver of the oil spill origin. The site is located immediately downstream of a pinch point in the CMZ, where a high bluff line on the north bank and industrial development on the south bank restrict the river corridor width to less than five hundred feet. In contrast, the corridor is several thousand feet wide at the project. The upstream opposite bank is well armored by both rock riprap and flow deflectors, protecting oil refinery infrastructure and lagoons. The project area occupies 192.0 acres. The majority of this area is owned by two landowners, and four other landowners own small portions of the project area. In approximately a quarter of the area, ownership is uncertain. There is no infrastructure within close proximity to the *Wicks Lane* project.

Project Highlights

- This project ranks in the lowest tier among all large woody debris projects. While wood recruitment potential is high, this is offset by abundant bank armor and Russian olive, and few additional resource benefits.
- The project boundary extends beyond the HMZ to include dense riparian forest at the downstream end where the channel is already beginning to migrate. The boundary excludes a small parcel to reduce the number of landowners.
- Erosion is high and accretion is moderate (1.1 and 0.63 acres per year respectively), and 126 acres of woody vegetation are present. Fifty-nine percent of the project area is within the HMZ. Bank length relative to the project area is low because the project is located on only one side of the channel.
- A floodplain dike dissects the project, extending across the floodplain for 2,200 feet at an orientation perpendicular to the river corridor axis. Floodplain channels visible in the 1950s imagery have largely atrophied due to floodplain grading and dike construction. Russian olive is abundant, and no agricultural land is located within the project area.
- The project includes only 27% public or conservation land and several landowners which decreases the benefit to cost ratio. The project has minor aquatic complexity in the form of a few active side channels. The project is not evaluated for riverine habitat.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
1.10	0.63	126.04	59	11

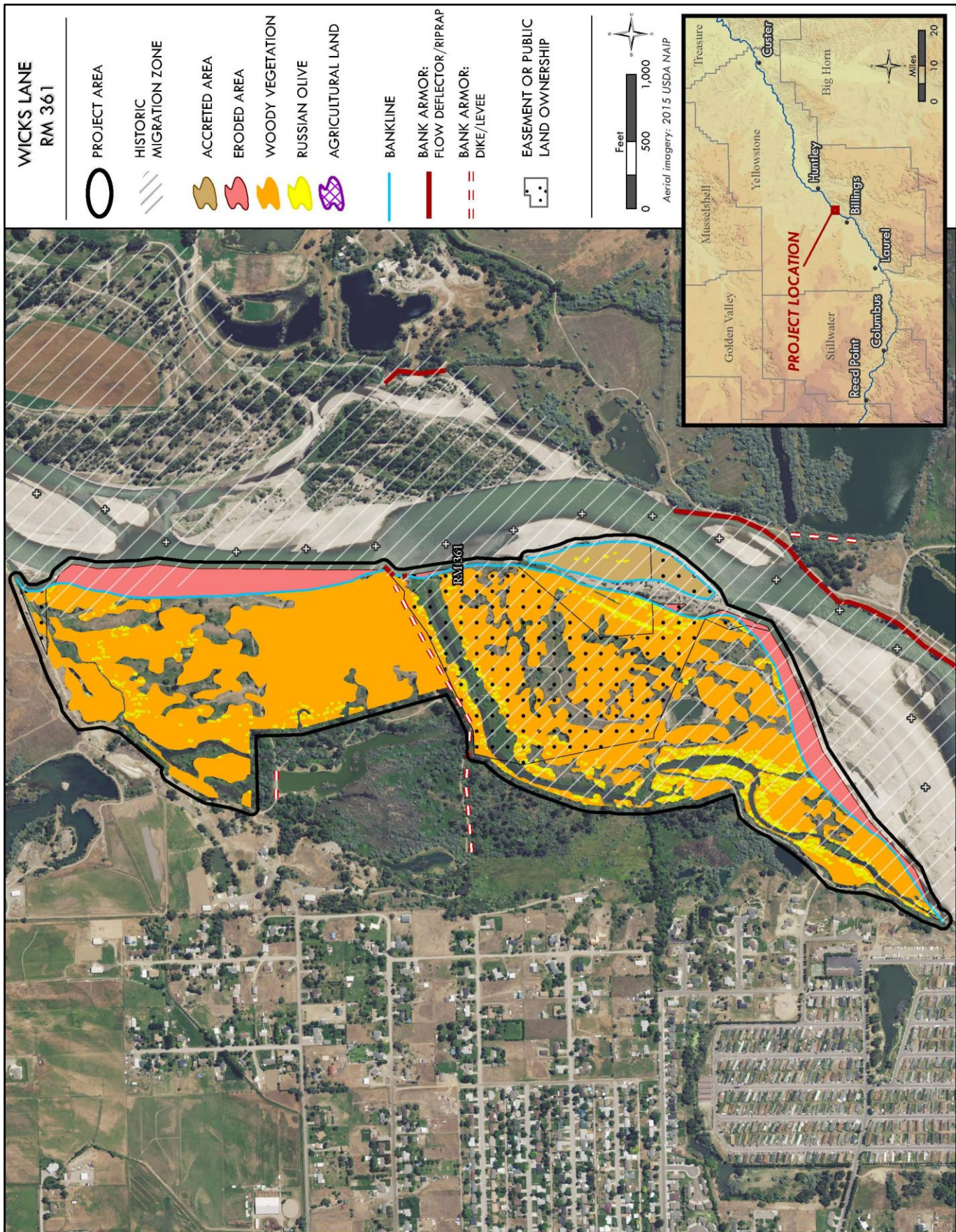


Figure 6. Wicks Lane RM 361, large woody debris project.

HILLTOP ROAD

PROJECT TYPE	TIER
Large woody debris potential	middle

Project Summary

Hilltop Road is located at RM 363 in Billings. It is downstream of the Business 90 bridge and 22 miles downriver of the oil spill origin on the Yellowstone River. The project area is located at a localized expansion of the CMZ between downtown Billings and the Exxon refinery. The project encompasses this expansion, incorporating riparian bottoms on both sides of the river. The project area is 125.7 acres. The majority of the area along the left bank is owned by Yellowstone County and is designated Two Moon Park. Exxon Corporation also owns approximately 30% of the total area across the river along the right bank, and the remainder of the ownership is uncertain. There is no infrastructure within close proximity to the *Hilltop Road* project.

Project Highlights

- This project ranks in the middle tier among all large woody debris projects as a result of slightly (relatively) lower inherent river function scores including very little area within the HMZ, slightly higher limiting factor scores including a high presence of Russian olive, and few additional resource benefits.
- The project boundary follows the *Two Moon Park* boundary on the left bank and crosses the channel to capture an area on the right bank, within the HMZ, that has long-term wood recruitment potential.
- Erosion is high (1.33 acres per year) and there is a large area of woody vegetation (198.2 acres). Only 55% of the project is within the HMZ because the HMZ does not extend into the left bank.
- There are 1,814 feet of bank armor protecting Exxon property and Russian olive is abundant. Public or conservation land makes up 70% of the project area, the project has estimated high benefit to cost compared to other projects, and because the project includes a park with public access, the project has some risk of adverse effects. The project has some aquatic complexity in the form of an active side channel and continuous floodplain swales. Side channel function has decayed in the reach over time due to flow concentrations around Billings and floodplain grading in the project area. The project is not evaluated as a riverine habitat project.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
1.33	2.08	198.62	55	8

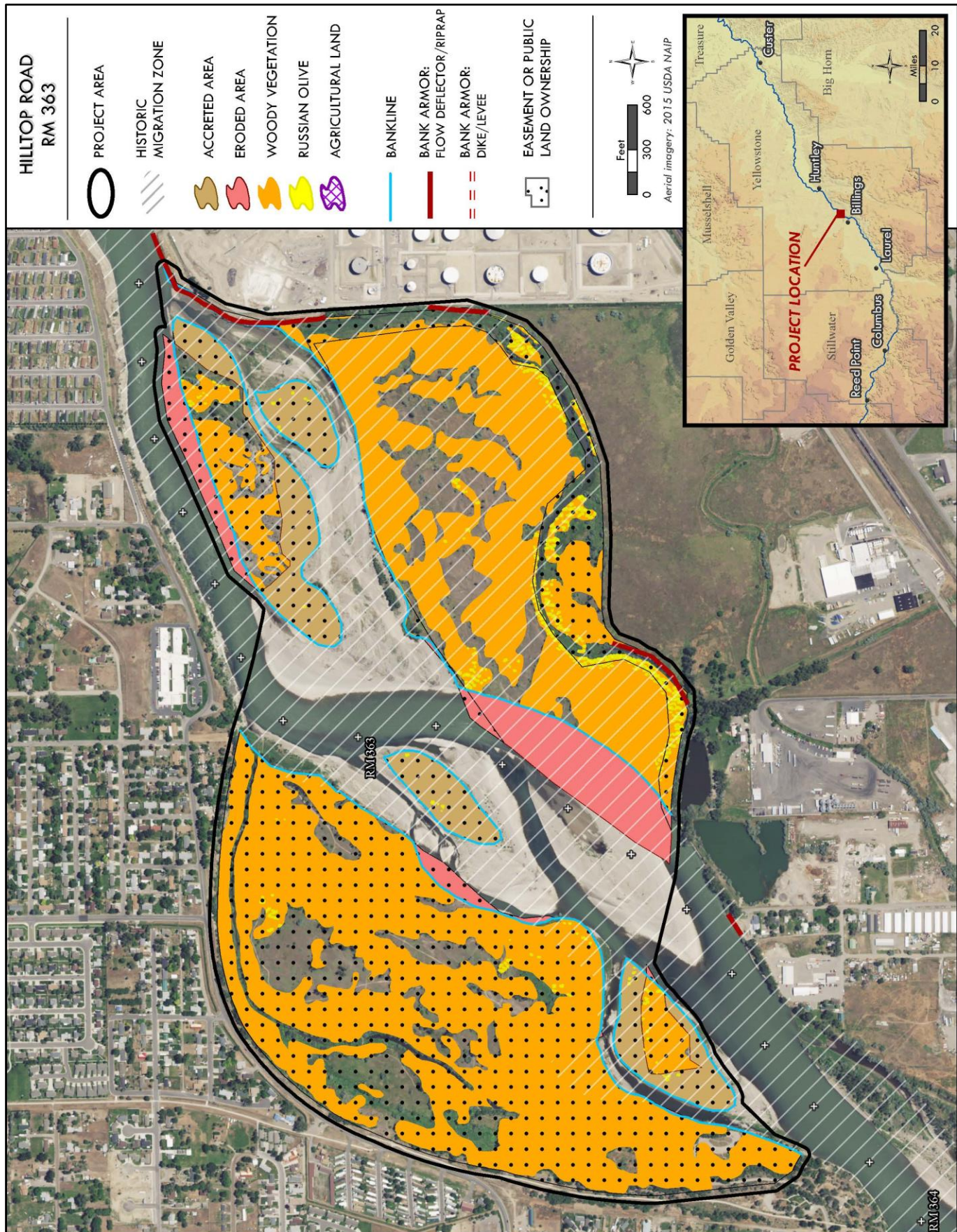


Figure 7. Hilltop Road RM 363, large woody debris project.

RIVERFRONT PARK

PROJECT TYPE	TIER
Large woody debris potential	middle

Project Summary

Riverfront Park is located at RM 370, in Billings. It is 15 miles downriver from the oil spill origin. The project extends downstream from South Billings Blvd for about 2.5 miles. It is mainly located on river left of the Yellowstone River, but it also spans the channel and includes a small section of right bank. The right bank is well armored, mostly with concrete rubble that isolates much of the CMZ on the south side of the river. The project area is 319.0 acres, one of the largest projects, and has six landowners. The majority of this project is public land or uncertain ownership (85%). The City of Billings owns approximately a quarter of the project and 50% is uncertain. The remaining public land is owned by the State of Montana. Private ownership includes smaller parcels on the right bank. Infrastructure includes several irrigation pumps on the right bank, a municipal intake on the left bank, and the South Billings Boulevard bridge directly upstream. The area on left bank (the majority of the project) is a city park and publicly accessible.

Project Highlights

- This project ranks in the middle tier among all large woody debris projects. Erosion is not very high and there is an abundance of Russian olive.
- The project boundary extends into Riverfront Park following the HMZ but excludes infrastructure such as ponds. The boundary extends beyond the HMZ in the center of the project to capture an area of dense riparian forest that is already beginning to erode. The boundary also captures a small portion of the right bank with a long-term wood recruitment potential that lies channel side of bank armor protecting six residences.
- Although erosion is not very high (1.1 acres per year) there are 246.1 acres of woody vegetation and accretion is high (5.0 acres per year). The most rapid erosion is currently occurring at an old bridge crossing at the end of Washington Street, where over seven acres of woody forest has been recruited into the river since 2001. Much of the forest in this area was established prior to the mid-1950s. Only 81% of the project is within the HMZ, not as high as other projects, because the middle section of the project is slightly higher in elevation.
- There is no bank armor present, Russian olive is abundant and no agricultural land is located within the project.
- The project includes a high percentage of public or conservation land (85%), one of the highest of all the projects. This project has a high cost, but an estimated moderate benefit to cost ratio compared to other projects, and because the project includes a park with public access, the project has some risk of adverse effects. The project has some aquatic complexity in the form of several side channels that backwater at the 2-year flow and has potential for multiple resource benefits in terms of terrestrial habitat and recreation. The project is not evaluated for riverine habitat, although it hosts numerous relic side channels that were perennially active in the 1950s.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
1.1	5.0	246.1	81	0

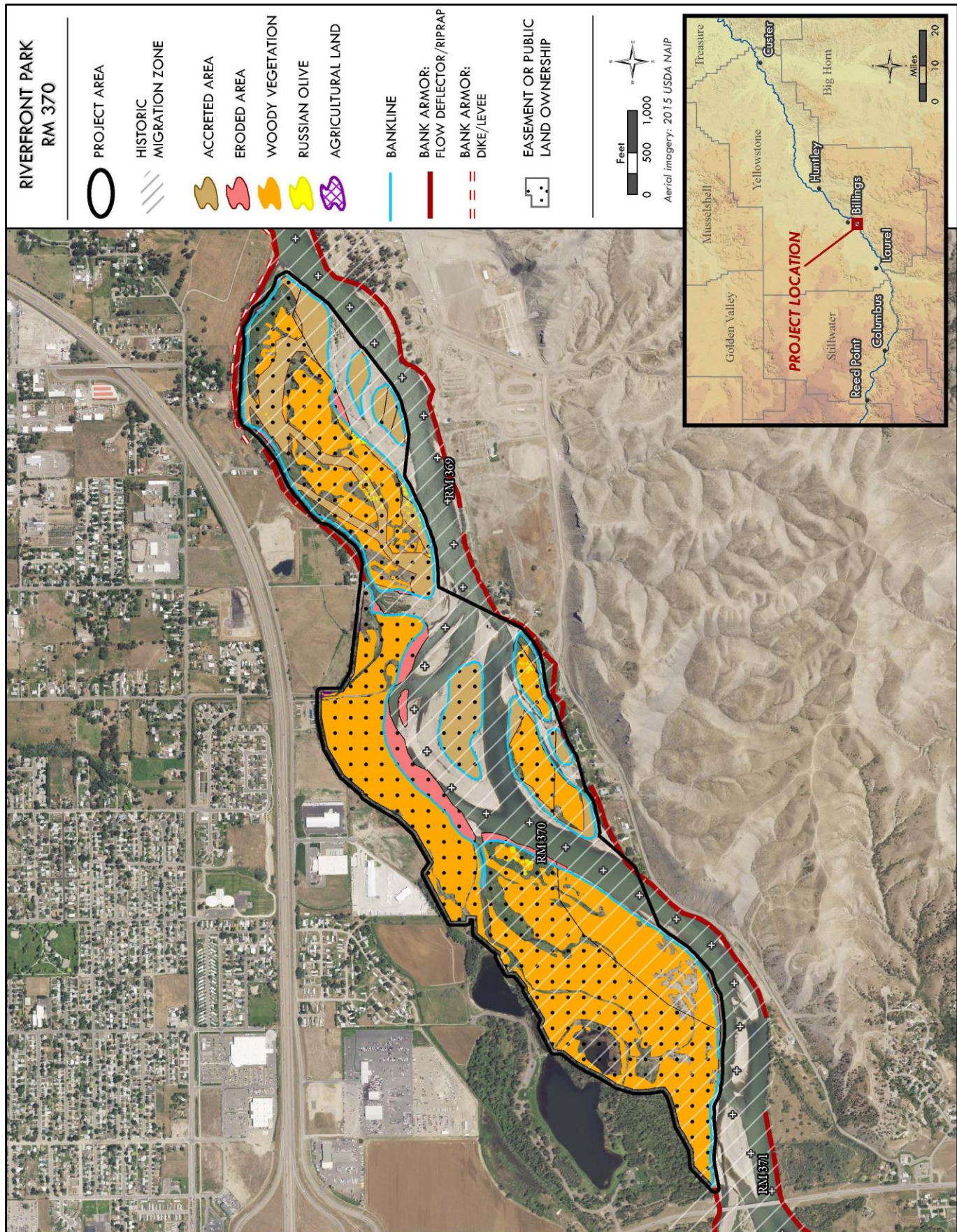


Figure 8. Riverfront Park RM370, large woody debris project.

NORM'S ISLAND

PROJECT TYPE	TIER
Large woody debris potential	middle

Project Summary

Norm's Island is located at RM 371.5, in Billings, on left bank of the Yellowstone River. It is 13.5 miles downriver from the oil spill origin. The project area is 174.0 acres and consists of two islands, one of which is Norm's Island, a City Park. Across the channel from Norm's Island, portions of the right bank are armored with rock riprap and concrete. The majority of this project is owned by Montana Department of State Lands and the City of Billings. Four other landowners are included in the project. The remaining ownership is uncertain. The project is just upstream of the South Billings Boulevard Bridge. There is no other infrastructure in close proximity to the project.

Project Highlights

- This project ranks in the middle tier among all large woody debris projects. Inherent river function score is not very high compared to other projects largely due to a lower accretion rate, while limiting factors include only some Russian olive.
- The project boundary includes parcels of two interested landowners and follows the HMZ to include Norm's Island, and a second island, located upstream, to improve overall stream corridor width in this geomorphically impacted reach. The project extends beyond the HMZ in one location to include an area with long-term wood recruitment potential. The boundary does not include sections of the river with bank armor protecting the bridge downstream and subdivision upstream.
- Erosion is high (1.78 acres per year), though the acres of woody vegetation is not as high as other projects (108.02). Almost the entire project is within the HMZ (97%).
- A lack of bank armor or agricultural land make the limiting factor score very low, although there is some Russian olive.
- The project includes a high percent of public or conservation land (77%) and a high likelihood of success because of the minimal limiting factors. Very little work is required to allow natural river processes to function in this project; however, the cost of the project is relatively high due to the numerous landowners. The project has some risk of adverse effect because the project includes a park with public access. The project has minor aquatic complexity in the form of an active side channel and a few side channels that backwater at the 2-year flow and has potential for multiple resource benefits in terms of terrestrial habitat and recreation. As the site does not contain blocked side channels, it was not evaluated as an aquatic habitat project type. However, it currently supports functional side channel habitat, with one primary active side channel and numerous floodplain swales that were inundated during the 2017 runoff event.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
1.78	0.09	108.02	97	0

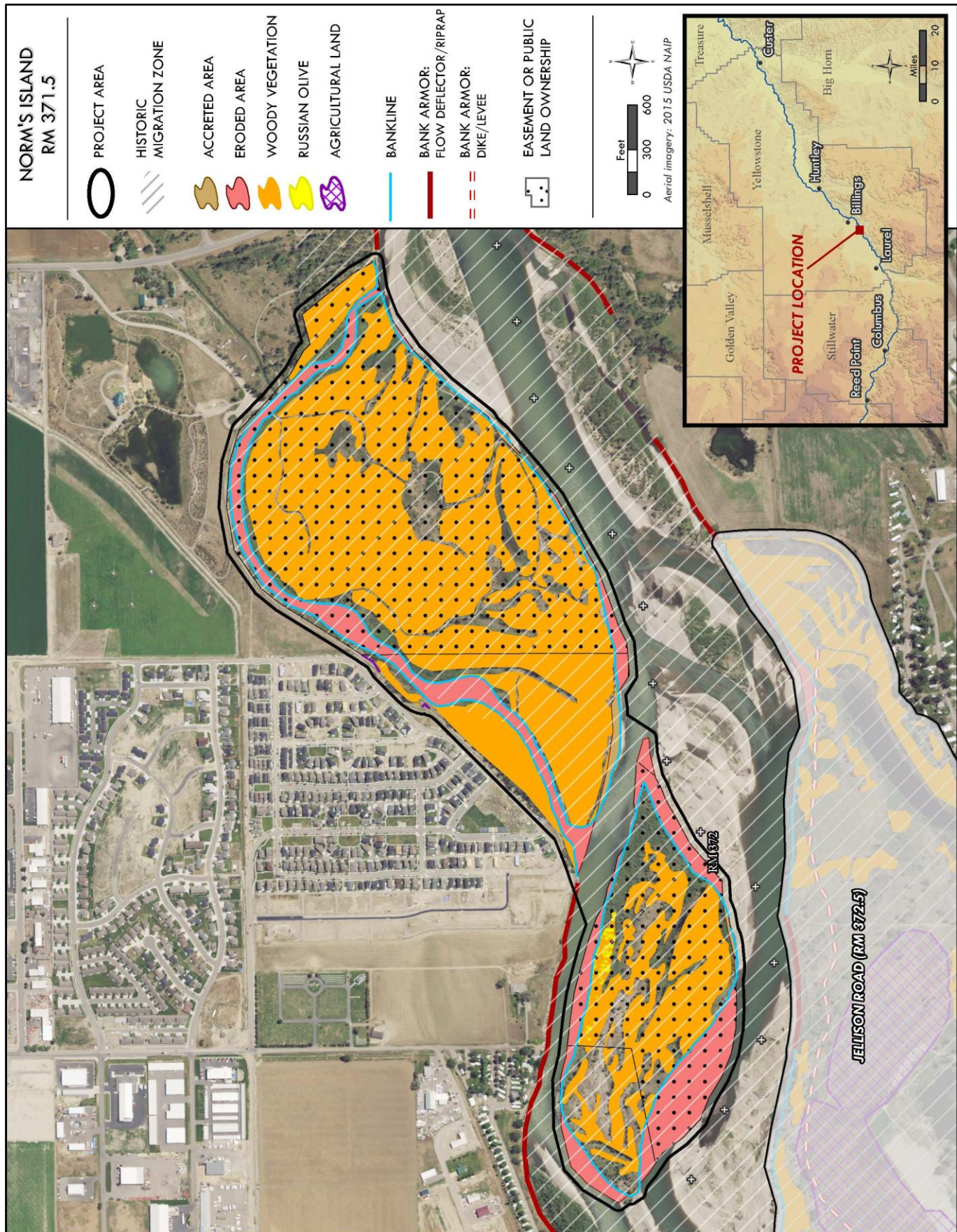


Figure 9. Norm's Island RM371.5, large woody debris project.

PROJECT TYPE	TIER
Large woody debris potential	lower

Project Summary

Jellison Road is located at RM 372.5, in Billings, on the right bank of the Yellowstone River just upstream of the South Billings Boulevard Bridge and near the Billings landfill. It is 12.5 miles downriver from the oil spill origin. The site is about two miles long, and is one of the largest areas of human caused floodplain/channel isolation on the entire river. In the 1950s, the site supported extensive active floodplain, dense woody riparian vegetation, and a major channel thread. The two mile-long dike and armor narrow the river corridor from about 4,000 feet to 1,600 feet, and across the channel, the left bank is armored with riprap precluding northward migration and corridor expansion in that direction. The isolated area has been cleared of woody vegetation and large portions have been mined for sand and gravel. Haul roads cross and block the historic side channel in several places. The project is 377.2 acres, one of the largest projects. The majority of this project is owned by a single landowner. There are four other land owners each owning 5% or less of the project. The remaining ownership is uncertain. A trailer park borders the eastern end of the project.

Project Highlights

- This project ranks in the lowest tier among all large woody debris projects because of very little existing woody vegetation and long lengths of bank armor.
- The project boundary captures a disconnected and disturbed side channel within the HMZ and extends beyond the HMZ following a topographic break.
- Erosion is 0.73 acres per year; however, there is very little woody vegetation (57.44 acres). Aerial imagery from 2015 shows various gravel roads and open water areas that have been excavated. Bank length is also low because the project is located on only one side of the channel.
- There are 11,488 feet of bank armor and floodplain dikes in the project. About 400 feet of concrete armor was flanked on the upper end of the project since 2005, and remnants are visible in the river. The combined length of the armor and dike exceeds the linear feet of actual bank. Agricultural land is present (13.2%), most of which appears to be cleared woody riparian area.
- The project has very little public or conservation land and the estimated benefit to cost ratio is low. The project does not have high inherent river function and would require significant work to remove bank armor and allow natural processes to occur. The project has some risk of adverse effects because of a trailer park bordering the project and a boat ramp on the opposite side of the channel. The project has minor aquatic complexity in the form of backwater areas during the 2-year flow. The project is also evaluated as a riverine habitat project.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.73	0.01	57.44	90	114

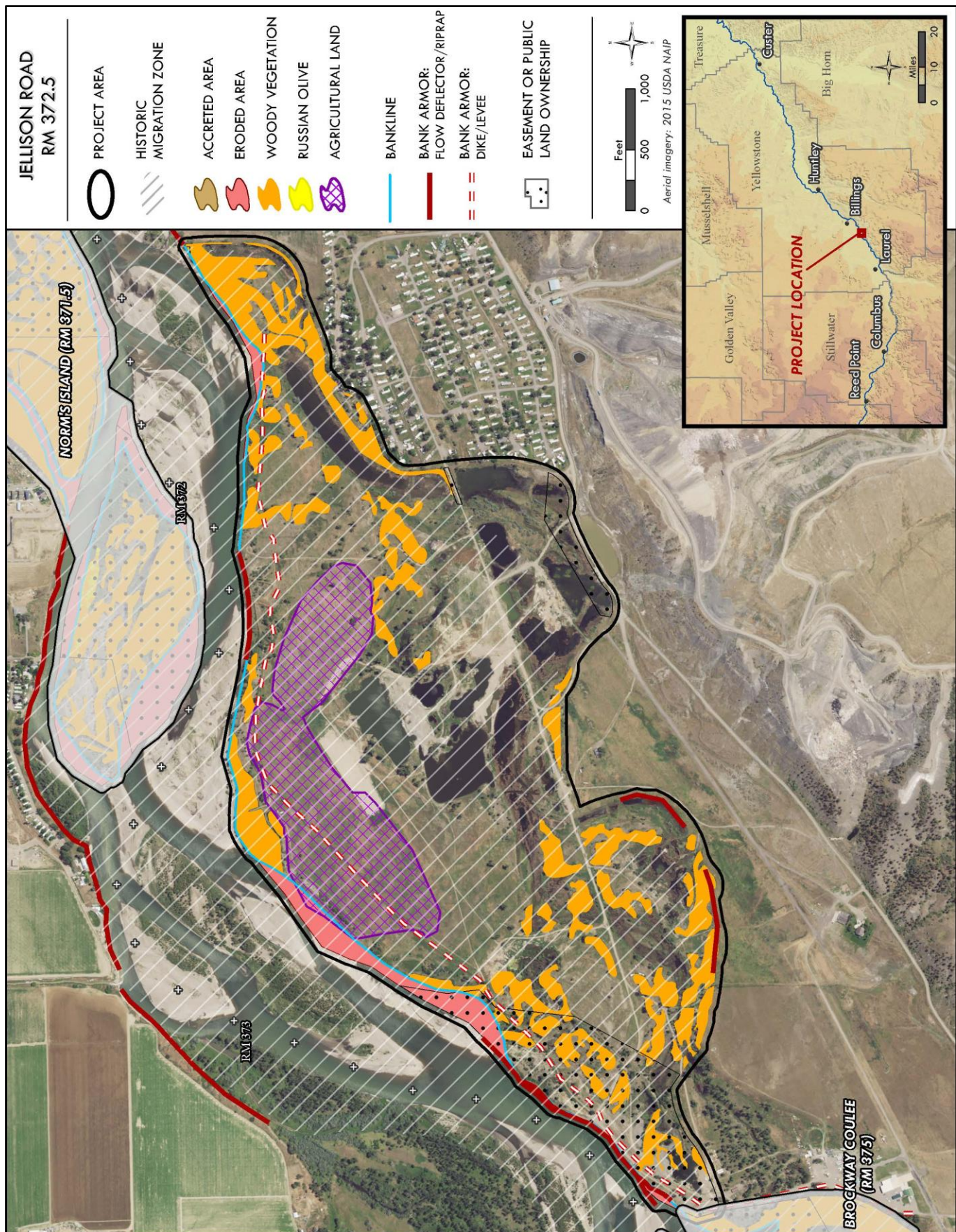


Figure 10. Jellison Road RM 372.5, large woody debris project.

BROCKWAY COULEE

PROJECT TYPE	TIER
Large woody debris potential	upper

Project Summary

Brockway Coulee is located at RM 375, at the mouth of Canyon Creek in Billings. It is 10.0 miles downriver from the oil spill origin on the Yellowstone River. The project encompasses two riparian bottom areas on opposite sides of the river, delineating an active corridor that is approximately 2.5 miles long by 3,500 feet wide. The project area is 491.0 acres, the largest project. The majority of ownership in the project is uncertain. Six other landowners are included in the project. There is no other infrastructure in close proximity to the *Brockway Coulee* project.

Project Highlights

- This project is ranked in the upper tier among all large woody debris projects. Inherent river function parameters are high with only some bank armor and Russian olive. High public ownership and aquatic complexity adds multiple resource benefit.
- The project boundary follows the HMZ and captures a large area of unknown ownership with potential for long-term wood recruitment. The boundary extends beyond the HMZ in one location to include an area of dense riparian forest while excluding a portion of a parcel to reduce the number of landowners.
- This is a dynamic section of the river with high erosion and accretion rates. Only bank length relative to the project size is low mainly because of the large size of the project.
- A floodplain dike isolates about 1,500 feet of historic side channel area on the edge of the project due south of RM 375.0 that could provide additional opportunity. Some Russian olive exists, and there is no agricultural land.
- The project includes a high percent of public or conservation land (68%). Aquatic complexity is high provided by seasonal side channels that are inundated at the 2-year flow and more frequently backwatered on their downstream ends. Although there is one side channel blockage, it is relatively minor so that the project has not been evaluated as an aquatic habitat project type.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
1.32	9.79	386.94	97	5

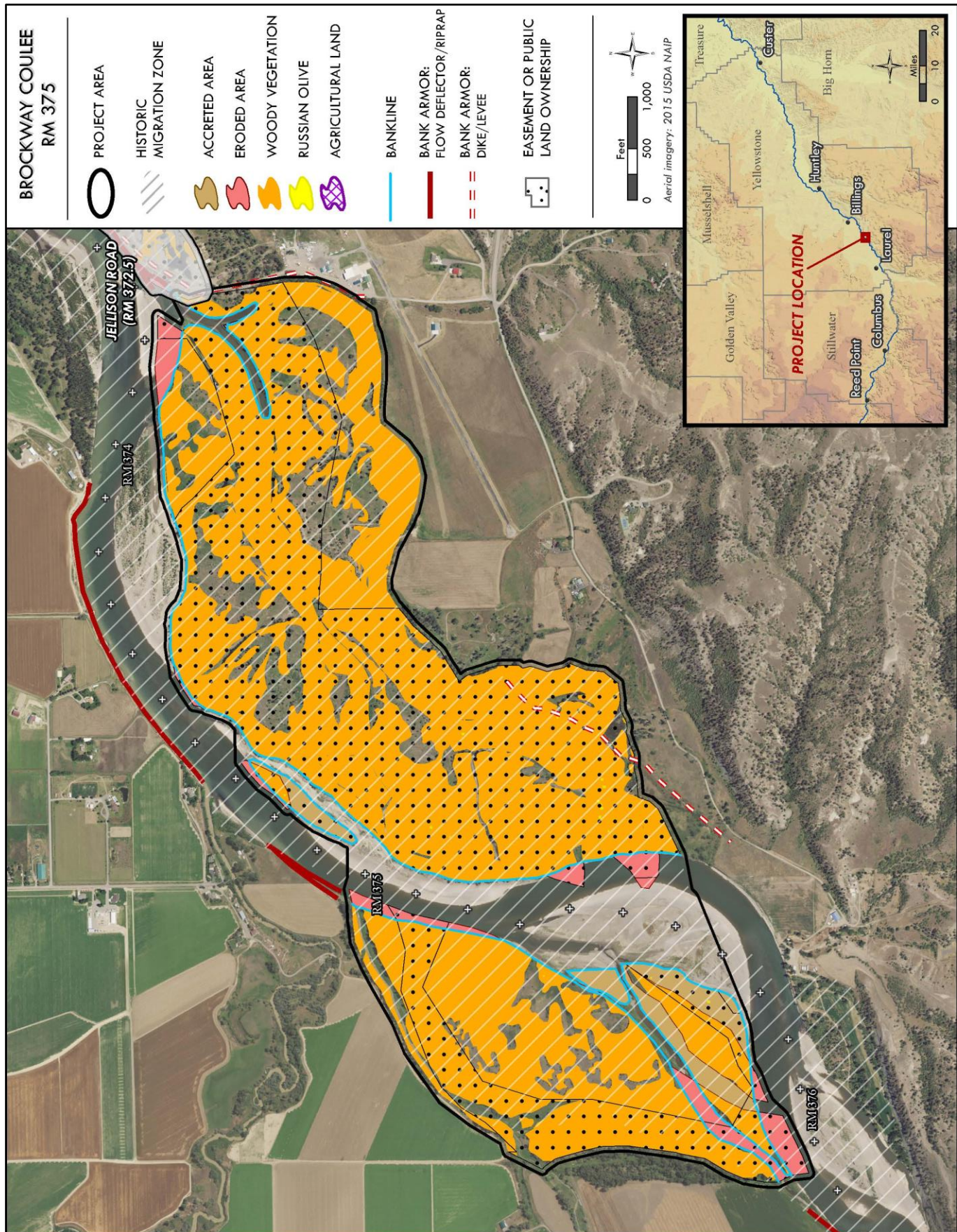


Figure 11. Brockway Coulee RM375, large woody debris project.

DUCK CREEK BRIDGE

PROJECT TYPE	TIER
Large woody debris potential	middle

Project Summary

Duck Creek Bridge is located immediately downstream of the bridge at RM 377.5. It is 7.5 miles downriver of the oil spill origin. The project includes two islands in a fairly confined segment on the Yellowstone River. The left bank outside the project is armored with both riprap and a dike/levee, and there is residential development on the south bank. The project area is 73.8 acres, one of the smallest projects. There are only two landowners within the project and 33% of the ownership is uncertain. There is no infrastructure within close proximity to the *Duck Creek Bridge* project.

Project Highlights

- This project ranks in the middle tier among all large woody debris projects. Though limiting factors are as low as possible, there is minimal woody vegetation and lower erosion than other higher ranking projects.
- The project boundary includes two islands with a parcel of an interested landowner. The entire boundary falls within the HMZ.
- Though there is some erosion (0.40 acres per year) wood vegetation acreage is low (24 acres). Accretion is more prevalent in this project (2.53 acres per year). The bank length to project area ratio (184 feet per acre) is also high because the project includes only islands.
- There are only 677 square feet of Russian olive which is very low compared to other projects. There is no bank armor and no agricultural land.
- The project includes 33% public or conservation land, has a high likelihood of success because of a lack of limiting factors, yet the benefit to cost ratio is not as high as other higher ranked projects because the inherent river functions are not very high. The project has some aquatic complexity in the form of several side channels that backwater at the 2-year flow and has potential for multiple resource benefits in terms of terrestrial habitat and recreation. Because there are no impacted side channels, the project is not evaluated as a riverine habitat project.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.40	2.53	65.47	100	0

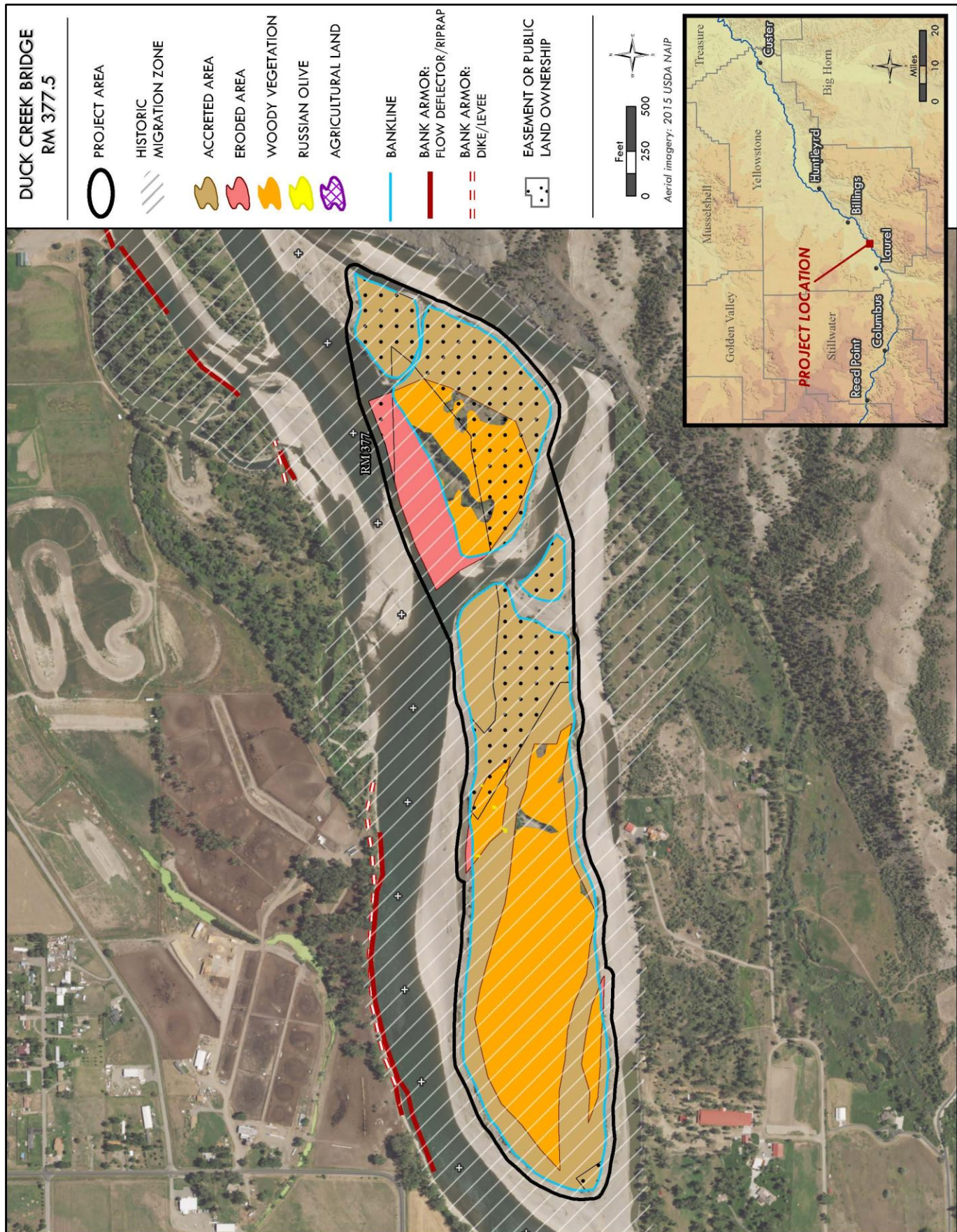


Figure 12. Duck Creek Bridge RM377.5, large woody debris project.

WEST of DUCK CREEK BRIDGE

PROJECT TYPE	TIER
Large woody debris potential	lower

Project Summary

West of Duck Creek Bridge is located at RM 380, upstream of Billings, on the left bank of the Yellowstone River. It is 8 miles downriver of the oil spill origin, on a stretch of the Yellowstone River that has been encroached on both sides by irrigated agriculture, which has narrowed the active stream corridor. The opposite bank is heavily armored by concrete riprap and at least 20 mapped flow deflectors which protect two center pivots on the south floodplain. The project area is 132.1 acres, one of the smallest projects, although it is about 1.5 miles long. Approximately half of this area is owned by a single landowner and ownership of the other half is uncertain. There is no infrastructure within close proximity to *West of Duck Creek Bridge* project.

Project Highlights

- This project ranks in the lower tier among all large woody debris projects mainly due to a lack of erosion, high bank armor and cost.
- The project boundary captures two disconnected side channels. The boundary follows the HMZ, but extends beyond the HMZ in several locations to capture areas with long-term wood recruitment potential.
- The project has no erosion and some woody vegetation (106.0 acres). Much of the site is located on a passive margin opposite the flow deflectors and also located only on one side of the river keeping the bank length low.
- There are 3,086 feet of bank armor, although most of the armor is on the landward side of the project boundary and this will have minimal effect on wood recruitment. There is some Russian olive.
- The project includes 52% percent of public or conservation land. While the project is very close to the point of injury and multiple resource benefits are high due to a high riverine habitat score and additional aquatic complexity, cost and likelihood of success are low. The project has some aquatic complexity in the form of side channels that backwater at the 2-year flow. The project is also evaluated for riverine habitat.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.0	2.1	106.0	84	21

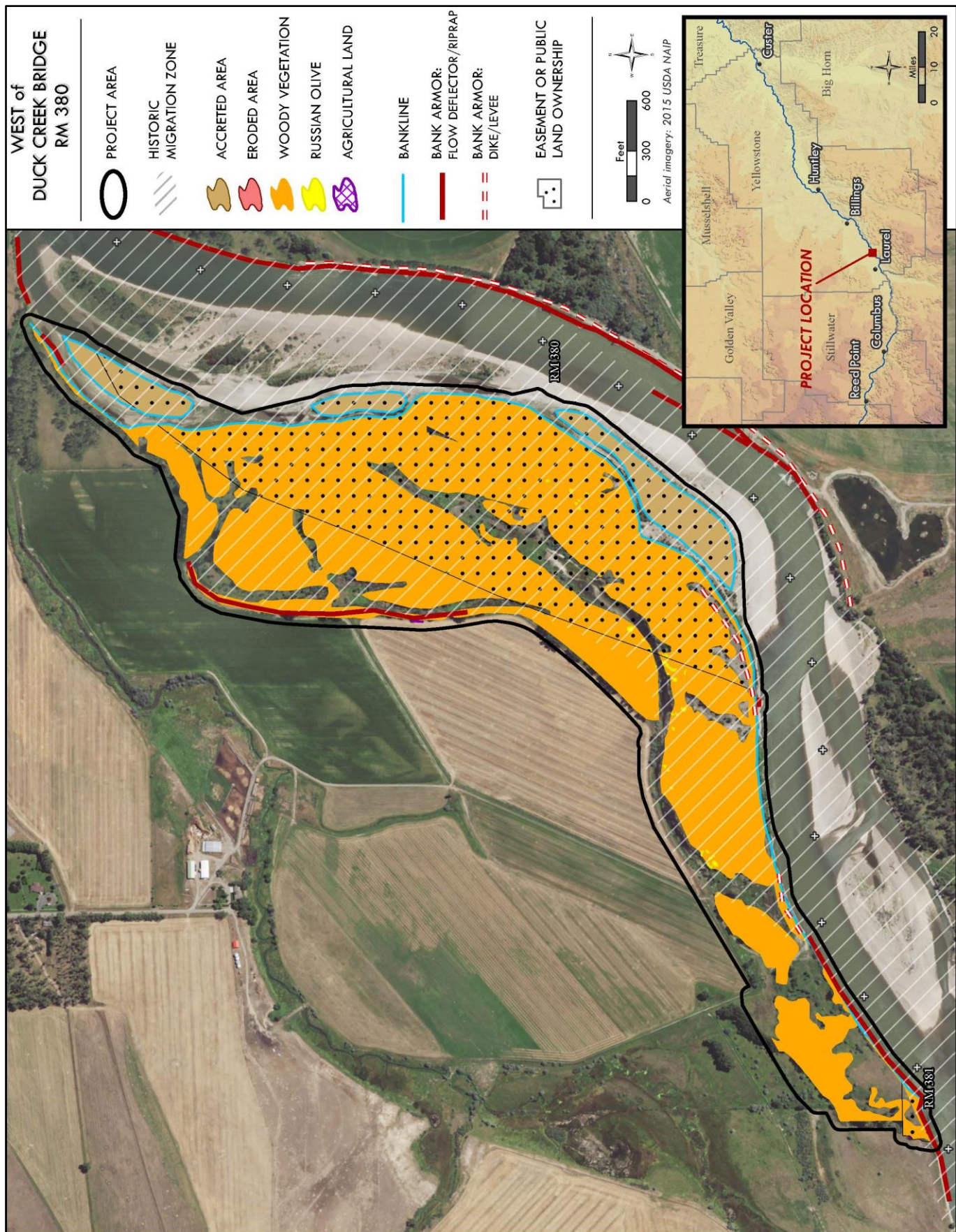


Figure 13. West of Duck Creek Bridge RM380, large woody debris project.

CLARKS FORK CONFLUENCE

PROJECT TYPE	TIER
Large woody debris potential	upper

Project Summary

Clarks Fork Confluence is located at RM 385 immediately downstream of Laurel, where it spans the confluence of the Clarks Fork Yellowstone River. It is immediately downstream of the oil spill origin. The project includes a small section of both right and left bank of the Yellowstone River and two islands. The upstream island formed after 1950, when an approximately 4,800 foot long avulsion caused a major meander cutoff. A chute channel formed through the meander core by 1976, but it was blocked by a small dike at RM 385.0. By 1995, this dike was flanked and a major cutoff channel developed, which has continued to enlarge with time, actively recruiting woody debris. There are sections of riprap on both banks outside the project that protect a main road and an irrigation canal. The project area is 433.3 acres, one of the largest projects. There are 11 landowners in this project, four that own less than 1% of the total area. The majority of ownership is uncertain, followed by a single landowner with 25% ownership. The project is just downstream of the Highway 212 and Highway 310 bridge. There is no other infrastructure within close proximity to the *Clarks Fork Confluence* project.

Project Highlights

- This project ranks in the upper tier among all large woody debris projects. The project has high erosion, little bank armor, and potential for multiple resource benefits.
- The project boundary includes parcels of several interested landowners and extends beyond the HMZ to include these landowners. The downstream portion of the boundary includes BLM land and/or unknown ownership.
- All three wood recruitment parameters (erosion, accretion, and woody vegetation) are high indicating the project is very dynamic. Bank length relative to the total area of the project (104 feet per acre) is lower because of the large project size. The percent of the project within the HMZ is slightly lower because of small areas on the right and left banks that are slightly higher; however, one of these areas is still inundated at the 2-year flow indicating its potential for connectivity and wood recruitment.
- Russian olive is abundant. There is no bank armor or agricultural land.
- The project includes 47% public or conservation land, slightly lower than other projects, and this is what primarily separates this project from the highest ranking project. The project would have a high estimated benefit to cost ratio despite the large number of land owners because of the lack of bank armor and high wood recruitment rates. Several of these landowners own a very small percentage of the project and this area is disconnected from the original parcel by the channel. The project is also located closer to the oil spill origin than any other project. The project has some aquatic complexity in the form of several side channels that backwater at the 2-year flow and has potential for multiple resource benefits in terms of terrestrial habitat and recreation. As there are no physically impacted side channels, the site was not evaluated as an aquatic habitat project type.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
2.65	5.97	317.45	91	0

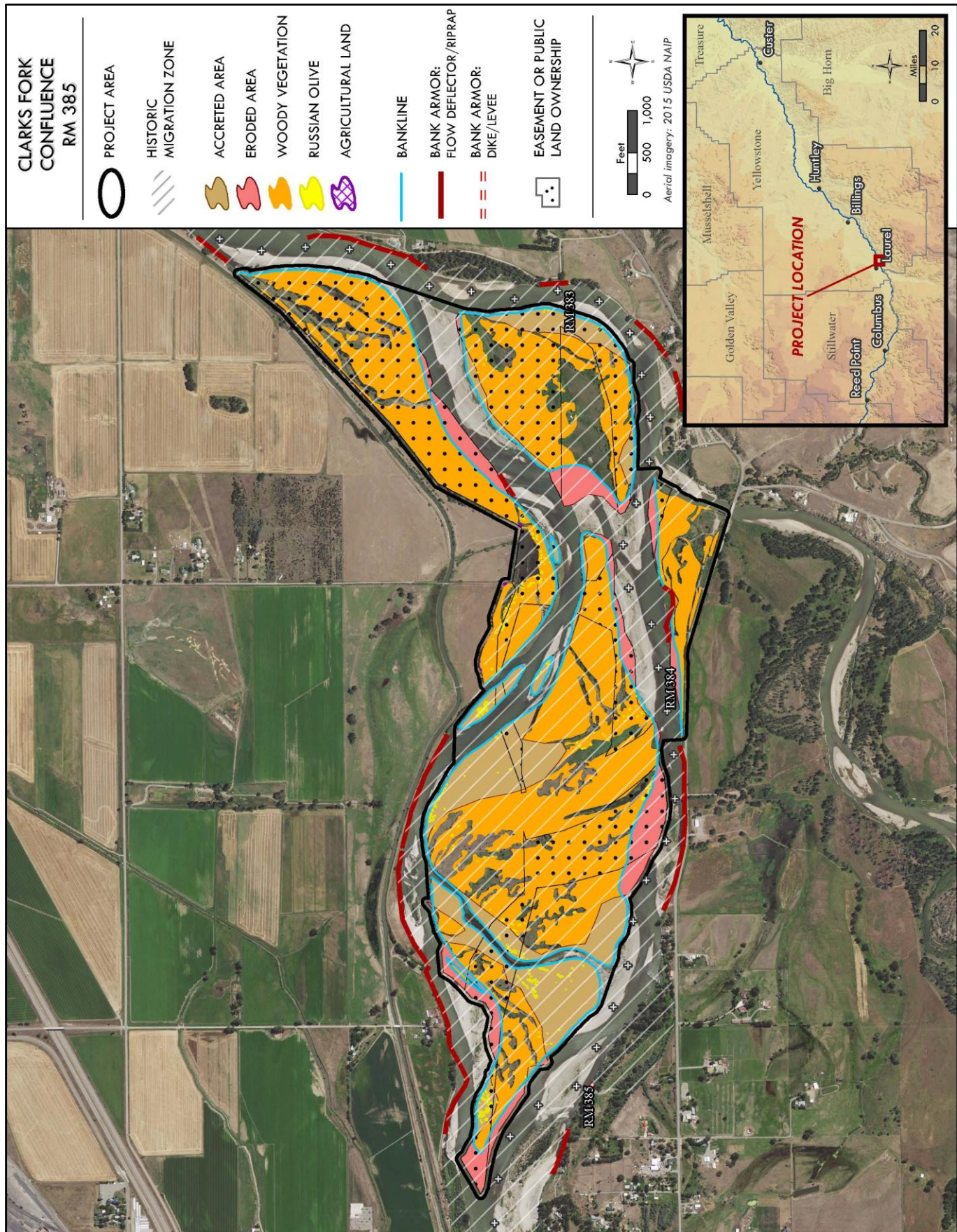


Figure 14. Clarks Fork Confluence RM 385, large woody debris project.

ABOVE LAUREL BRIDGE

PROJECT TYPE	TIER
Large woody debris potential	upper

Project Summary

Above Laurel Bridge is located at RM 387, just upstream of the Laurel Bridge and the site of the oil spill on the Yellowstone River. The project includes three riparian bottom areas that collectively define a corridor that is about two miles long and a half mile wide. There are short sections of riprap on the left bank outside the project. The project area is 451.2 acres, one of the largest projects. There are twelve landowners in this project, five who own less than 1% of the total area. The majority of ownership is uncertain, followed by the Montana Department of State Lands with 30% ownership. The project is just upstream of the Highway 212 and Highway 310 Bridge. There is no other infrastructure within close proximity to the *Above Laurel Bridge* project.

Project Highlights

- This project ranks in the upper tier among all large woody debris projects. Despite some bank armor and Russian olive, erosion rates are high, woody vegetation is extensive, and there is potential for multiple resource benefits.
- The project boundary includes an island and a section of right bank and follows the HMZ to capture an active side channel. The boundary extends beyond the HMZ in one location to capture an area of dense riparian forest that would provide long-term wood potential.
- All three wood recruitment parameters (erosion, accretion and woody vegetation) are high and indicate the project is relatively dynamic. Bank length relative to the total area of the project (87 feet per acre) is slightly lower because of the large project size.
- There are two sections of bank armor located on the south side of the project; one at the upstream end and one at the downstream end for a total of 1,425 feet. The downstream armor is on the landward edge of the project approaching the Laurel Bridge and won't affect channel migration within the project area. There are also 4,916 square feet of Russian olive. There is no agricultural land.
- The project includes a relatively high percent of public or conservation land (78%) and the estimated benefit to cost ratio would be high despite the large number of land owners because of the high inherent river function. Note that several of landowners own a very small percent of the project, most of which is located at the downstream end of the project and the project boundary could be adjusted to reduce coordination and costs. The project has some aquatic complexity in the form of several side channels that backwater at the 2-year flow and has potential for multiple resource benefits in terms of terrestrial habitat and recreation. The project is not evaluated for riverine habitat.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
1.20	4.13	341.86	95	6

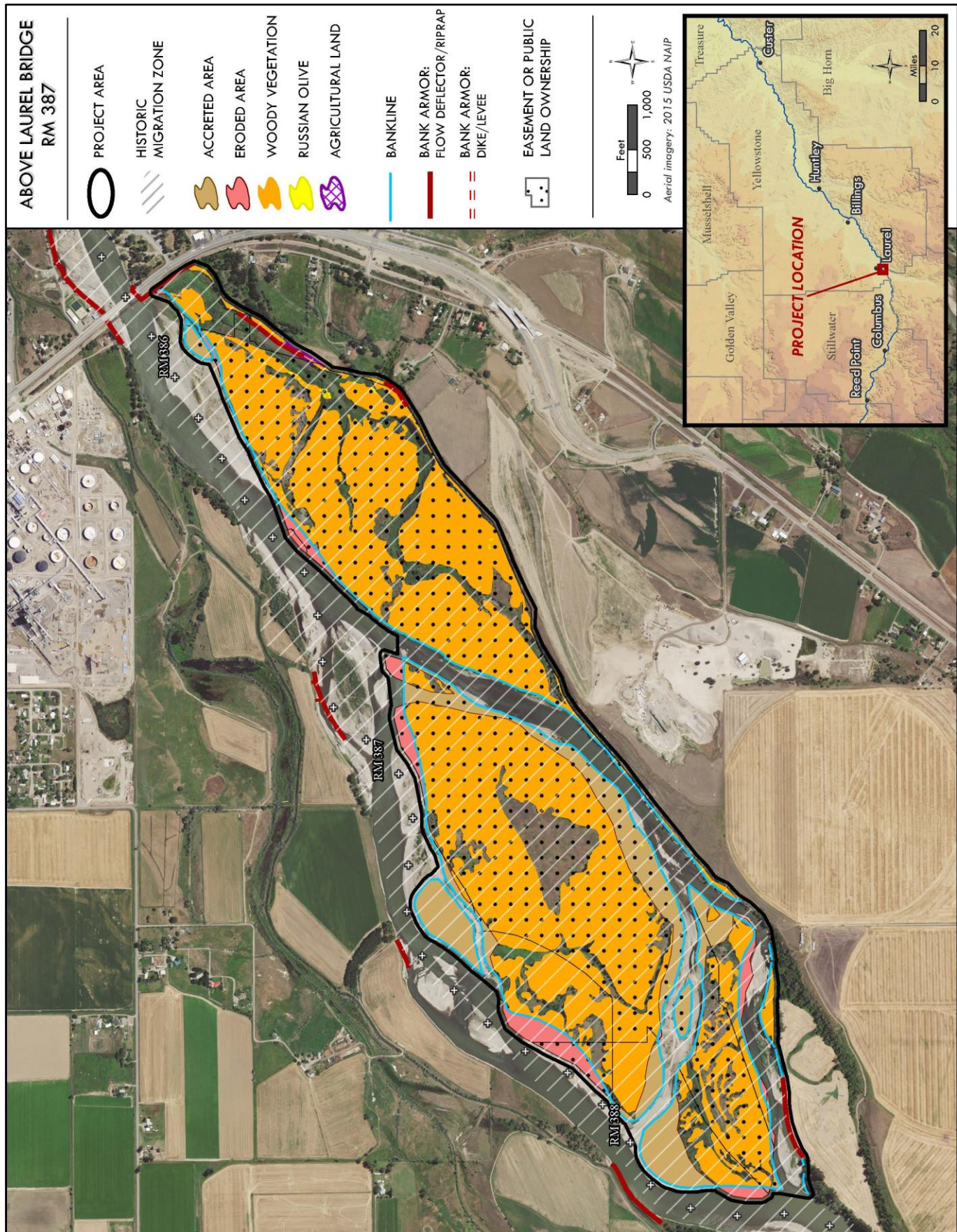


Figure 15. Above Laurel Bridge, RM 387, large woody debris project.

BUFFALO MIRAGE

PROJECT TYPE	TIER
Large woody debris potential	middle

Project Summary

Buffalo Mirage is located at the Buffalo Mirage Fishing Access Site at RM 391, upstream of Laurel. It is 6 miles upstream of the oil spill origin. The project extends beyond the Fishing Access Site and includes areas on both sides of the Yellowstone River. Just downstream of the project, both sides of the channel are armored and the CMZ is severely constricted. The project area is 252.4 acres and delineates a corridor width of about a half mile. There are six landowners in this project. The majority of ownership is uncertain (43%), followed by a single landowner with 26% ownership. There is no infrastructure within close proximity to the *Buffalo Mirage* project.

Project Highlights

- This project ranks in the lower middle tier among all large woody debris projects. Although there is abundant woody vegetation and the project has potential for multiple resource benefit in the form of aquatic complexity and aquatic habitat, erosion is low.
- The project boundary follows the HMZ and topography to include areas with long-term wood recruitment potential.
- Erosion and accretion are not as high as other higher ranking projects (0.89 and 2.39 acres per year respectively). Although this project is not as dynamic, it does have a large amount of woody vegetation (198.35 acres).
- There are 428 feet of bank armor located on the southern landward margin of the project on an old side channel that is about 1,500 feet south of the main thread. Russian olive is abundant.
- The project includes a high percentage of public or conservation land (66%). The likelihood of success and benefit to cost ratio are not as high as other higher ranking projects because of limiting factors. The project includes high aquatic complexity because of a side channel on the right bank. As a major side channel through the Fishing Access Site has been blocked, the project has also been evaluated as an aquatic habitat project type.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.89	2.39	198.35	93	2

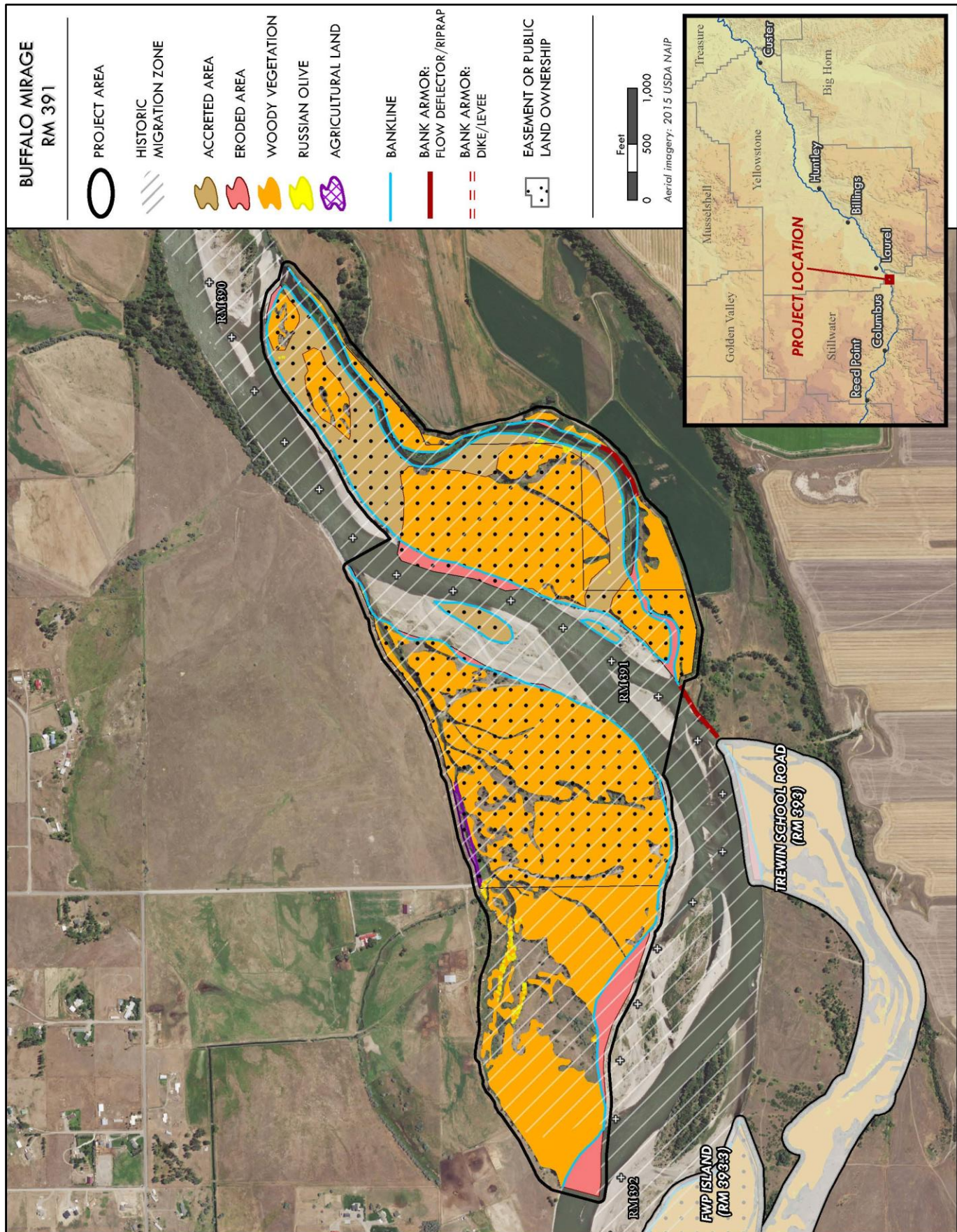


Figure 16. Buffalo Mirage RM 391, large woody debris project.

PROJECT TYPE	TIER
Large woody debris potential	upper

Project Summary

Fish, Wildlife & Parks (FWP) Island is located at RM 393.3, near Park City, upstream of Laurel. It is six miles upstream of the oil spill origin. The project encompasses a complex series of riparian bottoms on both sides of the Yellowstone River as well as several islands, defining a stream corridor that is about two miles long and a half mile wide. The banks are armored on portions of the left bank outside the project, protecting a rural subdivision on a low terrace. The project area is 456.0 acres, one of the largest projects. There are six landowners in this project. The majority of the project ownership is uncertain (42%) and Montana Fish, Wildlife & Parks owns 36% of the project. There is no infrastructure within close proximity to the *FWP Island* project; however, one of the islands is used as a camping and fishing area and there is a dirt boat ramp on the left bank outside the project area.

Project Highlights

- This project ranks in the upper tier among all large woody debris projects. Erosion rates are high and woody vegetation is extensive. There is also a high percentage of public land and the project has potential for several multiple resource benefits.
- The project boundary includes parcels of several interested landowners and follows the HMZ. The boundary expands beyond the HMZ to include a disconnected side channel and areas with long-term wood recruitment potential. The boundary does not include portions of the left bank with armor protecting residential property.
- All three wood recruitment parameters (erosion, accretion and woody vegetation) are high indicating the project is very dynamic. Bank length relative to the total area of the project (130 feet per acre) is high because a large portion of the project includes islands. Almost 90% of the project is within the HMZ; the remaining acreage is in the erosion hazard area of the CMZ, and migration into this wooded area is ongoing.
- There is no bank armor or agricultural land, only abundant Russian olive.
- The project includes a high percentage of public or conservation land (78%). Costs are low and the estimated benefit to cost ratio is high because of high inherent river function. The project has some risk of adverse effect because the project includes a large area of public land used as a camping area. The project has some aquatic complexity in the form of several side channels that backwater at the 2-year flow and has high potential for multiple resource benefits in terms of terrestrial habitat and recreation. The project is also evaluated for riverine habitat.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
1.96	8.94	374.81	86	0

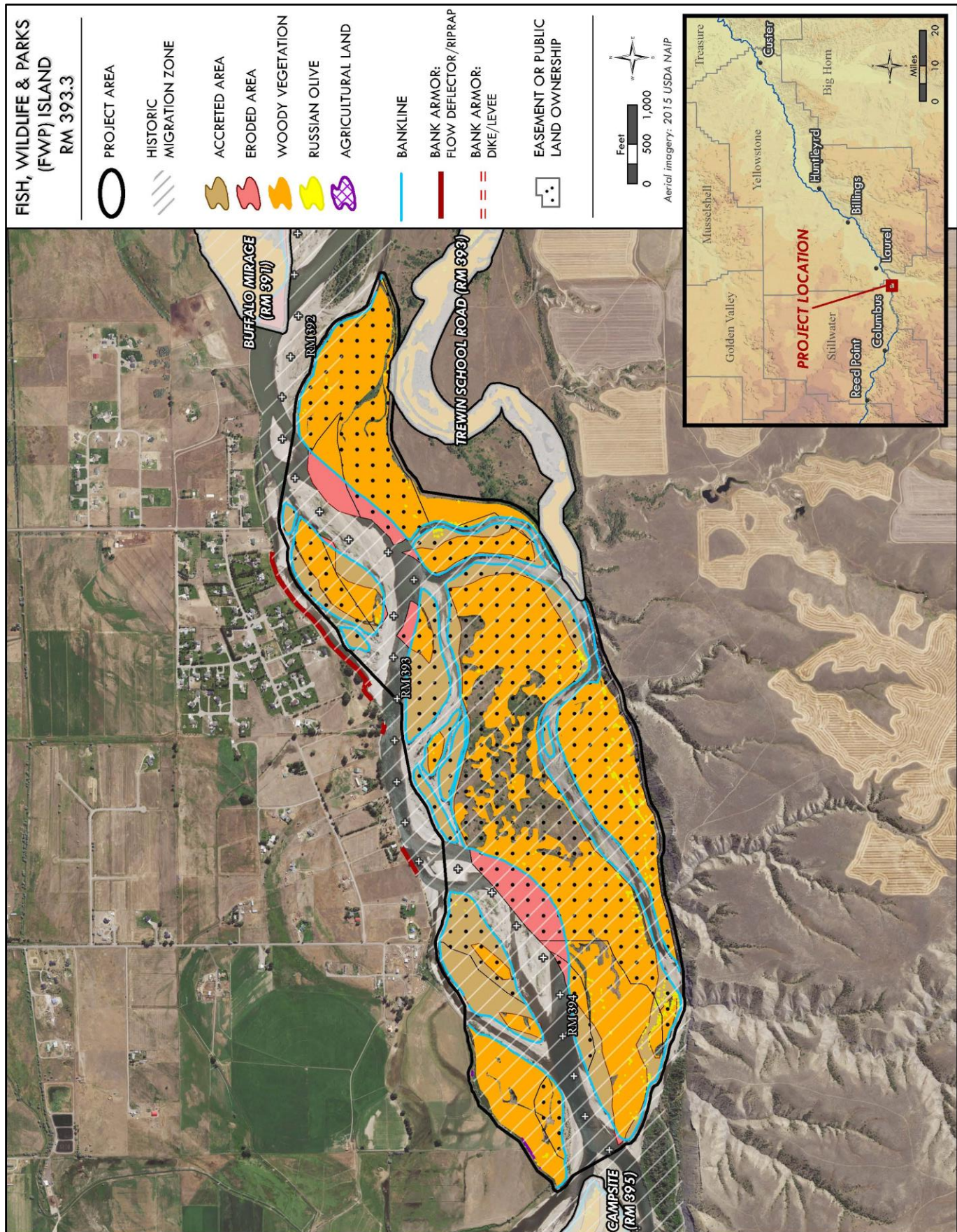


Figure 17. FWP Island RM 393.3, large woody debris project.

CAMPSITE

PROJECT TYPE	TIER
Large woody debris potential	middle

Project Summary

Campsite is located at RM 395, upstream of Laurel near Park City. It is 10 miles upriver of the oil spill origin. The project is about two miles long, consisting of two islands and two adjacent floodplain areas on either side of the Yellowstone River. The valley wall bluff line follows the south (right) bank of the project, and the north bank is partially armored by rock riprap. The project area is 243.3 acres. There are four landowners in this project. Approximately half of the area is owned by a single landowner and one landowner owns a very small corner of an island isolated from the original parcel. The remaining ownership is uncertain. There is no infrastructure within close proximity to the *Campsite* project.

Project Highlights

- This project ranks in the middle tier among all large woody debris projects. Erosion is somewhat low and there is abundant Russian olive; however, there is very little public land which separates this project from other higher ranking projects.
- The project boundary includes a parcel owned by an interested landowner. The boundary is almost entirely within the HMZ and the land would provide long-term wood recruitment potential.
- Although erosion is only 1.09 acres per year, there is abundant woody vegetation (191.85 acres) and almost the entire project is within the HMZ (99%). Bank length relative to the project area is somewhat lower than other projects due to the size of the project.
- There is abundant Russian olive and no bank armor or agricultural land.
- The project includes only 22% public or conservation land and estimated cost is high as a result of the large amount of private land reducing the estimated benefit to cost ratio. However, the property is under consideration as a terrestrial habitat purchase which would facilitate project implementation. The project has some aquatic complexity in the form of several side channels that backwater at the 2-year flow and has potential for multiple resource benefits in terms of terrestrial habitat and recreation. The project is not evaluated for riverine habitat.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
1.09	3.23	191.85	99	0

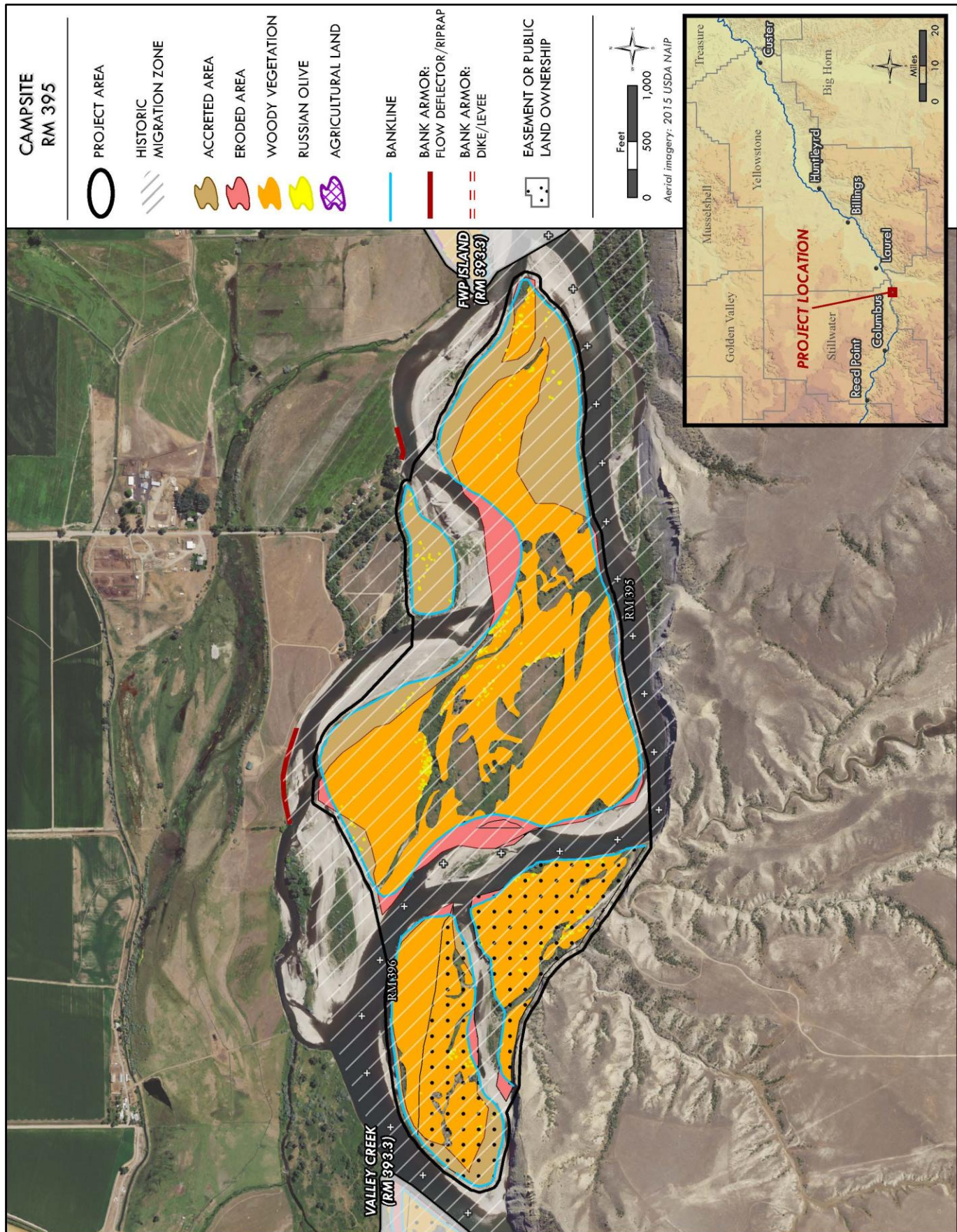


Figure 18. Campsite RM 395, large woody debris project.

PROJECT TYPE	QUARTILE
Large woody debris potential	upper

Project Summary

Valley Creek is located at RM 398, upstream of Park City, on the left bank of the Yellowstone River. It is 6 miles upstream of the oil spill origin. The project is a three mile long narrow swath of riparian bottoms on the north side of the river; the south side is a high bluff line. The project area is 242.0 acres. There are six landowners in this project. The majority of the project ownership is uncertain (54 %) and there are two other primary landowners. There is no infrastructure within close proximity to the *Valley Creek* project.

Project Highlights

- This project ranks in the upper tier among all large woody debris projects. Erosion is high, there is no bank armor and there is some potential for addition resource benefits in the form of aquatic complexity.
- The project boundary defines the only area available for active channel migration in the reach because of the high bluff line on the south side of the channel. The boundary captures two disconnected side channels. In some cases, the boundary expands beyond the HMZ to include areas where the channel is already beginning to migrate and that include dense riparian vegetation.
- Erosion is high (2.17 acres per year) and the bank length relative to the project area ratio is high (155 feet per acre) because the project runs almost three miles along the left bank.
- There is no bank armor, some Russian olive, and a small percentage of agricultural land (1.2 %).
- The project includes only 54% public or conservation land and this is what primarily separates this project from the highest ranking project. The estimated benefit to cost ratio and likelihood of success is high because there is no bank armor and there is high existing inherent river function. The project also includes potential for high aquatic complexity because of several existing side channels, several of which flow at the 2-year flow and provide refugia habitat. The project is also evaluated as a riverine habitat project type due to its potential for blocked side channel reactivation.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
2.17	0.40	158.34	59	0

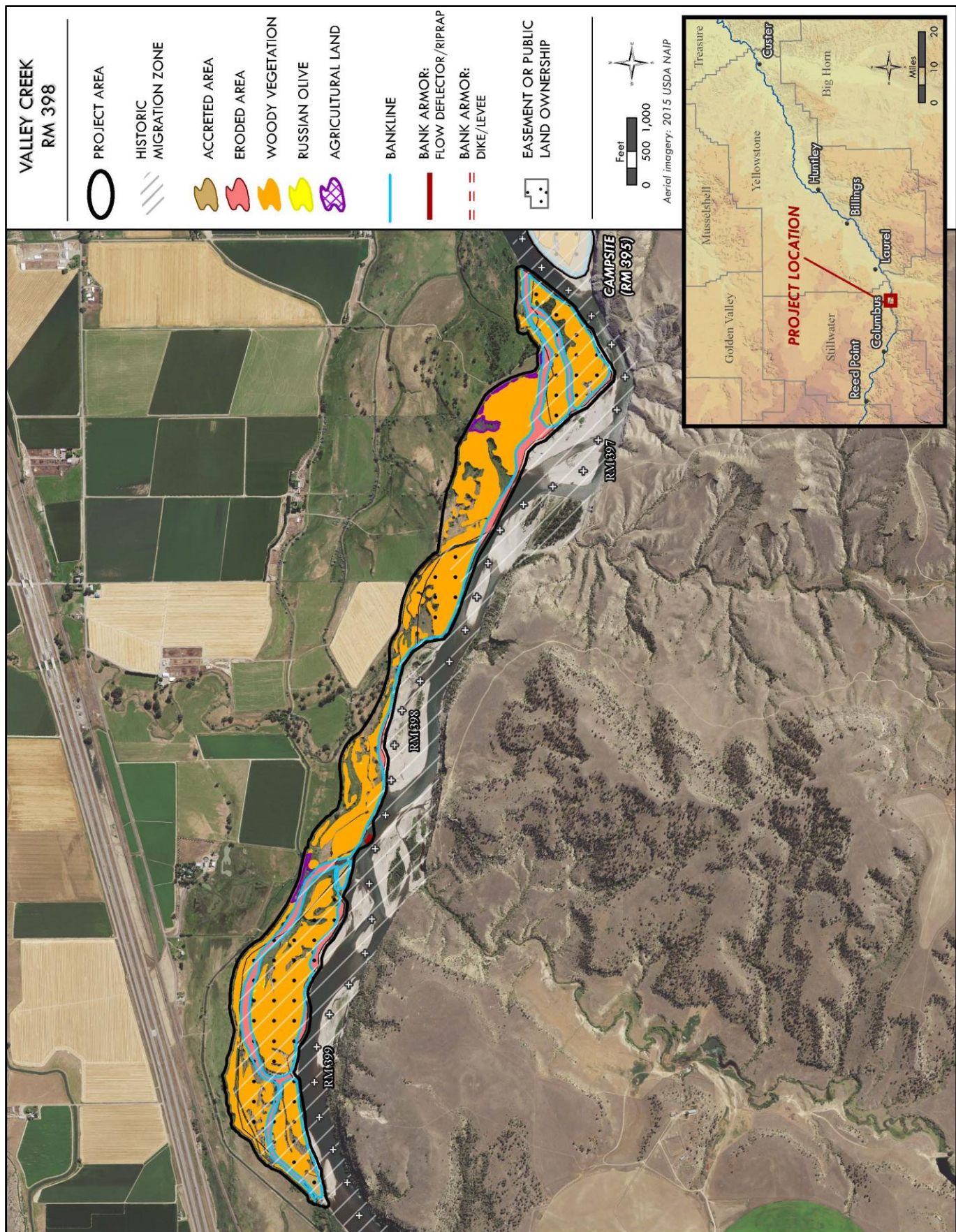


Figure 19. Valley Creek RM 398, large woody debris project.

YOUNGS POINT

PROJECT TYPE	TIER
Large woody debris potential	lower

Project Summary

Yongs Point is located at RM 401, upstream of Park City, on left bank of the Yellowstone River. It is 16 miles upstream of the oil spill origin. The project area is 1.8 miles long, encompassing 170.3 acres with several islands. Just downstream of the project rock riprap protects the Italian Ditch diversion structure, confining the stream corridor between the ditch and southern bluff line. The majority of the project is owned by a single landowner (59%). There are two other land owners with less than 3% ownership. The remaining ownership is uncertain (38%). The project extends inland toward the rail line and Interstate 90; however, because the channel tends to hug the bedrock bluff line on the opposite bank, there is a low risk the channel will migrate into the infrastructure. There is no other infrastructure within close proximity to the *Yongs Point* project.

Project Highlights

- This project ranks in the lower tier among all large woody debris projects. Erosion is very low; however, limiting factors are also the lowest of all projects.
- The project boundary follows the HMZ and extends beyond the HMZ in two locations to capture lower areas with long-term wood recruitment potential and aquatic habitat potential.
- There is low erosion in the project (0.2 acres per year) because the channel tends to hug the bluff line on the opposite (right) bank. Bank length to project area ratio is high (163 linear feet/acre) because of islands within the project.
- There is no bank armor, no agricultural land and only 337 square feet of Russian olive.
- The project includes only 38% public or conservation land and the benefit to cost ratio is low because inherent river function is low. The project has some aquatic complexity because of the presence of backwater in side channels at the 2-year flow. The project is not evaluated for riverine habitat.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.20	2.29	139.57	92	0

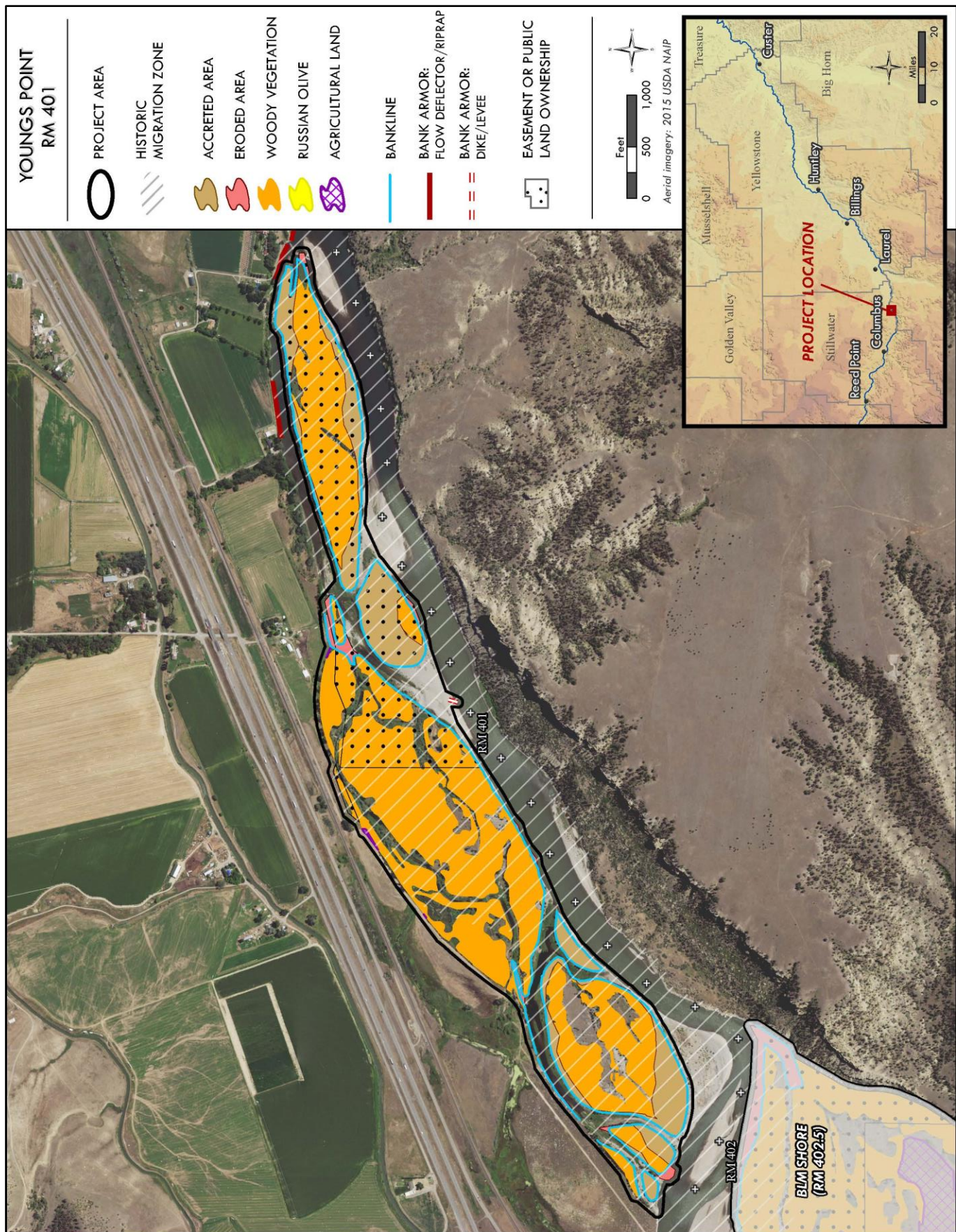


Figure 20. Youngs Point RM 401, large woody debris project.

BUREAU of LAND MANAGEMENT (BLM) SHORE

PROJECT TYPE	TIER
Large woody debris potential	lower

Project Summary

Bureau of Land Management (BLM) Shore is located at RM 402.5, about six miles upstream of Park City. It is 17.5 miles upstream of the oil spill origin. The project includes riparian bottoms on both sides of the Yellowstone River and collectively defines a corridor that is about 1.2 miles long and 0.4 miles wide. The project area is 219.9 acres. There is some bank armor on the left bank upstream of the project, protecting the Big Ditch canal. There are three landowners including the Bureau of Land Management (26% ownership). Thirty-two percent of the project ownership is uncertain. There is no infrastructure within close proximity to the *BLM Shore* project.

Project Highlights

- This project ranks in the lower tier among all large woody debris projects. Despite having little to no limiting factors, there is minimal erosion and very little of the project is within the HMZ.
- The project boundary expands beyond the HMZ following a topographic break and capturing areas with long-term wood recruitment potential and various backwater channels that would provide some riverine habitat potential.
- Erosion is 0.56 acres per year and there is very little accretion in the project (0.4 acres per year). Only 29% of the project is within the HMZ, concentrated on right bank. This section of the river is somewhat channelized because of the geology and the high bluff line to the south causing several inherent river functions to be lower than projects downstream where channel migration patterns are more pronounced.
- There is no bank armor and minimal agricultural land (4.4%) and only 236 square feet of Russian olive.
- The project includes 58% public or conservation land. Although the project cost is low, the estimated benefit to cost is low because of low public ownership and low inherent river function. The project has some aquatic complexity because of the presence of backwater in side channels at the 2-year flow. The project was not evaluated as a riverine habitat project.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.56	0.40	165.21	29	0

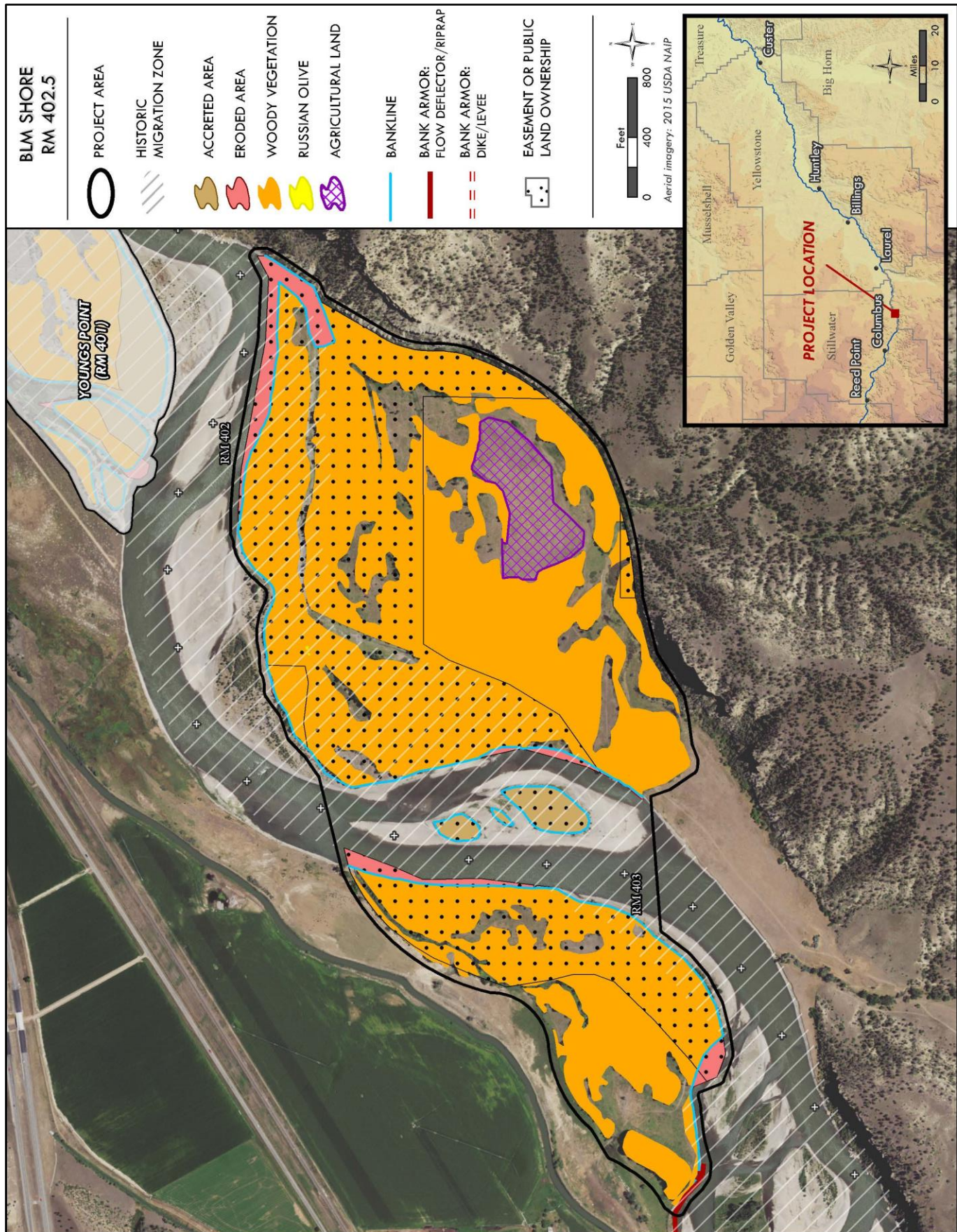


Figure 21. BLM/Shore RM 402.5, large woody debris project.

TUCKER CREEK

PROJECT TYPE	TIER
Large woody debris potential	lower

Project Summary

Tucker Creek is located at RM 405.4, about 10 miles downstream of Columbus and 20.4 miles upstream of the oil spill origin. The project includes two islands in the Yellowstone River. The project area is 136.9 acres, one of the smaller projects. There is a dike/levee protecting a lagoon on the left bank outside of the project boundary. The majority of land is owned by a single landowner (78%). A second landowner owns 5% and the remainder of the project ownership is uncertain. *Tucker Creek* can be accessed via a bridge on its upstream end and the Big Ditch diversion spans the entire side channel on the downstream end of the island. The bridge site includes bank armor on the upstream nose of the island.

Project Highlights

- This project ranks in the lower tier among all large woody debris projects. Erosion is very low, there are several hundred feet of bank armor and there is no apparent potential for multiple resource benefits.
- The project boundary focuses on two islands within the HMZ that would provide long-term wood recruitment potential.
- Erosion is only 0.15 acres per year because the channel tends to hug the bluff line on the right bank; however, the entire project is within the HMZ indicating this project has the potential to recruit wood long-term and there are 86 acres of woody vegetation.
- Limiting factors are driven by 646 feet of bank armor at the head of the island (5% of the total bank length). There is minimal Russian olive and no agricultural land.
- The project includes only 18% public or conservation land and the benefit to cost is low because of the high cost of acquiring private land. This project does not have any aquatic complexity because there are no side channels. The project was not evaluated as a riverine habitat project.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.15	1.25	86.00	100	5

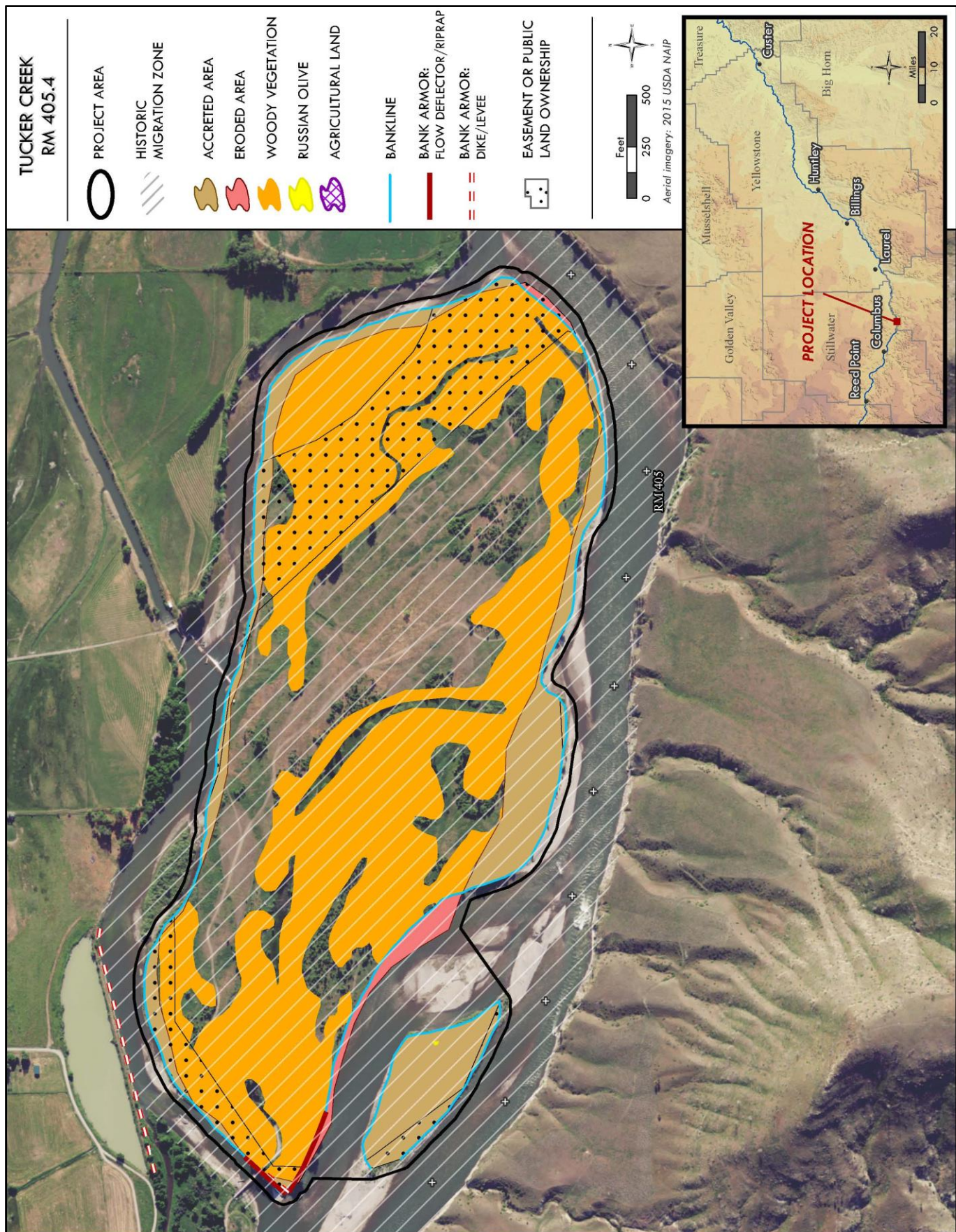


Figure 22. Tucker Creek RM 405.4, large woody debris project.

HENSLEY CREEK

PROJECT TYPE	TIER
Large woody debris potential	upper

Project Summary

Hensley Creek is located at RM 410.5, downstream of Columbus. It is 25.5 miles upstream of the oil spill origin. The project includes a large portion of right bank floodplain on the Yellowstone River and a densely vegetated island. The project area is 236.8 acres. Upstream of the project on the left bank, there is bank armor protecting the rail line and Interstate 90. There are also some small sections of bank armor directly across the channel, and bedrock is exposed in the channel bed at RM 409.8. The majority of land is owned by a single landowner (70%). A second landowner owns 4% and the Bureau of Land Management owns a small section disconnected from the main parcel by the channel. The remainder of the project ownership is uncertain. There is an irrigation diversion and head gate opposite the project on left bank.

Project Highlights

- This project ranks in the upper tier among all large woody debris projects. Inherent river functions are the highest of all projects and limiting factors are the lowest of all projects; however, public ownership is low.
- The project boundary captures a disconnected side channel and extends beyond the HMZ in one location where there is potential for long-term wood recruitment. The boundary also captures an island with unknown ownership and a dense riparian forest.
- All three wood recruitment parameters (erosion, expansion, and woody vegetation) indicate the project is very dynamic and almost the entire project is within the HMZ (96%).
- There are no limiting factors.
- The project has very little public ownership (26%). The project has high inherent aquatic complexity because of side channels throughout the project, and many of these connect through at the 2-year flow. As the project also has a blocked side channel, the project has been evaluated as a riverine habitat project type and is the only project in the upper tier of both injury categories.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
1.44	4.33	167.63	96	0.7

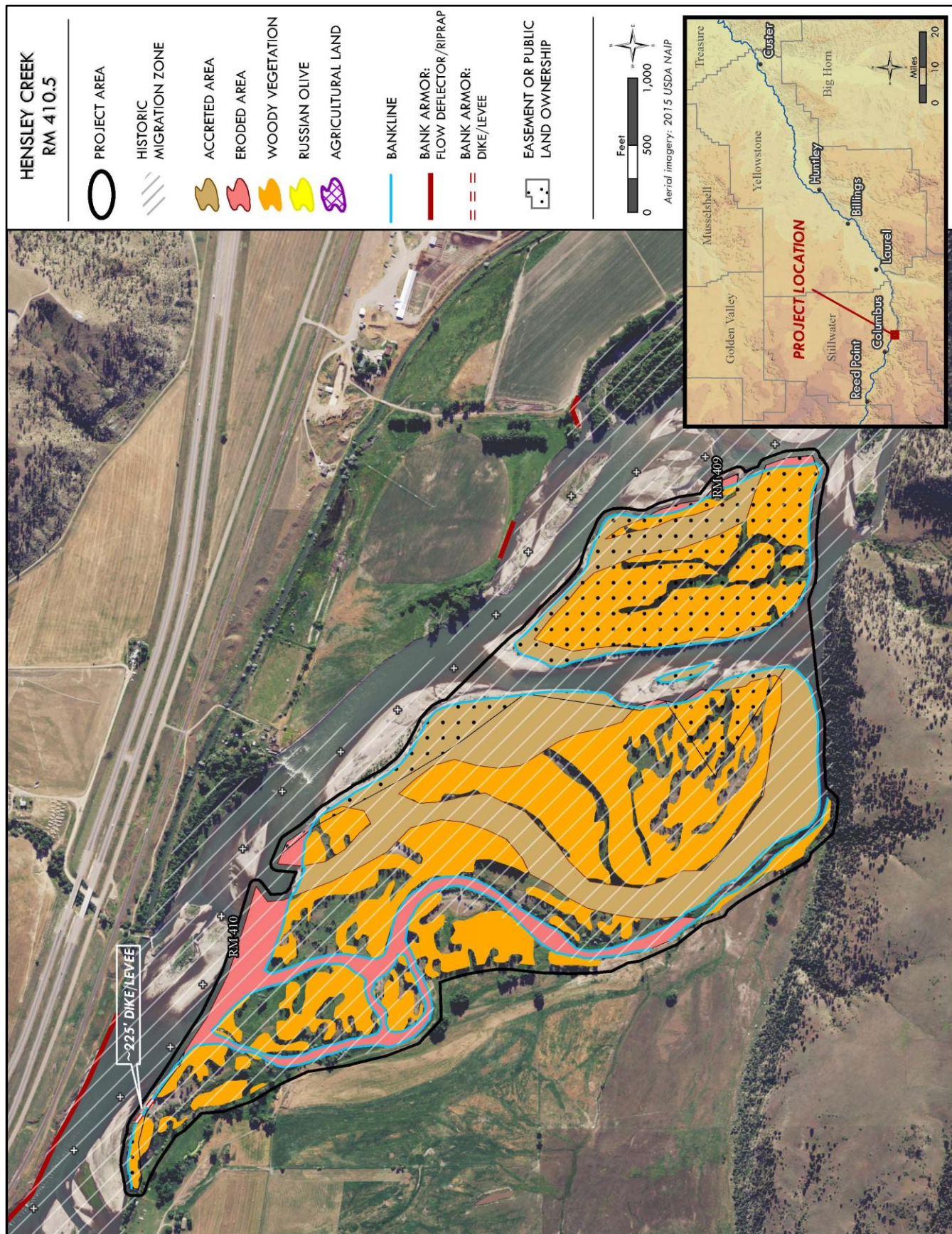


Figure 23. Hensley Creek RM 410.5, large woody debris project.

BELOW COLUMBUS

PROJECT TYPE	TIER
Large woody debris potential	middle

Project Summary

Below Columbus is located at RM 413, downstream of Columbus. It is 28 miles upstream of the oil spill origin. The project crosses the Yellowstone River and encompasses the core and downstream limb of a large meander bend. The project area is 323.7 acres. Downstream of the meander the river flows against the north bedrock valley wall which is armored to protect the adjacent rail line. There are seven landowners in this project and one parcel is under a conservation easement. A single landowner owns 32% of the project and Montana Department of Lands owns 2%. A large portion of the project ownership is uncertain (43%). The left bank of *Below Columbus* is up against a rail line and the right bank is against a local road. There is no other infrastructure within close proximity to the *Below Columbus* project.

Project Highlights

- This project ranks in the middle tier among all large woody debris projects. Although there is abundant woody vegetation, the meander bend has been very stable such that only a portion of the project is within the HMZ. There is some Russian olive.
- The project boundary includes a parcel owned by an interested landowner. The boundary expands beyond the HMZ following a topographic break and capturing areas with long-term wood recruitment potential. The boundary excludes a parcel to reduce the number of landowners.
- Although there is abundant woody vegetation (246.52 acres), erosion is only 0.56 acres per year and only 23% of the project is within the HMZ. The majority of the area within the HMZ is located at the downstream end of the project. This section of the river is somewhat simplified because of the geologic confinement causing several inherent river functions to be lower than projects downstream where channel migration patterns are more pronounced.
- There is no bank armor, only 4.2% agricultural land and 6,288 square feet of Russian olive, most of which is on the north side of the river.
- The project includes 49% public or conservation land. The project has no aquatic complexity because there are no side channels, though the project does have potential for additional terrestrial habitat and recreational resources. The project is not evaluated for riverine habitat.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.56	1.70	246.52	23	0

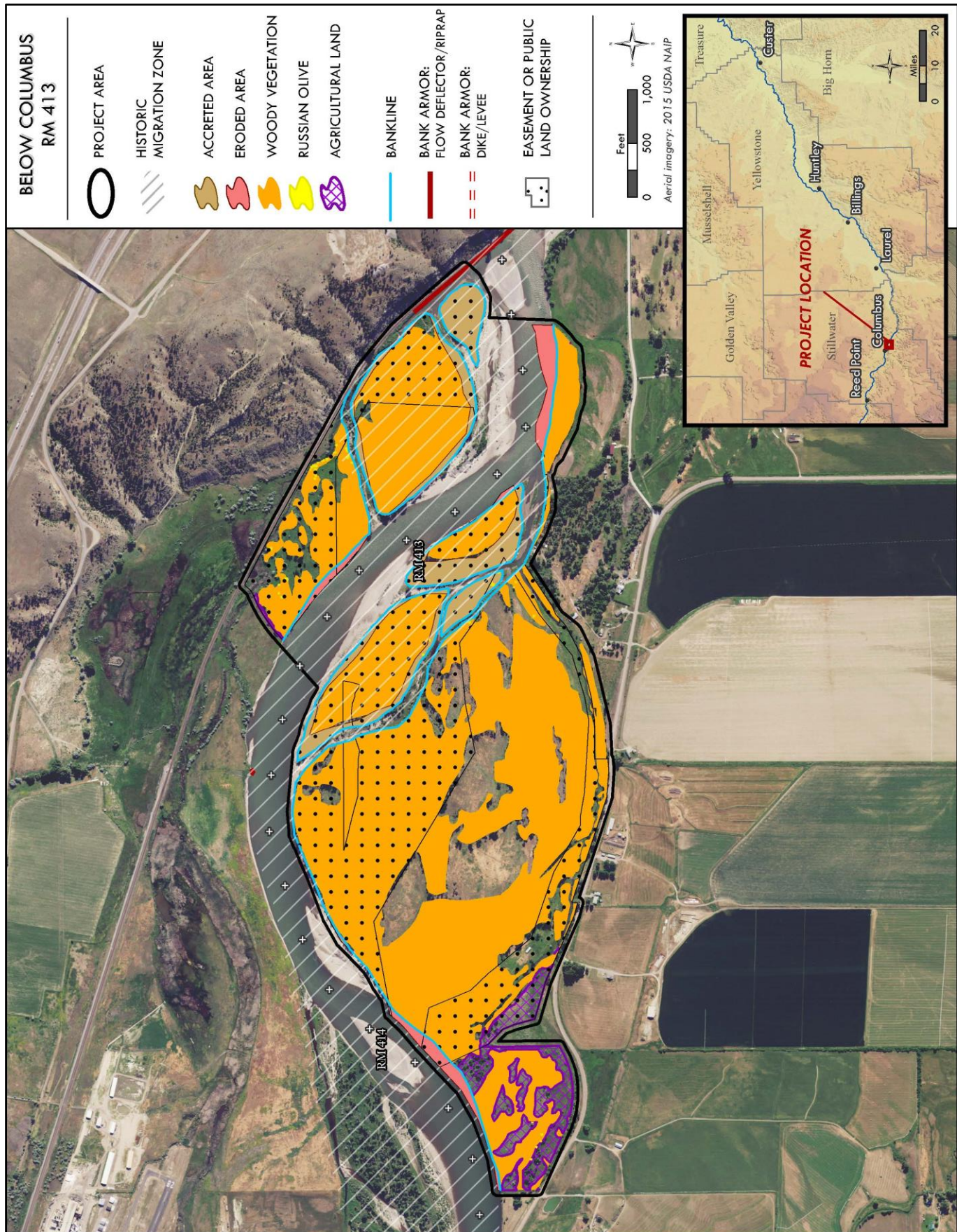


Figure 24. Below Columbus RM 413, large woody debris project.

STILLWATER CONFLUENCE

PROJECT TYPE	TIER
Large woody debris potential	middle

Project Summary

Stillwater Confluence is located at RM 418, upstream of Columbus at the Stillwater River confluence on the Yellowstone River. It is 33 miles upstream of the oil spill origin. The project includes a series of islands above and adjacent to the mouth of the Stillwater River, and includes the mouth of the Stillwater River itself. The project area is 218.7 acres. The north side of the corridor is confined by both the bedrock valley wall and a long stretch of rock riprap that protects the rail line as it closely follows the left (north) bank. Much of the ground south of the Yellowstone River adjacent to the Stillwater River confluence has been flood irrigated since at least the 1950s. A single landowner owns 47% of the project and there are two other landowners. A large portion of the project ownership is uncertain (45%). There is no infrastructure within close proximity to the *Stillwater Confluence* project.

Project Highlights

- This project ranks in the middle tier among all large woody debris projects. Erosion is high, but there is a significant amount of agricultural land and the project is relatively far from the point of injury.
- The project boundary follows the HMZ but also extends beyond the HMZ to capture an active side channel, the Stillwater confluence and some of the tributary, and an area of land where the river is already beginning to migrate. The boundary does not include an armored portion of the left bank protecting the rail line.
- Although erosion is high (1.26 acres per year), only 67% of the project is within the HMZ.
- There is a small section of bank armor on right bank and also some along the tributary, a high presence of agricultural land (11%) and 2,048 square feet of Russian olive.
- The project is far from the point of injury and includes 47% public or conservation land, lower than other projects with higher scores. This project does have some aquatic complexity because of several side channels that backwater at the 2-year flow. The project is not evaluated for riverine habitat.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
1.26	6.05	154.67	67	1

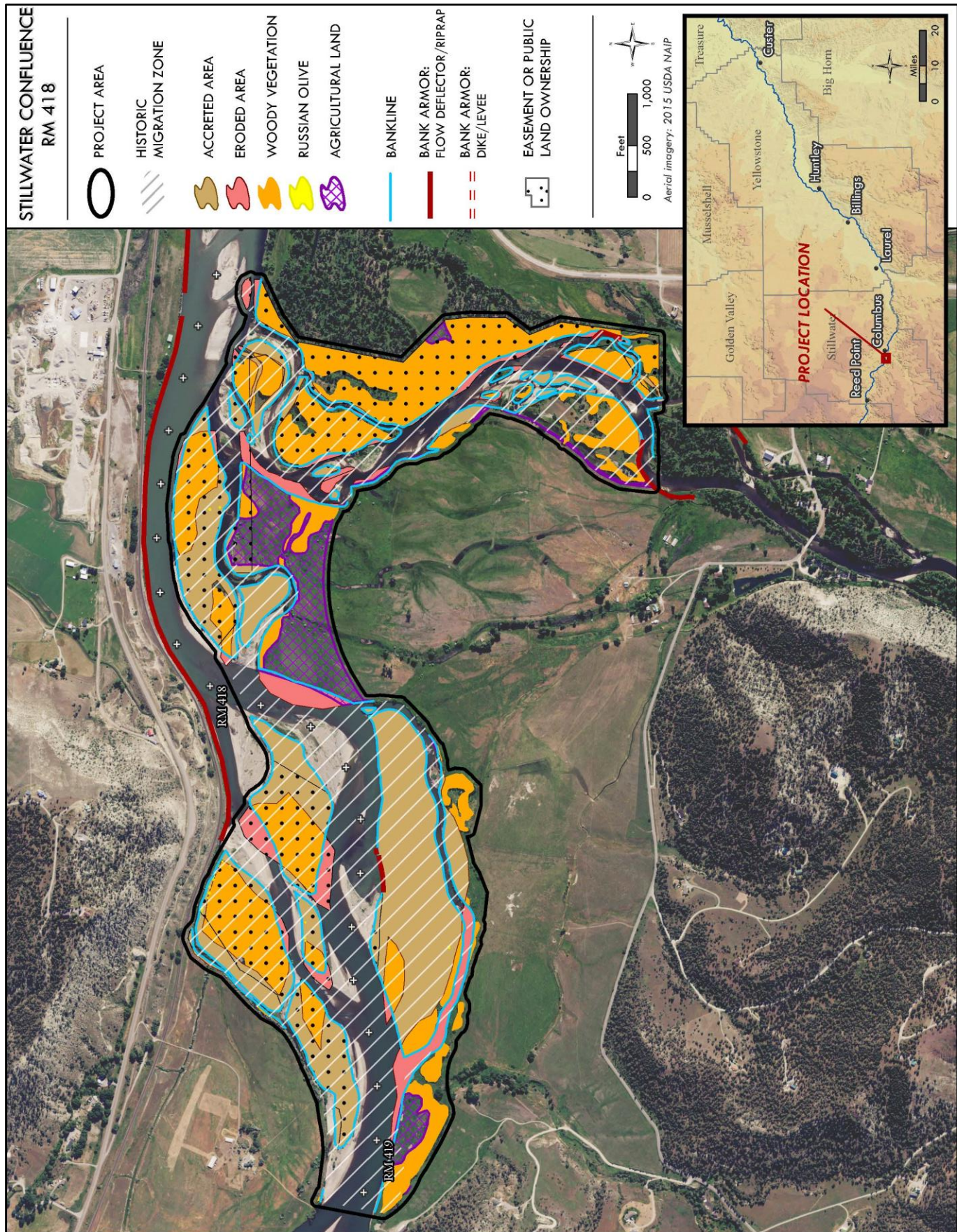


Figure 25. Stillwater Confluence RM 418, large woody debris project.

COUNTRYMAN CREEK

PROJECT TYPE	TIER
Large woody debris potential	middle

Project Summary

Countryman Creek is located at RM 420.4, upstream of Columbus, on right bank of the Yellowstone River. It is 35.4 miles upstream of the oil spill origin. The project area is 39.3 acres, one of the smallest projects. There are several small sections of bank armor on the opposite bank across from the project. The majority of the project ownership is uncertain (95%). There are three other landowners owning fringes of the project boundary, one of which is disconnected from the original parcel by the channel. There is no infrastructure within close proximity to the *Countryman Creek* project.

Project Highlights

- This project ranks in the middle tier among all large woody debris projects. Despite a high percentage of public ownership, erosion is one of the lowest for all large woody projects and there is very little woody vegetation.
- The project boundary captures a disconnected side channel area with long-term wood recruitment potential and follows the HMZ.
- The wood recruitment parameters, erosion and accretion, indicate the project is not very dynamic and even though the majority of the project is within the HMZ (99%) indicating the channel may migrate into the project in the future, available woody vegetation is very low (32.58 acres).
- There are no limiting factors.
- Despite having a higher percentage of public land (95%), the project is far from the oil spill origin. The project has no aquatic complexity because there are no active channels, and it has no apparent potential for multiple resource benefits in terms of recreation or terrestrial habitat. As the project footprint has a side channel that could be reactivated, it is also evaluated as a riverine habitat project type.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.09	0.39	32.58	99	0

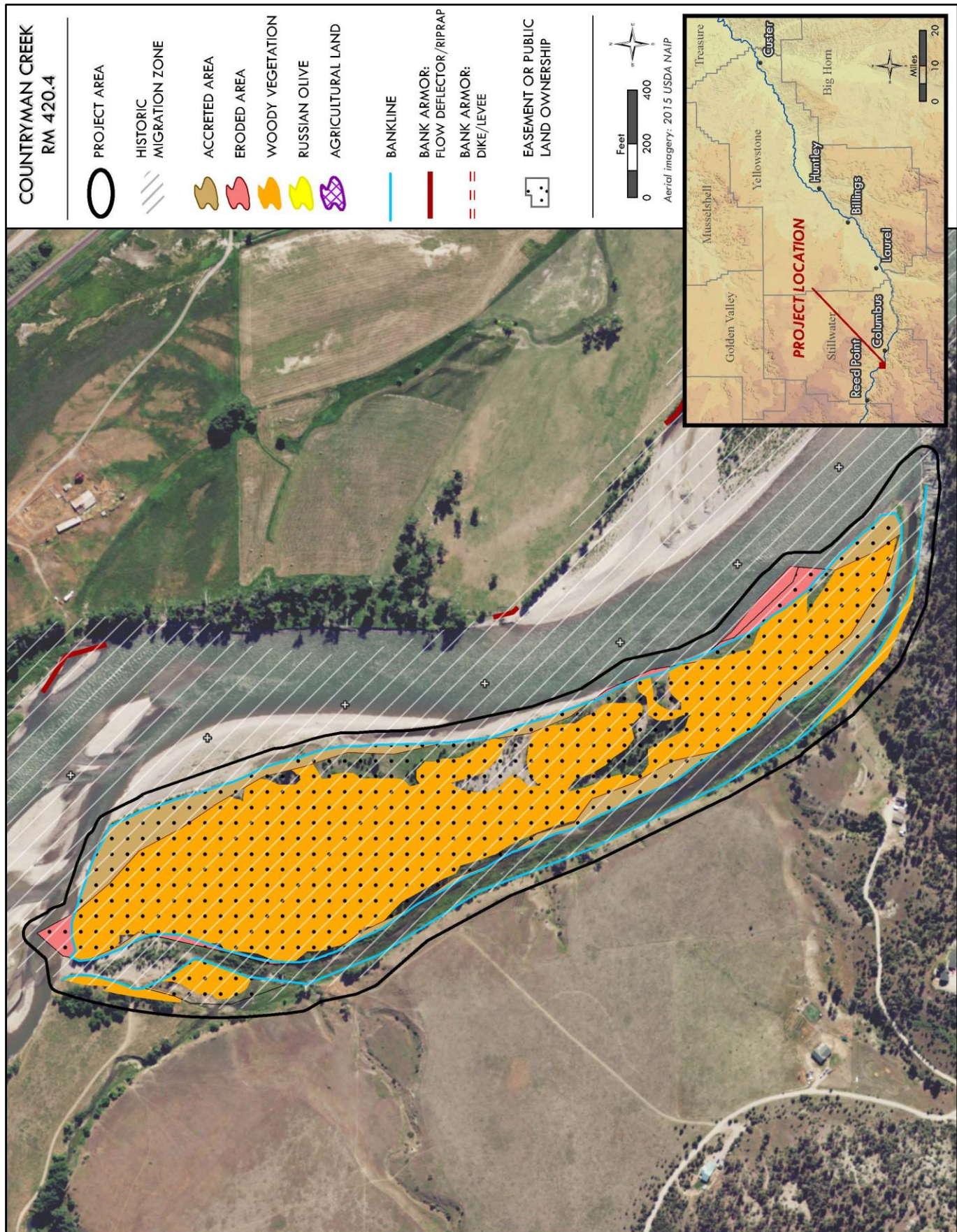


Figure 26. Countryman Creek RM 420.4, large woody debris project.

UPSTREAM of HOLMGREN FISHING ACCESS SITE (FAS)

PROJECT TYPE	TIER
Large woody debris potential	lower

Project Summary

Upstream of Holmgren Fishing Access Site (FAS) is located at RM 424, between Columbus and Reed Point, on left bank of the Yellowstone River. It is 39 miles upstream of the oil spill origin. The project is 163.3 acres. There is some bank armor on left bank upstream of the project where the river is within 100 feet of the rail line. Since 2005, over a thousand feet of bank armor has been eroded on the upstream end of the project at RM 424.5. The project includes only one landowner. The remainder of the project ownership is uncertain (17%). The project is up against the rail line and Interstate 90. There is no other infrastructure within close proximity to the *Upstream of Holmgren FAS* project.

Project Highlights

- This project ranks in the lowest tier among all large wood projects. Despite a lack of limiting factors and high percentage of public ownership, erosion and woody vegetation are low compared to other projects.
- The project boundary expands beyond the HMZ to capture a disconnected side channel and land with long-term wood recruitment potential. At the upstream end, the channel is already migrating beyond the HMZ within the project boundary.
- Erosion is 0.84 acres per year and accretion is 1.48 acres per year indicating there is some channel migration occurring in the project; however, only 26% of the project is within the HMZ.
- There is no bank armor, minimal Russian olive and only 1.2% agricultural land.
- The project is far from the point of injury and includes only 17% public or conservation land. The project has no aquatic complexity because it has no active side channels and has no apparent potential for multiple resource benefits in terms of terrestrial habitat and recreation. The project is also evaluated for riverine habitat.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.84	1.48	75.70	26	0.4

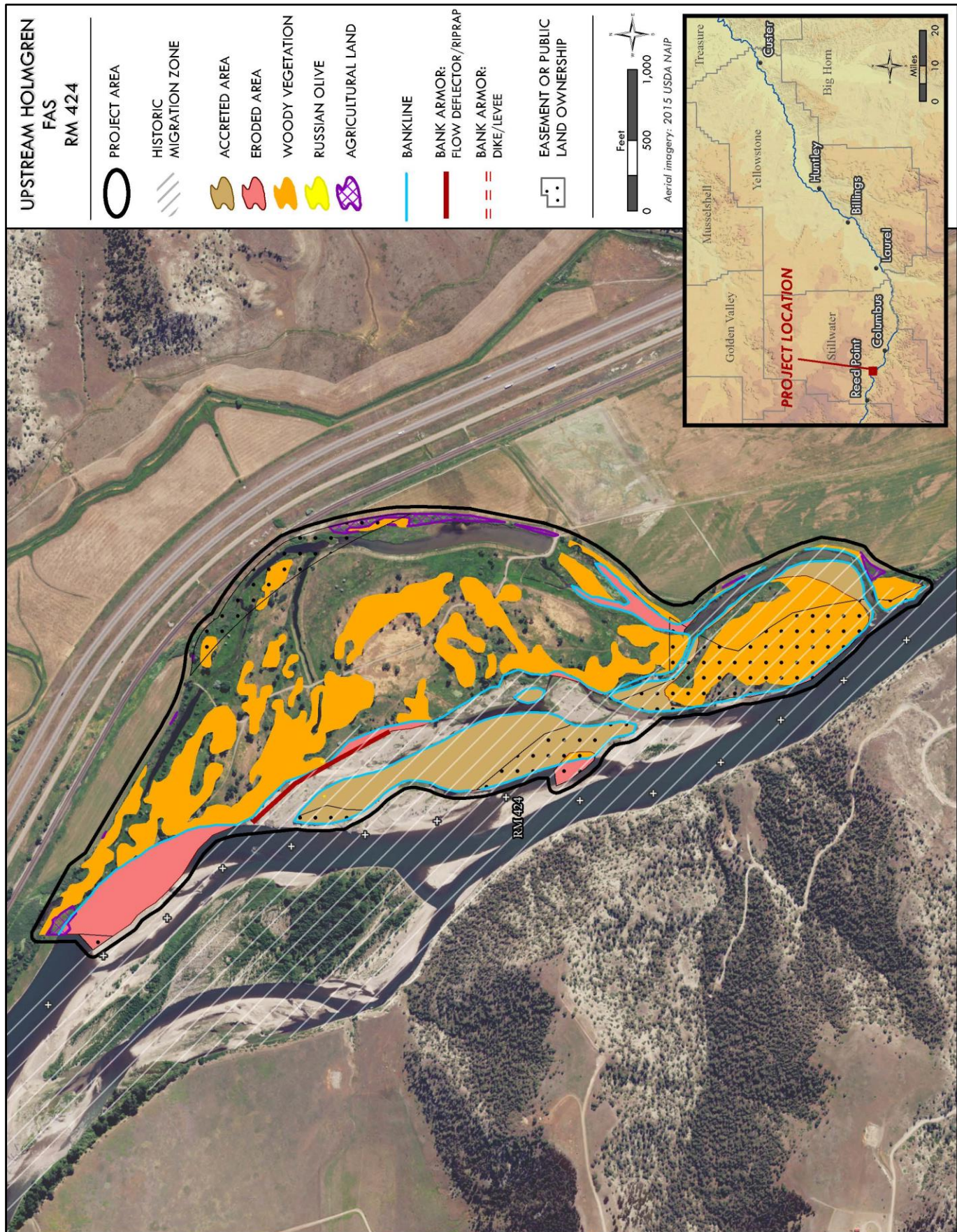


Figure 27. Upstream of Holmgren FAS RM 424, large woody debris project.

UPSTREAM of TWIN BRIDGES

PROJECT TYPE	TIER
Large woody debris potential	lower

Project Summary

Upstream of Twin Bridges is located at RM 430, just upstream of the I-90 bridge crossing. . It is 45 miles upstream of the oil spill origin. The project spans the channel and includes both portions of right and left bank as well as two islands in the Yellowstone River. The project area is 181.1 acres. About a mile of bank armor protects the rail line on the right bank in the lower portion of the project. The majority of the project ownership is uncertain (59%). There are two other landowners. The project is up against the rail line on the right bank. There is no other infrastructure within close proximity to the *Upstream of Twin Bridges* project.

Project Highlights

- This project ranks in the lowest tier among large wood projects. Though there is some erosion occurring in the project, only some of the project is within the HMZ and there is a large length of bank armor.
- The project boundary expands beyond the HMZ to capture land with long-term wood recruitment potential.
- Despite some erosion (0.59 acres per year) and some woody vegetation (116.23 acres), only 57% of the project is within the HMZ because the project is located in a narrow section of the Yellowstone River with confining geology on both sides.
- Although there is no bank armor, there are 8,434 square feet of Russian olive and there is 12.9% agricultural land.
- The project is far from the point of injury, includes 59% public or conservation land, has no aquatic complexity because there are no active side channels and has no apparent potential for multiple resource benefits in terms of terrestrial habitat, recreation and riverine habitat.

Erosion (acres/year)	Accretion (acres/year)	Woody vegetation (acres)	Area of project within HMZ (%)	Armored, diked or leveed banks (%)
0.59	1.39	116.23	57	0

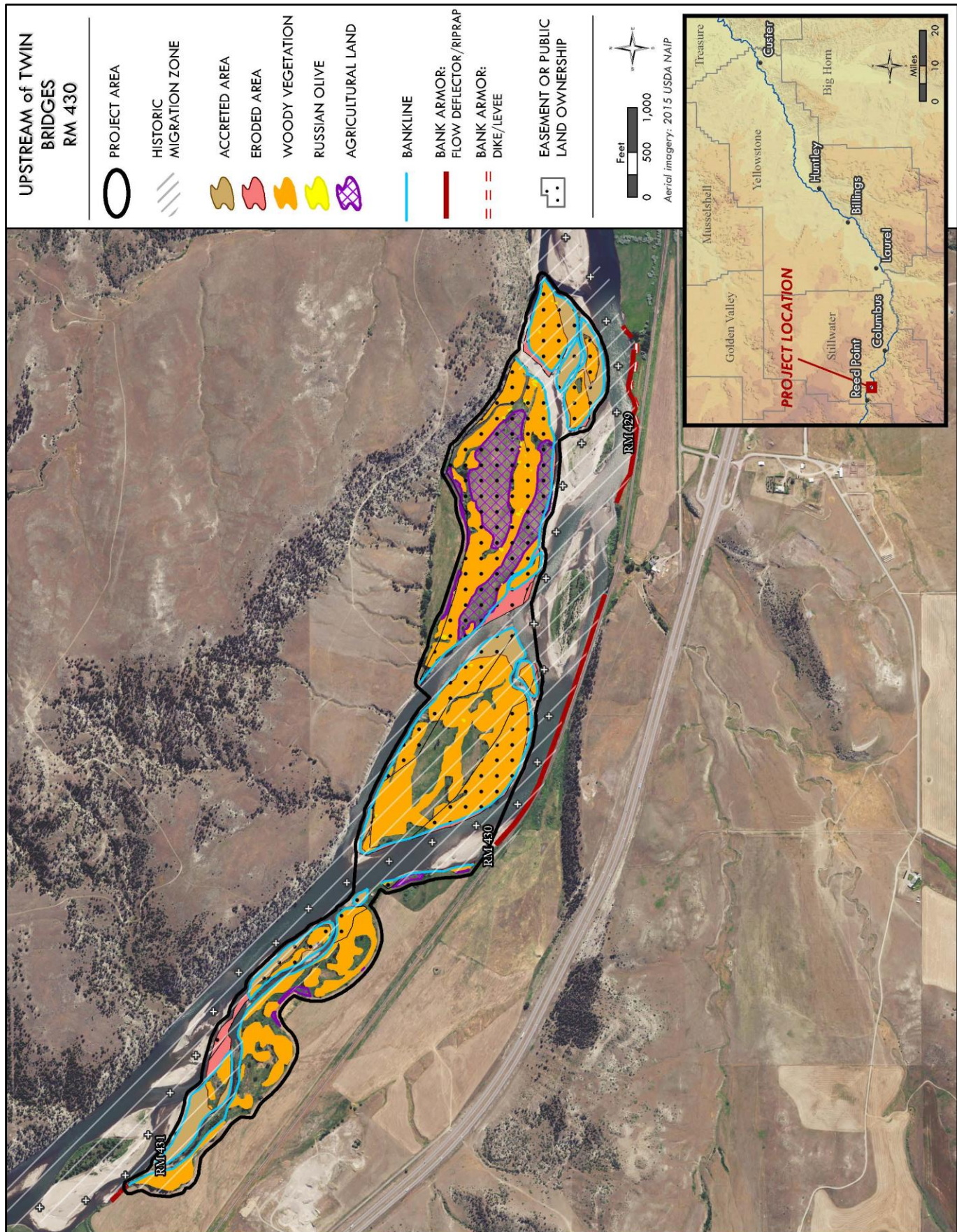


Figure 28. Upstream of Twin Bridges RM 430, large woody debris project.

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Riverine Habitat Projects

JUNCTION CITY

PROJECT TYPE	TIER
Riverine habitat potential	lower

Project Summary

Junction City is located at RM 305, near Custer, on the right bank of the Yellowstone River. It is 80 miles downriver of the oil spill origin. The project includes a side channel and associated riparian area which passes through agricultural land. The project area is 59.8 acres and includes 12,545 feet of disconnected off-channel habitat. This is one of six projects with more than 10,000 feet of disconnected off-channel habitat. The side channel was blocked prior to 1955 by a dike that is about 400 feet long. At the time the channel was blocked, it came off of the main thread of the Yellowstone River. The river has since shifted such that the head of the blocked side channel is connected to a smaller secondary thread of the Yellowstone, increasing its risk of hydrologic abandonment. There is irrigated agriculture on both sides of the channel, and several access roads cross it. There are two landowners, and there is no infrastructure in close proximity to *Junction City* project aside from access roads.

Project Highlights

- This project has one of the lowest ranks among all riverine habitat projects. Despite there being potential to reconnect a long side channel, the channel flows through agricultural land and is hydrologically disconnected from the Yellowstone River.
- The project boundary follows the riparian area and topography of the disconnected side channel that runs through agricultural land.
- While the blocked side channel is one of the longest among the riverine projects, only 29% of the project is inundated at the 2-year flow, and 99% of the project is outside the HMZ because the project is set away from the main channel, where migration typically occurs, and runs through agricultural land.
- The side channel blockage length is 181 feet, and 2% of bank length at the side channel entrance and outlet is armored. Russian olive is abundant.
- The project is far from the point of injury and includes no public or conservation land, has no active channels (low aquatic complexity), and has no apparent potential for multiple resource benefits in terms of large wood, recreation or terrestrial habitat.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
12,545	82	29	1	33	181	2

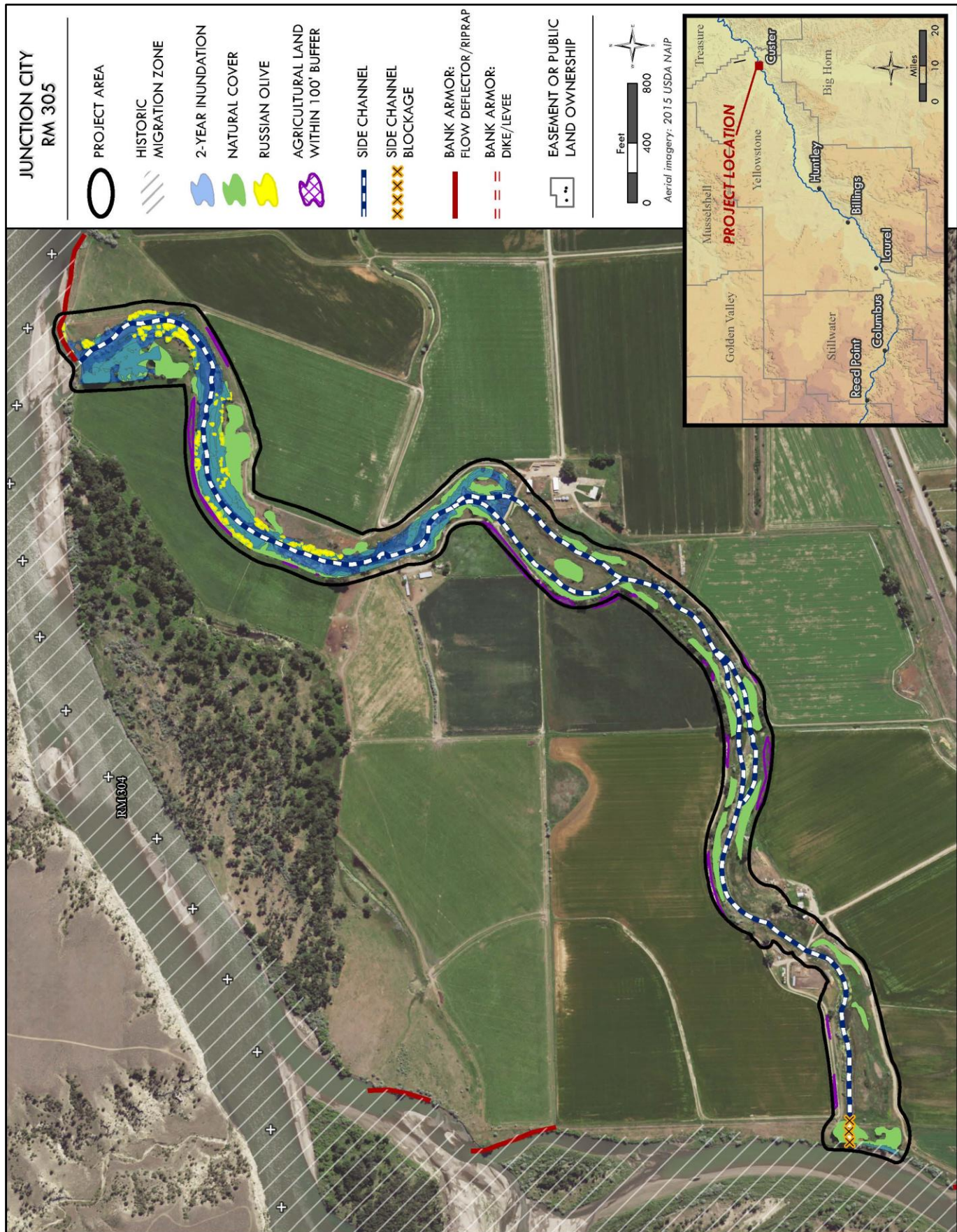


Figure 29. Junction City RM 305, riverine habitat project.

ROUGH COULEE

PROJECT TYPE	TIER
Riverine habitat potential	middle

Project Summary

Rough Coulee is located at RM 321, between Worden and Custer, on the right bank of the Yellowstone River. It is 64 miles downriver of the oil spill origin. The project extends beyond the rail line and frontage road to include a large, isolated, pond with potential for reconnection to the Yellowstone River. The project area is 184.2 acres and there are 6,908 feet of disconnected off-channel habitat. The habitat reflects an old meander of the Yellowstone River that was blocked by the rail line and frontage road by the 1950s. The downstream blockage includes a small drop inlet structure and dam that controls water surface elevations in the pond, but also blocks fish passage. The majority of the project is owned by two landowners, and a third landowner owns a small corner of the pond. The remaining ownership is uncertain. Infrastructure within close proximity to *Rough Coulee* project includes the rail line and frontage road as well as powerlines. The Waco-Custer Diversion is just downstream of the project.

Project Highlights

- This project ranks in the middle tier among all riverine habitat projects. While inherent river function and limiting factors are similar to higher ranking projects, distance from injury is high, public/conservation ownership is low, and additional resource benefits are not present.
- The project boundary includes a parcel of an interested landowner with a potential long-term wood source and extends beyond the rail line and frontage road to include a large, isolated, pond with potential for reconnection to the Yellowstone River.
- Vertical and lateral connectivity are low (34% and 18% respectively) because of the rail line and frontage road that isolate a large portion of the project. According to Montana Fish, Wildlife and Parks, the pond supports numerous fish species and may provide refugia and spawning habitat.
- The side channel blockage length is 174 feet, and 11% of the total bank length is armored. Russian olive is abundant.
- The project is far from the point of injury, includes 24% public or conservation land, and has an active channel, contributing to aquatic habitat complexity. It is not evaluated as a large wood project.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
6,908	97	34	18	49	174	11

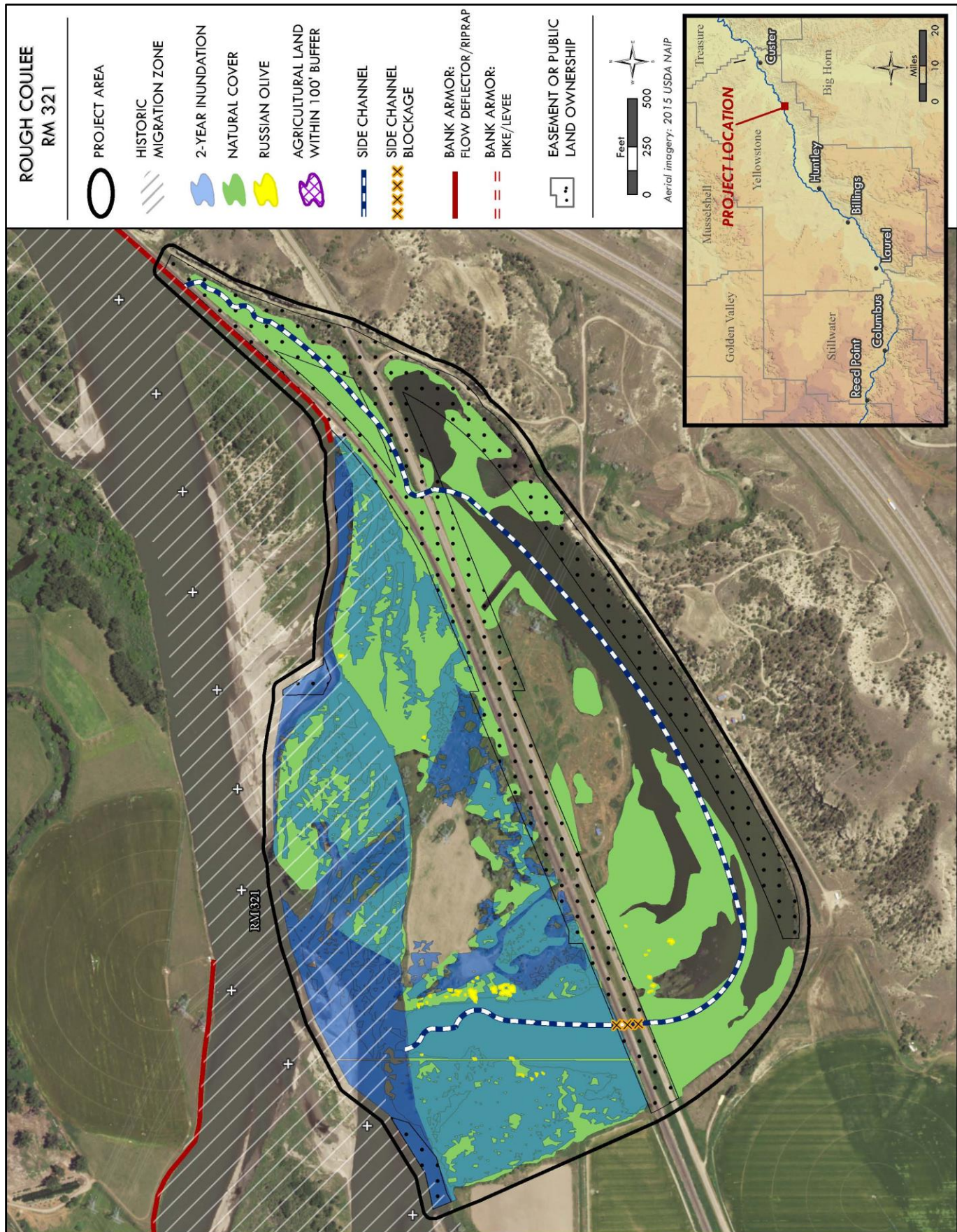


Figure 30. Rough Coulee RM 321, riverine habitat project.

PROJECT TYPE	TIER
Riverine habitat potential	lower

Project Summary

The *Mill Creek* project is located at RM 325, between Worden and Custer, on the Yellowstone River right bank. It is 60 miles downriver of the oil spill origin. The project includes a side channel and associated riparian area which passes mainly through agricultural land. The project area is 50.3 acres, and there are 12,502 feet of disconnected off-channel habitat with potential to be reconnected at the upper end. Fifty percent of the project area is owned by two landowners and there are five total landowners within the project. There is no infrastructure within close proximity to the *Mill Creek* project.

Project Highlights

- This project ranks in the lowest tier among all riverine habitat projects. Despite there being potential to reconnect a long side channel, the channel flows through agricultural land and is largely hydrologically disconnected from the Yellowstone River. There is no evidence of hydrologic connectivity between the river and side channel inlet since at least the 1950s.
- The project boundary includes a parcel owned by an interested landowner and follows the riparian area and topography of the disconnected side channel which passes mainly through agricultural land.
- Seventy-four percent of the project is inundated at the 2-year flow, and 93% of the project is outside the HMZ.
- The side channel blockage length is 515 feet and no bank armor is present. Russian olive is present but not dominant.
- The project is far from the point of injury, includes no public or conservation land, has minor aquatic complexity, and has potential for multiple resource benefits in terms of terrestrial habitat. This project is not evaluated as a large wood project.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
12,502	88	74	7	31	515	0

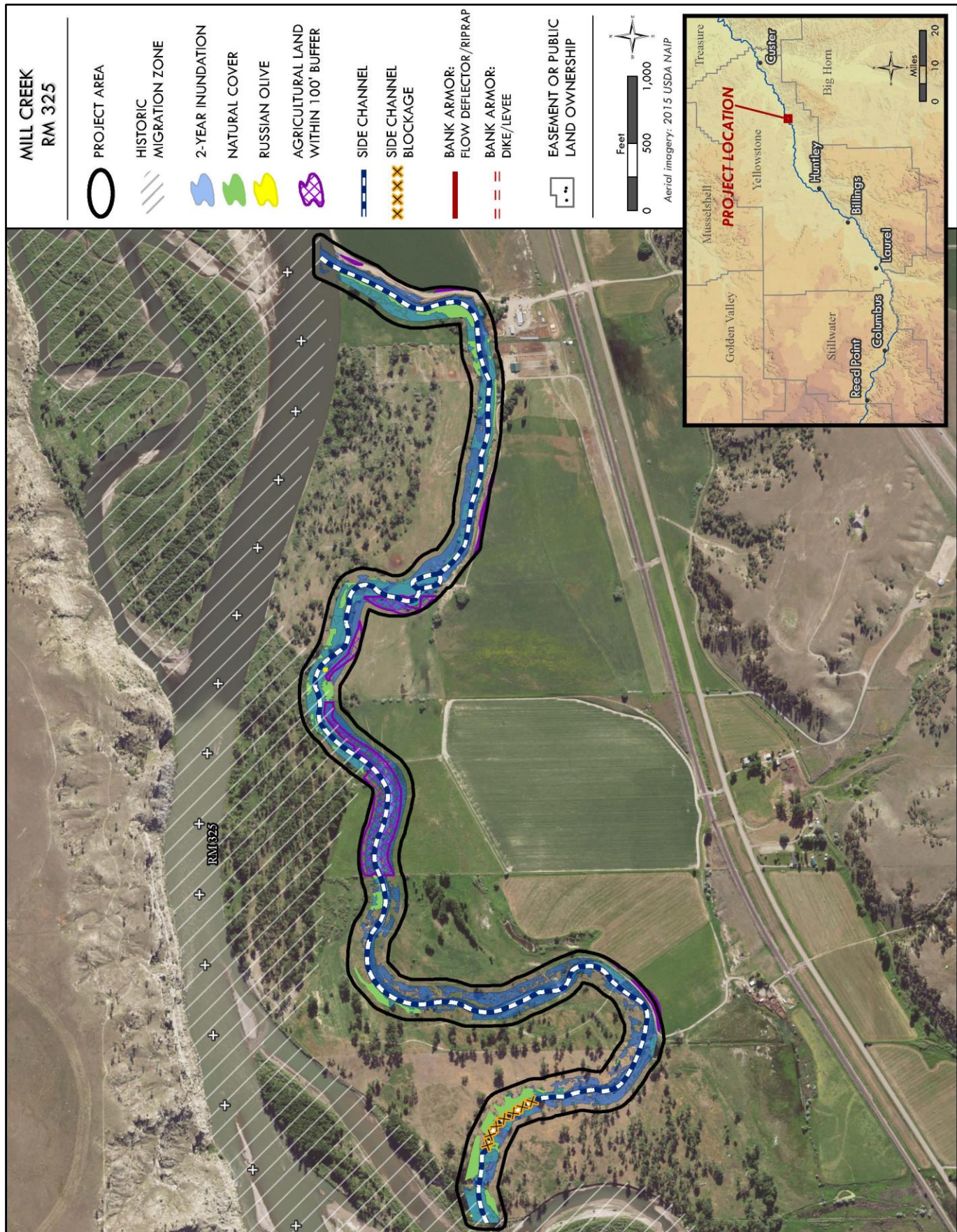


Figure 31. Mill Creek RM 325, riverine habitat project.

BUREAU of RECLAMATION (BOR)

PROJECT TYPE	TIER
Riverine habitat potential	lower

Project Summary

Bureau of Reclamation (BOR) is located at RM 347, upstream of Worden, on the right bank of the Yellowstone River. It is 38 miles downriver of the oil spill origin. The project includes a side channel and associated riparian area which passes along the edge of agricultural land. The project area is 66.9 acres and there are 9,591 feet of disconnected off-channel habitat. There are a total of seven landowners, but the majority of the project area is owned by three landowners with the Bureau of Reclamation owning approximately 6%. There is also a small portion (9%) where ownership is uncertain. There is no infrastructure within close proximity to the *BOR* project.

Project Highlights

- This project ranks in the lowest tier among all riverine habitat projects. While there is potential to reconnect a 9,951 feet side channel, the channel is adjacent to agricultural land and is only somewhat hydrologically connected to the Yellowstone River. Ownership is mostly private and fragmented.
- The project boundary includes a parcel owned by the Bureau of Reclamation and follows the riparian area and topography of a disconnected side channel that runs through agricultural land. A portion of the downstream boundary falls within the HMZ and supports patches of dense riparian forest.
- Fifty-six percent of the project is inundated at the 2-year flow. Unlike other isolated side channel projects, this project runs along agricultural land rather than within it and is located at a lower elevation and within the HMZ (38%). Perennial surface water is also high.
- The side channel blockage length is 320 feet, and 21% of the bank length is armored. The side channel entry point appears to have been armored by concrete rubble in 2001; however, that armor has evidently failed and the river has migrated about 70 feet towards the side channel blockage since then. Russian olive is abundant.
- The project is far from the point of injury, includes some public or conservation land, lacks aquatic complexity, and has no apparent potential for multiple resource benefits in terms of terrestrial habitat, recreation or large wood.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
9,591	91	56	38	75	320	21

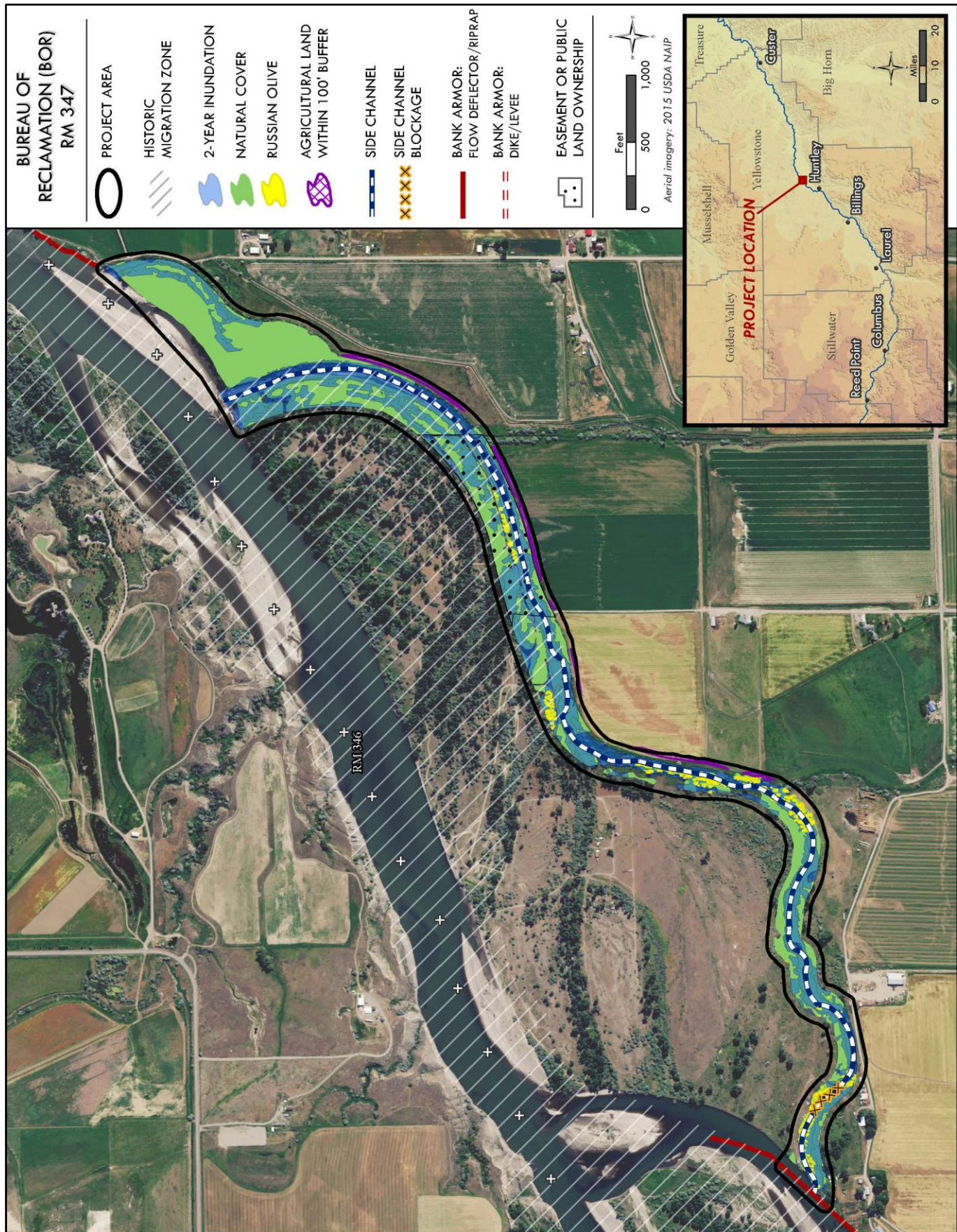


Figure 32. BOR RM 347, riverine habitat project.

12 MILE CREEK

PROJECT TYPE	TIER
Riverine habitat potential	lower

Project Summary

12 Mile Creek is located at RM 354.8, at Huntley, on the Yellowstone River left bank. It is 30.2 miles downriver of the oil spill origin. The project includes a side channel and associated riparian area which passes through agricultural land. The project area is 71.7 acres, and there are 11,107 feet of disconnected off-channel habitat with potential to be reconnected at the upstream end. The head of the side channel is blocked by both concrete armor and a dike, which appear to have been constructed in the early-1970s. The majority of the project area is owned by one landowner. The remaining ownership is uncertain. There is no infrastructure within close proximity to *12 Mile Creek* project.

Project Highlights

- This project ranks in the lowest tier among riverine habitat projects. While there is opportunity to reconnect over 11,000 feet of side channel, the area is entirely outside the HMZ, is largely agricultural, and is privately owned. Even in the 1950s when the head of the channel was open, the channel footprint was small and vegetated, suggesting that it was rarely accessed by Yellowstone River flows.
- The project boundary follows the riparian area and topography of the disconnected side channel that runs through agricultural land.
- Similar to other side channel projects, vertical connectivity is high (74% of the area is connected at the 2-year flow), and lateral connectivity is low with 0% of the project being within the HMZ. Natural cover is only 38% because the project runs through agricultural land.
- The side channel blockage length is 220 feet, and 437 feet of bank armor are present, located at the side channel inlet (riprap and a levee). No Russian olive is mapped in this project area.
- The project includes little public or conservation land, lacks aquatic complexity, and has no apparent potential for multiple resource benefits in terms of terrestrial habitat, recreation and riverine habitat.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
11,107	88	74	0	38	220	103

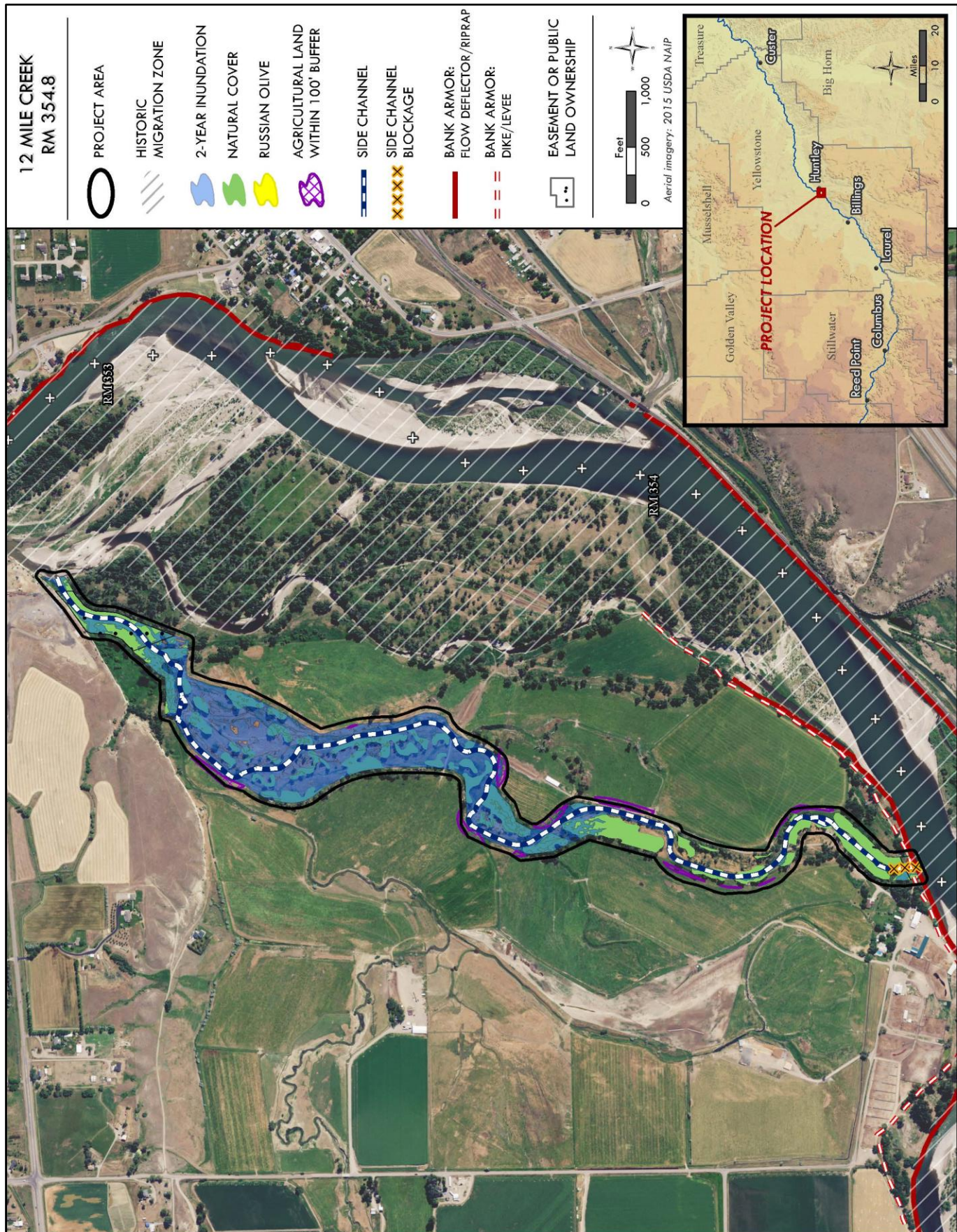


Figure 33. 12 Mile Creek RM 354.8, riverine habitat project.

DOVER ISLAND

PROJECT TYPE	TIER
Riverine habitat potential	upper

Project Summary

Dover Island is located at RM 359, downstream of Billings, on the left bank of the Yellowstone River. It is 26 miles downriver of the oil spill origin. On the opposite bank the rail line runs close to the channel and the bank is heavily armored. The project area is 125.7 acres and there are 4,638 feet of disconnected off-channel habitat. The majority of the project is owned by a single landowner and is under a conservation easement. There are three other landowners who own small percentages of the project area, and there are some areas where ownership is uncertain. There is no infrastructure within close proximity to the *Dover Island* project.

Project Highlights

- This project ranks in the upper tier among all riverine habitat projects. The project is located within the zone of active river process, so it is connected with the river.
- The project boundary includes parcels of two interested land owners and extends beyond the HMZ on the upstream end to include dense riparian forest protected by bank armor under the premise that the bank armor could be removed. The boundary excludes agricultural land within a conservation easement because this land does not provide either a potential large woody debris source or riverine habitat. The boundary also includes two islands protected by a conservation easement or of unknown ownership with long-term wood recruitment potential.
- Vertical and lateral connectivity are 41% and 86% respectively. While the disconnected side channel is relatively short (4,638 feet), several other connected side channels are present. The disconnected channel appears to have been blocked around the mid-1970s; it currently receives irrigation return flows from agricultural fields to the west. The blockage is at the very downstream end of a floodplain dike that closely follows the left river bank for about 1,800 feet.
- The side channel blockage length is 152 feet, and 9% of bank length is armored. Russian olive is present.
- The project includes 94% public or conservation land, has some aquatic complexity in the form of multiple active channels, and has high potential for multiple resource benefits in terms of terrestrial habitat, recreation and riverine habitat. The project is also evaluated as a large woody debris project.

Length of disconnected off-channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
4,638	89	41	86	75	152	9

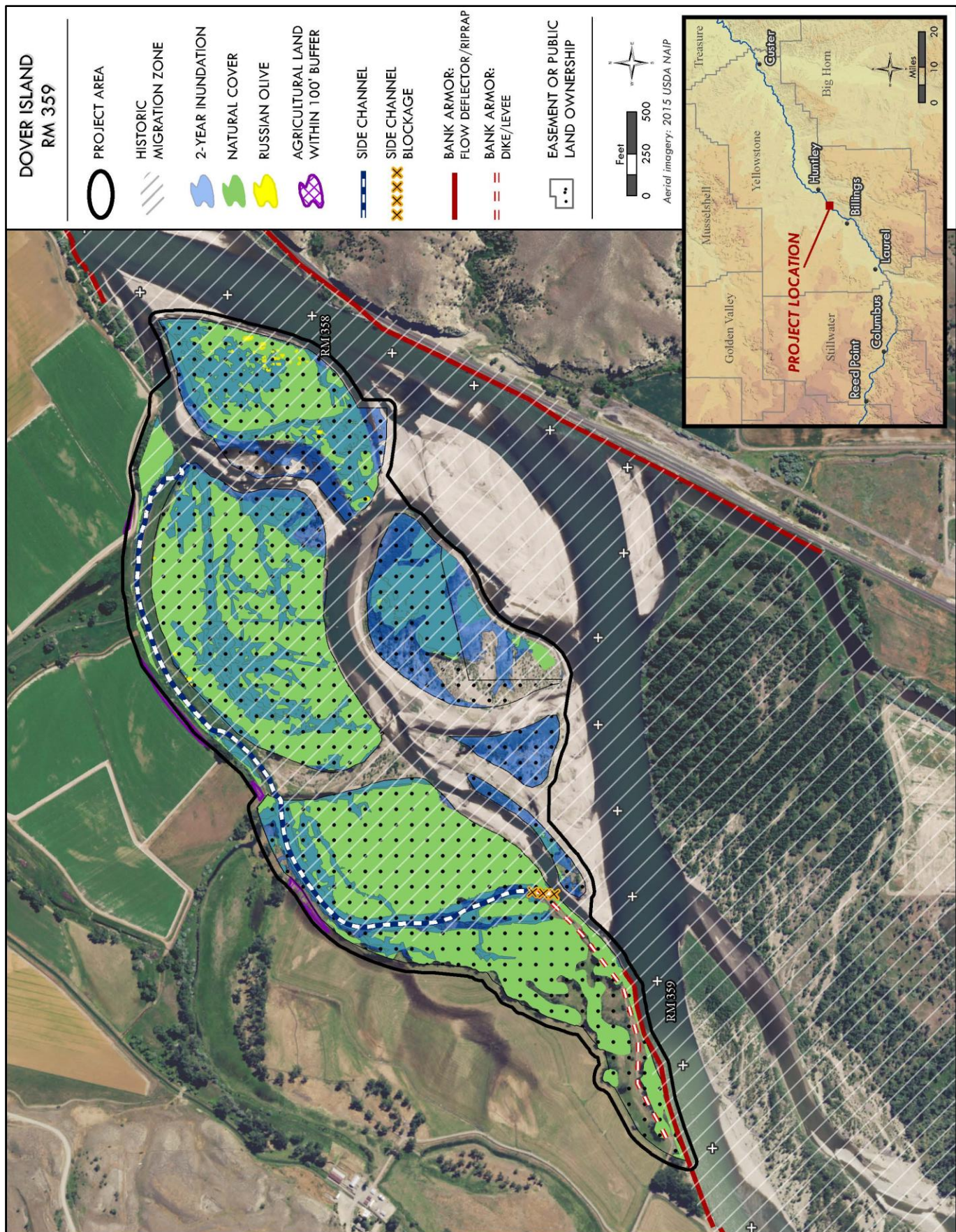


Figure 34. Dover Island RM 359, riverine habitat project.

PROJECT TYPE	TIER
Riverine habitat potential	middle

Project Summary

Jellison Road is located at RM 372.5, in Billings, on right bank of the Yellowstone River just upstream of the South Billings Boulevard Bridge and just north of the Billings landfill. It is 12.5 miles downriver from the oil spill origin. This site contains a major historic floodplain/side channel isolation effort that was initiated sometime between 1950 and 1976, when a long dike complex was constructed to block a major Yellowstone River thread and isolated extensive wooded floodplain area from the river. In the 1950s the site had about three miles of perennial Yellowstone River channel length, indicating the potential for several miles of channel reactivation. These channel remnants have been dissected by sand and gravel pits, haul roads, and other blockages. The opposite bank is armored with riprap. The project area is 377.2 acres, one of the largest projects, and there are 13,409 feet of disconnected off-channel habitat, the most linear feet of disconnected off-channel habitat. The majority of this project is owned by a single landowner. There are four other landowners each owning 5% or less of the project area. The remaining ownership is uncertain. There is no other infrastructure in close proximity to the project.

Project Highlights

- This project ranks in the middle tier among all riverine habitat projects. While there is potential to reconnect a long and multi-thread historical side channel, the large side blockage and extensive bank armor contribute to one of the highest limiting factor scores of all riverine habitat projects.
- The project boundary captures the disconnected and disturbed side channel within the HMZ and extends beyond the HMZ following a topographic break.
- Hydraulic modeling indicates that a large portion of the project is inundated at the 2-year flow (62%), although the overflow points are limited due to the floodplain dike. Ninety percent of the project is within the HMZ, which reflects the extent of active river corridor that has been lost since the 1950s. Natural cover is very low (30%); however, it was denser historically.
- The side channel blockage length is high (573 feet) and the combined lengths of the bank armor and floodplain dike exceeds the total bank length.
- The project includes only 10% public or conservation land and the high cost associated with bank armor reduces the estimated benefit to cost ratio. The project has some backwatering in side channels, contributing to minor aquatic habitat complexity. The project is also evaluated as a large woody debris project.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
13,409	82	62	90	30	573	114

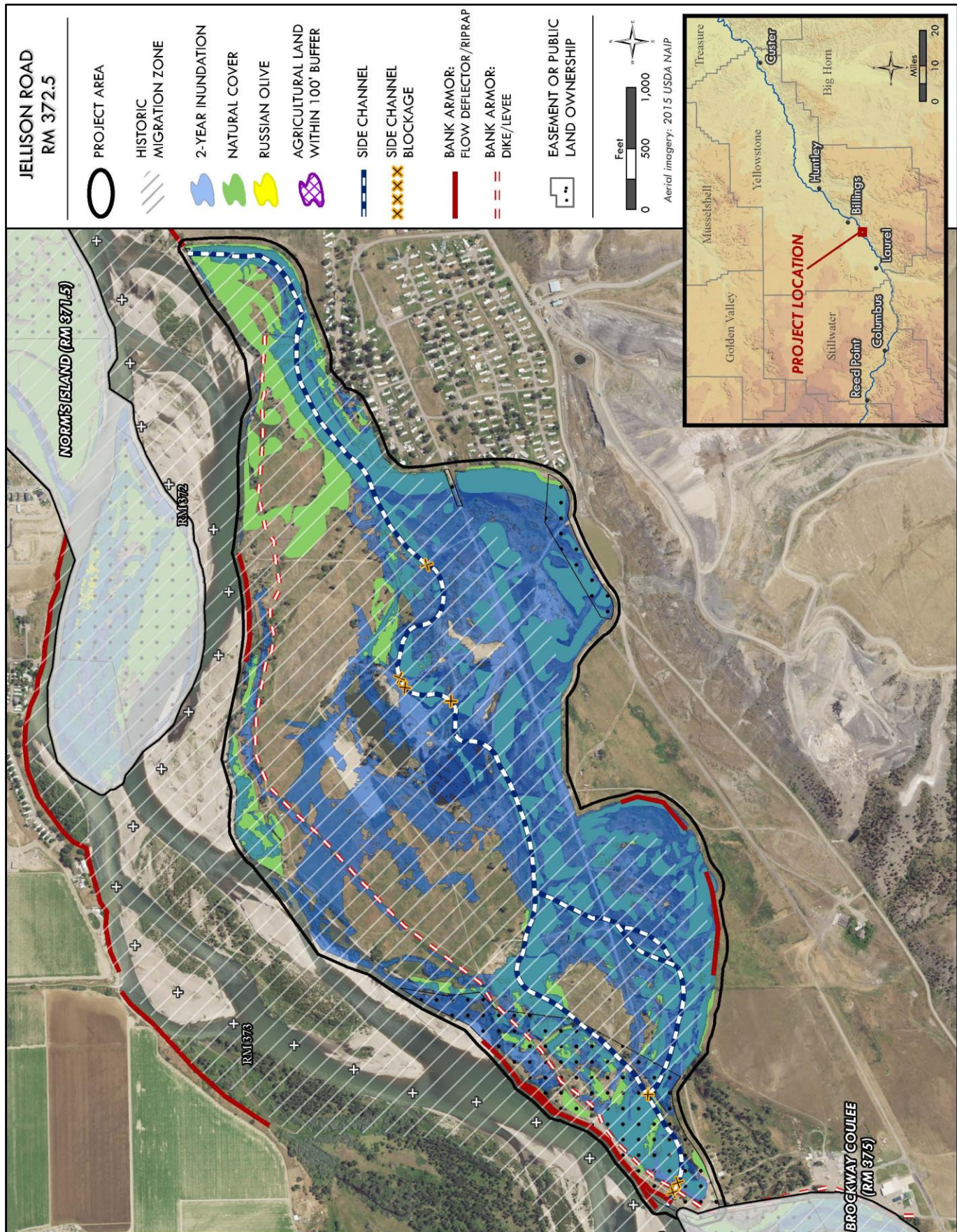


Figure 35. Jellison Road RM 372.5, riverine habitat project.

WEST of DUCK CREEK BRIDGE

PROJECT TYPE	TIER
Riverine habitat potential	upper

Project Summary

West of Duck Creek Bridge is located at RM 380, upstream of Billings, on the left bank of the Yellowstone River. It is 8 miles downriver of the oil spill origin. The opposite bank is heavily armored. The project area is 132.1 acres, one of the smallest projects, and there are 10,193 feet of disconnected off-channel habitat. Riverine habitat consists of two intersecting side channels that are both blocked on their upper end by floodplain dikes. The uppermost channel was originally blocked at RM 380.8 in the early 1970s, and after that blockage eroded out, it was rebuilt about 100 feet northward by 1995. The downstream blockage was added between 1976 and 1995. This is one of six projects with more than 10,000 feet of disconnected off-channel habitat. Approximately half of the project is owned by a single landowner, the other half is uncertain. There is no infrastructure within close proximity to *West of Duck Creek Bridge* project.

Project Highlights

- This project ranks in the upper tier among all riverine habitat projects. The main difference between this and higher ranked projects is a low linear footage of perennial surface water.
- The project boundary captures all disconnected side channels. The boundary follows the HMZ, but extends beyond the HMZ in several locations to capture areas of potential long-term wood recruitment.
- The 2-year flow inundates 52% of the project area primarily along historical side channels and natural cover is high (86%) a portion of which is wooded. The disconnected side channel length is long because of a split channel and two potential locations for reconnection.
- The side channel blockage length is 169 feet and split into two locations and 21% of the banks are armored. Russian olive is present as is a very small amount of agricultural land.
- The project includes only 52% public or conservation land, has a high likelihood of success (based on ratio of inherent river function to limiting factors) and has some aquatic habitat complexity from side channels that backwater at the 2-year flow. The project is also evaluated as a large woody debris project.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
10,193	63	52	84	86	169	21

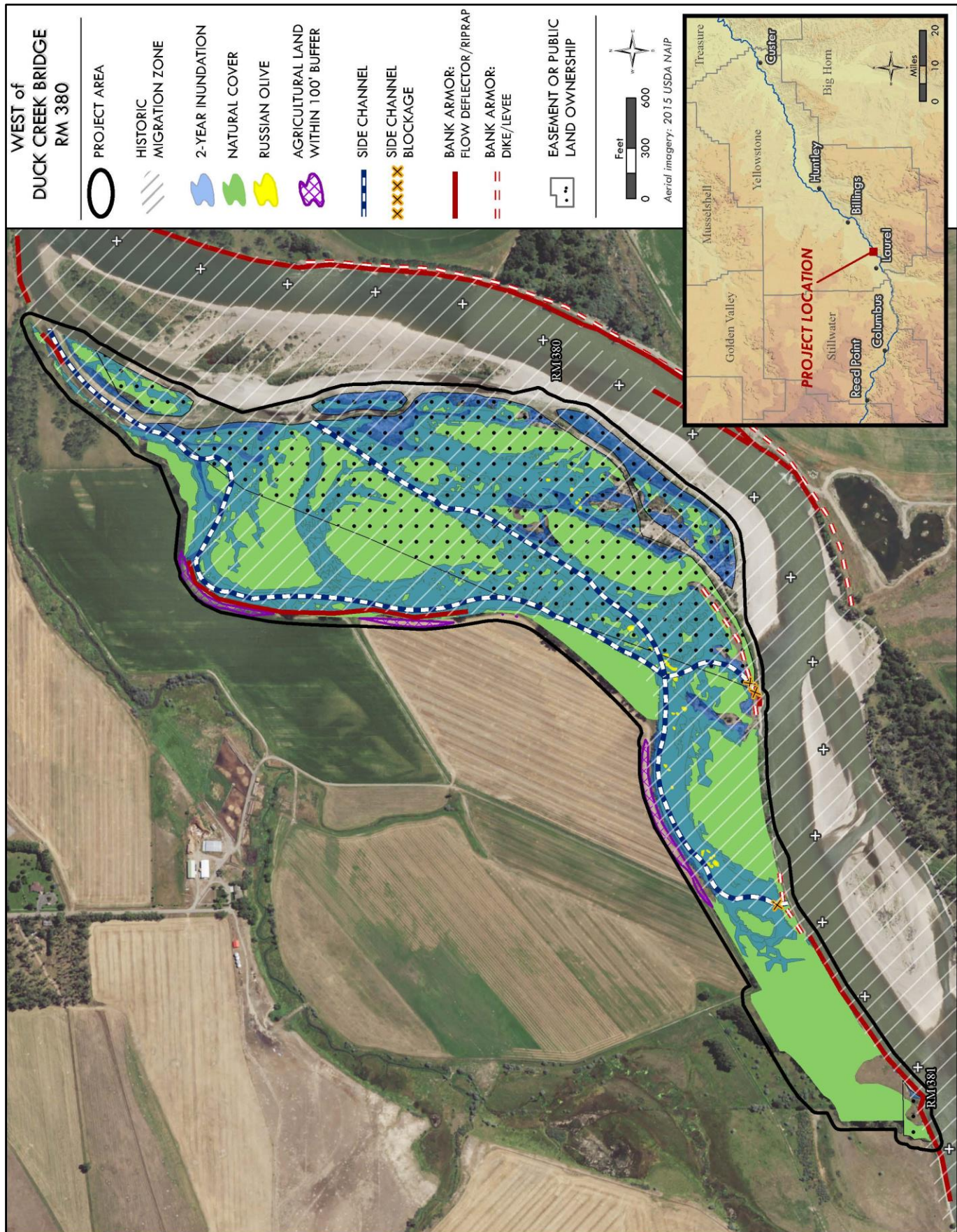


Figure 36. West of Duck Creek Bridge RM 380, riverine habitat project.

BUFFALO MIRAGE

PROJECT TYPE	TIER
Riverine habitat potential	upper

Project Summary

Buffalo Mirage is located at RM 391, upstream of Laurel. It is 6 miles upstream of the oil spill origin. The project spans the channel and includes portions of the right and left banks of the Yellowstone River. The project area is 252.4 acres and the riverine habitat consists of 6,089 feet of disconnected off-channel habitat on the north side of the river through private land and the Buffalo Mirage Fishing Access Site. A large portion of the isolated side channel is inundated at the 2-year flow, and the lower portion has surface water present at lower discharges. The upstream connectivity of the channel was lost sometime prior to 1950, and there are currently remnants of flanked riprap in the river at the head of the channel. As recently as 2005 a house and outbuildings were located at the head of the side channel, but these structures were moved due to northward river erosion at RM 392.1. Just downstream of the project, both sides of the channel are armored. There are six landowners in this project. The majority of ownership is uncertain (43%), followed by a single landowner with 26% ownership. There is no infrastructure within close proximity to the *Buffalo Mirage* project.

Project Highlights

- This project ranks in the upper tier among all riverine habitat projects despite a short disconnected off-channel habitat length and high limiting factors.
- The project boundary captures the disconnected side channel and follows the HMZ and topography to include areas with long-term wood recruitment potential.
- Forty percent of the project area is inundated at the 2-year flow, 93% of the project is within the HMZ and there is 75% natural cover with high potential to grow woody vegetation.
- The side channel blockage is 174 feet. There are 17,880 square feet of Russian olive and 19.7 % of the land within a 100ft buffer of the side channel is agricultural.
- The project includes a large portion of public or conservation land (66%). The likelihood of success and benefit to cost ratio are not as high as other projects because of limiting factors. The project also includes high aquatic complexity because of an active side channel on right bank. The project is also evaluated as a large woody debris project.

Length of disconnected off-channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
6,089	92	40	93	75	174	2

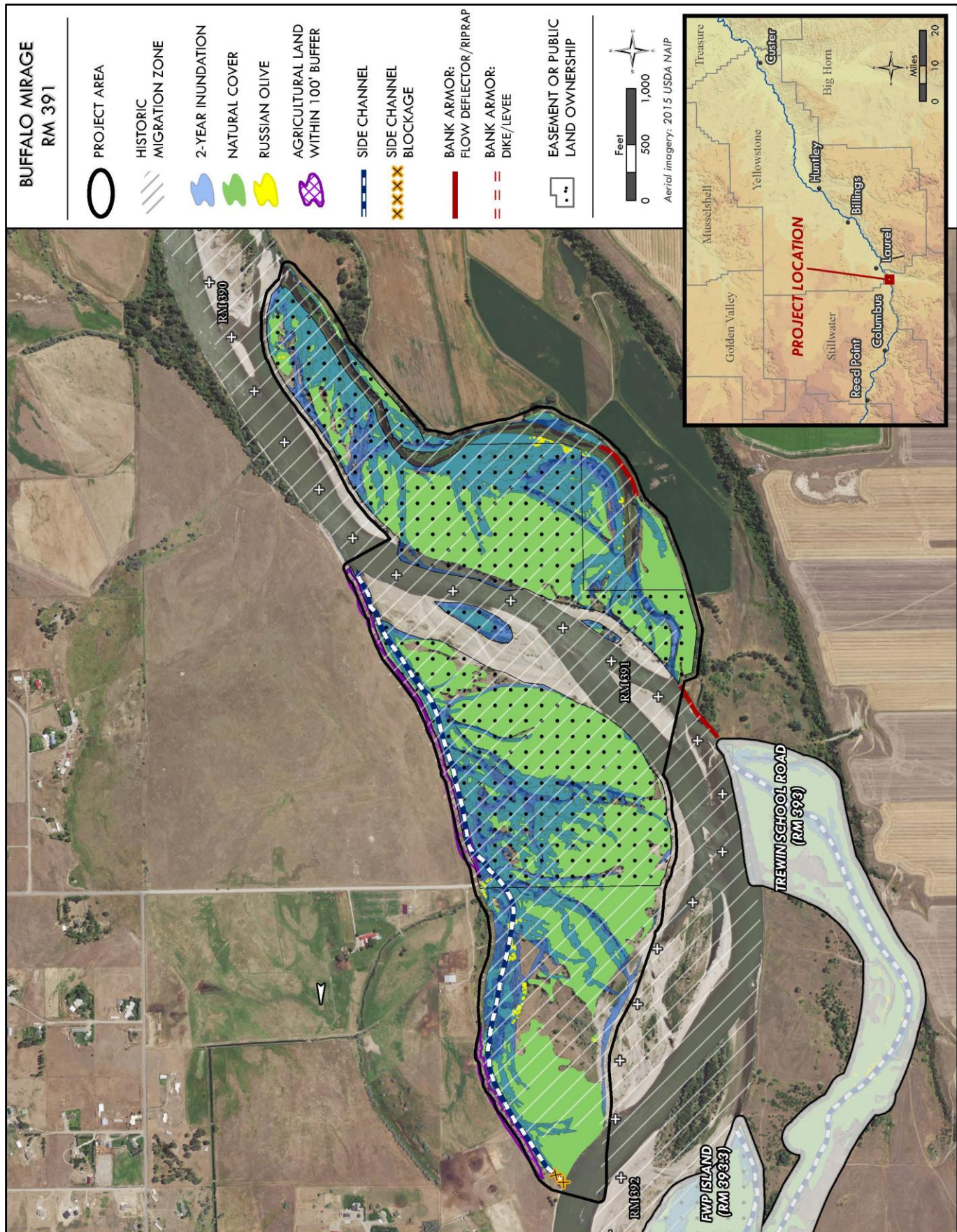


Figure 37. Buffalo Mirage RM 391, riverine habitat project.

TREWIN SCHOOL ROAD

PROJECT TYPE	TIER
Riverine habitat potential	lower

Project Summary

Trewin School Road is located at RM 393, southeast of Park City, on the right bank and south floodplain of the Yellowstone River. It is 8 miles upstream of the oil spill origin. The project consists of a blocked side channel that is almost two miles long. The channel lost connectivity with the main river sometime prior to 1950, and has been decaying ever since. Floodplain area between the channel and river has been cleared for agriculture, although the channel remnant still supports a narrow discontinuous thread of woody vegetation. The project area is 82.7 acres, one of the smallest projects. The side channel sits on a low terrace and includes the surrounding riparian area. This is one of six projects with over 10,000 feet of disconnected off-channel habitat. The majority of this project is owned by a single landowner (64%), followed by a second landowner with 35% ownership. The remaining ownership is uncertain and less than 1% of the project (at the downstream end) is owned by the State of Montana. There is no infrastructure within close proximity to the *Trewin School Road* project.

Project Highlights

- This project ranks in the lower tier among all riverine habitat projects, despite a long disconnected off-channel habitat length. Perennial surface water, little area of inundation at the 2-year flow and its location entirely outside the HMZ greatly reduce the inherent river function. The project is hydrologically disconnected from the Yellowstone River.
- The project boundary follows the riparian area and topography of the disconnected side channel and sits on a low terrace.
- Only 12 % of the project is inundated at the 2-year flow, primarily at the downstream end of the side channel, and none of the project is within the HMZ because the channel sits on a low terrace. Only half of the disconnected off-channel habitat channel has surface water present.
- The side channel blockage is 341 feet. There are 8,781 square feet of Russian olive and there is no bank armor in the project.
- The project is close to the point of injury, includes only 1% public or conservation land and the likelihood of success and benefit to cost ratio are not as high as other higher ranking projects because of limiting factors. The project has no apparent potential for multiple resource benefits because the project was not evaluated as a large wood project and has no additional aquatic complexity because the project is isolated to the riparian area surrounding the existing channel.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
10,478	52	12	0	70	341	0

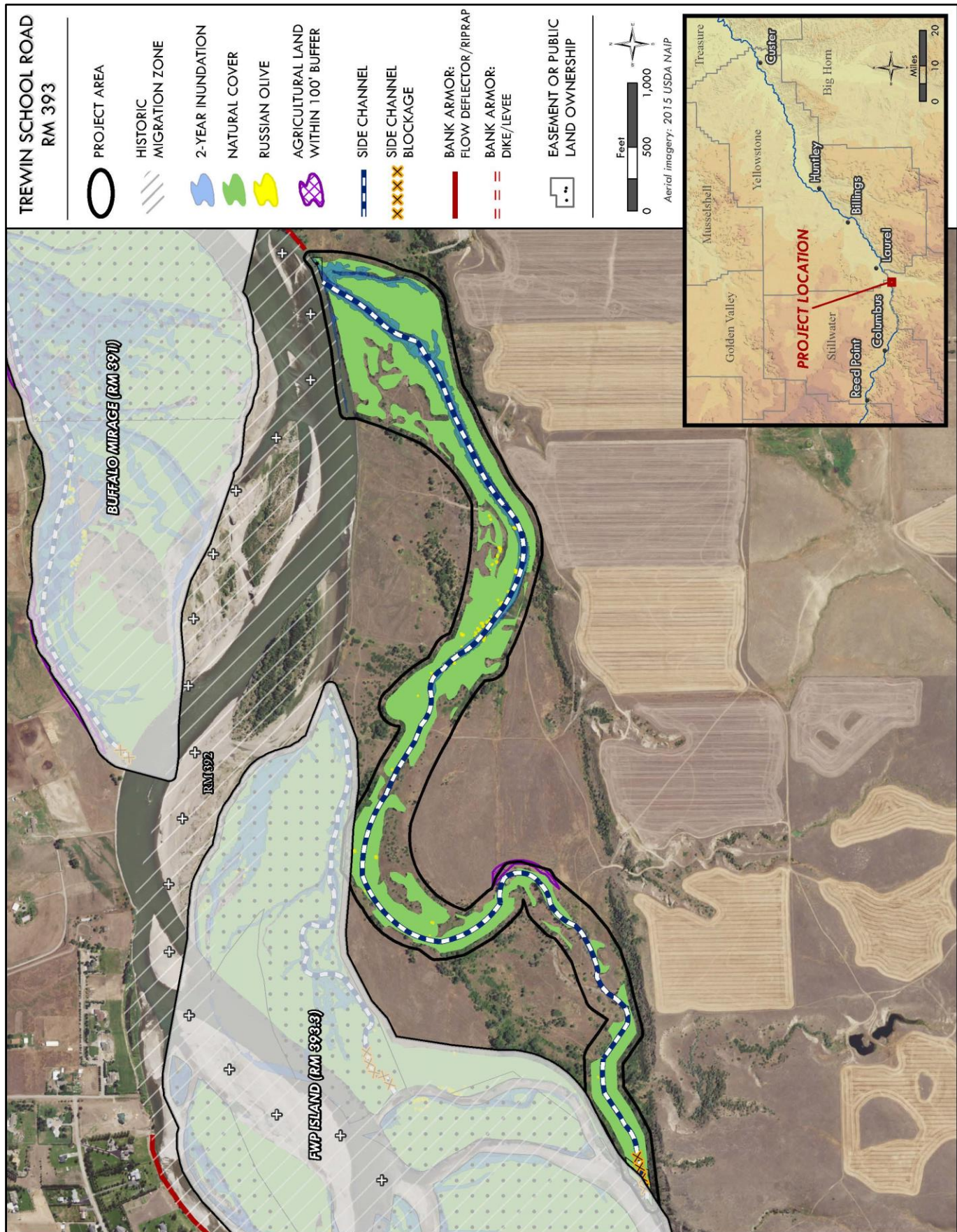


Figure 38. Trewin School Road RM 393, riverine habitat project.

FISH, WILDLIFE & PARKS (FWP) ISLAND

PROJECT TYPE	TIER
Riverine habitat potential	middle

Project Summary

Fish, Wildlife & Parks (FWP) Island is located at RM 393.3, near Park City, upstream of Laurel. It is 6 miles upstream of the oil spill origin. The project consists of a relatively short side channel that has lost connectivity with the river at its upstream end. The side channel is within a broader project polygon that spans the channel and includes islands and portions of the right and left banks of the Yellowstone River. Portions of the left bank outside the project are armored. The project area is 456.0 acres, one of the largest projects. There are six landowners in this project. The majority of the project ownership is uncertain (42%) and Montana Fish, Wildlife and Parks owns 36% of the project. There is no infrastructure within close proximity to the *FWP Island* project; however, one of the islands is used as a camping and fishing area and there is a dirt boat ramp on the left bank outside the project.

Project Highlights

- This project is in the middle tier among all riverine habitat projects. The project has potential to reconnect only a small length of side channel and the side channel blockage is long.
- The project boundary includes parcels of several interested landowners and follows the HMZ. The boundary expands beyond the HMZ to include a disconnected side channel and areas with long-term wood recruitment potential. The boundary does not include portions of the left bank with armor protecting residential property.
- Eighty-six percent of the project is within the HMZ and only 21% of the project is inundated at the 2-year flow. Only 34% of the disconnected side channel has perennial surface water, probably because the side channel originates from another side channel. Natural cover is high (80%) with a mosaic of herbaceous areas.
- The side channel blockage is 394 feet; however, there is no bank armor. The blockage is broad and may reflect floodplain aggradation and associated passive loss of connectivity. The river is currently eroding into the blockage at RM 392.6, such that connectivity will naturally increase with time. Russian olive is abundant and there is no agricultural land.
- The project is close to the point of injury, includes a high percentage of public or conservation land (78%) and the estimated benefit to cost ratio is high because of the high percentage of public land. The project has some aquatic habitat complexity from side channels that backwater at the 2-year flow and high potential for multiple resource benefits in terms of terrestrial habitat and recreation. The project is also evaluated as a large woody debris project.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
3,814	34	21	86	80	394	0

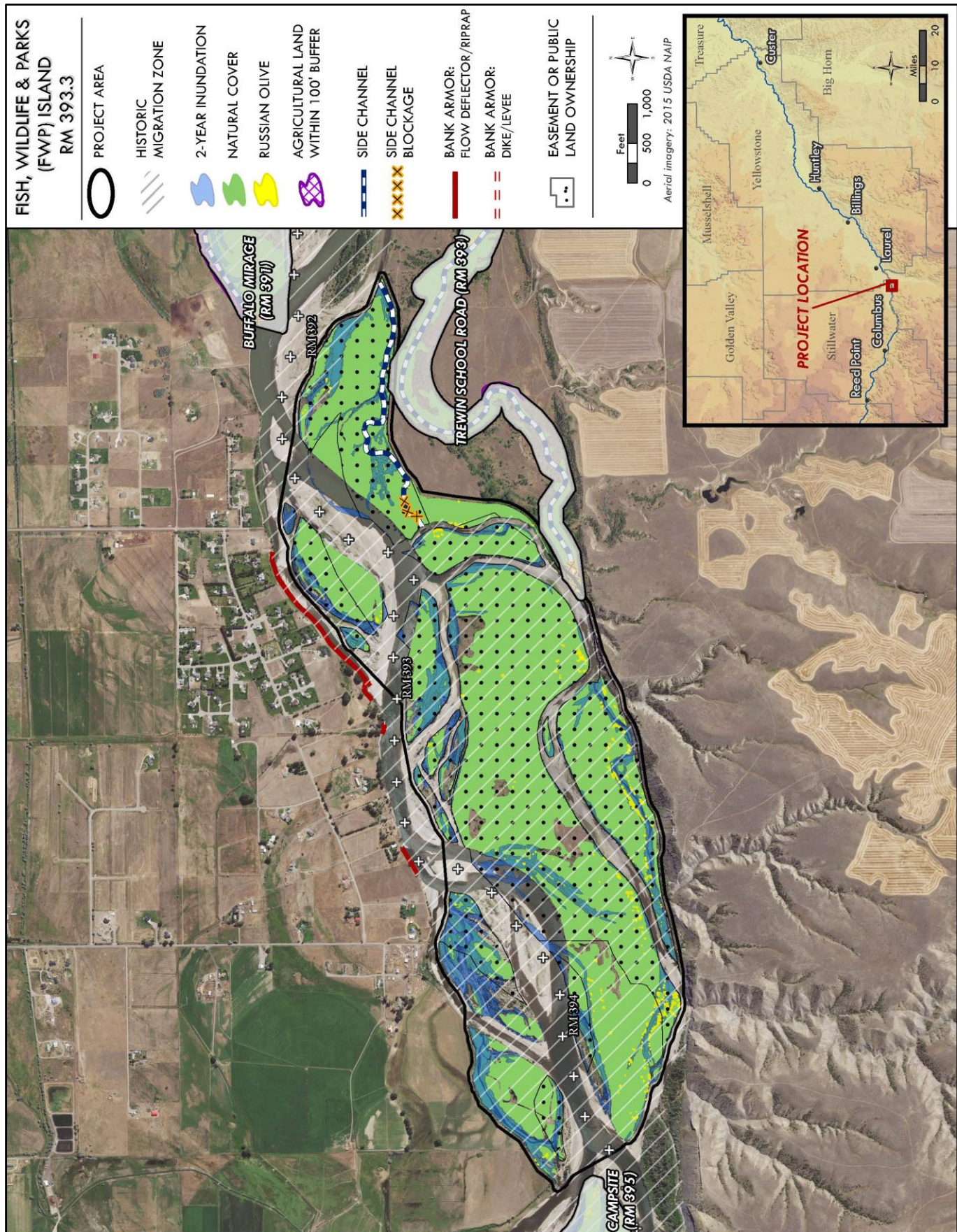


Figure 39. FWP Island RM 393.3, riverine habitat project.

PROJECT TYPE	TIER
Riverine habitat potential	middle

Project Summary

Valley Creek is located at RM 398, upstream of Park City, on the left bank of the Yellowstone River. It is 6 miles upstream of the oil spill origin. The project area is 242.0 acres and there are 6,633 feet of disconnected off-channel habitat divided into two segments. The upper segment was a major river channel in 1950 that lost connectivity sometime prior to 2001, whereas the downstream segment is an older channel remnant that was blocked by 1950. There are six landowners in this project. The majority of the project ownership is uncertain (54%) and there are two other primary landowners. There is no infrastructure within close proximity to the *Valley Creek* project.

Project Highlights

- This project ranks in the middle tier among all riverine habitat projects. Despite having potential to reconnect two separate disconnected side channels, the project has areas outside the HMZ as well as minimal inundation at the 2-year flow. Side channel blockage length is also one of the highest of all projects.
- The project boundary defines the only area available for active channel migration in the reach because of the high bluff line on the south side of the channel. The boundary also captures two disconnected side channels. In some cases, the boundary expands beyond the HMZ to include areas where the channel is already beginning to migrate and that include dense riparian vegetation.
- Both the area of 2-year inundation and area within the HMZ are lower than other higher ranking projects (28% and 59% respectively). This is a somewhat channelized section of the river with little movement. There is relatively little perennial surface water in the disconnected off channel habitat (41%).
- Although there is no bank armor, off channel side channel blockage is 587 feet, one of the longest lengths of blockages of all the projects. The blockage is divided between the two side channels, with an earth blockage on the upstream channel and a man-made blockage (road) on the downstream channel. There is some Russian olive and some agricultural land.
- The project is relatively close to the point of injury, includes 54% of public or conservation land and a low likelihood of success because of the large blockage and higher agricultural land presence. The estimated benefit to cost ratio is high because there is no bank armor. The project has high aquatic habitat complexity from active side channels. The project area is part of a broader footprint that is evaluated as a large woody debris project.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
6,633	41	28	59	75	587	0

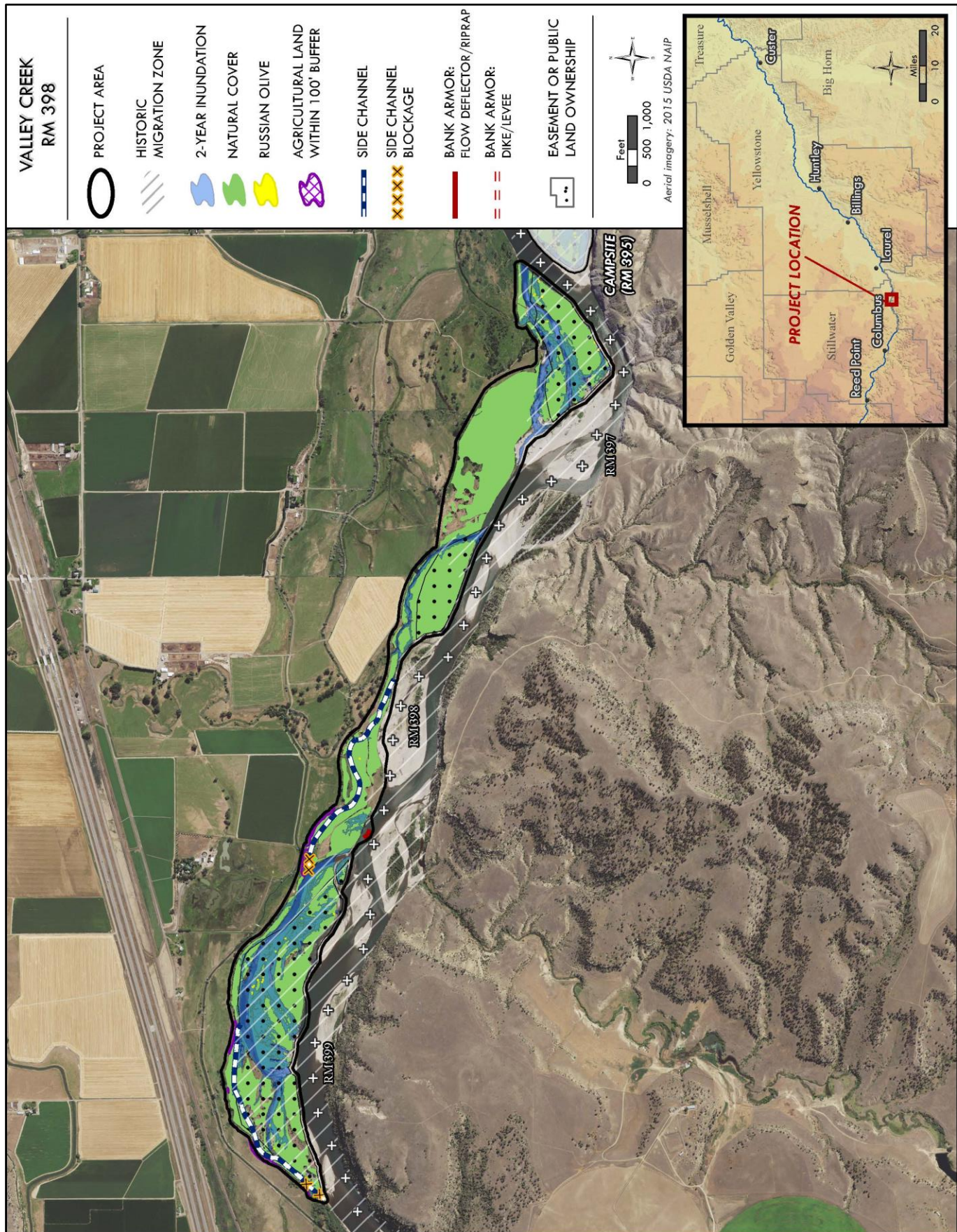


Figure 40. Valley Creek RM 398, riverine habitat project.

HENSLEY CREEK

PROJECT TYPE	TIER
Riverine habitat potential	upper

Project Summary

Hensley Creek is located at RM 410.5, downstream of Columbus. It is 25.5 miles upstream of the oil spill origin. The project area is 236.8 acres and consists of 8,880 feet of disconnected off-channel habitat. The side channel was blocked by a short dike sometime between 1950 and 1976. The majority of land shown in the overall project boundary is owned by a single landowner (70%). A second landowner owns 4% and the Bureau of Land Management owns a small section disconnected from the main parcel by the channel. The remainder of the project ownership is uncertain.

Project Highlights

- This project ranks in the upper tier among all riverine habitat projects. Inherent river functions are slightly lower than other higher ranking projects while limiting factors are the lowest of all projects.
- The project boundary captures a disconnected side channel and extends beyond the HMZ in one location where there is potential for long-term wood recruitment. The boundary also captures an island with unknown ownership and a dense riparian forest.
- Almost the entire project is within the HMZ (96%), though the 2-year inundation area (37%) is limited to side channels. There is some perennial surface water in the disconnected off channel habitat (86%).
- There is small side channel blockage (34 feet) and there are no other limiting factors.
- The project includes only 26% public or conservation land; however, the estimated benefit to cost ratio is very high because there is minimal side channel blockage. *Hensley Creek* is evaluated as a large woody debris project as well as a riverine habitat project and is the only project in the upper tier of both injury categories.. The project has high inherent aquatic complexity because of multiple side channels that currently show seasonal activation at the 2-year flow.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
8,880	86	37	96	68	34	0

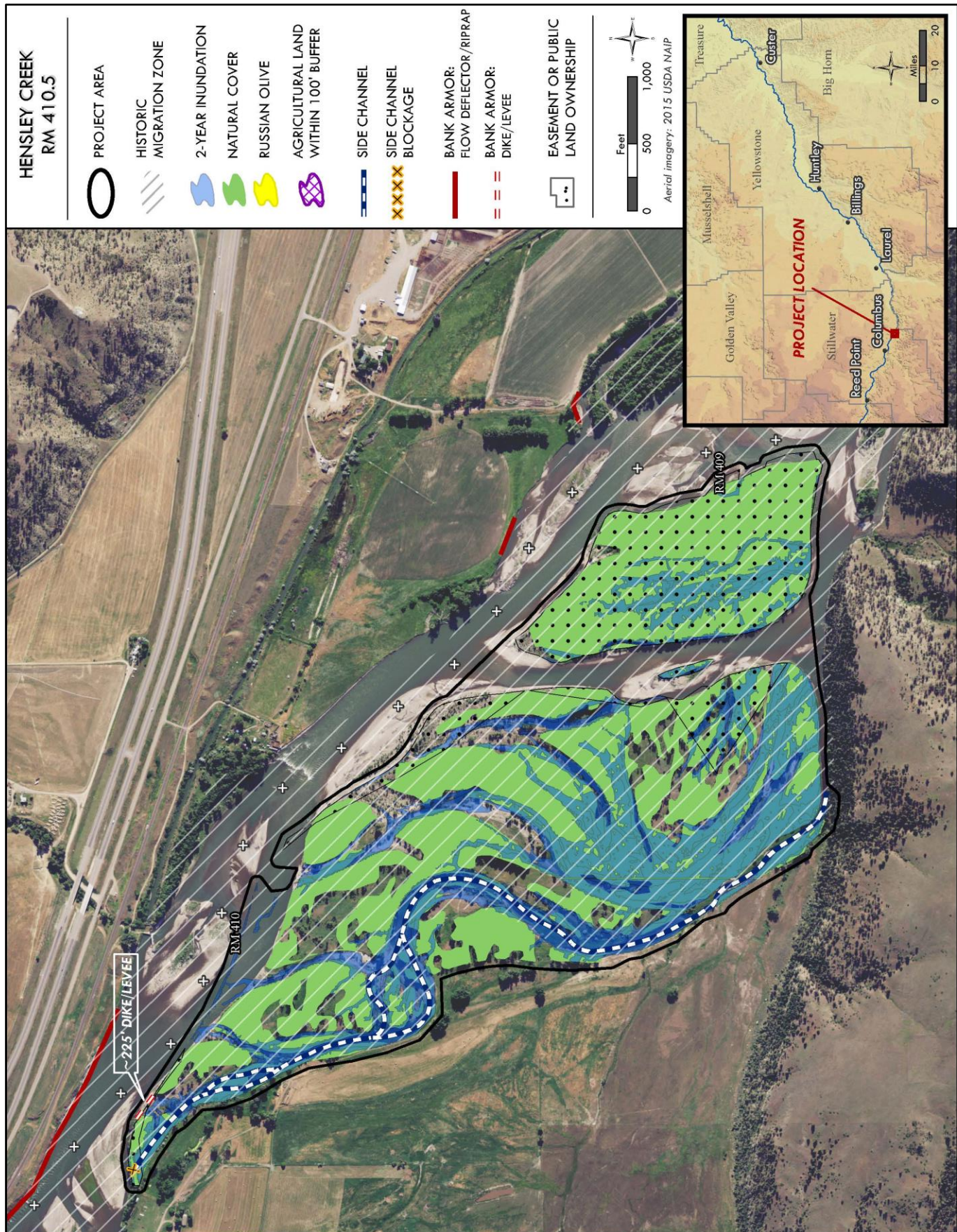


Figure 41. Hensley Creek RM 410.5, riverine habitat project.

COUNTRYMAN CREEK

PROJECT TYPE	TIER
Riverine habitat potential	middle

Project Summary

Countryman Creek is located at RM 420.4, upstream of Columbus, on right bank of the Yellowstone River. It is 35.4 miles upstream of the oil spill origin. The project area is 39.3 acres, one of the smallest projects, and there are 4,135 feet of disconnected off-channel habitat. The riverine habitat is within a side channel that was part of the main river thread in 1950. By 1976, the river shifted westward, leaving the channel remnant as a high flow swath through a gravel bar. The head of the channel has continued to decay since that time, although periodic inundation and associated scour is evident. Within the entire project polygon, the majority of the project ownership is uncertain (95%). There are three other landowners owning fringes of the project boundary, one of which is disconnected from the original parcel by the channel. There is no infrastructure within close proximity to the *Countryman Creek* project.

Project Highlights

- This project ranks in the middle tier among all riverine habitat projects. Though there is potential to reconnect a side channel, the length of the side channel is short and limiting factors such as the length of blockage are high.
- The project boundary captures a disconnected side channel area with long-term wood recruitment potential and follows the HMZ.
- Almost the entire project is within the HMZ (99%) and the 2-year inundation covers 46% of the project following the disconnected side channel. There is some perennial surface water in the disconnected side channel (85%) and 80% natural cover, one of the highest of all the projects.
- The side channel blockage is very long (521 feet) but there are no other limiting factors.
- The project is far from the point of injury, includes a large portion of public or conservation land (95%). This project has no active channels (low aquatic complexity), and has no apparent potential for multiple resource benefits in terms of recreation or terrestrial habitat, but is also evaluated as a large woody debris project.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
4,135	85	46	99	80	521	0

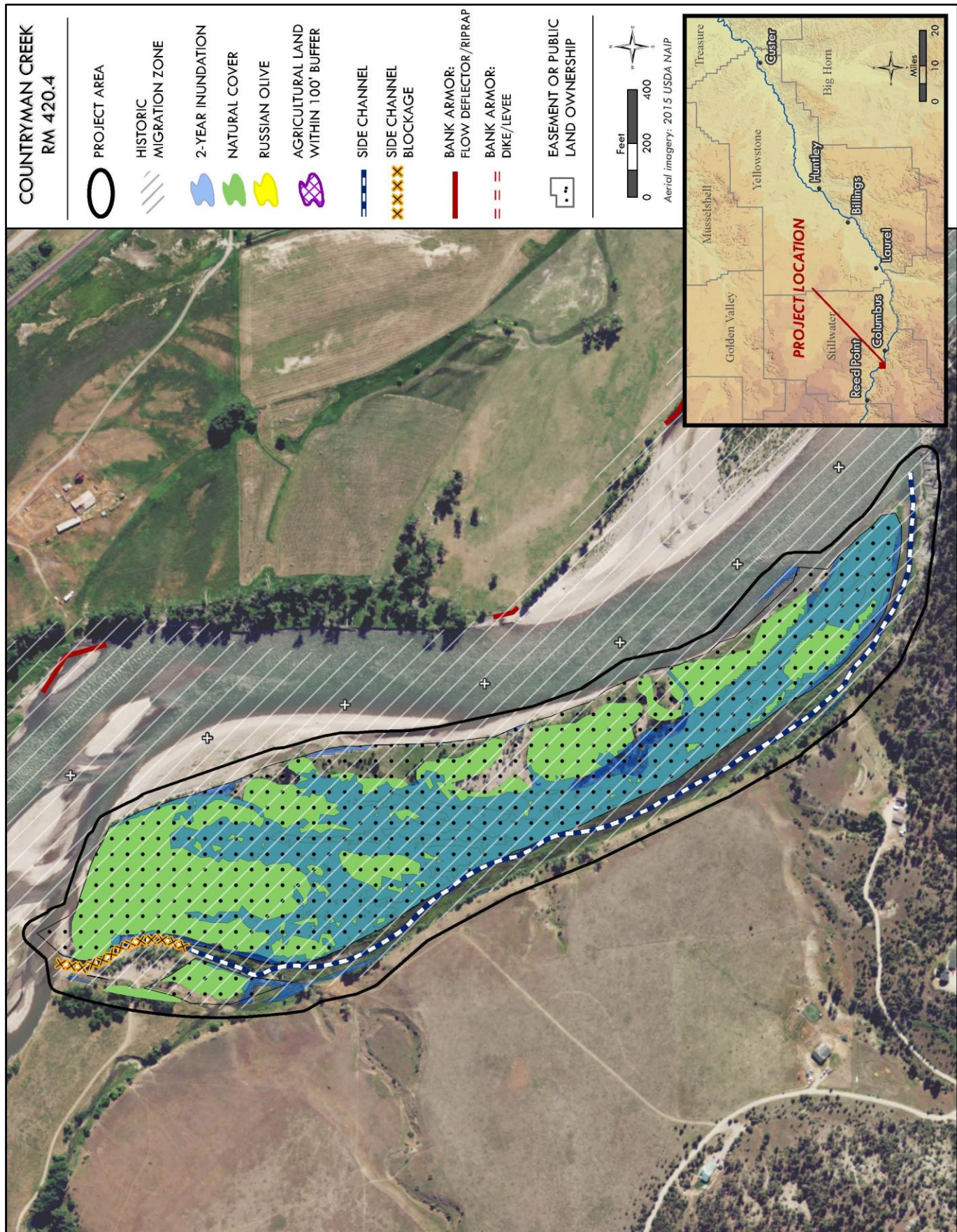


Figure 42. Countryman Creek RM 420.4, riverine habitat project.

UPSTREAM of HOLMGREN FISHING ACCESS SITE (FAS)

PROJECT TYPE	TIER
Riverine habitat potential	lower

Project Summary

Upstream of Holmgren Fishing Access Site (FAS) is located at RM 424, between Columbus and Reed Point, on left bank of the Yellowstone River. It is 39 miles upstream of the oil spill origin. The project is 163.3 acres and includes 6,355 feet of disconnected off-channel habitat. Riverine habitat consists of a side channel that was blocked at several locations by the 1950s. Since then, the head of the channel has been armored and further disconnected from the river. There appears to have been some recent excavation in the old side channel to create groundwater ponding. The project is owned by only one landowner. The remainder of the project ownership is uncertain (17 %). The project is adjacent to the rail line and Interstate 90. There is no other infrastructure within close proximity to the *Upstream of Holmgren FAS* project.

Project Highlights

- This project ranks in the lowest tier among all riverine habitat projects. While this project has the potential to reconnect a side channel with 88% perennial surface water, the side channel blockage is relatively long, raising the cost and lowering the benefit to cost ratio.
- The project boundary expands beyond the HMZ to capture a disconnected side channel and land with long-term wood recruitment potential. At the upstream end, the channel is already migrating beyond the HMZ within the project boundary.
- Only 18% of the project is inundated at the 2-year flow and only 26% of the project is within the HMZ. Natural cover is also low compared to other higher ranking projects (51%).
- Limiting factors are high because of a long channel blockage (352 feet). There is no bank armor, minimal Russian olive, and only 1.2% agricultural land.
- The project is far from the point of injury and includes only 17% public or conservation land. The project has no active side channels (no aquatic complexity) and has no apparent potential for multiple resource benefits in terms of terrestrial habitat, recreation and riverine habitat. The project is also evaluated as a large woody debris project.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
6,355	88	18	26	51	352	0.4

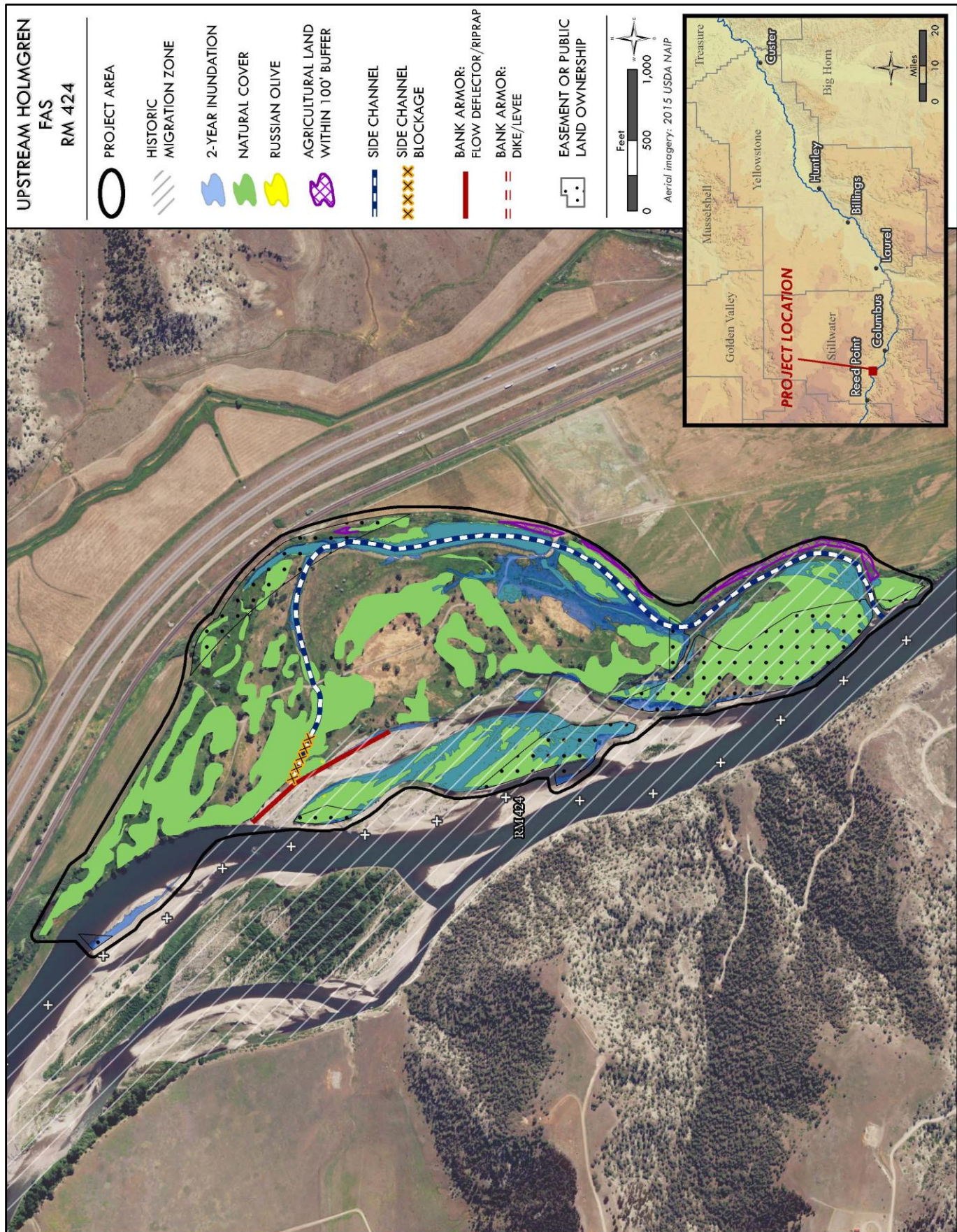


Figure 43. Upstream of Holmgren FAS RM 424, riverine habitat project.

INDIAN FORT

PROJECT TYPE	QUARTILE
Riverine habitat potential	middle

Project Summary

Indian Fort is located at RM 434.8, just upstream of Reed Point, on left bank of the Yellowstone River. It is 39 miles upstream of the oil spill origin. The project area is 6 acres, the smallest of all the projects and there are 1,177 feet of disconnected off-channel habitat. The project consists of a 1950s channel remnant that transitioned from a perennial channel to high flow channel between 1950 and 1976, and then to an abandoned, vegetated remnant swale by 2001. The downstream end of the channel would naturally remain connected to the river as a slackwater feature; however, it has become blocked and supports a small isolated pond. The project concept would be to recover perennial connectivity on the downstream end of the channel remnant. There is armor on the left bank downstream of the project and across the channel on the right bank which help maintain the river alignment to the Reed Point Bridge. The majority of the project ownership is uncertain (92 %). There are two other landowners. The project is up against the road to Indian Fort fishing access site. There is no other infrastructure within close proximity to the *Indian Fort* project.

Project Highlights

- This project ranks in the middle tier among all riverine habitat projects. Despite having the potential to reconnect a backwater area with 82% perennial surface water, there is very little public ownership and the project is very far from the point of injury.
- The project boundary follows the riparian area and topography of the disconnected backwater area.
- Almost the entire project is within the HMZ (88%) and there is some perennial surface water in the disconnected off channel habitat (82%). Natural cover is the highest of all projects (88%).
- The side channel blockage is 202 feet and there is some agricultural land (6.2%).
- The project is far from the point of injury and has very little public ownership. This project lacks aquatic complexity (no side channels), and has no apparent potential for multiple resource benefits in terms of terrestrial habitat, recreation, or large wood.

Length of disconnected off- channel habitat (feet)	Area of disconnected off-channel habitat with surface water (%)	Area of project with 2-year inundation extent (%)	Area of project within HMZ (%)	Area of project with natural cover (%)	Length of blockage (feet)	Armored, diked or leveed banks (%)
1,177	82	38	96	88	202	0

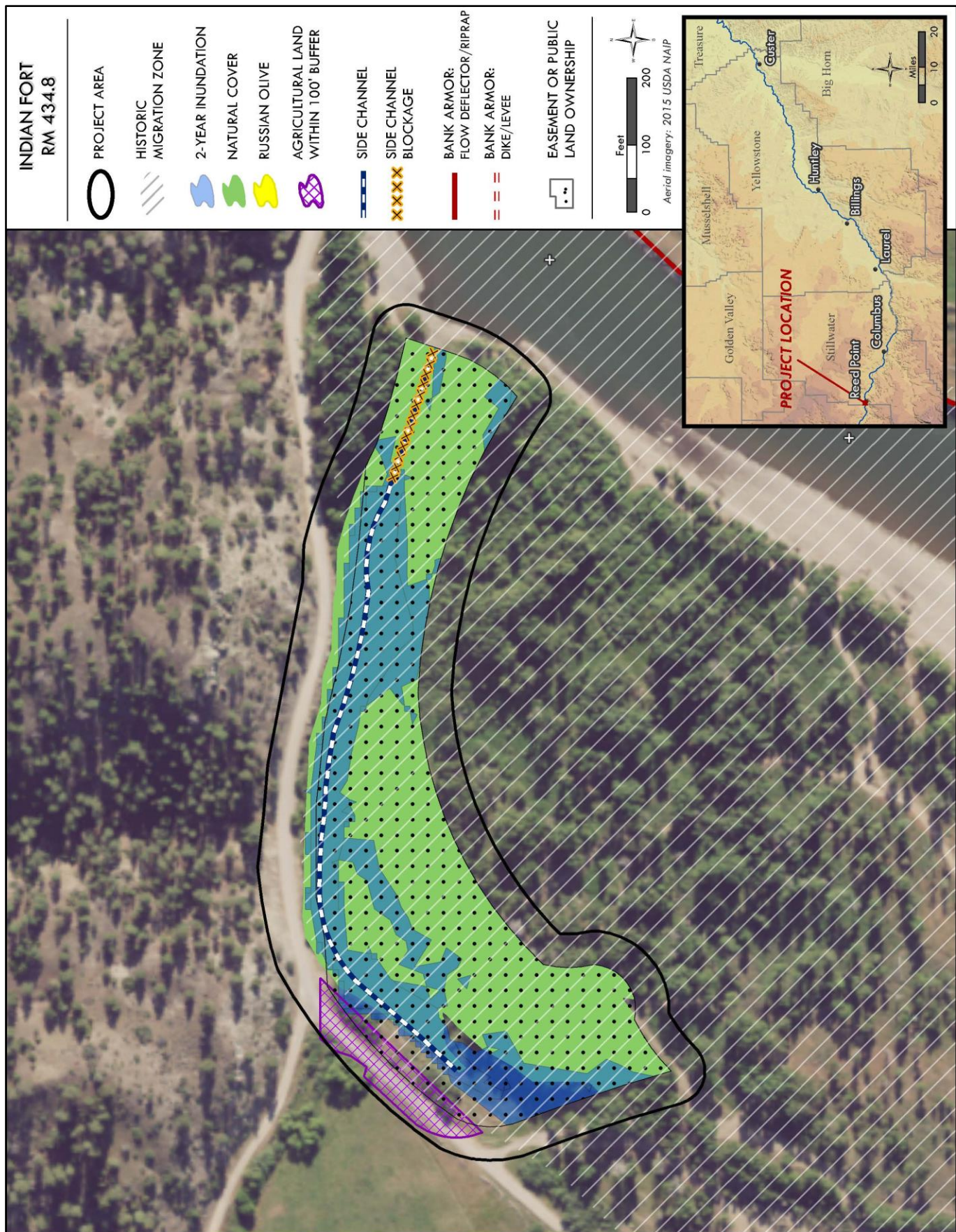


Figure 44. Indian Fort RM 434.8, riverine habitat project.

Project Feasibility and Development

The results presented above provide an objective inventory and ranking of potential restoration projects based on how well a project satisfies the restoration plan goals and objectives. These results should provide enough information for the Natural Resource Damage Program (NRDP) to initiate conversations with landowners who have high-ranking projects on their land, or pursue projects with other agencies on public land. Once willing landowners have been identified, feasibility evaluation, planning, design and implementation would be completed as described below for the different project types. NRDP has contracts in place with entities to help establish relationships with landowners, determine the feasibility of a particular project and keep projects moving forward.

Project boundaries can be modified based on landowner interest or other feasibility factors. With the existing datasets, modified projects can be rapidly reassessed in terms of prioritization parameters.

For a large woody debris project that requires either a conservation easement or land acquisition the project would include several important steps. The first step would be to select the most appropriate site protection mechanisms for a project among options including channel migration easements through Land Trusts, Farm Bill programs, and adding covenants to land titles. Because land protections require a long-term commitment by the landowner, the next step would be conversations with the landowner to identify their objectives for their land, and determine what type of land protection would be the best match for them. Montana Aquatic Resources Services (MARS) has connections with organizations such as Montana Land Reliance and The Nature Conservancy and both have expressed interest in working with NRDP and the consultant team to help identify the best possible land protection measures for each landowner. Evaluating feasibility for a conservation easement or deed restriction would involve reviewing data assembled as part of the inventory process to verify that a property provides conservation benefits that qualify it for a particular land protection program. Depending on the type of land protection mechanism selected, a type of baseline assessment may need to be completed to ground-truth and document conditions at the beginning of the land protection agreement. In some cases, an easement-holding organization such as a land trust might complete the baseline assessment and take on monitoring responsibilities. In other cases NRDP, with assistance from the consultant team, may need to complete this work. Components of land protection, conservation values of the easement, development restrictions, the land appraisal process, details regarding the easement purchase or donation, future access for monitoring, and other aspects specific to the type of agreement need to be documented in a landowner agreement. It may be necessary to develop a Memorandum of Understanding between NRDP and an easement-holding organization to make sure natural resource damages are addressed in the long-term per the restoration plan.

Pursuing a riverine habitat project would require several important steps. Once a project with a willing landowner has been identified, the consultant team would conduct a site evaluation to verify benefits that would be provided by blockage removal, and document engineering feasibility issues that would need to be addressed during design. Key data compiled during the inventory process would be overlaid on field maps and updated in the field as needed. The consultant team would then develop a conceptual project plan that shows project components spatially, matches project benefits with project objectives, identifies uncertainties and risks, and quantifies project elements sufficiently to develop a rough cost estimate. The consultant team would meet with NRDP and review the conceptual project plan to verify that the benefit to cost ratio is high enough to proceed with the project. If the project is

still feasible and cost-effective, based on the conceptual planning effort, a landowner plan would be developed describing project objectives, anticipated changes to their land, examples of similar completed projects to help them understand what they might be agreeing to, and a clear statement of their obligations in terms of project maintenance, land management and access. Once the general project approach has been agreed on, the consultant team would develop a design plan suitable to support contractor procurement, in addition to an engineer's cost estimate. Once a contractor has been selected, the consultant team would provide oversight support as needed. In addition, the consultant team would work with NRDP to develop a cost-effective monitoring plan tailored to the project and focused on documenting progress toward achieving restoration objectives.

References

State of Montana and US Department of the Interior. 2017. Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Assessment for the ExxonMobil Pipeline Company July 1, 2011 Yellowstone River Oil Spill. January 2017.

U.S. Army Corps of Engineers and Yellowstone River Conservation District Council. 2015. Yellowstone River Cumulative Effects Analysis. U.S. Army Corps of Engineers Omaha District. Omaha, NE

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Appendix A. Project Ranking and Scoring Tables

Table A-1. Large woody debris project ranking and parameter group scores.

Project Name	River Mile	Inherent Function and Process Score	Limiting Factors Score	Other Parameters Score	Total Score	Project Rank
Dover Island	359	8.0	2.8	8.5	13.8	10
Wicks Lane	361	8.3	4.0	4.0	8.3	20
Hilltop Road	363	9.0	3.0	6.3	12.3	13
Riverfront Park	370	9.0	2.0	7.0	14.0	8
Norms Island	371.5	8.5	1.8	7.3	14.0	8
Jellison Road	372.5	5.5	4.0	4.5	6.0	23
Brockway Coulee	375	10.3	2.8	8.5	16.0	3
Duck Creek Bridge	377.5	8.5	1.5	6.8	13.8	10
West of Duck Creek Bridge	380	6.3	3.8	6.0	8.5	19
Clarks Fork Confluence	385	10.3	2.0	6.8	15.0	6
Above Laurel Bridge	387	10.8	2.8	8.3	16.3	2
Buffalo Mirage	391	8.3	3.0	9.3	14.5	7
FWP Island	393.3	10.8	2.0	9.5	18.3	1
Campsite	395	9.5	2.0	5.8	13.3	12
Valley Creek	398	9.3	1.8	8.5	16.0	3
Youngs Point	401	6.8	1.5	4.0	9.3	17
BLM Shore	402.5	5.8	1.5	5.0	9.3	17
Tucker Creek	405.4	6.8	2.5	1.5	5.8	24
Hensley Creek	410.5	11.3	1.5	5.8	15.5	5
Below Columbus	413	7.8	1.8	4.8	10.8	15
Stillwater Confluence	418	10.75	3.25	4	11.5	14
Countryman Creek	420.4	5.8	1.5	5.3	9.5	16
Upstream of Holmgren FAS	424	7.0	1.5	2.3	7.8	22
Upstream of Twin Bridges	430	7.5	2.3	2.8	8.0	21

Table A-2. Riverine habitat project ranking and parameter group scores.

Project Name	River Mile	Aq Hab: Inherent Function and Process Score	Aq Hab: Limiting Factors Score	Aq Hab: Other Parameters Score	Aq Hab: Total Score	Aq Hab: Project Rank
Junction City	305	7.0	4.0	1.5	4.5	16
Rough Coulee	321	8.0	3.0	3.3	8.3	9
Mill Creek	325	8.5	4.5	3.5	7.5	11
BOR	347	9.3	4.5	1.8	6.5	14
12 Mile Creek	354.8	8.8	4.3	2.3	6.8	13
Dover Island	359	9.0	2.8	9.0	15.3	1
Jellison Road	372.5	9.3	5.0	5.5	9.8	8
West of Duck Creek Bridge	380	8.5	3.3	7.0	12.3	4
Buffalo Mirage	391	8.8	4.5	9.5	13.8	2
Trewin School Road	393	6.8	3.3	3.8	7.3	12
FWP Island	393.3	5.8	4.5	9.0	10.3	6
Valley Creek	398	7.0	4.5	8.3	10.8	5
Hensley Creek	410.5	8.8	2.0	6.8	13.5	3
Countryman Creek	420.4	8.8	4.0	5.3	10.0	7
Upstream of Holmgren FAS	424	7.0	4.3	2.8	5.5	15
Indian Fort	434.8	8.0	3.3	3.5	8.3	9

Table A-3. Large woody debris project parameter data and scores.

Project Name	River Mile	Eroded Acres/Yr	Short-Term Wood Recruitment Score	Woody Vegetation Acres	Long-Term Wood Recruitment Score	Accreted Acres/Yr	Short-Term Expansion Score	Linear Ft Bank Per Acre	Bank Length Score	Percent in HMZ	Lateral Connectivity Score	Natural Recovery Potential Score	Bank Armor (ft)	Total Bank Length (ft)	Percent Armor	Bank Armor Score	Russian Olive (sq ft)	Russian Olive Score	Percent in Ag	Ag Present Score	Prox. To Injury (miles)	Prox. To Injury Score	Public/ Conservation Percent	Ownership Score	Ratio of Inherent Function to Limiting Factors	Likelihood of Success Score	Project Cost per Acre	Cost Score	Benefit/ Cost Ratio x1000	Cost Effectiveness Score	Risk of Adverse Effects Score	Public Health & Safety Score	Multiple Resource Benefits Score
Dover Island	359	0.36	2	97.3	2	2.36	2	180	3	86	2	2	1,926	22,654	9	2	5,424	2	0	1	26	2	94	3	2.9	1	\$1,983	1	6.9	3	1	1	3
Wicks Lane	361	1.10	3	126.0	2	0.63	2	59	1	59	2	3	1,237	11,333	11	3	195,670	3	0	1	24	2	27	2	2.1	1	\$4,131	3	2.0	1	1	1	1
Hilltop Road	363	1.33	3	198.6	3	2.08	2	80	2	55	1	3	1,814	22,774	8	2	85,181	3	0	1	22	2	70	3	3.0	1	\$2,308	1	5.3	3	1	2	1
Riverfront Park	370	1.06	2	246.1	3	4.99	3	109	2	81	2	2	0	34,878	0	1	19,106	3	0	1	15	2	85	3	4.5	2	\$2,103	1	6.7	3	3	2	2
Norms Island	371.5	1.78	3	108.0	2	0.09	1	123	2	97	3	3	0	21,392	0	1	8,780	2	0	1	13.5	2	77	3	4.9	3	\$2,554	1	5.5	3	3	2	2
Jellison Road	372.5	0.73	2	57.4	1	0.01	1	27	1	90	2	2	11,488	10,079	114	3	151	1	13	3	12.5	3	10	1	1.4	1	\$4,279	3	1.4	1	1	2	2
Brockway Coulee	375	1.32	3	386.9	3	9.79	3	57	1	97	3	3	1,491	27,950	5	2	2,054	2	0	1	10	3	68	3	3.7	2	\$2,474	1	6.5	3	1	1	2
Duck Creek Bridge	377.5	0.40	2	65.5	1	2.53	3	184	3	100	3	2	0	13,559	0	1	677	1	0	1	7.5	3	33	2	5.7	3	\$3,865	3	3.6	2	1	1	2
West of Duck Creek Bridge	380	0.00	1	106.0	2	2.05	2	113	2	84	2	1	3,086	14,941	21	3	5,400	2	0	1	5	3	52	2	1.7	1	\$3,035	2	2.8	1	1	1	2
Clarks Fork Confluence	385	2.65	3	317.4	3	5.97	3	104	2	91	2	3	0	45,261	0	1	56,513	3	0	1	0	3	47	2	5.1	3	\$3,312	2	4.5	2	2	1	2
Above Laurel Bridge	387	1.20	3	341.9	3	4.13	3	87	2	95	3	3	2,364	39,203	6	2	4,916	2	0	1	2	3	78	3	3.9	2	\$2,388	1	6.8	3	2	1	2
Buffalo Mirage	391	0.89	2	198.3	3	2.39	2	109	2	93	2	2	428	27,413	2	2	17,880	3	0	1	6	3	66	3	2.8	1	\$2,699	1	5.4	3	1	1	3
FWP Island	393.3	1.96	3	374.8	3	8.94	3	130	3	86	2	3	0	59,350	0	1	73,306	3	0	1	8.3	3	78	3	5.4	3	\$2,175	1	8.4	3	1	2	3
Campsite	395	1.09	2	191.8	3	3.23	3	108	2	99	3	2	0	26,317	0	1	35,062	3	0	1	10	3	22	1	4.8	3	\$3,999	3	3.3	2	1	1	2
Valley Creek	398	2.17	3	158.3	2	0.40	2	155	3	59	2	3	0	37,438	0	1	2,094	2	1	1	13	3	54	2	5.3	3	\$3,164	2	5.1	3	1	1	3
Youngs Pt	401	0.20	1	139.6	2	2.29	2	163	3	92	2	1	0	27,764	0	1	337	1	0	1	16	2	38	2	4.5	2	\$3,508	2	2.6	1	3	1	1
BLM Shore	402.5	0.56	2	165.2	2	0.40	1	64	1	29	1	2	0	14,172	0	1	236	1	4	1	17.5	2	58	2	3.8	2	\$2,793	2	3.3	2	1	1	1
Tucker Creek	405.4	0.15	1	86.0	2	1.25	2	95	2	100	3	1	646	12,981	5	2	252	1	0	1	20.4	2	18	1	2.7	1	\$4,095	3	1.4	1	3	1	0
Hensley Creek	410.5	1.44	3	167.6	3	4.33	3	130	3	96	3	3	225	30,780	1	1	0	1	0	1	25.5	2	26	1	7.5	3	\$3,766	3	4.1	2	2	1	3
Below Columbus	413	0.56	2	246.5	3	1.70	2	88	2	23	1	2	0	28,593	0	1	6,288	2	4	1	28	2	49	2	4.4	2	\$3,336	2	3.2	2	2	1	1
Stillwater Confluence	418	1.77	3	195.24	3	6.63	3	389.75	3	67	2	3	1,263	106,441	1	2	2,048	2	11	3	33	1	47	2	3.3	1	\$3,155	2	3.6	2	1	1	1
Countryman Creek	420.4	0.09	1	32.6	1	0.39	1	298	3	99	3	1	0	11,106	0	1	0	1	0	1	35.4	1	95	3	3.8	2	\$2,823	2	3.4	2	1	1	1
Upstream of Holmgren FAS	424	0.84	2	75.7	2	1.48	2	123	2	26	1	2	77	20,083	0	1	118	1	1	1	39	1	17	1	4.7	3	\$3,948	3	2.0	1	3	1	1
Upstream of Twin Bridges	430	0.59	2	116.2	2	1.39	2	178	3	57	1	2	0	32,177	0	1	8,434	2	13	3	45	1	59	2	3.3	1	\$2,725	1	2.9	1	1	1	0

Table A-4. Riverine habitat project parameter data and scores.

Project Name	River Mile	Side Channel Length Feet	Off Ch. Aq. Habitat Length Score	Percent Perennial	Perennial Flow Score	Percent 2yr Conn.	Vertical Connectivity Score	Percent of Project in HMZ	Lateral Connectivity Score	% Natural Cover	Natural Cover Score	Natural Recovery Score	Blocked Side Channel Length (ft)	Side Channel Blockage Score	Bank Armor (ft)	Total Bank Length (ft)	Percent Armor	Bank Armor Score	Russian olive (sq ft)	Russian Olive Score	Acres Ag	Percent in Ag	Ag. Present Score	Prox. To Injury (miles)	Prox. To Injury Score	Public/ Conservation (%)	Ownership Score	Ratio of Inherent Function to Limiting Factors	Likelihood of Success Score	Project Cost per Acre	Cost Score	Benefit/ Cost Ratio x1000	Cost Effectiveness Score	Risk of Adverse Effects	Public Health & Safety	Multiple Resource Benefits Score
Junction City	305	12,545	3	82	1	29	2	1	1	33	1	2	181	2	21	904	2	2	48,006	3	52.78	4	1	80	1	0	1	1.8	1	\$14,278	2	0.3	1	1	1	0
Rough Coulee	321	6,908	2	97	3	34	2	18	1	49	1	2	174	1	176	5,592	3	2	11,718	3	32.37	0	1	64	1	23	1	2.7	3	\$2,783	1	3.0	2	3	1	1
Mill Creek	325	12,502	3	88	2	74	3	7	1	31	1	1	515	3		426	0	1	725	1	57.10	12	3	60	1	0	1	1.9	2	\$19,330	3	0.4	1	1	1	2
BOR	347	9,591	2	91	3	56	3	38	1	75	2	2	320	2	434	2,053	21	3	71,309	3	44.73	3	1	38	1	15	1	2.1	2	\$11,463	2	0.6	1	1	1	0
12 Mile Creek	354.8	11,107	3	88	2	74	3	0	1	38	1	2	220	2	437	423	103	3	0	1	50.36	6	2	30.2	2	6	1	2.1	2	\$10,794	2	0.6	1	2	1	0
Dover Island	359	4,638	1	89	3	41	3	86	2	75	2	3	152	1	1,926	22,654	9	2	5,424	2	21.94	4	1	26	2	94	3	3.3	3	\$3,006	1	5.1	3	1	1	3
Jellison Road	372.5	13,409	3	82	2	62	3	90	2	30	1	2	573	3	11,488	10,079	114	3	151	1	59.80	0	1	12.5	3	10	1	1.9	1	\$2,767	1	3.5	2	1	2	2
West of Duck Creek Bridge	380	10,193	2	63	1	52	3	84	2	86	3	3	169	1	3,086	14,941	21	3	5,400	2	47.00	4	1	5	3	52	2	2.6	3	\$5,331	2	2.3	2	1	1	2
Buffalo Mirage	391	6,089	1	92	3	40	3	93	2	75	2	2	174	2	428	27,413	2	2	17,880	3	28.67	20	3	6	3	66	3	1.9	2	\$1,977	1	7.0	3	1	1	3
Trewin School Road	393	10,478	3	52	1	12	1	0	1	70	2	2	341	2	0	1,272	0	1	8,781	2	48.81	1	1	8	3	1	1	2.1	2	\$9,401	2	0.8	2	1	1	0
FWP Island	393.3	3,814	1	34	1	21	1	86	2	80	3	2	394	3	0	59,350	0	1	73,306	3	18.17	0	1	8.3	3	78	3	1.3	1	\$904	1	11.3	3	1	2	3
Valley Creek	398	6,633	2	41	1	28	2	59	2	75	2	2	587	3	0	37,438	0	1	2,094	2	31.88	7	2	13	3	54	2	1.6	1	\$2,630	1	4.1	3	1	1	3
Hensley Creek	410.5	8,880	2	86	2	37	2	96	3	68	2	3	34	1	225	30,780	1	1	0	1	38.09	0	1	25.5	2	26	1	4.4	3	\$2,539	1	5.3	3	2	1	3
Countryman Creek	420.4	4,135	1	85	2	46	3	99	3	80	3	2	521	3	0	11,106	0	1	0	1	19.70	0	1	35.4	1	95	3	2.2	2	\$10,834	2	0.9	2	1	1	1
Upstream of Holmgren FAS	424	6,355	2	88	3	18	1	26	1	51	1	1	352	3	77	20,083	0	1	118	1	29.89	6	2	39	1	17	1	1.6	1	\$3,047	1	1.8	2	3	1	1
Indian Fort	434.8	1,177	1	82	2	38	2	96	3	88	3	2	202	2	0	114	0	1	0	1	6.12	6	2	49.8	1	92	3	2.5	3	\$24,748	3	0.3	1	2	1	0