Riparian Habitat Management Plan

Upper Lemhi River, Leadore, ID

January 6, 2016

Cardno
Shaping the Future

Document Information

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Executive Summary

After The Lemhi Regional Land Trust's July 2015 completion of the 4,682 acre Leadore Partners Conservation Easement, Bonneville Power Administration required that a Habitat Management Plan be developed for the Riparian areas within the conservation easement. In late October 2015, Lemhi Regional Land Trust secured the services of Cardno, Inc. and The Freshwater Trust to complete the required Riparian Management portion of this Plan which included identification and analysis of limiting factors affecting Riparian vegetation growth and instream shade within the conservation easement.

A combined analysis approach was used including both on-the-ground data collection and remote sensing using available Geographic Information System (GIS) data. Field observations revealed that riparian conditions were primarily limited by three characteristics, 1) existing and/or relic disturbance associated with land use, especially grazing, 2) bank height relative to the Ordinary High Water Mark (OHWM), and 3) the location of the riparian area along stream bends. Vegetation, especially willow, was limited when the area had been disturbed, banks were more than 1-foot above the OHWM, and/or located along the outside of a bend.

Effective shade was also modeled along each stream throughout the project area and compared with effective shade targets for the willow / reedgrass riparian community associated with this site. Effective shade is a relative measure dependent on vegetation type, height, density and overhang in addition to stream aspect and stream width. Existing effective shade, as measured for the project area, generally falls far below shade targets, although variations in the methodology for calculating effective shade produce a range of results. Due to the complex association between effective shade and actual riparian conditions and the range of effective shade results, riparian height was considered a better analog for riparian "health" and was therefore used in addition to bank height and location along a bend in order to classify riparian areas into five tiers:

1. Functioning – Vegetation height is greater than 10 feet
2. Recovering – Vegetation height is between 3 and 10 feet
3. Impaired – Vegetation height is less than 3 feet and the area is along the outside of a bend and on a high bank
4. Impaired – Vegetation height is less than 3 feet and the area is along the outside of a bend and on a low bank
5. Impaired – Vegetation height is less than 3 feet and the area is along the inside of a bend and on a high bank
6. Impaired – Vegetation height is less than 3 feet and the area is along the inside of a bend and on a low bank

Various treatments have been identified for each tier including passive (planting) and active (excavation and/or otherwise manipulating the stream or banks). The goal for all treatments is to create an environment where riparian vegetation will become established and thrive. It is recommended that effective shade, riparian height, density and aerial extent be monitored qualitatively and quantitatively over the short- and long-term in order to measure recovery success.

Detailed data representing site conditions and effective shade are provided in tabular (Excel spreadsheets) and spatially (GIS shapefiles).

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1 Project Overview and Objectives

Carndo, Inc. (Cardno), in partnership with The Freshwater Trust (TFT), has prepared this Riparian Management Plan on behalf of the Lemhi Regional Land Trust (LRLT) as requested by the Bonneville Power Administration (BPA) for the Leadore Land Partners Conservation Easement (Conservation Easement) near Leadore, Idaho. This Riparian Management Plan presents a thorough analysis of existing riparian conditions, identification and evaluation of limiting factors affecting Riparian habitats, and identification of management prescriptions and treatment options which could be implemented to successfully regenerate and stabilize riparian habitats to increase total effective shade on the upper Lemhi River.

1.1 Project Location

The Conservation Easement is located approximately 45 miles south of Salmon, Lemhi County, Idaho on 4,682 acres of lands managed for agriculture and livestock grazing. The Conservation Easement includes 11 miles of the upper Lemhi River and approximately 13 miles of tributaries of the Lemhi River including Big Springs Creek, Texas Creek, Eighteen Mile Creek, and Canyon Creek.

1.2 Objectives

The goal of this Riparian Management Plan is to provide a roadmap to improve riparian conditions and guidance for monitoring the improvement over time for the upper Lemhi River and Big Springs, Canyon, Eighteen Mile, and Texas Creeks. Improved riparian conditions are intended specifically to address DEQ's TMDL shade targets and generally to improve riparian and stream function for fish and wildlife habitat. The plan includes information regarding current and potential future riparian conditions and associated shade values. Several treatment options are outlined to address factors limiting the establishment and growth of riparian vegetation. Geographic Information System (GIS) shapefiles and associated data have been provided with this plan highlighting the conditions and proposed treatments for specific locations.

1.3 Historic Context

The Lemhi River is an alluvial stream located within a northwest trending valley between the Lemhi Range to the west and the Beaverhead Range on the Idaho-Montana border to the east. The valley is a block of the northern Rocky Mountain overthrust belt that dropped along basin and range normal faults during the past several million years (Alt and Hyndman, 1989). As a result, folded and faulted Precambrian, Paleozoic, and Mesozoic sedimentary rocks are exposed in the mountains on either side of the valley, while the Lemhi Valley itself is composed of deep deposits of valley-fill alluvium accumulated during the relatively warm/dry Pliocene (3-5 million years ago). Since the onset of the relatively cool/moist Pleistocene ice age (2 million years ago), the Lemhi River has carved a broad, erosional valley into the thick deposits of alluvium leaving remnant benches of the original basin-fill surface along the valley margins.

Thick deposits of unconsolidated alluvium underlain by bedrock permit the presence of an aquifer in the Lemhi basin. The Lemhi River exchanges water with the aquifer, generally gaining from ground water sources when the water table is high during the spring and early summer and losing to the aquifer when the water table is low during autumn (Donato, 1998). Surface runoff is also seasonally variable, with the greatest discharge corresponding to periods of spring and early summer snow melt.

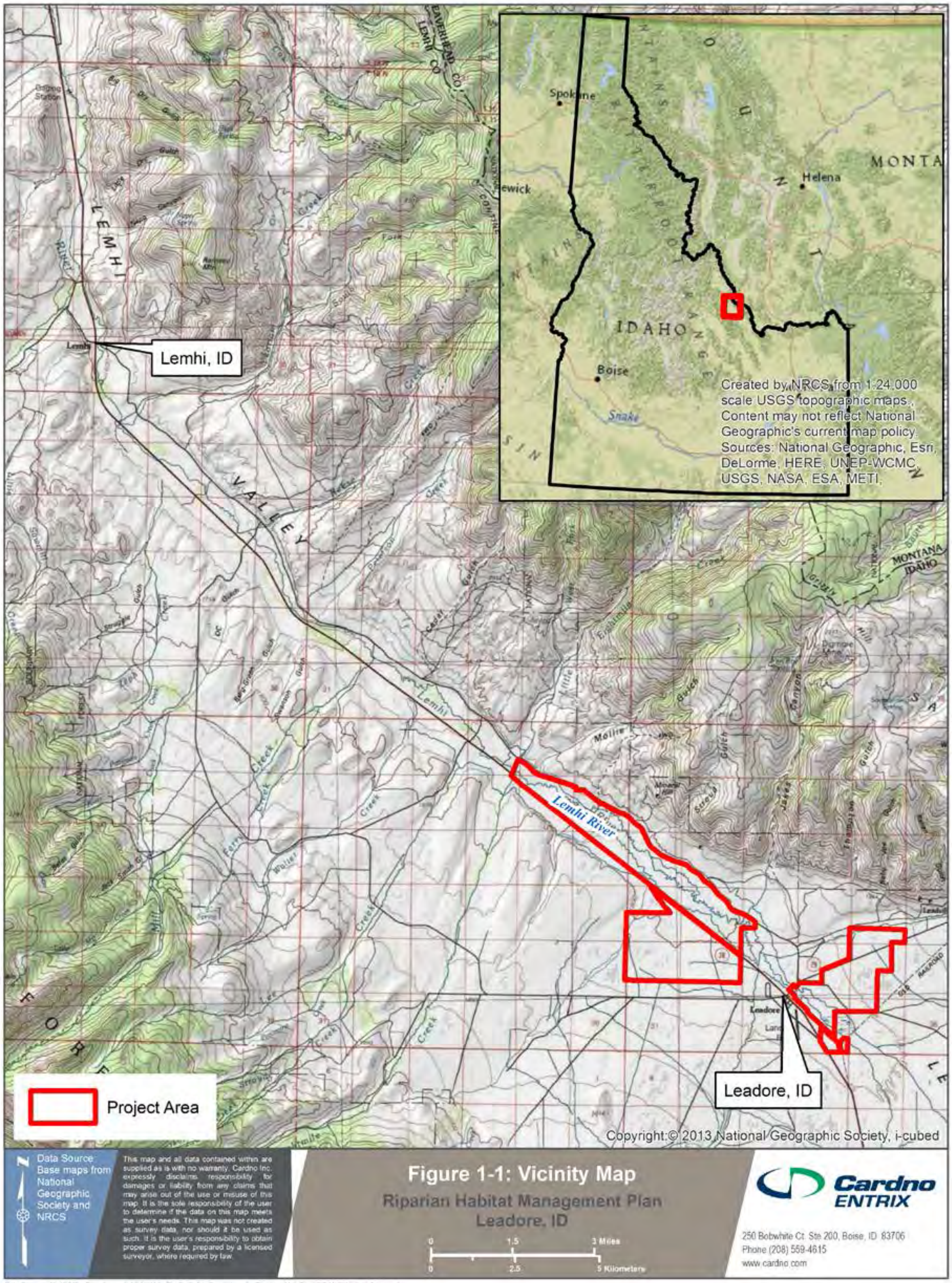

Figure 1-1 Project Location Map

Prior to large-scale human disturbance, the upper Lemhi River was likely characterized as a primary channel with multiple split flows, side channels and spring-fed tributaries within a meadow-like floodplain confined by terraces on either side. Although there are no known measurements of channel geometry prior to large-scale settlement and disturbance, there are several anecdotal accounts of the river's form from historic journals and maps as well as ancient channel scars visible on the floodplain from detailed LiDAR topography. From the journals of W. A. Ferris (1830-1835), the lower Lemhi River is described as "forty paces wide, bordered with willows, and birch, and aspen, and flows norwestward fifty miles to Salmon River." It is likely that stream crossings occurred at unobstructed riffles where the water was shallow and wide and the riparian vegetation was limited, suggesting the widest portion of the channel may have been upwards of 80-100-feet on the lower river. Identification of the "principal stream" by W. A. Ferris (1830-1835) also suggests a primary channel with side channels. A true multi-threaded (anabranching) stream does not have a principal thread, while a single-threaded stream with no side channels would not warrant mention of the "principal" stream, which implies multiple branches. Additionally, maps from Lewis and Clark (1805) show a single-threaded stream with areas of multiple side channels and many tributaries flowing through the valley bottom further supporting this characterization (Figure 1-2). Channel scars seen on LiDAR topography reveal historic channel widths ranging from roughly 30-75-feet. Smaller channels likely existed, but their scars have been obscured by time and disturbance. Channel scars of varying obscurity (assumed of varying antiquity) are seen across broad areas of the floodplain suggesting side channels were historically common within the project area.

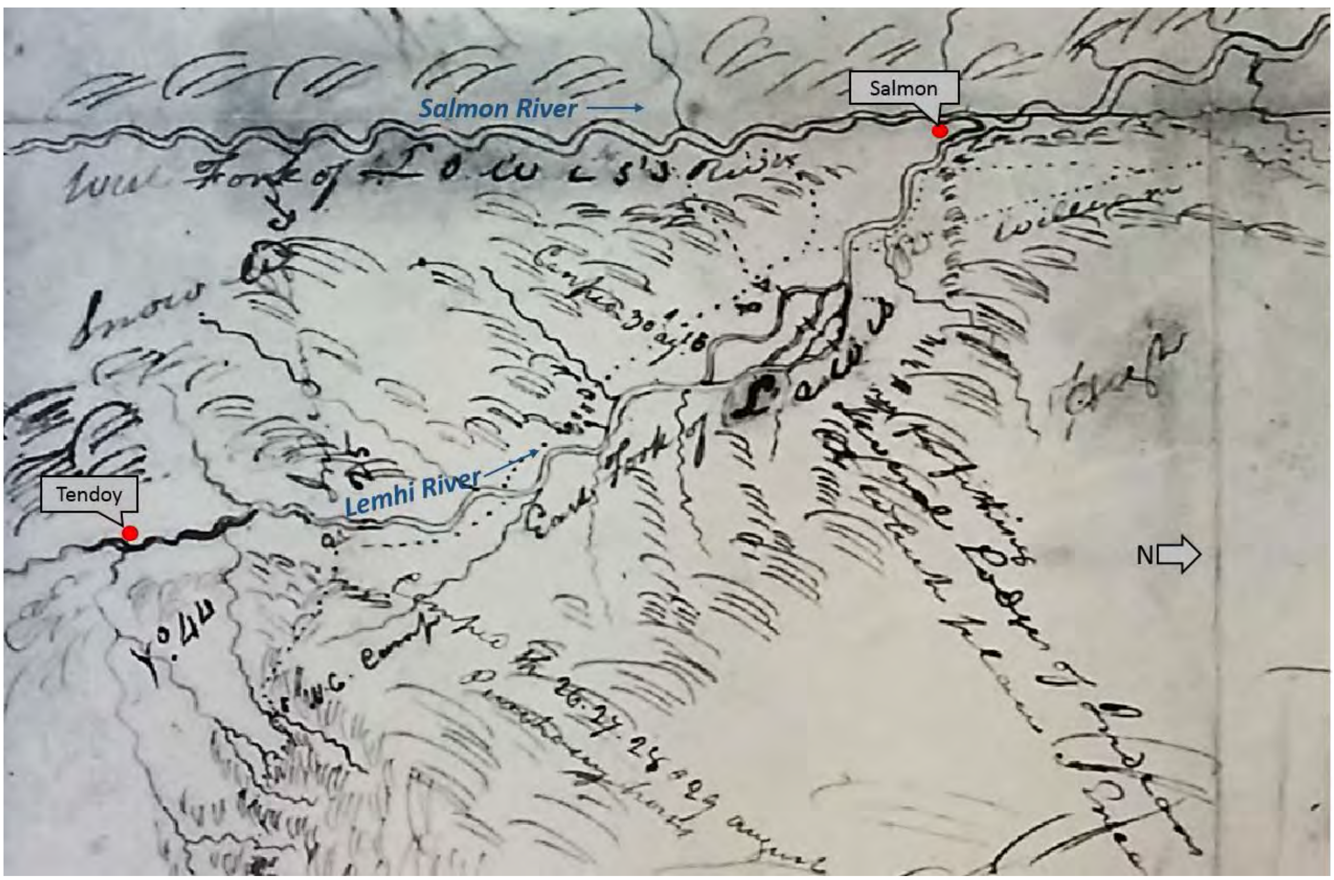

Figure 1-2 Lewis and Clark Map

Illustrating the Lemhi River approximately 25 miles downstream of the project area.

Based on historical evidence and basic hydraulic modeling (see methods below), it is assumed that the historic single-threaded portions of the historic Lemhi River near the downstream end of the project reach had an average top-width of 25-30-feet with an average bankfull depth of 2.0- to 2.25-feet. Side channels were likely of similar width-to-depth ratio. Observations of similar streams in a natural condition suggest the banks would have been relatively steep to undercut where undisturbed, and pools would have been 2-3-times the average depth associated with structure and the outside of bends. Pools may have formed by scouring the bed and/or as backwater pools from beaver dams and other channel obstructions. Observations of reference analogs and the lack of large meander scrolls visible on LiDAR topography suggest the channel was relatively stable (low rates of channel migration) and trended toward episodic split flow and avulsion versus rapid channel migration.

The historic channel character was influenced by the geologic history of the area and beavers. Beaver dams obstructed flow causing fine sediment deposition across the floodplain and episodic channel avulsion resulting in side channels and oxbows. Across the entire valley bottom, 4-to-5-feet of fine sediment consisting of silt and clay has been deposited over gravel and cobble from the ancient river bed. Exposures of these sediments are visible on cutbanks of the river today. The depth of fine sediment and lack of visible layering suggests the period of deposition occurred over hundreds to thousands of years and supports the large-scale presence and influence of beaver historically versus episodic deposition from debris flows or catastrophic events. Trapper journals (e.g.: Ferris, 1830-1835) further support the likely influence of beaver documenting the capture of 50-60 beaver per day in the vicinity of the Lemhi River.

The riparian conditions of the ancient Lemhi River were likely similar to undisturbed beaver-populated meadow streams seen in a handful of locations throughout the Rocky Mountain West today. These systems are in a constant state of flux as a result of disturbance from grazing animals (bison, elk, and deer) and ever-changing water levels associated with beaver activity. Beaver dams create a mosaic of open water, emergent wetland, floodplain and upland. It is likely that the riparian community of the ancient Lemhi River mirrored this diversity with areas of open water, wetland meadow (grass), floodplain shrubs (willow) and upland vegetation (sage and rabbit brush). Occasional stands of cottonwood may have persisted where well-draining soils were found, likely at the confluence with tributaries that would deliver coarse sediment (sand and gravel) as opposed to the fine-grained sediment (silt and clay) dominating the majority of the floodplain. Riparian diversity was likely further influenced by grazing herds of bison and elk maintaining areas of open pasture between large, dense stands of willow.

Since the late 1800s the property has been occupied by a series of working farms and ranches with active livestock production, holding pasture, grazing, and hay production. Over the past 20 years the Leadore Land Partners have consolidated several properties into single ownership which has recently been protected with a conservation easement. The easement consists of two parcels separated by another property. A large portion of the eastern parcel is irrigated by center pivots for the production of alfalfa in and around Canyon, Texas and Eighteen Mile Creeks. The majority of the larger western parcel is predominantly flood and sub-irrigated pasture and riparian zone along the Lemhi River and Big Springs Creek. The conservation easement has four principal goals: 1) protecting and restoring fish and their habitat, 2) protecting stream corridors, 3) preserving open spaces, and 4) continuing existing ranching and agricultural practices.

2 Habitat Evaluation Methods

Three principal habitat evaluation methods were utilized to develop the findings and recommendations in this report. The first was a high-level geomorphic evaluation to understand the physical context in which the riparian community is founded. These conditions were largely determined from observation (direct field observation, topographic evaluation and/or aerial photo analysis) and empirical calculations from regional data. The second evaluation method included a shoreline vegetation and wetland assessment. This assessment was conducted via a combination of field observation, aerial photo analysis and geographic information system (GIS) data analysis from readily available data sources. The third evaluation method included a shade analysis using GIS analysis tools and a combination of Light Detection and Ranging (LiDAR) topography, field measurements, and empirical calculations derived from regional datasets. LiDAR included waveform data enabling the discernment of first returns (vegetation) from last returns (ground or "bare-earth") (Figure 2-1). In this way the relative height of vegetation can be measured by subtracting the last returns (ground elevation) from the first returns (vegetation). The LiDAR signal does not penetrate water, therefore ground and water are both identified as last returns. Bathymetry was estimated in the field.

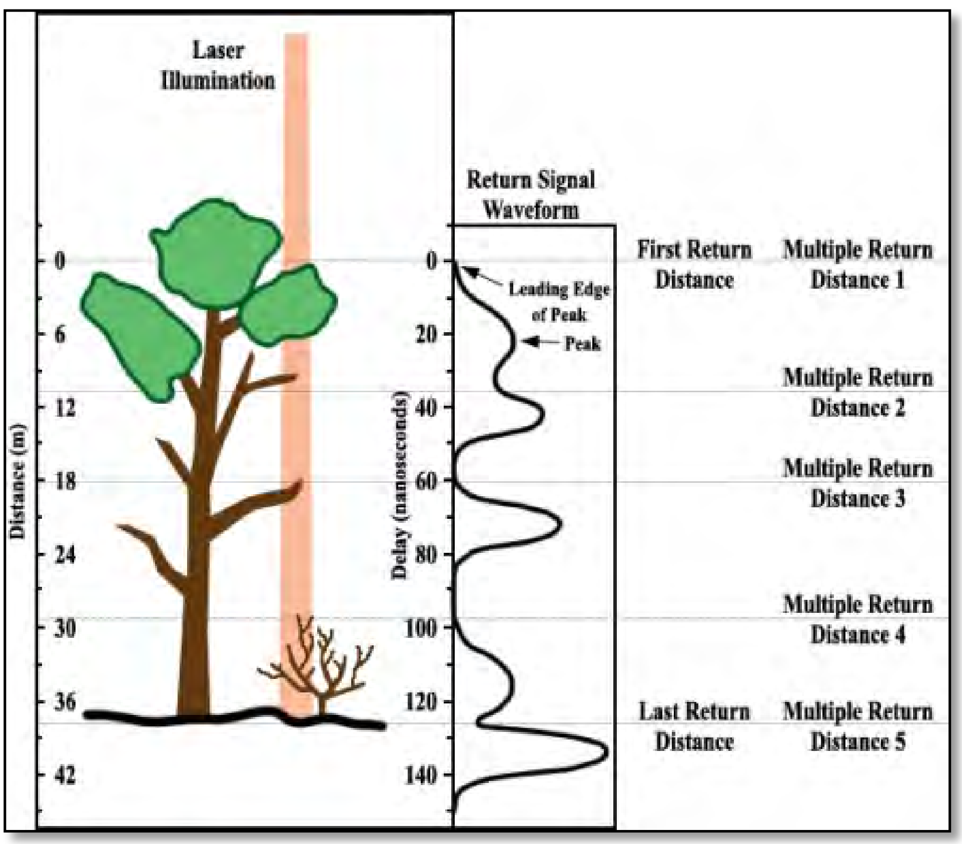

Figure 2-1 LiDAR Waveform Data

LiDAR waveform data enables the discernment of first returns (vegetation) from last returns (ground or "bare-earth". In this way various analyses can be performed to calculate vegetation height or bank height be subtracting one surface from another.

2.1 Geomorphic Evaluation

The geomorphic evaluation focused on understanding the physical conditions that historically formed and currently maintain the character of the project area as well as those that may have altered or impacted the system.

Channel bed, bank, and floodplain conditions were measured using a combination of field observations and GIS analysis. Bed material was directly observed in the field and grain sizes were estimated at representative locations throughout the project area. Where possible, soil exposures were located along the banks and on the floodplain to observe bank and floodplain composition in the field. Soil and sediment composition were documented using ocular estimates and standard field techniques.

Channel geometry was measured at representative cross sections of the Lemhi River, Big Springs Creek, Texas Creek, Eighteenmile Creek, and Canyon Creek, Channel width was measured in the field and in GIS while average depth was estimated based on field observations. Channel gradient and sinuosity were measured from LiDAR in GIS. Historic channel conditions were estimated via observable channel scars evident in LiDAR topography and (where possible) their width was also measured in the field.

Channel hydraulics were evaluated at a coarse-scale using channel geometry estimates described above and discharge estimates from USGS Stream Stats and readily available reports. A spreadsheet analysis incorporating these data into Manning's equation at representative cross sections was used to estimate water surface elevations and velocity for various discharges. Similarly, potential ancient channel geometries were evaluated using the same methods to estimate representative channel width and depth for single-threaded channels and multi-threaded channels assuming width-to-depth ratios appropriate for low-gradient meadow systems.

LiDAR modeling was completed to evaluate the elevation of the floodplain and banks relative to the water surface elevation as measured from the LiDAR surface. A broad-scale relative surface model was made by applying the water surface elevation to cross sections spanning the valley roughly every 500 feet. These cross sections attributed with the water surface elevation were used to create a Triangulated Irregular Network (TIN) which was then converted to a grid with 1-foot resolution. This water-surface grid was then subtracted from the bare-earth LiDAR digital elevation model (DEM) to create a relative surface model whereby all grid points greater than zero represent increasing height above the water and all grid points less than zero represent increasing depth below the water. In this way, relative high and low areas can be easily identified across the entire floodplain.

Similarly, the bank heights were measured relative to the water surface elevation from the LiDAR bare earth model at a much finer resolution. A line was drawn down the middle of each channel within the project area and then converted to points at 10-foot intervals. The 3D analyst extension in GIS was used to apply the bare earth LiDAR elevation to each point which was then spatially joined to the nearest point along the banks similarly drawn and similarly attributed with the bare earth LiDAR elevation of the bank. The two LiDAR elevations were then subtracted (bank elevation minus water surface elevation) resulting in a bank height at each point along the bank.

A GIS analysis enabled the rapid evaluation of bank points located near the apex of a bend versus those on the inside of a bend or along a straight corridor. This was accomplished by creating a 100-foot buffer around each bank line and drawing a new line that intersected the buffer only in the vicinity of a bend apex. This line was drawn from apex to apex along the entire length of each channel. Next a spatial join was completed between the line drawn and the bank points described above such that the bank points were attributed with the character of the line only in areas where the line fell within 100 feet of the points (i.e.: within the 100-foot buffer). Following the spatial join, only those bank points near a bend apex were attributed with the fields from the bend apex line allowing for the segregation of those points near an apex and those not near an apex.

A vegetation height model was also created using LiDAR where by the first-returns LiDAR data set was subtracted from the bare-earth LiDAR data set. The resulting DEM represents the relative height of the vegetation captured in the first-returns data set above the ground captured in the bare-earth data set.

2.2 Shoreline Vegetation and Wetland Assessment

Shoreline vegetation assessment and categorization was based off of existing Vegetation Types defined in the 2009 Idaho DEQ Potential Natural Vegetation Temperature Total Maximum Daily Load Procedure Manual document. This allowed for consistency in evaluation of existing vegetation types between those identified as a result of the field survey and past shade assessments completed by the Idaho Department of Environmental Quality. While the vegetation types identified across the assessment area relatively generic, they do provide simple and cursory evaluation of existing vegetation.

Wetland Assessments were completed using a combination of analyses used in Montana Wetland Assessment Method and Idaho Interim Functional Assessment for Riverine Wetlands on the Floodplains of Low to Moderate Gradient 2nd or 3rd Order Streams on Fine Textured Substrates. Both of these documents provide insight in the evaluation of the overall health and function of both wetlands in general and wetlands associated with low gradient floodplains systems. While the details of these evaluations are not specifically outlined in this Habitat Management Plan, they were used to provide insight into the factors limiting wetland function and factors limiting the overall role of support wetlands' contribution to health of the existing riparian corridor.

2.3 Shade Analysis

Identification and evaluation of limiting factors affecting Riparian habitats including instream shade analysis was completed through a combination of LIDAR aided ground-level modeling and vegetation modeling. This information was used to complete shade modeling using a combination geographically-calibrated module of Heat Source (Version 8) named Shade-a-lator. A complete methodology of the shade analysis is provided in Appendix A.

The analysis in this report used Heat Source Version 8 to calculate effective shade values while shade targets for the area were generated by ID DEQ using HeatSource Version 6. A hypothetical future scenario was run through the Version 8 software following the same assumptions used by ID DEQ (ID DEQ, 2009) which included 6-meter vegetation, 1.5-meter overhang and an August 1 sun angle to compare with target conditions generated by DEQ from Version 6 software. There appears to be a discrepancy between the two whereby the Version 6 software calculates a greater effective shade value than the Version 8 software as a result of different methods of calculating sun angle between the two software versions. The result is a condition whereby effective shade measurements using Version 8 are less than the same calculations using Version 6 software (Table 2-1). It is believed that the Version 8 software is more up-to-date and therefore more accurate, for this reason all effective shade values reported in this document represent Heat Source Version 8 calculations unless explicitly stated otherwise. This is important to recognize when comparing calculated effective shade values from this report with target conditions, because the numbers in this report are undervalued relative to the DEQ targets (see comparison in Appendix C-13 and C-14). Riparian management goals should take this discrepancy into consideration when comparing measured effective shade versus targeted values. Results using both Version 8 and approximating Version 6 software have been tabulated, and are available as part of the GIS shapefile and Excel spreadsheet deliverables associated with this report.

Table 2-1 Effective Shade Calculations Comparison

	Target	Future Condition w/ standard v8 setting	Future Condition rerun w/ v6-like setting
Lemhi	25.4%	20.0%	49.0%
Big Springs	39.7%	28.9%	50.0%
Canyon	67.8%	47.9%	64.0%

Hypothetical future conditions (6-meter vegetation and 1.5-meter overhang along all banks with an August 1 sun angle) were calculated for three sample areas using Version 8 (v8) and settings within Version 8 to mimic Version 6 (v6) settings in the HeatSource software used in this report and by DEQ to calculate effective shade. The v8 results, which are the results published throughout the rest of this report, are significantly lower than the v6 results (i.e.: targets).

3 Reach Characterization

A summary of the geomorphic, riparian, and existing shade conditions is provided in this section to provide a foundation for reach categorization, proposed treatments, and future monitoring efforts. To facilitate discussion, the project area has been broken down into reaches representing each stream evaluated. The longer streams (Lemhi and Big Springs) have been further broken down into sub-reaches based on similar geomorphic and riparian characteristics. The streams and reaches occupying the valley bottom (all but Canyon Creek) exhibit similar characteristics which have been described both generally and individually below. Canyon Creek is a tributary that flows across a broad alluvial fan rather than flowing within the valley bottom. As such, Canyon Creek exhibits slightly different overall characteristics and has been described separately.

3.1 Canyon Creek

Within Isom Upper Pivot Field (Figure 3-1)

Figure 3-1 Representative photo of Canyon Creek

Within the Isom Upper Pivot Field. Photo is taken looking upstream illustrating three floodplain surfaces – low surface with willow, moderate surface with sparse cottonwood and/or grass, and high surface with sage and rabbit brush.

Channel Conditions:

> Geometry in disturbed areas (lower 1/3 of reach)
  > Representative bank full width of 8ft with a max width of 15ft
  > Representative average bank full depth of 1ft
  > Max bank full depth at pools is 3ft (backwater pool upstream of channel obstruction)

- Geometry in minimally disturbed areas (upper 2/3 of reach)
  - > Representative bank full width of 4ft
  - > Representative average bank full depth of 2ft
  - > Max bank full depth at pools is 4ft (backwater pool upstream of channel obstruction).
- Composition
  - > Bed is composed of gravel with large quantities of sand deposited in slack-water areas; armored with cobble lag
  - > Banks are composed primarily of sand and silt overlying gravel and cobble; bank erosion and recession is abundant in the lower 1/3 of the reach
- Morphology
  - > Forced riffle-pool (Figure 3-2)
  - > Pools are typically a result of backwater conditions upstream of channel obstructions (large woody debris or live willow encroachment; occasional gravel/cobble riffles)
    - Obstructions provide grade control
  - > Banks are vertical to undercut where Riparian vegetation is abundant; vertical and eroding where Riparian vegetation is lacking or disturbed
  - > Much of the site appears to have become incised by 1-2ft and lacks adequate grade control structure to aggrade the bed sufficiently to reconnect the existing floodplain resulting in many high banks lacking riparian vegetation.

> Floodplain Conditions:

- Composition
  - > Silt and sand; generally well-draining, permeable
- Morphology
  - > Low floodplain is inches above the bank full water surface elevation
    - Narrow or nonexistent
  - > Low terrace is approximately 1ft above the bank full water surface elevation
    - Narrow or nonexistent
  - > High terrace is broad and approximately 3ft above the bank full water surface elevation

> Riparian Conditions:

- Vegetation Community Associations: Geyer Willow/Reedgrass Association. Sapling cottonwood occupy low floodplain and decadent cottonwood occupy well-draining soils of the terraces; however they do not dominate the vegetation community. Cottonwood Riparian Vegetation Types Association for shade evaluation would be inappropriate given the existing density/occurrence of mature cottonwood. Gramaniod/Sagebrush Vegetation Type Association for shade evaluation would be inappropriate as adjacent reaches are largely occupied by sagebrush terraces and willow flooplains.
  - > Low floodplain is dominated by reedgrass (Calamagrostis canadensis), willows (Salix geyeriana) (S. boothii) (S. exigua), sapling cottonwood (Populus spp.), with rose (Rosa woodsii)

and occasional river birch (Betula sp.). Low floodplain is heavily foraged. Very little/no vegetative recruitment.

> Low terrace dominated by upland graminoids, mature/decadent willow, with scattered decadent cottonwood and rose.

> High terrace is dominated by rabbit brush (*Chrysothamnus* spp.), sagebrush (*Artemisia tridentata*), and juniper (*Juniperus* spp.) trees.

- Adjacent Wetlands – Low floodplain and low terrace wetlands are modified by existing land management practices and largely non-functioning. These wetlands will continue to provide limited vegetative recruitment opportunities (via decadent willow, cottonwood, and birch).
- Disturbance - Historic impacts to shoreline soils and vegetation have resulted in decreased riparian cover and function. Adjacent properties (north and south) are well vegetated with willow dominated riparian corridor. Riparian vegetation regeneration is occurring in small pockets of naturalized vegetation particularly where grazing is excluded. Improvements to floodplain and low terrace function will likely improve recovery by increasing the width of the effective riparian buffer, thereby promoting vegetative recruitment from both upstream riparian corridors and adjacent wetlands.

Figure 3-2 Forced pool formed as a result of scour

Associated with an obstruction (large woody cottonwood debris seen in the photo) and backwater from willow growth obstructing the channel (located behind the photographer, not seen in the photo). Photo taken looking upstream.

> Shade Conditions:

- Existing effective shade averaged for the entire reach of Canyon Creek = 11.3%
- Effective shade target averaged for the entire reach of Canyon Creek = 67.8%
- Currently 0% of the reach is meeting established shade targets

> Shade targets based on channel width and geyer willow – reed grass riparian community

>

3.2 Lemhi River and Big Springs Creek – General Conditions

> Channel Conditions:

  > Bed and banks

- Generally gravel bed composition with residual (lag) cobble in places
- Significant fine sediment (sand, silt, clay) component to the sediment budget
- Bed is moderately to highly embedded with fines
- Pools observed infrequently; where present, pools were associated with in-stream structure (willow root mats, coarse debris, hard infrastructure)
- Banks composed of silt and clay overlying gravel and cobble

    > Banks are stable and vertical to undercut where riparian vegetation is dense/mature.

    > Banks are poorly defined and/or eroding where riparian vegetation is limited to high terrace vegetation grass/shrub communities. Sagebrush

- Channel width is correlative to historic and/or existing grazing and riparian health

    > Low width-to-depth ratio where grazing was/is limited and willow density is high

    > High width-to-depth ratio where grazing was/is common and willows are thin or absent

  > Morphology

- Moderate to highly sinuous; little to no channel straightening

    > Exception: straightened portions of Big Springs creek and Lemhi River adjacent Hwy 28.

- Forced riffle pool morphology (where dense willow riparian areas are present)

    > Live willow encroachment provides the forcing mechanism creating obstructions, contraction, and scour.

- Plane-bed morphology (where dense willow riparian is lacking)
- Both the Lemhi and Big Springs are believed to be slightly incised (as much as 1-to-2-feet) compared to historic (pre-disturbance) conditions.
    - Coarse hydrologic and hydraulic analyses suggest the floodplain is not broadly inundated until flows exceed the 2yr recurrence interval. Additionally, the low terrace that persists at an elevation of roughly 1-3 feet above the annually inundated floodplain was likely formed as low floodplain prior to historic disturbance. Several decadent willow communities that must have originated on the floodplain are currently located on the terrace. This suggests the incision has occurred within the lifetime of the willows and is likely related to human disturbance within the past 100 years.
    - Relic channel scars evident in LiDAR topography suggest the confluence with Big Springs Creek has migrated upstream several thousand feet in the past (Figure 3-3). The most downstream channel scars associated with the historic confluence are more heavily obscured by years of erosion and disturbance (i.e.: older) than the scars located farther upstream suggesting the migration has been consistently upstream and has not bounced back and forth. Consistent upstream migration of a tributary confluence is indicative of main-stem channel incision. As the main-stem incises, the confluence migrates upstream in order to maintain a consistent gradient, otherwise the tributary will also become incised. It is likely that some amount of main-stem and tributary incision have occurred in order to maintain hydraulic balance in the system.

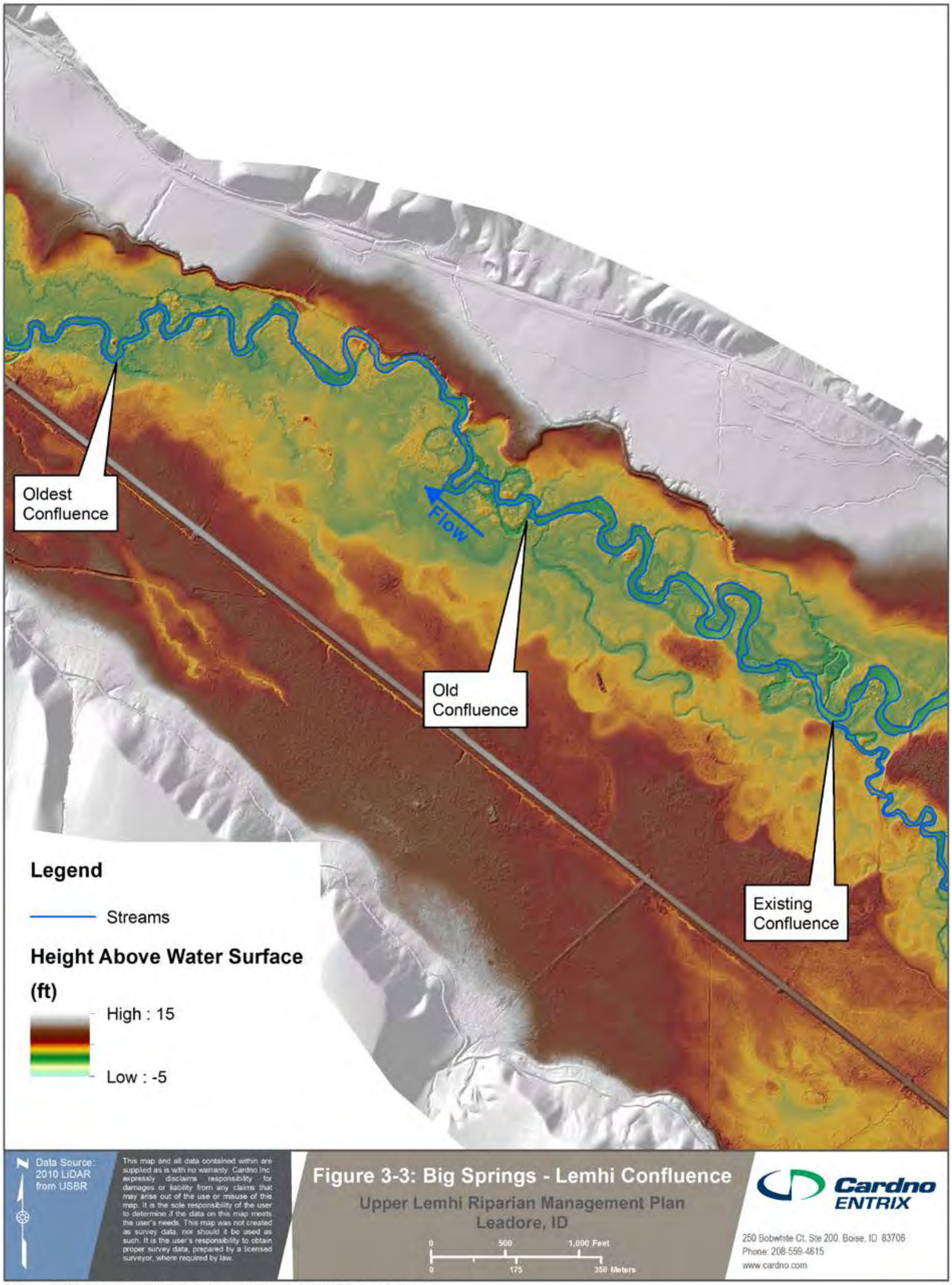

Figure 3-3 Big Springs – Lemhi Confluence

- Bankfull conditions are more likely related to a discharge less than the commonly accepted 1.5yr return interval discharge. Varying climactic characteristics have been shown to alter the average flood return interval associate with bankfull conditions. In the western interior basin and range, of which the project area is a part, streams tend toward a median bankfull return interval of 1.3 years (Castro and Jackson, 2001). Meadow systems, such as those formed by beaver dam activity, are maintained by flow obstruction, raising the water surface elevation, and therefore increasing the frequency of overbank flow even beyond the median. For this reason the 1.25yr recurrence interval (Q = 251cfs) has been chosen to represent historic bankfull discharge for the project area as opposed to the 1.3yr (Q = 265cfs) or 1.5yr (Q = 328cfs). A 1.25yr recurrence interval flood also better fits estimated historic channel geometries than the 1.5yr recurrence interval when calculating bankfull conditions using Manning's Equation. Using the 1.25yr bankfull discharge and a 30-foot channel width (based on LiDAR channel scars), the historic Lemhi River likely had a width-to-depth ratio of approximately 15 and an average bankfull depth of 2-feet.

> Floodplain Conditions:

> Soil composition

> Clay with varying amounts of silt and fine sand (poorly draining, impermeable) overlaying gravel and cobble at 2-5ft depth.

> Three dominant surfaces and corresponding Riparian communities (Figure 3-4):

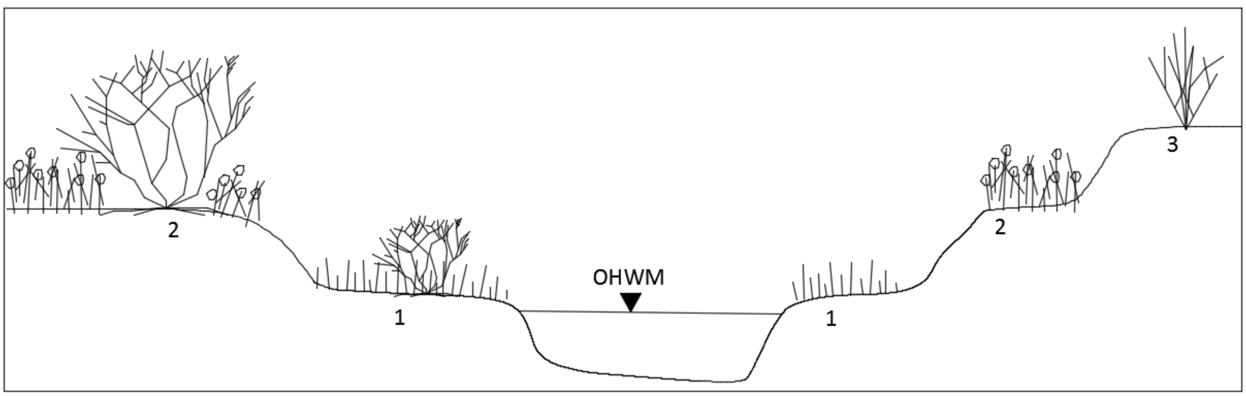

Figure 3-4 Generalized cross section with 3 surfaces.

Most willow vegetation was observed on the low (1) or intermediate (2) surface.

- 1) Inches above the ordinary high water mark consisting of sedge (*Carex ultircata*) (*Carex aquatilis*), reedgrass (*Calamagrostis Canadensis)*, willows (*Salix geyeriana*) (*S. boothii*) (*S. exigua*), rose (*Rosa woodsia*), and weeds.

  > Significantly greater density of willow where grazing disturbance is (and/or has been) low

  > Significantly greater density of weeds and conspicuous lack of willow where disturbance (grazing) is (and/or has been) high.

- 2) Approximately 1-to-2ft above ordinary high water mark consisting of intermittent willow, juncus (*Juncus* spp.) and weeds – dominated by weeds where disturbance is (and/or has been) high.

- 3) Greater than approximately 3ft above ordinary high water mark consisting of rabbit brush, grease wood, weeds

- Riparian Conditions:
  - Vegetation Community Associations: Lemhi and Big Springs support current riparian conditions driving two Riparian Community Associations: Geyer's Willow/Reedgrass occupying what is believed to be a late succession riparian corridor (mature willow community) and Graminoid or Graminoid/Sagebrush (shrub like) Vegetation Type occupying portions of both Big Springs Creek and Lemhi River in areas where willow growth is largely absent. Dominance/occurrence of Graminoid Vegetation Type Associations are presently driven by land management practices and elevation of low floodplain.
    - Low floodplain is dominated by either reedgrass (Calamagrostis canadensis) or sedge (Carex aquatilis, C. ultricata, C. rostrata), willows (Salix geyeriana, S. boothii, S. exigua), rose (Rosa woodsii) and river birch (Betula sp.). Low floodplain is foraged in areas. Land use practices are obvious (heavy vs. dispersed grazing is easily discernable). Vegetative recruitment was classified as impaired. Little (willow) recruitment is occurring outside decadent willow/reedgrass communities as existing system has high outside banks which provide both high levels of herbivory and have limited annual saturation necessary for willow germination.
    - Low terrace dominated by decadent willow (Salix spp.), rushes (Juncus spp.) and graminoids (Agrostris spp., Deschampsia cespitosa, Calamagrostis spp.), mature/decadent willow (Salix spp.), and rose (Rosa spp.).
    - High terrace is dominated by pasture grasses, common weeds, infrequent decadent willow (Salix spp.), rabbit brush (*Chrysothamnus* spp.), sagebrush (*Artemisia tridentata*), and greasewood (*Sarcobatus vermiculatus*).
  - Adjacent Wetlands – Low floodplain and low terrace wetlands have been modified by past land management practices and are currently functioning below what is believed to be optimal condition. Remnant wetlands in historic oxbows, bends, and flow channels are ageing, decadent, and continue to provide limited recruitment and function to the existing riparian bank system. Wetlands surrounding the riparian corridors are lacking shrubs and trees. The largest contributing factor limiting wetlands regrowth and recruitment for riparian bank community was identified as lack/alteration of hydrology and reduction in recruitment from adjacent wetlands.
  - Disturbance: Lemhi and Big Springs riparian community conditions vary greatly depending upon conditions. One or both of the following conditions exist which preclude willow from vegetating banks not presently dominated by willow. 1) Shoreline vegetation has been and/or continues to be foraged by both livestock grazing and big game, limiting regeneration of young willow. 2) Shoreline elevation is too high and does not allow for contact to moist soils required for willow regeneration.
    - Causes: Livestock Management; herbivory. Historic land use was incompatible with natural regeneration of Willow/Reedgrass Vegetation Type. Willow recruitment requires minimal disturbance for several years until the plants can become established.
      - With grazing (Figure 3-5)
        - Little to no new willow growth or expansion even in low-lying areas
        - Heavy browse and observable damage on existing willow plants
        - Many weeds
        - Areas of bare/compacted soil
        - Generally less willow density on the outside of bends
      - Grazing exclusion (Figure 3-6)
        - Moderate to dense, mature willow Riparian community

> Generally less willow density on the outside of bends

> Significant new willow growth or expansion into low-lying areas

- Shoreline elevation; Bank elevation in places is incompatible with natural regeneration of Willow/Reedgrass Vegetation Type. Existing Willow/Reedgrass Vegetation Type is spatially limited as a result of past land use practices. In many cases no low floodplain exists.

> Willow tend to dominate the Riparian area where poorly drained soils persist (i.e.: silt and clay as observed throughout the majority of the project area).

> Historic Land Use. Loss of wetland function and recruitment from adjacent wetlands as a result of wildlife/vegetation management to promote agricultural development.

- Loss of function of floodplain and low terrace required to promote annual inundation for optimal riparian function and regeneration. Few areas of functioning floodplain and low terrace exist.

> Shade Conditions:

- Lemhi River:

> Existing effective shade averaged for the entire reach of the Lemhi River= 11.6%

> Effective shade target averaged for the entire reach of the Lemhi River = 25.4%

> Currently 4% of the reach is meeting established shade targets

- Big Springs Creek:

> Existing effective shade averaged for the entire reach of Big Springs Creek = 8.6%

> Effective shade target averaged for the entire reach of Big Springs Creek = 39.7%

> Currently 1% of the reach is meeting established shade targets

- Shade targets based on channel width and geyer willow – reed grass riparian community

Figure 3-5 Photos of the Lemhi River at Fayle illustrating representative conditions where grazing has not been excluded

The channel has a high width-to-depth ratio and willow Riparian vegetation is sparse, typically located on the inside of meander bends.

Figure 3-6 Photo of the Lemhi River near the downstream end of the project site illustrating representative conditions where grazing has been largely excluded

Dense willow Riparian growth dominates the low floodplain areas, while higher banks are more sparsely vegetated with willow

3.2.1 Big Springs Creek (Headwaters)

Primarily within Triangle Pasture (23) – Figure 3-7

Figure 3-7 Representative photo illustrating the headwaters area of Big Springs Creek

Photo is taken looking upstream along the southern branch of the channel. Note the sparse willow Riparian vegetation on high banks (left half of photo) and the high width-to-depth ratio of the channel.

- Channel Conditions:
  - Two main branches
    - North branch = 12ft representative width
    - South branch = 20ft representative width
  - Spring-fed channels becoming full width almost immediately
  - Gravel bed with substantial subaqueous vegetation
- Floodplain Conditions:
  - See general description above
- Riparian Conditions:
  - See general description above for grazed riparian areas
  - See general description above for shoreline elevation

3.2.2 Big Springs Creek (Mid)

Within exclusion area adjacent Upper Island Pasture (14), Doug Way Field/Upper Wind Break (18), Neibaur (22) and Unknown pasture (31) – Figure 3-8.

Figure 3-8 Representative photo of Big Springs Creek looking upstream within the exclusion area between the Neibaur pasture (22) and Unknown pasture (31).

The photo illustrates willow riparian vegetation on the low floodplain surface along the inside of the bend, and the lack of willow riparian vegetation on the relatively high surface located along the outside of the bend.

> Channel Conditions:
  > 20ft representative bank full width
  > 0.5ft representative average bank full depth
> Floodplain Conditions:
  > See general description above
> Riparian Conditions:
  > See general description above for riparian exclusion areas
  > See general description above for shoreline elevation

3.2.3 Lemhi River (Fayle)

Within Billy's Pasture (24) – Figure 3-9

Figure 3-9 Representative photo of the Lemhi River within Billy's Pasture (24).

Photo is looking downstream and illustrates the lack of Riparian willow vegetation associated with historically heavy grazing. Areas of dense willow Riparian vegetation occur where grazing is limited, such as on islands (left side of photo) and along the inside of some bends.

Limited Access due to landowner request

- Channel Conditions:
  - Generally the highest width-to-depth ratio observed
- Floodplain Conditions:
  - See general conditions above
- Riparian Conditions:
  - See general conditions above for grazed riparian areas
  - See general description above for shoreline elevation
  - Generally the most disturbed riparian conditions observed, especially on the north side of the Lemhi River.
  - Willow densities are generally greater on the southern side of the Lemhi River.

3.2.4 Lemhi River (Mid)

Within Neibaur Middle Pasture (21) and within an exclusion adjacent Island Pasture (13), Upper Island Pasture (14), Stroud Pasture (16) and Filo Pasture (19) – Figure 3-10.

Figure 3-10 Representative photo of the Lemhi River in the middle of the project reach within the Neibaur Middle Pasture (21).

Photo illustrates generally dense willow Riparian vegetation in low areas, and sparse willow Riparian vegetation in high areas and/or along the apex of bends.

- Channel Conditions:
  - 30ft representative bank full width
  - 1.5ft representative average bank full depth
- Floodplain Conditions:
  - See general conditions above
- Riparian Conditions:
  - See general conditions above for exclusion areas
  - See general description above for shoreline elevation

3.2.5 Lemhi River (Confluence with Big Springs Creek)

Within Junction Pasture (12) – Figure 3-11

Figure 3-11 Representative photo of the Lemhi River immediately upstream of the confluence with Big Springs Creek

The majority of the floodplain in this area is lacking willow Riparian vegetation with the exception of areas isolated from grazing (left side of image – along the inside of a bend).

- Channel Conditions:
  - 30ft average bank full width
  - Bank full width approaching 100ft in places
  - Bank full width measured in abandoned channel is 20-25-feet suggesting an excessively high width-to-depth ratio currently
    - Abandoned channels no longer maintain sharp bank edges; likely the banks have sloughed off over the years of inactivity resulting in a narrower width. Representative “pre-disturbance” channel width is therefore likely closer to 30-feet.
- Floodplain Conditions
  - See general conditions above
  - Irrigation diversion within relic oxbow has been periodically dredged with spoils consisting of sand with silt and gravel lining both sides of the ditch leading to the fish screen (L-58C)
- Riparian Conditions:
  - See general conditions above for grazed Riparian areas
  - See general description above for shoreline elevation

3.2.6 Lemhi River (Downstream)

Exclusion area below the confluence with Big Creek adjacent Bull Pasture (1), Feed Lot Pasture (6), River Field (7), and Longhorn Pasture (8) – Figure 3-12

Figure 3-12 Representative photo of the Lemhi River near the downstream end of the project area – within the exclusion area

Adjacent the Bull pasture (1) and Feed Lot pasture (6). The majority of low-lying floodplain areas are densely populated with mature or emerging willow Riparian vegetation. Willow Riparian vegetation is sparse or lacking on relatively high floodplain surfaces and/or the outsides of several meander bends.

- Channel Conditions:
  - 30ft representative bank full width
  - 2ft representative average bank full depth
- Floodplain Conditions:
  - See general conditions above
- Riparian Conditions:
  - See general conditions above for exclusion areas
  - Generally the most dense and intact Riparian vegetation observed within the entire easement
  - Conditions generally best in the lower 2/3 of this reach

3.3 Texas Creek

Isom Hawley/Eighteen Mile Field (35) – Figure 3-13

Figure 3-13 Representative photo of Texas Creek

(Right side of photo) and adjacent floodplain (left side of photo) illustrating extensive natural willow regeneration in existing low-lying areas of the floodplain.

> Channel Conditions:
  > 6-7-feet representative bank full width
  > 2-feet representative average bank full depth
  > 2.5-3-feet max bank full depth
> Floodplain Conditions:
  > Three dominant surfaces (floodplain, low terrace and high terrace) and corresponding Riparian communities as described for the Lemhi and Big Springs Creek above.
  > Soil composition
    > Clay with varying amounts of silt and fine sand (poorly draining, impermeable) overlaying gravel and cobble at 2-5ft depth.
> Riparian Conditions:
  - Vegetation Community Associations: Texas Creek supports current riparian conditions driving two Riparian Community Associations: Geyer's Willow/Reedgrass occupying what is believed to be a late succession riparian corridor (mature willow community) and Graminoid Vegetation Type occupying areas where willow growth is largely absent. Dominance/occurrence of Graminoid Vegetation Type Associations are presently driven by historic or present-day land management practices and elevation of low floodplain. Early succession Geyer's Willow/Reedgrass Vegetation Type Association was observed and is expected to, over time, dominate the existing Graminoid Vegetation Type Associations. <u>Floodplain and low terrace vegetation communities are intact and regenerating.</u>
  > Low floodplain is dominated by either reedgrass (Calamagrostis canadensis) or sedge (Carex aquatilis, C. ultricata, C. rostrata), willows (Salix geyeriana, S. boothii, S. exigua), rose (Rosa woodsii) and river birch (Betula sp.). Low floodplain is foraged in areas. Vegetative recruitment

was classified as impaired and improving. Willow recruitment is occurring outside decadent willow/reedgrass communities along existing channel and in areas >100 ft. beyond existing channel where the intact low floodplain hydrology is present and functioning. Annual saturation necessary for willow germination occurs throughout the low floodplain.

> Low terrace dominated by decadent willow (Salix spp.), rushes (Juncus spp.) and graminoids (Agrostris spp., Deschampsia cespitosa, Calamagrostis spp.), mature/decadent willow (Salix spp.), and rose (Rosa spp.). Low summer water levels (during irrigation season) may be restricting summer growth

> High terrace is dominated by pasture grasses, common weeds, rabbit brush (Chrysothamnus spp.), sagebrush (Artemisia tridentata), and greasewood (Sarcobatus vermiculatus).

- Adjacent Wetlands – Low floodplain and low terrace wetlands have been modified by past management practices and are presently recovering toward optimal conditions. Wetlands in historic oxbows, bends, flow channels and the seasonally inundated low floodplain are dominated by both mature and decadent willows. Low floodplain and low terrace is broad, regenerating, and presently providing vegetative recruitment and function to the existing riparian bank system. The largest contributing factor limiting these wetlands regrowth and recruitment for riparian bank community was identified as lack/alteration of hydrology and reduction in recruitment from adjacent wetlands.

- Disturbance: Classified as low. One or both of the following conditions exist which preclude willow from vegetating banks not presently dominated by willow. 1) Shoreline vegetation was/is foraged by both livestock grazing and big game, restricting regeneration of young willow. 2) Shoreline elevation is too high and does not allow for contact to water moist soils required for willow regeneration.

> Causes: Historic Livestock Management; herbivory. Historic land use was incompatible with natural regeneration of Willow/Reedgrass Vegetation Type. With recent changes to land use practices, willow recruitment is expected to improve.

- Generally fits the general description for grazing exclusion areas listed above with some exceptions

> Shoreline elevation.

- Poor riparian vegetation along the outsides of most bends and on high banks (over 2ft above bank full water surface elevation)

- Historic Land Use. Minimal loss of wetland function and recruitment from adjacent wetlands as a result of wildlife/vegetation management to promote agricultural development.

- Function of floodplain and low terrace required to promote annual inundation for optimal riparian function and regeneration is recovering.

> Shade Conditions:

- Existing effective shade averaged for the entire reach of Texas Creek = 6.5%

- Effective shade target averaged for the entire reach of Texas Creek = 53.9%

- Currently 0% of the reach is meeting established shade targets

> Shade targets based on channel width and geyer willow – reed grass riparian community

3.4 Eighteen Mile Creek

Isom Hawley/Eighteen Mile Field (35) – Figure 3-14

Figure 3-14 Representative photo of Eighteen Mile Creek

Illustrating dense willow Riparian vegetation in some areas with sparse willow Riparian vegetation in others.

> Channel Conditions:
  > 4-6-feet representative bank full width where disturbance is limited
  > 2-feet representative average bank full depth where disturbance is limited
  > 8-feet representative bank full width where disturbed
  > 0.8-feet representative average bank full depth where disturbed

> Floodplain Conditions:
  - See description above for Texas Creek

> Riparian Conditions:
  > Fits the description of riparian condition, vegetation type communities, wetlands, and disturbance regimes of Texas Creek.
    - Poor riparian vegetation along the apex of bends and on high banks (over 2ft above bank full)

> Shade Conditions:
  - Existing effective shade averaged for the entire reach of 18-Mile Creek = 8.1%
  - Effective shade target averaged for the entire reach of Texas Creek = 63.9%
  - Currently 0% of the reach is meeting established shade targets
    > Shade targets based on channel width and geyer willow – reed grass riparian community

4 Riparian Classification

Riparian Classification tiers were identified using a combination of inputs from field work and computer aided modeling to compare shade values and physical conditions along the banks of each stream in the project area. Where the existing vegetation heights fall within acceptable parameters, or trends suggest vegetation is becoming established naturally within an acceptable timeframe, the existing riparian condition is considered to be acceptable. Where vegetation heights are less than acceptable and are not likely to become established within an acceptable timeframe, the existing riparian condition is considered to be impaired and in need of treatment. Where treatment is necessary, there are two site characteristics most affecting riparian potential outside of existing and historic grazing management – the location of the bank on the outside of a bend and the relative height of the bank above the ordinary high water mark (OHWM).

4.1 Lemhi Valley

Includes: Lemhi, Big Springs Creek, Texas Creek, and 18-Mile Creek

Field observations reveal significantly less riparian vegetation and regeneration on the outsides of meander bends, likely due in part to the historic and existing concentrations of cattle and grazing in these locations. Cattle paths and observations of browse suggest a higher concentration of cattle along the outside of meander bends versus the inside of bends resulting in greater grazing impact in these locations (Figure 4-1). In general, the greater the impact, the longer the recovery time. This is part of the reason we suspect riparian regeneration has been slow to occur in several areas despite years of cattle exclusion (e.g.: the outside of bends along most of Big Springs Creek). The second reason is the relative height of the bank. Field observations suggest willow within this portion of the Lemhi Valley prefer areas less than roughly 1ft above the ordinary high water mark. Within exclusion areas and other reference locations, willow density and regeneration was noted to be significantly greater in areas frequently inundated – typically less than 1ft above the OHWM. Unless a channel is actively aggrading its bed (not the case here) the outside of a bend is cut into older and typically higher ground than the recently deposited material on the inside of the bend. Therefore the outside of the bend is relatively high and often more than 1ft above the OHWM resulting in less favorable conditions for willow growth. These and other riparian areas greater than 1ft above the OHWM tend not to support dense stands of willow resulting in low amounts of shade.

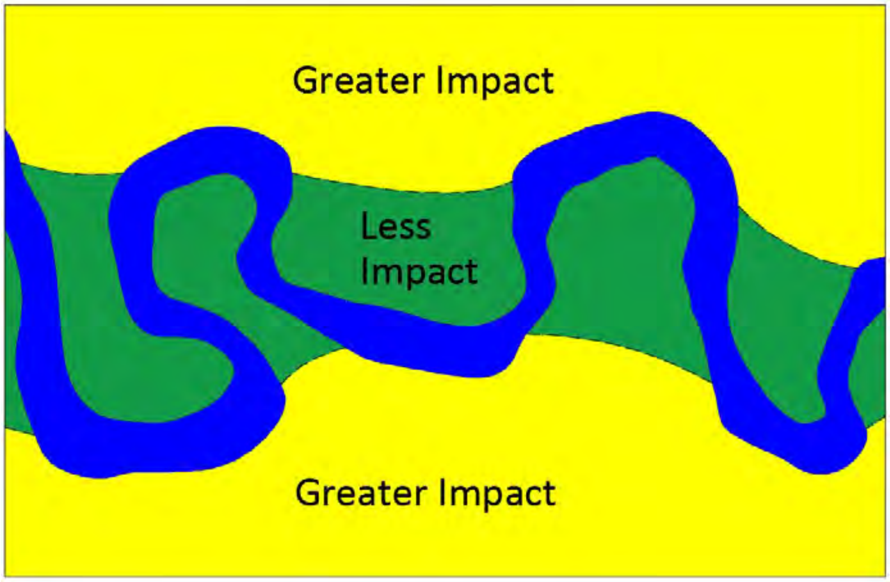

Figure 4-1 Grazing Impacts on the outside of bends is greater than the inside of bends due to the concentration of historic and existing grazing and cattle paths near the outside of bends.

Cattle tend to transit the pasture in a relatively straight line from bend apex to bend apex rather than following the contours of the river. This tends to concentrate impacts along those path near the apex of bends versus dispersed grazing in other areas exhibiting generally less overall impact.

4.2 Canyon Creek

As with the Lemhi Valley described above, Canyon Creek has similar site characteristics affecting riparian potential. In addition to greater disturbance on the outsides of bends, observations of Canyon Creek within the Tyler Easement suggest the height of the banks and adjacent floodplain relative to the ordinary high water mark (OHWM) also significantly affect riparian vegetation. Willow and river birch were observed growing on surfaces less than 1ft above the OHWM; cottonwood was observed growing on surfaces between 1 and 3 feet above the OHWM, while rabbit brush, grease wood and sage dominated surfaces greater than 3ft above the OHWM.

4.3 Riparian Classification Tiers

In an effort to quantify the existing riparian conditions and to simplify future management strategies, the riparian conditions have been classified into tiers collectively representing the entire project area. The classification is based on a combination of the vegetation height, bank height, and relative position along the bank (outside of a bend or not) as described above. Vegetation height was considered more representative of actual riparian conditions based on field observations compared with effective shade values which are relative to aspect and stream width. The relative gap between existing relative shade and targeted relative shade was considered with regards to separating each riparian tier, but the results that did not accurately integrate with field observations. Excessive stream width, in particular, skewed effective shade results toward “acceptable” even in areas that were considered impaired and in need of treatment based on field observations. Using vegetation height as opposed to effective shade provided results that very closely integrated with field observations (i.e.: sites lacking riparian vegetation are considered impaired regardless of the stream width). The riparian conditions have been grouped into six (6) tiers described below and in Table 4-1.

1) Functioning/Climax Condition

   a. Riparian vegetation height is greater than 10 feet based on 2010 LiDAR. Existing riparian corridor and adjacent wetlands are functioning to support a diverse and mature riparian community under current conditions. Effective shade targets may or may not be met within this tier. Existing management is effective – no recommendations.

2) Functioning/Stable Recovery Condition

   a. Riparian vegetation height is greater than 3 feet but less than 10 feet based on 2010 LiDAR. The existing riparian corridor and/or adjacent wetlands are currently recovering. Although impaired, it is believed these areas will support Climax Conditions in the future. Existing management may be effective, with considerations. Effective shade targets may or may not be met within this tier.

3) Impaired/Unstable Recovery Condition – Bend Apex and High Bank

4) Impaired/Unstable Recovery Condition – Bend Apex and Low Bank

5) Impaired/Unstable Recovery Condition – Inside of Bend and High Bank

6) Impaired/Unstable Recovery Condition – Inside of Bend and Low Bank

   a. For Tiers 3-6: Riparian vegetation is less than 3 feet tall representing an impaired condition based on field observations. Existing riparian corridor and adjacent wetlands are impaired. Existing management is not likely to result in recovery within an appropriate period of time. Management considerations advised.

Table 4-1 Riparian Classification Tiers

Riparian Classification Tiers		Lemhi	Eighteen-mile	Big Springs	Canyon	Texas
1	Functioning / Climax Condition	23.4%	4.6%	10.7%	3.2%	0.9%
2	Functioning / Recovery Condition	35.1%	20.7%	18.3%	20.4%	30.1%
3	Impaired / Bend Apex & High Bank	14.3%	14.5%	17.5%	17.6%	16.7%
4	Impaired / Bend Apex and Low Bank	2.5%	7.0%	2.9%	3.2%	3.5%
5	Impaired / Inside of Bend and High Bank	18.4%	18.6%	41.9%	35.6%	20.8%
6	Impaired / Inside of Bend and Low Bank	6.4%	34.6%	8.7%	19.9%	28.0%

Riparian Classification Tier percentages for existing conditions within the project area = the total amount of each Tier measured divided by the total amount of stream bank. Tier were determined based on a combination of vegetation height, bank height, and location along a bend.

It is understood that one approach for assessing riparian conditions is by measuring effective shade. Effective shade targets for this project area were determined following the effective shade curve for Geyer

Willow-Reedgrass as described by Idaho Department of Environmental Quality (2009). Effective shade was measured at 25-meter increments along the stream channels for the entire project area. Each of the points measured for existing effective shade included channel width and aspect which are the two principal variables used to determine the effective shade targets from the DEQ manual. Given this information, a specific shade target was calculated for every point measured throughout the entire project area. The sum of these targets was averaged for each stream to produce an estimate of the hypothetical Geyer Willow-Reedgrass effective shade target for each stream within the project area. These targets could then be compared with measured current conditions and a hypothetical future condition assuming 18-foot-tall willow and 25% overhang along all banks (Table 4-2).

Table 4-2 Riparian Conditions and Targets

	Average Geyer Willow - Reedgrass Effective Shade (Aug 1)		
	Current Conditions w/ overhang	Target (For Geyer Willow and Existing Width)	Hypothetical Future Condition (18ft tall willow on all banks w/ overhang)
Lemhi	11.6%	25.4%	20.0%
Eighteen-mile	8.1%	63.9%	47.5%
Big Springs	8.6%	39.7%	28.9%
Canyon	11.3%	67.8%	47.9%
Texas	6.5%	53.9%	40.9%

Current riparian conditions, target conditions and hypothetical future conditions are compared as a percentage of the total available length of bank for each stream in the project area.

5 Management Alternatives and Treatment Options

Management alternatives and treatment options have been considered specifically for improving shade and generally for improving riparian and stream function understanding that the two are mutually dependent. Specifically, to improve shade, increasing the percentage of bank area growing and sustaining willow (and cottonwood where applicable) is the primary goal. More areas of mature willow (and cottonwood) will provide greater shade than existing areas currently growing primarily weeds and grass. Treatment options for specifically improving shade typically represent a passive approach related to planting, managing vegetation, and livestock exclusion described below in more detail. Ironically, as an artifact of the shade target evaluation method, meeting shade targets can also be addressed by increasing stream width to lower the target rather than actually improving the current condition. It is accepted in this report that, while the practice of increasing stream width may artificially improve shade target scores, wider streams in fact reduce the actual shade on a stream and increase solar load and therefore temperature – the opposite of the desired effect. Vegetation height (independent of stream width) has therefore been used to remove the stream width bias from selecting riparian classification tiers and their respective treatments. Stream width will be treated separately as discussed below.

Generally, to improve riparian and stream function, several treatment options have been considered to address areas with excessive width-to-depth ratios, poor floodplain connection, and/or homogenous (plane-bed) stream morphology. Treatment options for generally improving riparian and stream function typically represent an active approach including stream bank stabilization, channel narrowing, and grade control. Such treatments require engineering design and construction resulting in greater amounts of short-term disturbance and often greater cost per unit area than passive treatments. Such treatments have only been prescribed where it is believed that passive treatments will not meet management goals within an acceptable timeframe.

5.1 Passive Approach

A passive approach is recommended where the channel and floodplain geometry will support riparian vegetation such as willow. These areas are represented by Riparian Classification Tiers 1, 2, 4 and 6 where the stream bank is low enough to support willow growth. The field and GIS analyses used to develop the reach characterizations and riparian classifications have identified which areas fall within these Tiers and have been provided via GIS shapefiles and Rasters to facilitate planning and implementation of treatments.

5.1.1 Tier 1 and Tier 2 Treatment Recommendations

No treatments are recommended for the majority of Tier 1 and Tier 2 areas given that riparian conditions are generally considered acceptable or trending toward an acceptable level within these areas. Existing management strategies appear to allow recovery and sustainable riparian function and/or shade without need for change. Some portions of Tier 1 and Tier 2 areas appear to also meet targeted shade values as a result of mature riparian vegetation on one bank while the other bank is lacking mature vegetation. In other cases, an excessively wide channel, with associated low shade targets, appears to have resulted some areas meeting shade targets despite very little mature (willow) riparian vegetation. In both instances, bank treatments (as described below) may be selected to improve riparian conditions in these areas on a case-by-case basis recognizing that these treatments may improve overall riparian conditions and absolute shade values but may not improve effective shade values that are dependent on channel width and aspect. Tier 1 and Tier 2 are considered low priority relative to Tiers 4-6.

5.1.2 Tier 4 Treatment Recommendations

Tier 4 areas are considered impaired (i.e.: few or no willow growth) and represent low floodplain areas on the outside of bends. Two primary limiting factors result in poor willow and riparian conditions in these areas: 1) the location along the outside of a bend (specifically the apex of a bend) and 2) the lack of new willow recruitment potential. Even where grazing has been excluded or limited, grazing impacts are concentrated near the apex of meander bends. Such impacts have a legacy effect reducing the fecundity of willow growth in these areas. Secondly, these areas tend to be distant from mature willow stock and/or overrun with weeds reducing the ability for willow reproduction.

To address these limiting factors we recommend planting new, healthy willow stock from near-by live cuttings, embedding the base of the cuttings into the soil to a depth of at least 12-inches (i.e.: below the OHWM) and reducing the future disturbance from cattle grazing. Plantings should be spaced at a relatively high density of 1 every 2-3 feet to account for some mortality and should occur in early spring before breaking dormancy. Reducing grazing disturbance can be achieved through management of existing exclusion fences or by discouraging cattle from concentrating near the apex of meander bends. Field observations suggest that cattle transit back and forth along paths leading from bend apex to apex rather than following the sinuous contours of the channel. As such, a higher frequency of disturbance is focused at the apex of each bend compared with grazing throughout the rest of the pasture. Building 50-foot-long fence barbs extending perpendicularly from the apex of a meander bend into the pasture will cut off current cattle paths without reducing pasture area (Figure 5-1). These obstructions will force the highest concentrations of cattle beyond this buffer similar to stream barbs forcing erosive flow away from the bank along the outside of a bend. Multiple barbs may be necessary along large bends. This is an innovative approach which has not be tested or established by others.

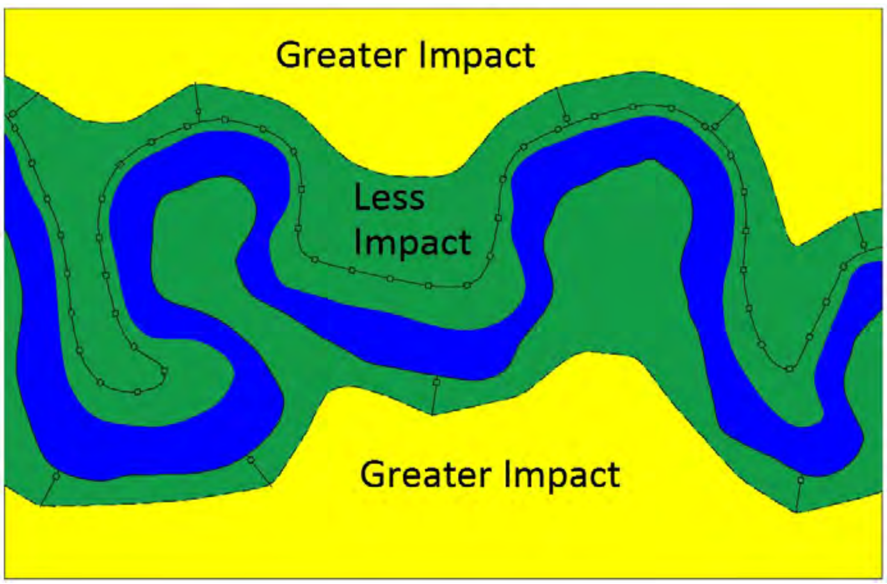

Figure 5-1 Conceptual drawing of fence barbs used to force cattle concentrations away from the apex of meander bends creating a disturbance buffer without reducing pasture area.

This treatment can be used with or without existing exclusion fence.

5.1.3 Tier 6 Treatment Recommendations

Tier 6 areas are considered impaired (i.e.: few or no willow growth) and represent low floodplain areas that are not on the outside of bends. Unlike Tier 4, it does not appear that current cattle concentrations are significantly different in these locations than other areas within each pasture and/or exclusion area. The factors limiting willow reproduction and growth in these areas is attributed to excessive grazing and/or poorly timed grazing, legacy impacts from past grazing, and/or a lack of new willow recruitment.

It is recommended that excessive or poorly timed grazing be managed with existing exclusion fences and/or the use of temporary fences providing a minimum 30-foot buffer around the stream bank until riparian vegetation can become established. Overcoming legacy impacts and a lack of willow recruitment due to weeds and/or distance from available seed stock can be treated by planting new, healthy willow stock from nearby cuttings. Plantings should be embedded into the soil at a depth of at least 12-inches, spaced at a relatively high density of 1 every 2-3 feet to account for some mortality, and should occur in early spring before breaking dormancy.

5.2 Active Approach

An active approach is recommended where the channel and floodplain geometry will not currently support riparian vegetation such as willow. These areas are represented by Riparian Classification Tiers 3 and 5 where the stream bank is too high to support healthy willow growth. The field and GIS analyses used to develop the reach characterizations and riparian classifications have identified which areas fall within these Tiers and have been provided via GIS shapefiles and Rasters to facilitate planning and implementation of treatments

5.2.1 Tier 3 Treatment Recommendations

Tier 3 areas are considered impaired (i.e.: few or no willow growth) and are characterized with high banks that fall on the outside of bends. Factors limiting riparian production include the location along the outside of a bend (specifically the apex of a bend) and the height of the bank above the preferred range for willow. Even where grazing has been excluded or limited, grazing impacts are concentrated near the apex of meander bends. Such impacts have a legacy effect reducing the fecundity of willow growth in these areas. Even more limiting is the height of the bank in these locations. Field observations showed that willow reproduction and growth is severely limited in areas in excess of 1-foot above the OHWM such as those within Tier 3.

Recommendations for addressing the riparian limiting factors within Tier 3 include building fence barbs as discussed for Tier 4. Fence barbs extending 50-feet into the pasture at each meander apex will force cattle concentrations away from these heavily impacted areas allowing recovery without reducing pasture area. Multiple barbs may be required for large bends.

Even with less impact from cattle, willow are unlikely to grow and thrive at heights greater than 1-foot above the OHWM. Where stream width is considered appropriate, excavating an inset floodplain at an elevation less than 1-foot above the OHWM is recommended (Figure 5-2). The inset floodplain should be as broad as the desired riparian area (minimum of 10-feet). Where the stream width is excessive, the banks should be mechanically pushed down into the channel simultaneously reducing the height of the bank and the width of the channel (Figure 5-3). To avoid undue fine sediment input to the stream, place biodegradable silt fence within the channel at the desired location of the new bank and push bank material to fill the space between the silt fence and the existing bank. The fill should be placed at an elevation no greater than 1-foot above the OHWM.

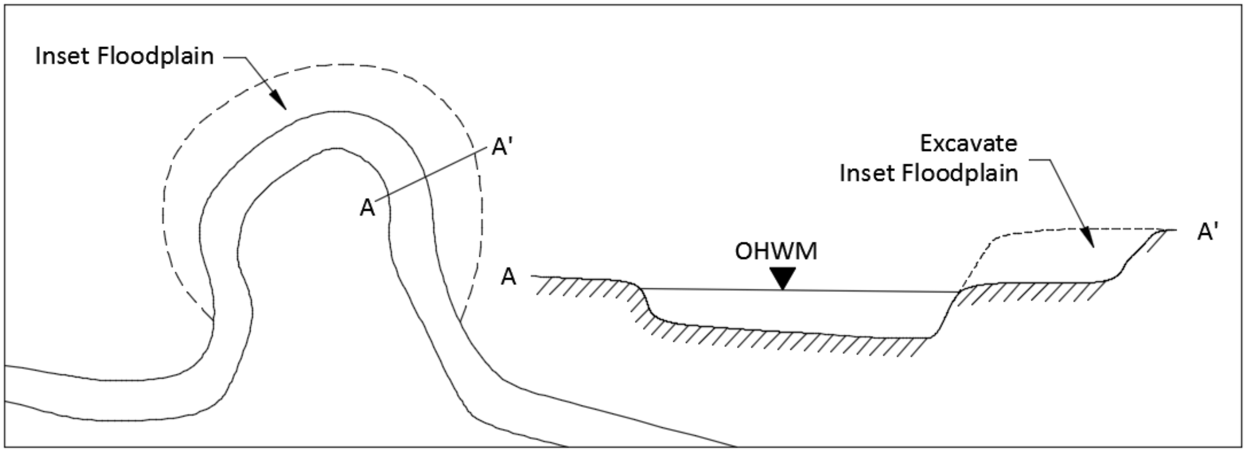

Figure 5-2 Excavated inset floodplain

This treatment can be used to create a low-lying floodplain surface suitable for willow and other riparian vegetation in areas where bank heights are greater than 1-foot above the OHWM and existing channel width is considered appropriate.

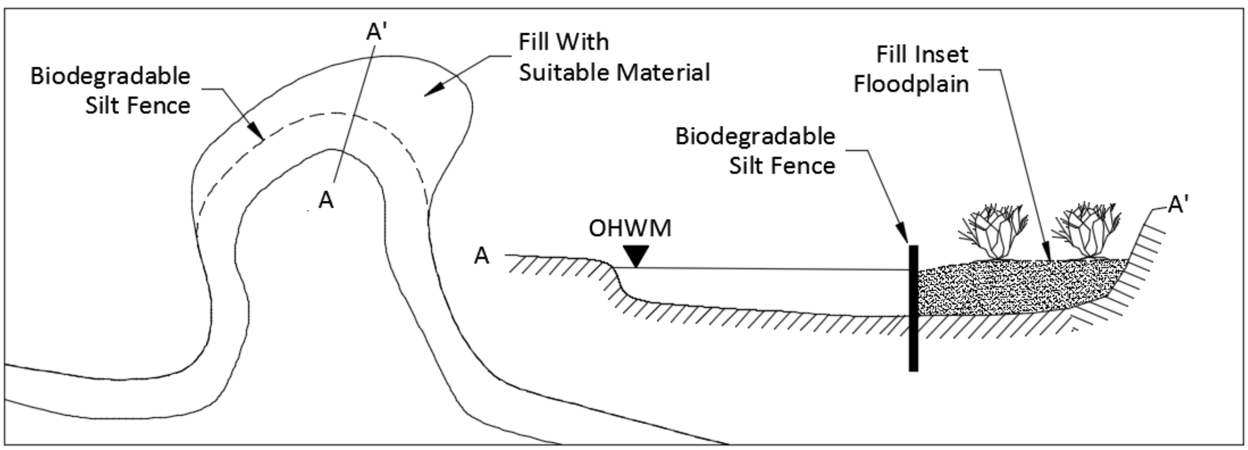

Figure 5-3 Filled inset floodplain

This treatment can be used to simultaneously narrow the channel and create a low-lying floodplain surface suitable for willow and other riparian vegetation.

Where insufficient fill material exists along the bank, additional fill material suitable for riparian vegetation can be imported, or stream barbs can be used to capture sediment over time (Figure 5-4). Barbs should be built from biodegradable materials capable of withstanding in-stream forces. Logs are the preferred material for this task, but biodegradable silt fence or similar product may be suitable given site conditions. Although boulders are suitable, they are considered inappropriate for most locations within the project area given the lack of large rock in the channel naturally. Each barb should be built extending from the existing bank into the channel to a point where the desired bank will form. Multiple barbs will be required and should be spaced such that the tips of the barbs (the points demarking the new bank) are less than one new-channel width apart. The top of the barb should be positioned less than 1-foot above the ordinary high water mark for its entire length. If multiple logs are required to achieve this height, the logs should be lashed together using biodegradable materials such as hemp or manila rope. A small amount of clean gravel and/or one or two small-diameter wood pilings may be necessary to hold the barbs in place until sediment deposition and riparian vegetation are established. Detailed designs from an experienced river restoration engineer are strongly encouraged to ensure barbs achieve the desired objectives over the short- and long-term. To the extent possible, willow cuttings or transplanted whole trees should be incorporated into the barbs.

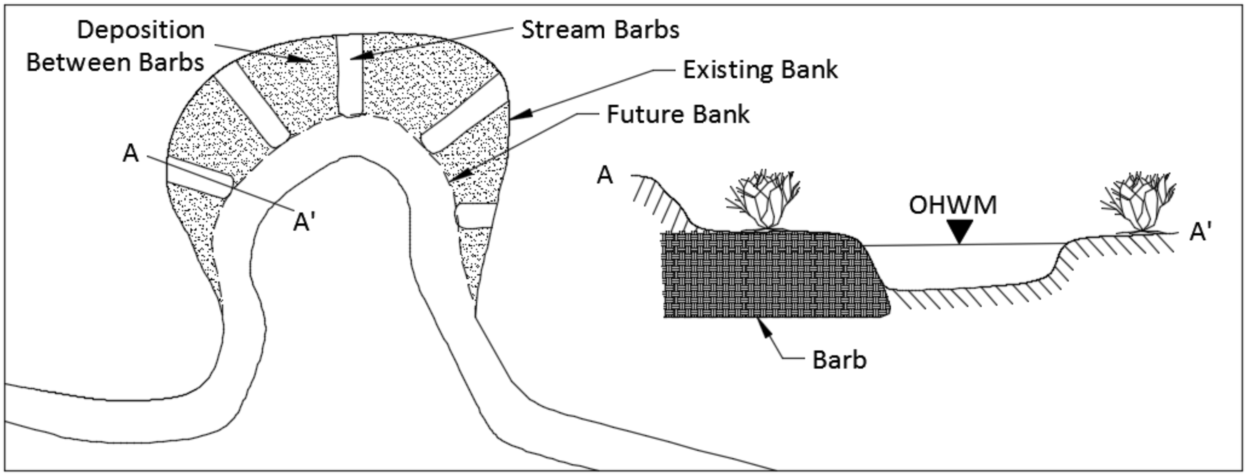

Figure 5-4 Stream barbs

Barbs can be used to encourage sediment deposition along the bank of an overly wide channel creating a new low-lying floodplain surface and narrowing the channel width over time.

In all instances described above, fresh, locally-derived willow cuttings should be planted in the newly developed floodplain area such that the base of the willow cuttings are embedded to a depth at least 12-inches below the OHWM. Cuttings should be planted at relatively high density of 1 every 2-3 feet to account for some mortality, and should occur in early spring before breaking dormancy.

Given the extent of Tier 3 areas within the project reach, treatment options and implementation should be prioritized based on stakeholder objectives, schedule, and funding. We recommend a detailed prioritization and implementation plan be developed to accompany this document. For example, Tier 3 areas could be treated over two or three phases: 1) Heavily impacted areas identified by stakeholders to be of high importance could be treated using the methods described above over the first few years. 2) Less heavily impacted areas identified by stakeholders to be less important and possibly of greater risk to existing spawning habitat and/or ranch infrastructure could be treated only with deeply-rooted plantings and allowed to fill in over many years. 3) As discussed below (Section 5.2.2), high banks can also be treated by raising the bed and therefore water surface elevation. This treatment relies on deposition and channel aggradation within the backwater formed by a channel obstruction or grade control (i.e.: beaver dam analog). Deposition in a backwater environment is likely to be dominated by fine sediment (silt and sand) the spatial extent of which must be taken into consideration given the existing high utilization of this reach for spawning.

5.2.2 Tier 5 Treatment Recommendations

Tier 5 areas are considered impaired (i.e.: few or no willow growth) and are characterized with high banks that are not located along the outside of a bend. Factors limiting riparian reproduction and growth are largely related to grazing impacts (both legacy and current) and the height of the bank above what is considered to be the preferred range for willow.

Recommendations for addressing grazing impacts include improving exclusion management by adjusting the timing and/or duration of the exclusion. Consider placing temporary fences for sufficient time to allow the establishment of mature riparian vegetation. Independent of any changes to grazing management, the height of the bank in Tier 5 areas will preclude successful riparian development. To address the bank height, the development of an inset floodplain is recommended as described for narrow channel widths and excessively wide channel widths for Tier 3 above.

An alternative treatment for developing an inset floodplain is to raise the water surface sufficiently to activate the existing floodplain. Where permissible given existing spawning habitat, infrastructure and ranch management objectives, grade control structures are recommended to raise the water surface and therefore the OHWM sufficiently to allow willow growth without the need to excavate the banks (Figure 5-5). Grade controls can be constructed as an engineered riffle composed of streambed material ranging from d85 to d100 (85th percentile or greater of the measured bedload grainsize). Potentially more appropriate for this site given its history, beaver analogs can be built by driving small-diameter piles at roughly 18-inch centers across the channel and weaving small-woody material and slash between the piles creating a semi-porous, low-head dam similar to a beaver dam. The design of any channel-spanning structure should consider fish passage to ensure a barrier is not inadvertently created. Raising the water surface by using grade control structures is highly recommended where incision has occurred over a large area and can therefore represent a significantly cost savings over cut-and-fill excavation alternatives. This treatment relies on deposition and channel aggradation. Deposition in a backwater environment is likely to be dominated by fine sediment (silt and sand) the spatial extent of which must be taken into consideration given the existing high utilization of this reach for spawning. Engineered riffles and constructed beaver analogues should be designed by an experienced river restoration engineer.

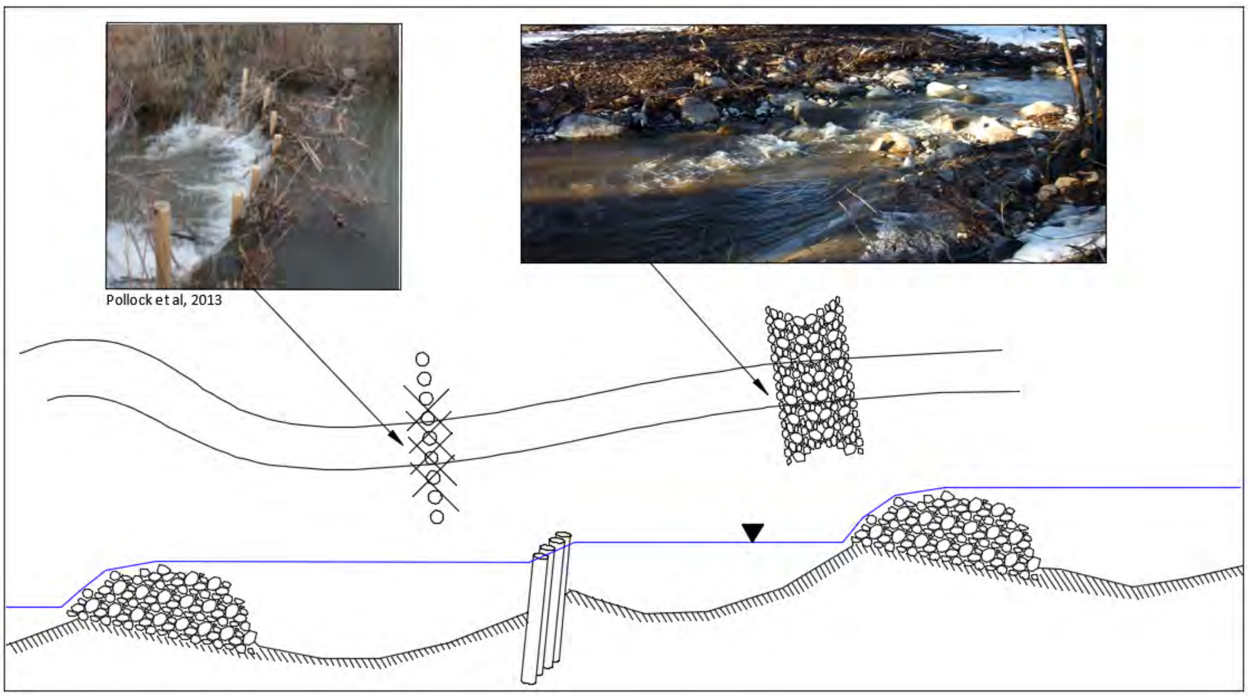

Figure 5-5 Grade control structures

Rather than creating an inset floodplain, the water surface can be raised using grade controls structures to reactivate an otherwise abandoned surface (i.e.: terrace). Engineered riffles and/or beaver analogs can be used for grade control.

In all instances described above, fresh, locally-derived willow cuttings should be planted in the newly developed floodplain area such that the base of the willow cuttings are embedded to a depth of at least

12-inches below the OHWM. Cuttings should be planted at relatively high density of 1 every 2-3 feet to account for some mortality, and should occur in early spring before breaking dormancy.

5.2.3 Additional Treatment Options

In addition to planting willow within the range no higher than 1-foot above the OHWM, sedge mats (or similar wetland sod products and/or coir logs) can be used to create a relatively stable bank and planting platform for willow cuttings. Properly installed sedge mats can withstand relatively high in-stream velocities and are recommended for bank stabilization in addition to riparian development by producers such as North Fork Native Plants (http://www.northforknativeplants.com). Following the manufacturer's specifications for suitability and installation is highly recommended for use of any pre-made bank stabilization or riparian product.

Absolute shade values and therefore temperature can be improved at any stream location that is considered excessively wide independent of its current shade characteristics. As noted above, stream width affects the shade target at any given point along a channel. Decreasing the width of the stream allows for a greater proportion of the stream to be shaded by riparian vegetation, thus stream width and target shade are inversely proportional. As a result of this relationship, establishing mature riparian vegetation in conjunction with narrowing the stream (reducing the width-to-depth ratio) may not in fact improve the overall effective shade value relative to the target, but it is well understood that this treatment will significantly improve of absolute shade value and therefore improve temperature. It is recommended that the methods for narrowing the channel described above for Tiers 3 and 5 are considered anywhere the channel is considered to be excessively wide.

One of the primary reasons for improving shade on the streams within the project area is to reduce the amount of solar radiation intercepting the water thereby cooling the channels and improving habitat for fish. Although difficult to quantify, one of the principal elements keeping cold streams cold in the summer is cold groundwater input. Increasing the amount of cold groundwater feeding into the surface water channels during the hot summer months will have a cooling effect on the channels. Raising the water level and inundating larger areas of floodplain for greater periods of time is the most practical means by which the groundwater table and associated aquafer can be recharged more fully allowing for larger and longer periods of cool groundwater discharge into the streams. For this reason, utilizing grade controls to raise the water surface where appropriate may provide additional value-added benefit beyond riparian improvements.

5.3 Site-Specific Recommendations

Specific recommendations have been developed for a handful of individual reaches and sites in addition to the Tiers of recommendations provided above.

5.3.1 Canyon Creek

The entire Canyon Creek reach is incised 1-to-2-feet. Existing natural grade controls are not sufficient to overcome the incision, but have created many pools and elevated water surfaces enabling existing riparian vegetation to persist. The stream also has not become over-widened. The combination of these characteristics suggest the stream and riparian area would respond well to the installation of more grade control sufficient to raise the water surface and therefore the OHWM 1-to-2-feet to overcome the incision.

Unlike much of the remainder of the project area, the soils along the banks and floodplain of Canyon Creek are composed of sand with silt and gravel. These highly draining soils are much more conducive to cottonwood than much of the clay-rich soils in the Lemhi valley bottom. Willow plantings are recommended in the areas within 1-foot of the OHWM, but cottonwood plantings are recommended in areas between 2 and 3-feet above the OHWM. Elevating the water surface using engineered riffle and/or beaver analog grade controls can greatly expand the area suitable for both willow and cottonwood revegetation.

5.3.2 Texas Creek

Despite the GIS analysis identifying large portions of this reach as impaired (Tiers 3-6), the majority of Texas creek was observed to be recovering naturally. Much of the riparian vegetation is currently too small to register as “Functioning” or “Recovering” in the GIS analysis based on 2010 LiDAR, but 2015 field observations confirmed that young willow saplings are becoming established naturally over a broad riparian area extending well into the floodplain. Individual areas can be planted to supplement existing willow as desired, but in general, this-reach should be considered a low priority relative to reaches further downstream.

5.3.3 Lemhi River (Fayle)

The Fayle area exhibited some of the most disturbed stream and riparian areas observed within the project area, particularly along the right bank. Much of the disturbance may be attributable to historic/antecedent conditions, which have left the riparian area impaired and less likely to recover without treatment. In addition to the recommendations for Tiers 3-6 above, improved exclusion fencing may further improve success rates for riparian recovery in this area. There are several springs along the right bank that should also be considered for grazing exclusion.

5.3.4 Lemhi River (Downstream)

Exclusion area downstream from the confluence with Big Creek adjacent Bull Pasture (1), Feed Lot Pasture (6), River Field (7), and Longhorn Pasture (8)

Despite a mix of results, a mosaic of willow and graminoid vegetative assemblages, and several high banks, this reach of the Lemhi River is generally considered to be recovering. Individual areas can be planted with willow as desired, but in general, this-reach should be considered a low priority relative to reaches further upstream.

6 Monitoring

The following monitoring recommendations have been made to facilitate rapid assessment of select locations across the Leadore Partners Conservation Easement. Through this monitoring, LRLT will be capable of tracking success of natural regeneration as well as tracking the success of management activities employed throughout the Conservation Easement.

Tracking improvement and regeneration of Geyer's Willow/Reedgrass Vegetation Type Associations is recommended on a short-term and long-term basis. Evaluating specific sites and in-stream temperatures is recommended on an annual basis, while more comprehensive quantification of overall riparian health and shade density is recommended on a 5-year cycle.

6.1 Annual Monitoring

Annual monitoring should include photo points, and in-stream temperature records at established monitoring locations, plus vegetation height and density at monitoring plots within new implementation areas for the first five years following implementation. At least three photo points should be established within each of the 5 Tiers (See Appendix C7 – C12 for recommended photo point locations and coordinates) and within completed implementation areas in order to monitor qualitative progress in each. In-stream temperature data loggers (e.g.: HOBO or similar) should be placed in the channel at three locations (lower Lemhi near Tyler Lane, lower Big Springs near the Lemhi confluence, and upper Lemhi near Fayle) to monitor daily temperature trends over time. Temperature data should be downloaded from the data loggers and included in annual monitoring reports. Within completed implementation areas, a minimum of five vegetation monitoring plots should be established. The total area sampled within the plots should meet or exceed 2% of the total area treated if the total area treated is over 15 acres, 5% if the total area treated is between 5 and 15 acres, and 10% if the total treatment area is less than 5 acres in order to obtain statistically accurate results. The plots should be equally distributed throughout the project area within representative locations. Within each plot identify and count the total number of plants of interest (e.g.: willow) recording the species, relative vigor (live, poor health, dead) and height. These data may be used to calculate vegetation density, average vegetation height and growth rate for comparison in future years. Comparisons of 2010 LiDAR vegetation heights versus measured vegetation height during 2015 field work revealed a growth rate for willow within the project area averaging about 0.5 feet/year with a range between 0 and 1.4 feet/year and a maximum height around 15 feet (with a handful of outliers up to 25+ feet). Based on this information, it is expected that 30 or more years of treatment and subsequent management will be required before approaching target conditions.

6.2 5-Year Monitoring

To accommodate long-term monitoring, a five-year schedule is recommended including select vegetation plots as well as a comprehensive reach-scale shade analysis. Vegetation plots should be established within areas represented by each of the 5 Tiers of riparian conditions (ideally at an existing photo point), and at least one completed treatment area greater than 5-years old. Vegetation plots should be established and monitored on a 5-year rotation following the same procedure as discussed above for annual monitoring. In addition to vegetation plots, a reach-scale shade analysis is recommended in order to compare large-scale, long-term results. It is recommended that a shade analysis be completed for the entire project area using LiDAR and/or aerial photo data in GIS. This work should follow the methods outlined in this report, specifically Appendix A. Additionally, it is recommended that aerial photo interpretation be used to measure the total area of tree/shrub riparian versus non-tree/shrub riparian within a 50-foot buffer of each stream bank within the project area to aid in the quantification of riparian health and recovery for the project area. The total riparian area measured on a 5-year cycle and the stream temperature data measured annually will help quantify absolute stream and riparian conditions versus relative conditions provided by the effective shade measurements (which is relative to stream width and aspect).

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Riparian Habitat Management Plan

APPENDIX A

EFFECTIVE SHADE ANALYSIS

Appendix A
Effective Shade Analysis

Lemhi Land Trust Effective Shade Analysis

By Bob Chappell – The Freshwater Trust

Purpose

The purpose of this analysis was to quantify the amount of effective shade on streams within the Lemhi River Land Trust (LRLT) boundary (Figure 1). Effective shade is the amount of direct solar radiation in a given time period that is blocked by vegetation or topography. With the results of this analysis, sites and reaches can be prioritized for revegetation.

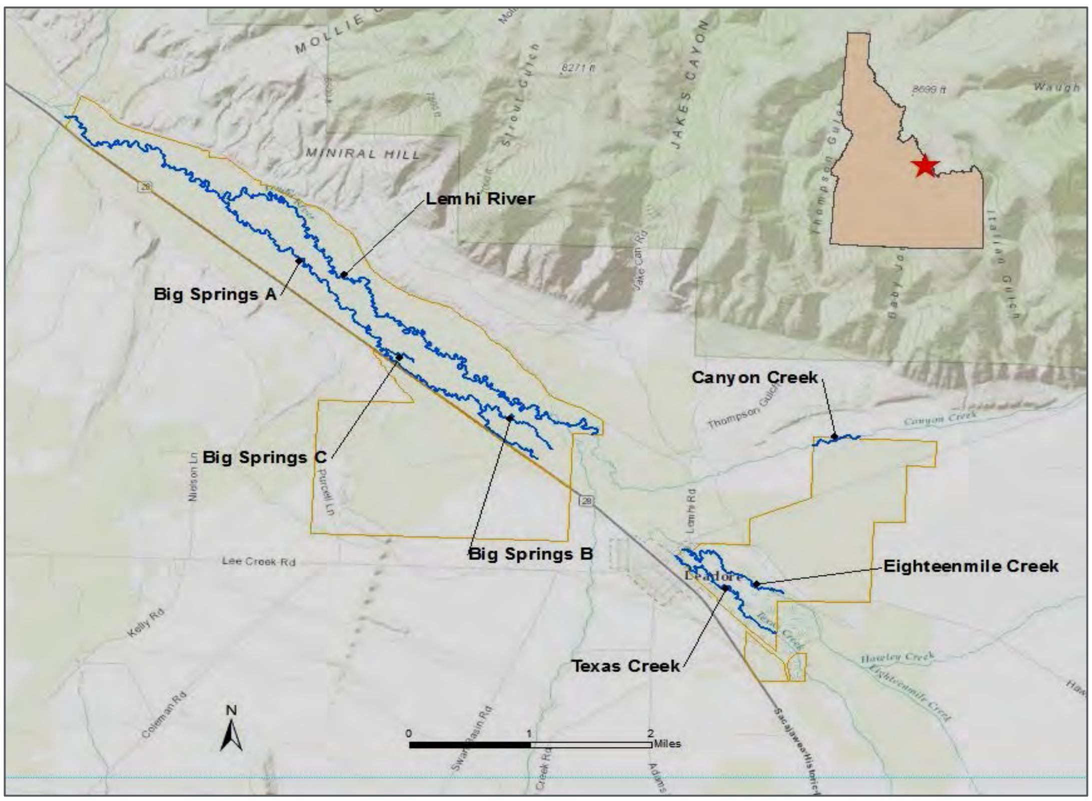

Figure 1 - Project location map with modeled stream reaches.

Methodology

The materials used for this analysis consisted of NAIP 2013 aerial photography (USDA), 10 meter DEM (USGS), 1 meter LiDAR canopy model (Watershed Sciences, 2010), and digitized stream banks and center lines for each stream.

Stream banks for each stream within the area of interest were digitized using aerial photography interpretation at a scale of 1:2000. A center line was then derived from these. A buffer of 5 km was created around each stream centerline, and then used to clip the 10 meter DEM. The canopy model was created by subtracting a bare earth LiDAR model from a highest hit LiDAR model. This was then clipped to the area of interest.

In order to run the shade model, stream morphology, topography, and vegetation heights must first be sampled using the bank and center lines, DEM, and canopy model which are respectively fed into a remote sampling tool called TTools (an extension for ArcGIS). This creates a network of stream centerline nodes (figure 1).

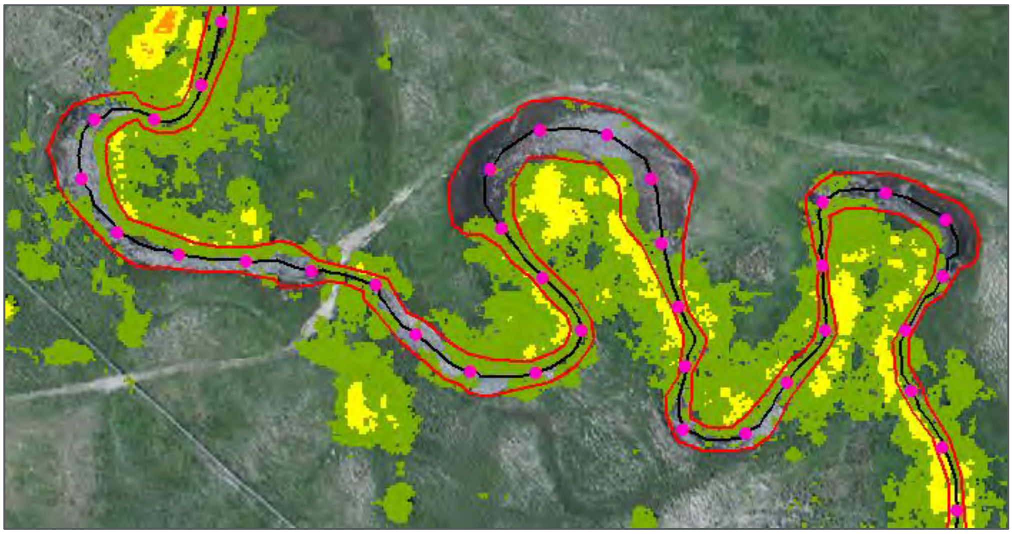

Figure 1 - An example of the stream bank lines, centerline, LiDAR canopy model, and stream centerline nodes spaced at 25 meters.

A table of these nodes is then fed into the Shade-a-lator model in order to calculate effective shade. Shade-a-lator is a module of Heat Source which simulates direct solar radiation experienced at the center line of a stream by taking into account topographic shade, canopy shade, vegetation density, overhang, and solar attenuation. The model outputs percent effective shade at user-defined sampling intervals.

	Longitude (deg)	Latitude (deg)	Topograpic Elev. (deg) West	South	East	Emergent Veg	Veg_1_NE	Veg_2_NE	Veg_3_NE	Veg_4_NE	Veg_5_NE	Veg_6_NE	Veg_7_NE	Veg_8_NE	Veg_9_NE	Veg_1_E
17.9	-113.37099	44.69832	0.39329	0.84183	2.18600	0.00000	0.54199	0.00000	0.47998	0.55005	2.48999	1.12000	0.00000	0.73999	0.00000	0.00000
17.875	-113.37079	44.69847	0.38220	0.83163	1.84891	0.48999	0.35999	0.00000	0.00000	0.00000	0.83008	0.00000	0.00000	1.29993	1.76001	0.59998
17.85	-113.37052	44.69837	0.37545	0.83114	1.94990	0.86194	3.39002	1.72998	1.76001	0.73999	0.00000	0.74011	0.85999	0.00000	0.00000	0.88001
17.825	-113.37024	44.69844	0.35866	0.81506	2.49462	0.00000	0.56995	0.34998	0.70007	0.30994	0.37000	0.26001	0.00000	0.00000	0.00000	0.18005
17.8	-113.37018	44.69866	0.35772	0.80545	2.19857	0.00000	0.00000	0.00000	0.00000	0.00000	0.52002	0.00000	0.00000	0.33997	0.32007	0.21008
17.775	-113.37011	44.69888	0.34782	0.79152	1.87473	1.07495	0.00000	0.46997	1.17004	0.58008	0.56201	0.28003	1.52002	0.68005	0.81006	0.00000
17.75	-113.37013	44.69907	0.34806	0.77675	1.88382	1.70203	1.05200	1.34204	0.00000	0.00000	0.00000	0.51001	0.00000	0.00000	0.00000	0.00000
17.725	-113.37043	44.69905	0.36811	0.79522	1.94572	1.20581	2.57007	2.09998	2.59998	1.45007	1.37000	1.77002	1.01416	1.08460	0.00000	1.76978
17.7	-113.37071	44.69910	0.37542	0.80162	1.86700	0.00000	0.91504	1.45764	1.23938	1.12488	1.40002	1.01892	1.23547	1.00891	0.53516	1.55005
17.675	-113.37097	44.69918	0.38601	0.80555	1.86621	0.00000	0.23010	0.00000	0.00000	0.26001	0.00000	0.00000	0.00000	0.00000	0.26001	0.55273
17.65	-113.37128	44.69920	0.39640	0.81405	2.24815	0.00000	0.35999	0.22998	0.00000	0.30005	0.00000	0.34998	0.17004	0.00000	0.00000	0.00000
17.625	-113.37152	44.69909	0.40809	0.82412	1.84803	0.53967	0.00000	0.00000	0.51502	0.25000	0.36011	0.39002	0.00000	0.00000	0.00000	0.00000
17.6	-113.37179	44.69901	0.42016	0.83966	1.85012	0.68030	0.77197	0.28003	0.19995	0.00000	0.17993	0.34998	0.32996	0.30005	0.21997	2.31201
17.575	-113.37209	44.69907	0.43480	0.84556	1.83736	0.00000	0.28992	0.00000	0.00000	0.21997	1.64002	0.23999	0.28003	0.28992	0.25000	0.00000
17.55	-113.37240	44.69906	0.44530	0.85199	1.82851	0.00000	1.85205	1.91992	0.71997	0.00000	0.26990	0.21997	0.25000	0.29004	0.27002	0.00000
17.525	-113.37271	44.69906	0.45737	0.86042	1.80556	0.00000	1.71204	0.62000	1.39002	3.13001	0.78003	0.00000	0.00000	1.85742	1.77002	1.60754
17.5	-113.37275	44.69925	0.45458	0.85001	1.80607	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.31995	0.83997	1.42993	0.00000	0.00000
17.475	-113.37248	44.69933	0.44552	0.83911	1.82172	1.09509	0.00000	0.00000	1.68994	2.52002	2.95996	0.00000	0.00000	0.00000	0.00000	0.92505
17.45	-113.37222	44.69944	0.43452	0.82961	1.82552	1.65503	2.43994	2.17993	0.00000	0.58203	0.22998	0.00000	0.25000	0.00000	0.00000	1.64917
17.425	-113.37199	44.69959	0.42198	0.81414	1.83798	0.00000	0.57996	0.00000	0.00000	0.35999	0.00000	0.00000	0.00000	0.00000	0.00000	0.16992
17.4	-113.37209	44.69978	0.41974	0.80243	1.83946	0.00000	0.32996	0.21997	0.33997	0.00000	0.00000	0.00000	0.00000	0.00000	0.25000	0.65002
17.375	-113.37228	44.69996	0.42758	0.79838	1.83189	0.00000	0.00000	0.55005	0.00000	0.00000	0.00000	0.00000	0.00000	0.40002	0.32996	0.14002
17.35	-113.37222	44.70016	0.42074	0.78488	1.83652	0.86707	0.00000	0.00000	0.00000	0.00000	0.00000	0.15991	0.00000	0.00000	0.00000	0.00000
17.325	-113.37227	44.70036	0.42115	0.77724	1.83134	0.00000	0.12000	0.00000	0.17993	0.35169	0.00000	0.00000	0.00000	0.29004	0.40002	0.61011
17.3	-113.37254	44.70034	0.43082	0.78578	1.81451	0.00000	0.48706	0.13001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17.275	-113.37280	44.70022	0.44561	0.79953	1.81304	0.00000	0.00000	0.00000	0.10999	0.14002	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17.25	-113.37292	44.70005	0.44998	0.81142	1.79855	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.45996	0.00000	0.00000	0.00000
17.225	-113.37302	44.69986	0.45567	0.82360	1.79408	0.00000	0.00000	1.92993	0.00000	0.00000	0.80005	1.12000	0.00000	0.00000	0.00000	0.72327
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17.175	-113.37348	44.69957	0.48118	0.85431	1.77676	0.00000	0.00000	0.00000	0.62000	0.50000	0.59998	0.00000	0.00000	0.00000	0.00000	0.00000
17.15	-113.37375	44.69946	0.48679	0.86468	1.76341	0.00000	0.00000	0.00000	1.72009	0.00000	0.42993	0.38001	0.29004	1.87000	1.78992	0.00000
17.125	-113.37402	44.69940	0.49455	0.87243	1.75255	1.45752	3.83008	2.64002	1.08997	0.00000	0.65002	3.18994	0.81995	0.00000	0.37012	0.23401
17.1	-113.37431	44.69947	0.50104	0.87521	1.74583	2.42078	0.37000	0.00000	0.00000	0.00000	0.00000	0.00000	0.33997	0.33008	1.06995	1.37940
17.075	-113.37462	44.69946	0.50634	0.87991	1.71713	1.41003	0.82007	5.19006	2.75000	0.00000	0.00000	0.00000	0.00000	0.00000	2.28003	1.75195
17.05	-113.37471	44.69925	0.50304	0.88432	1.70252	1.13074	0.00000	3.95996	2.16003	0.88196	1.43628	0.00000	0.00000	0.00000	0.00000	0.00000
17.025	-113.37498	44.69930	0.50767	0.88672	1.67053	1.66773	0.90991	0.00000	0.44006	0.35999	0.00000	0.00000	0.00000	0.00000	0.00000	1.05005

Table 1 – The vegetation and topography sampling table within the Shade-a-lator model.

Once effective shade modeling is completed, the values for a given date range can be reassigned to the original stream centerline nodes for visualization and analysis.

Results

Model results are shown here with the 3 different iterations of the current condition effective shade averages of the stream centerline nodes, as well as other morphological characteristics which serve as primary shade drivers. The 3 iterations included July 15 – August 1 with no stream overhang, July 15 – August 1 with 1.5 meter overhang, and August 1 with 1.5 meter overhang.

Stream Name	Width Avg.	Aspect Avg.	Jul 15-Aug1 Avg.	Jul 15-Aug 1 Min.	Jul 15-Aug 1 Max.	Jul 15-Aug 1 STDEV.
Big Springs Creek A	7.9	244	4%	1%	25%	4%
Big Springs Creek B	2.9	238	9%	1%	23%	6%
Big Springs Creek C	3	293	1%	0%	3%	1%
Canyon Creek	2.8	246	6%	1%	19%	5%
Eighteen mile Creek	3.1	236	4%	0%	19%	4%
Lemhi River	10.9	225	7%	1%	43%	6%
Texas Creek	4.4	239	3%	0%	16%	3%

Table 2 – Summary results table with morphological and effective shade statistics for July 15 – August 1 with no overhang.

Stream Name	Width Avg.	Aspect Avg.	Jul 15-Aug1 Avg.	Jul 15-Aug 1 Min.	Jul 15-Aug 1 Max.	Jul 15-Aug 1 STDEV.
Big Springs Creek A	7.9	244	7%	1%	40%	7%
Big Springs Creek B	2.9	238	16%	1%	48%	11%
Big Springs Creek C	3	293	1%	0%	6%	1%
Canyon Creek	2.8	246	11%	2%	39%	9%
Eighteen mile Creek	3.1	236	8%	0%	35%	8%
Lemhi River	10.9	225	11%	1%	80%	10%
Texas Creek	4.4	239	6%	1%	37%	6%

Table 3 – Summary results table with morphological and effective shade statistics for July 15 – August 1 with 1.5 meter overhang.

Stream Name	Width Avg.	Aspect Avg.	Aug1 Avg.	Aug 1 Min.	Aug 1 Max.	Aug 1 STDEV.
Big Springs Creek A	7.9	244	8%	1%	46%	8%
Big Springs Creek B	2.9	238	17%	1%	58%	13%
Big Springs Creek C	3	293	1%	0%	5%	1%
Canyon Creek	2.8	246	12%	2%	40%	9%
Eighteen mile Creek	3.1	236	8%	0%	37%	8%
Lemhi River	10.9	225	11%	1%	83%	10%
Texas Creek	4.4	239	6%	1%	43%	7%

Table 4 – Summary results table with morphological and effective shade statistics for August 1 with 1.5 meter overhang.

Additionally, latitude/longitude, stream gradient, and the effective shade averages for each stream centerline node can also be viewed on the results spreadsheets and shapefiles. In addition to modeling the current conditions, future scenarios were also modeled. This model extrapolated future vegetation heights of 6 meters within a consistent riparian buffer width along each river. These widths were 25 feet on the Lemhi River, 15 feet on Big Springs Creek, Texas Creek, and Eighteenmile Creek, and 10 feet on Canyon Creek. The current condition effective shade can then be subtracted from the future condition on each stream centerline node to derive a delta (change).

Figure 3 – An example screenshot showing the stream centerline nodes attributed with average current condition effective shade values at 10% intervals, with red being below 10% effective shade.

Limitations

2010 LiDAR was used. While this is 5 years old, it is still more accurate than aerial interpretation, although there is a chance that non-mature vegetation has grown since that date. Additionally, stream banks were digitized using 2013 NAIP imagery using aerial interpretation. This was the newest NAIP imagery available, so there is the possibility that there have been some changes to the stream channel since then.

Future work

Different date/time ranges can be extracted from the existing data set, as well as creating a new data set using a different date range. Additional future planting scenarios can also be modeled to compare with current conditions. This could include different future vegetation heights, different date ranges, varied riparian buffer widths as well as the modeling of site-specific planting plans within specific targeted reaches along the streams.

Sources

Heat Source and TTools. (n.d.) Retrieved November 10, 2015, from
http://www.deq.state.or.us/wq/tmdls/tools.htm

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NAIP Imagery Program (n.d.) Retrieved October 20, 2015, from
http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/

APPENDIX B

RIPARIAN CLASSIFICATION

Tyler Ranch Riparian Classification and Treatment Tool

All Effective Shade values were derived from August 1 sun angle with 25% overhang using Version 8 of Heat Source software unless explicitly stated otherwise.

Definitions:
- Riparian Classification = based on existing vegetation height (from 2010 LiDAR), location relative to channel bends, and relative elevation above the Ordinary High Water Mark (OHWM)
- Bend Apex = Bank and floodplain areas located generally along the outside of a bend as observed in aerial photos
- High Bank = Areas directly adjacent the channel greater than 1ft above the OHWM as estimated using LiDAR with minimal field verification; Difference between LiDAR water surface and OHWM have been estimated based on field observations (Lemhi, Big Springs and Texas Creek = OHWM is 0.5ft above LiDAR water surface; 18mi and Canyon Creeks = OHWM is 0.0ft above LiDAR water surface).
- Existing = Measured and/or observed either in the field or remotely via GIS
- Treated = Linear feet (LF) of proposed treatment per classification type
- Target = Calculated based on Idaho DEQ targets set for Geyer Reedgrass riparian community and stream width. Existing stream width measured approximately every 25m
- Proposed = The sum of all proposed treatments (LF)
- Total Average Shade (%) = The linear feet of bank adjacent the channel that is shaded divided by the total linear feet of bank.

Instructions:
- Define the percentage of effective shade coverage considered Good, Moderate and Poor by filling in the blue shaded cells below
- Define the bank height above which riparian vegetation does not easily become established (1.5 ft for Lemhi, Big Springs, Texas Cr; 1.0ft for 18-mile Cr. and Canyon Cr.)
- Fill in the number of linear feet (LF) of treatment proposed per classification type (blue highlighted cells)
- Change the treatment quantities as described above until desired results are achieved.

Define "Good" Veg Height:	10.0	= greater than this value (ft)
Define "Moderate" Veg Height:	3.0	= between this value and "Good" veg height (ft)
Define "Poor" Veg Height:	N/A	= Anything less than "Moderate"
Define "High Bank":	1	= Bank height above ordinary high water mark where appropriate riparian vegetation struggles to establish and mature
Proposed Conditions:	Average	= Identify how successful treated areas will become (Equal to the Target, Hypothetical Future Condition, or an average of both)

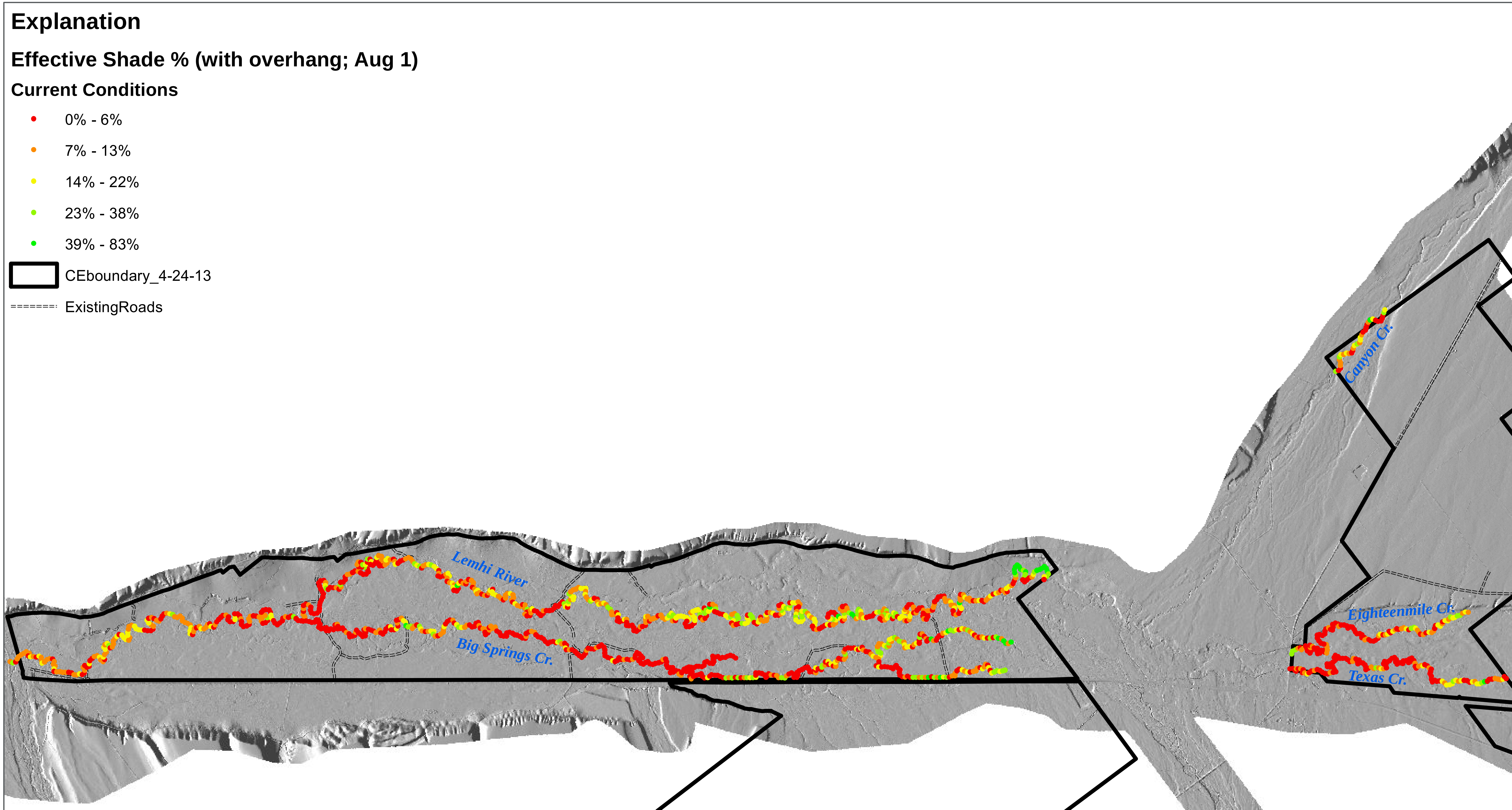
		Riparian Classification Tiers										Total Average Effective Shade (Aug 1 sun angle) (%)			
		1	2	3		4		5		6		Current Conditions w/ overhang	Target (For Geyer Willow and Existing Width)	Hypothetical Future Condition (18ft tall willow on all banks w/ overhang)	Proposed Conditions (Current Conditions plus Treated)
	Shade:	Good	Moderate	Poor		Poor		Poor		Poor					
	Bend Apex:	N/A	N/A	Yes		Yes		No		No					
	High Bank:	N/A	N/A	Yes		No		Yes		No					
	Total LF (both banks)	Existing	Existing	Existing	Treated	Existing	Treated	Existing	Treated	Existing	Treated				
Lemhi	117,200	27,425	41,125	16,750		2,875		21,575		7,450		11.6%	25.4%	20.0%	16.5%
Eighteenmile	16,900	775	3,500	2,450		1,175		3,150		5,850		8.1%	63.9%	47.5%	18.0%
Big Springs	72,625	7,775	13,275	12,700		2,075		30,450		6,350		8.6%	39.7%	28.9%	14.5%
Canyon	5,400	175	1,100	950		175		1,925		1,075		11.3%	67.8%	47.9%	20.0%
Texas	19,025	175	5,725	3,175		675		3,950		5,325		6.5%	53.9%	40.9%	17.1%
Total (LF):	231,150	36,325	64,725	36,025	0	6,975	0	61,050	0	26,050	0	N/A	N/A	N/A	N/A
Total (%):	100.0%	15.7%	28.0%	15.6%		3.0%		26.4%		11.3%		9.9%	36.0%	27.2%	16.1%

Riparian Classification Tiers		Lemhi	Eighteen-mile	Big Springs	Canyon	Texas
1	Functioning / Climax Condition	23.4%	4.6%	10.7%	3.2%	0.9%
2	Functioning / Recovery Condition	35.1%	20.7%	18.3%	20.4%	30.1%
3	Impaired / Bend Apex & High Bank	14.3%	14.5%	17.5%	17.6%	16.7%
4	Impaired / Bend Apex and Low Bank	2.5%	7.0%	2.9%	3.2%	3.5%
5	Impaired / Inside of Bend and High Bank	18.4%	18.6%	41.9%	35.6%	20.8%
6	Impaired / Inside of Bend and Low Bank	6.4%	34.6%	8.7%	19.9%	28.0%

	Average Geyer Willow - Reedgrass Effective Shade (Aug 1)		
	Current Conditions w/ overhang	Target (For Geyer Willow and Existing Width)	Hypothetical Future Condition (18ft tall willow on all banks w/ overhang)
Lemhi	11.6%	25.4%	20.0%
Eighteen-mile	8.1%	63.9%	47.5%
Big Springs	8.6%	39.7%	28.9%
Canyon	11.3%	67.8%	47.9%
Texas	6.5%	53.9%	40.9%

APPENDIX C

BANK AND SHADE CONDITIONS



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Appendix C-1
Effective Shade: Current Conditions (Aug 1 Sun Angle)

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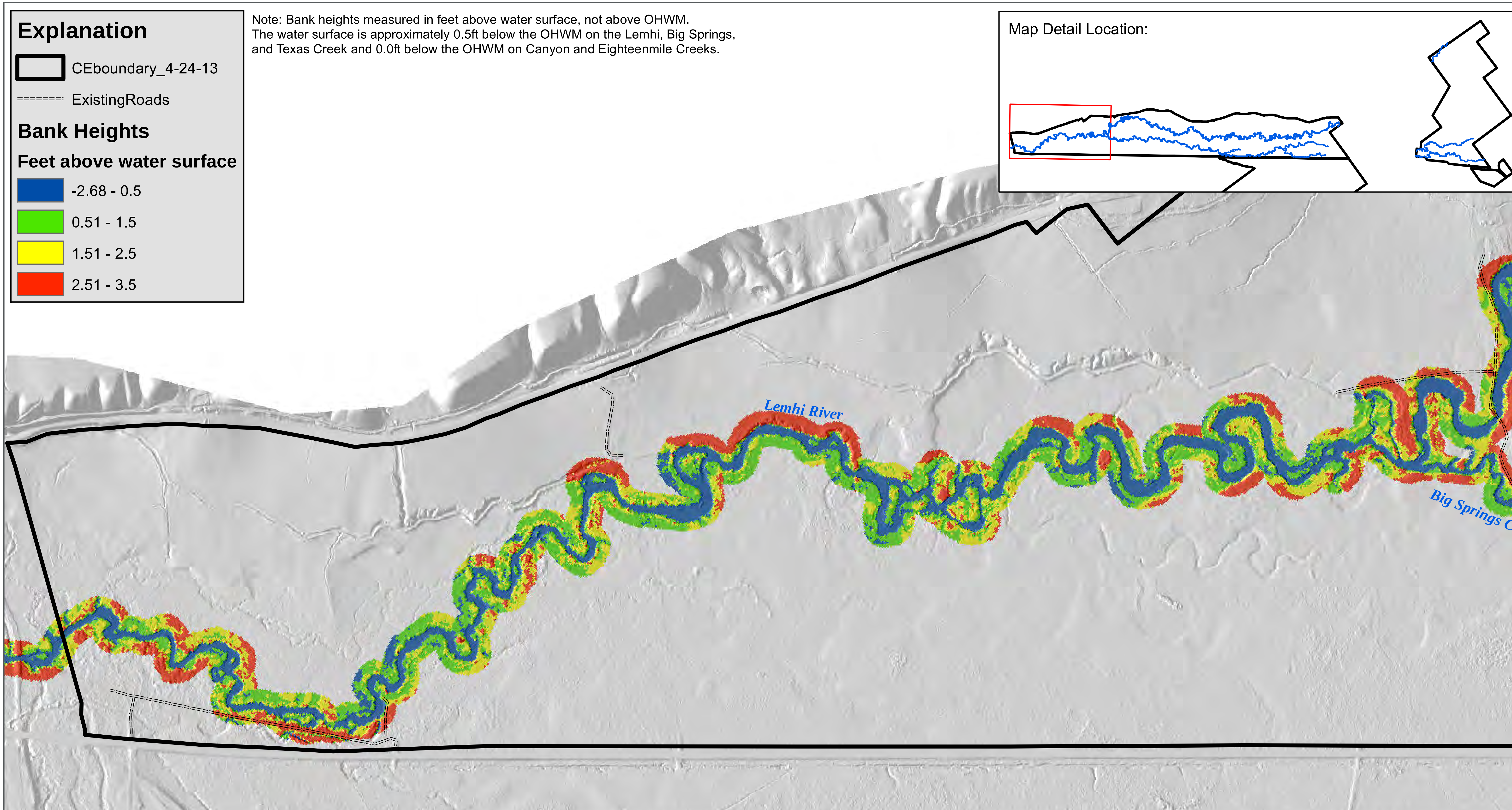
GIS Analyst: Rob.Richardson



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0 1,000 Feet

Appendix C-2
Bank Heights -- Lower Lemhi

Upper Lemhi River
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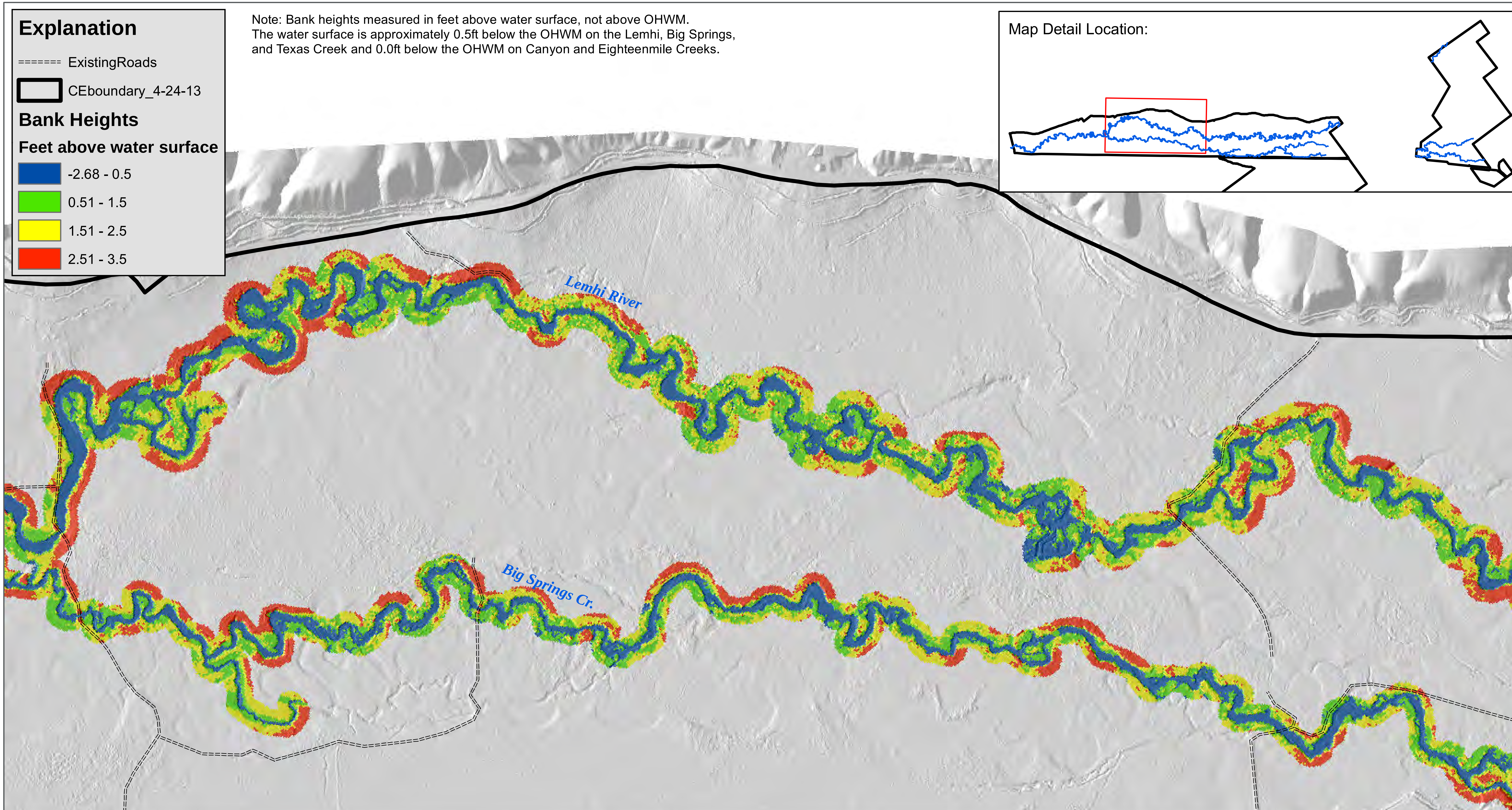
GIS Analyst: Rob.Richardson



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0 1,000 Feet

Appendix C-3
Bank Heights -- Confluence; Lemhi & Big Springs Lower-Mid

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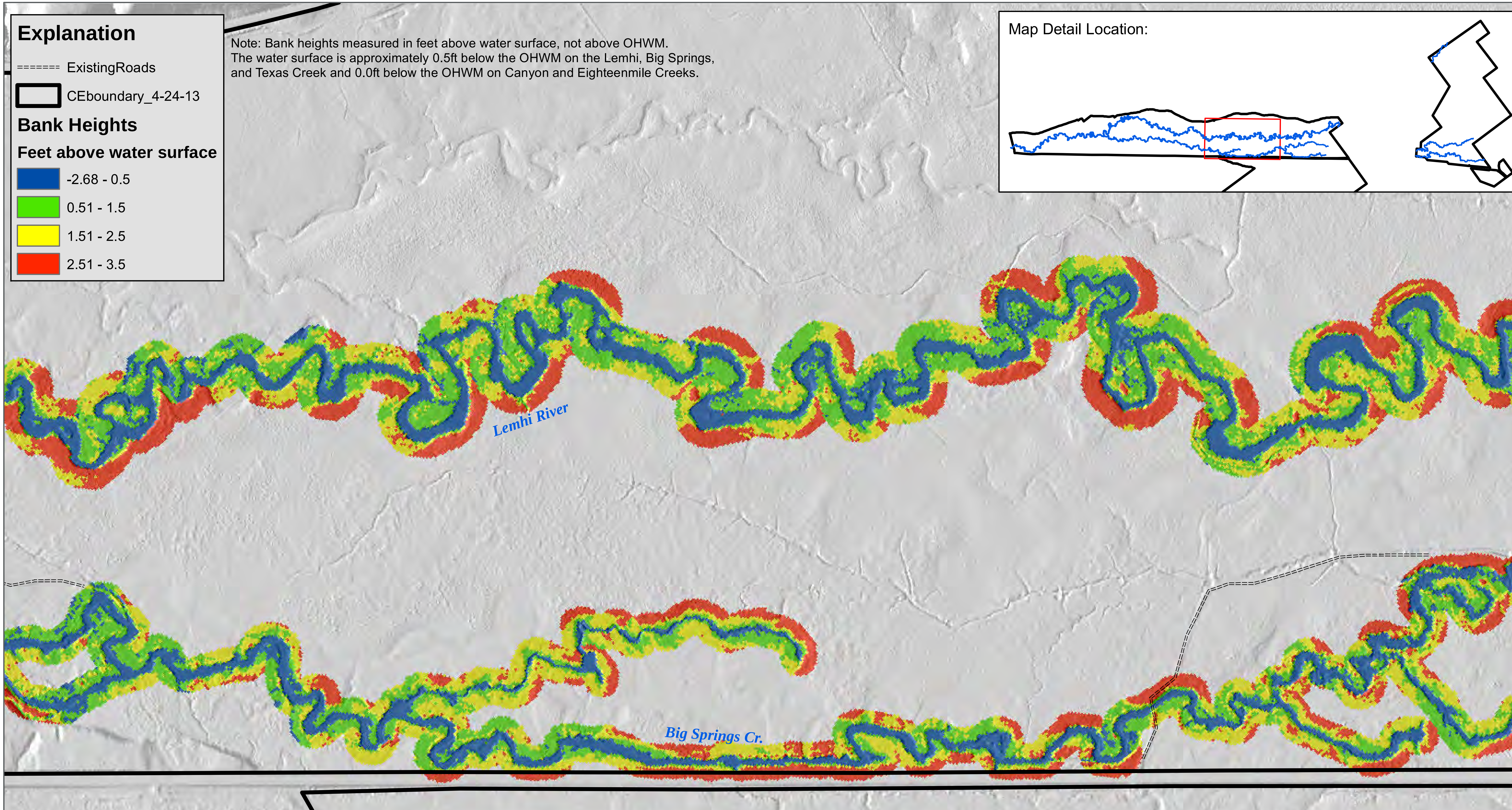
GIS Analyst: Rob Richardson



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0 1,000 Feet

Appendix C-4
Bank Height -- Lemhi and Big Springs (Upper Mid)

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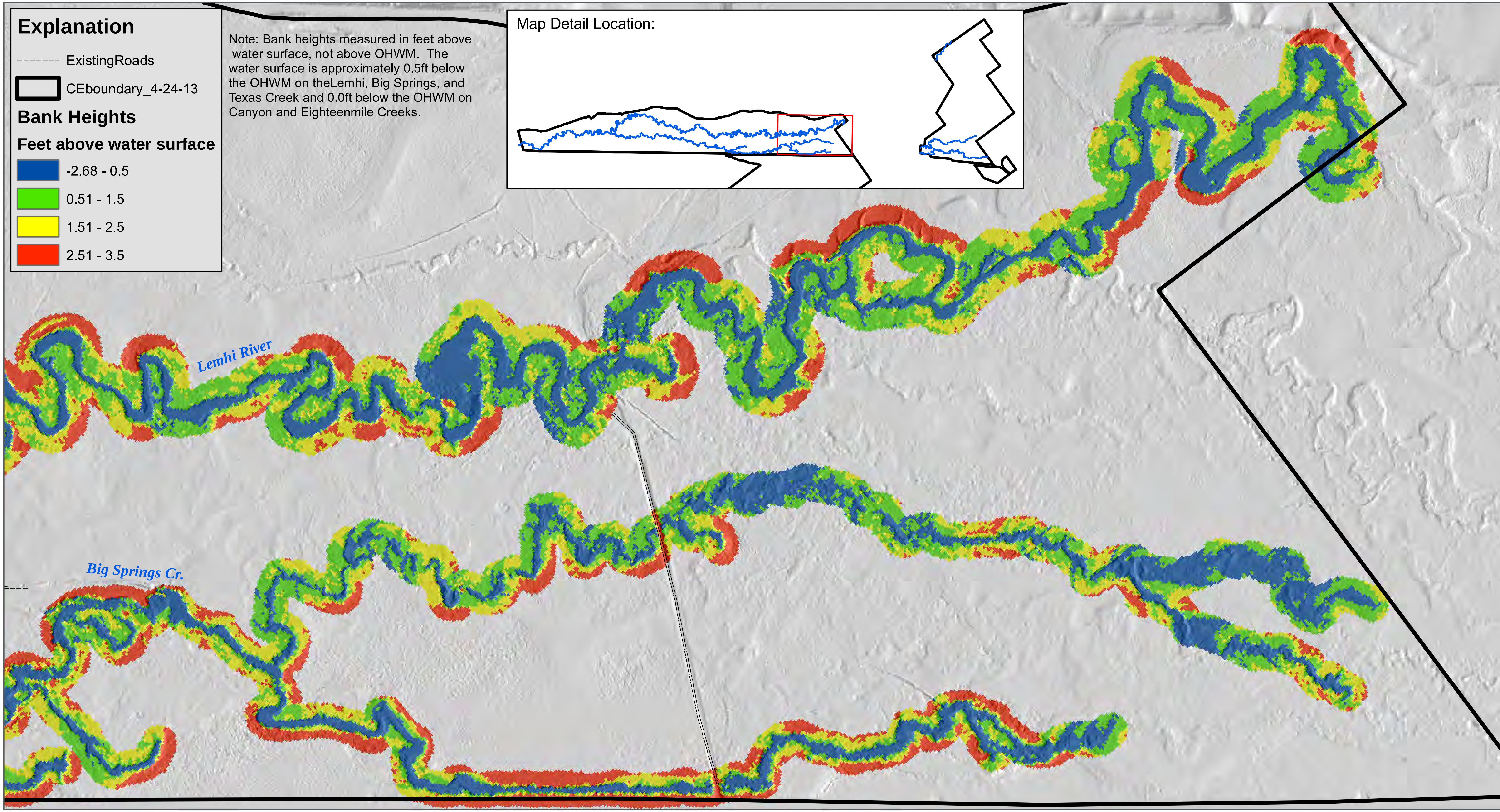
GIS Analyst: Rob.Richardson



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0 1,000 Feet

Appendix C-5
Bank Height -- Lemhi (Fayle); Big Springs (Headwaters)

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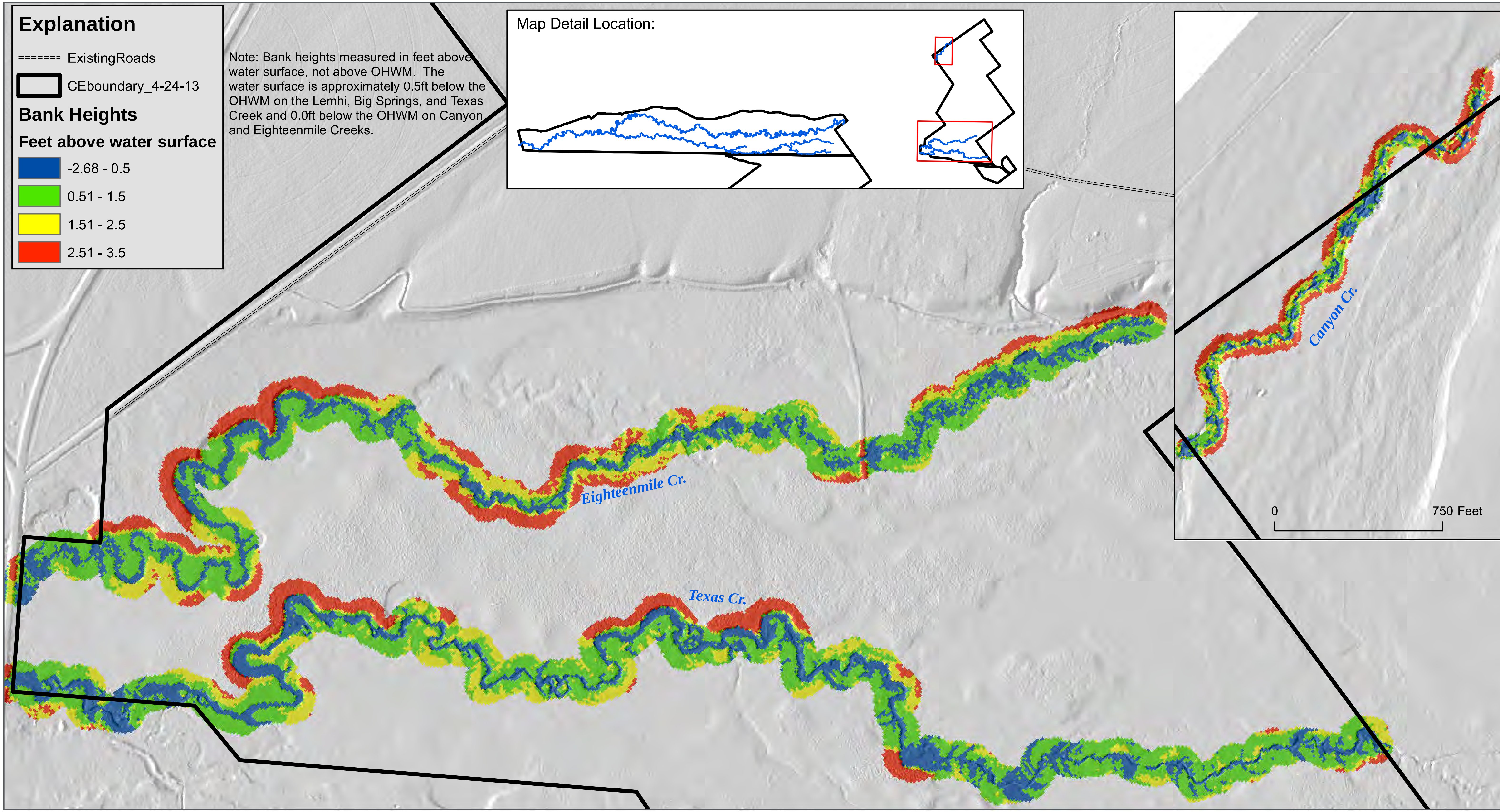
GIS Analyst: Rob.Richardson



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0 1,000 Feet

Appendix C-6
Bank Height -- Texas, Eighteenmile, and Canyon Creeks

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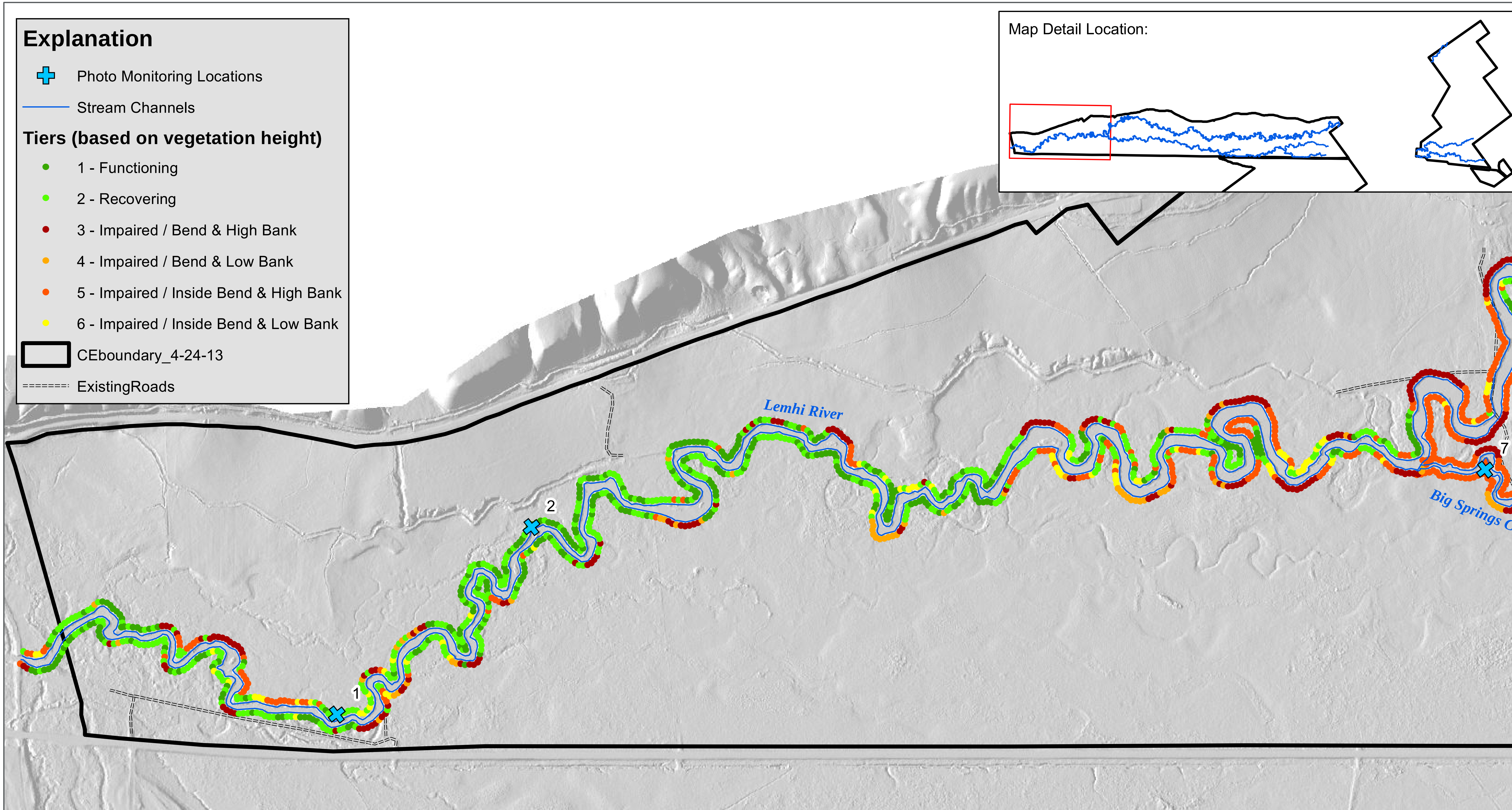

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0 — 1,000 Feet

Appendix C-7
Bank Condition Tiers (1-6) -- Lower Lemhi

Upper Lemhi River
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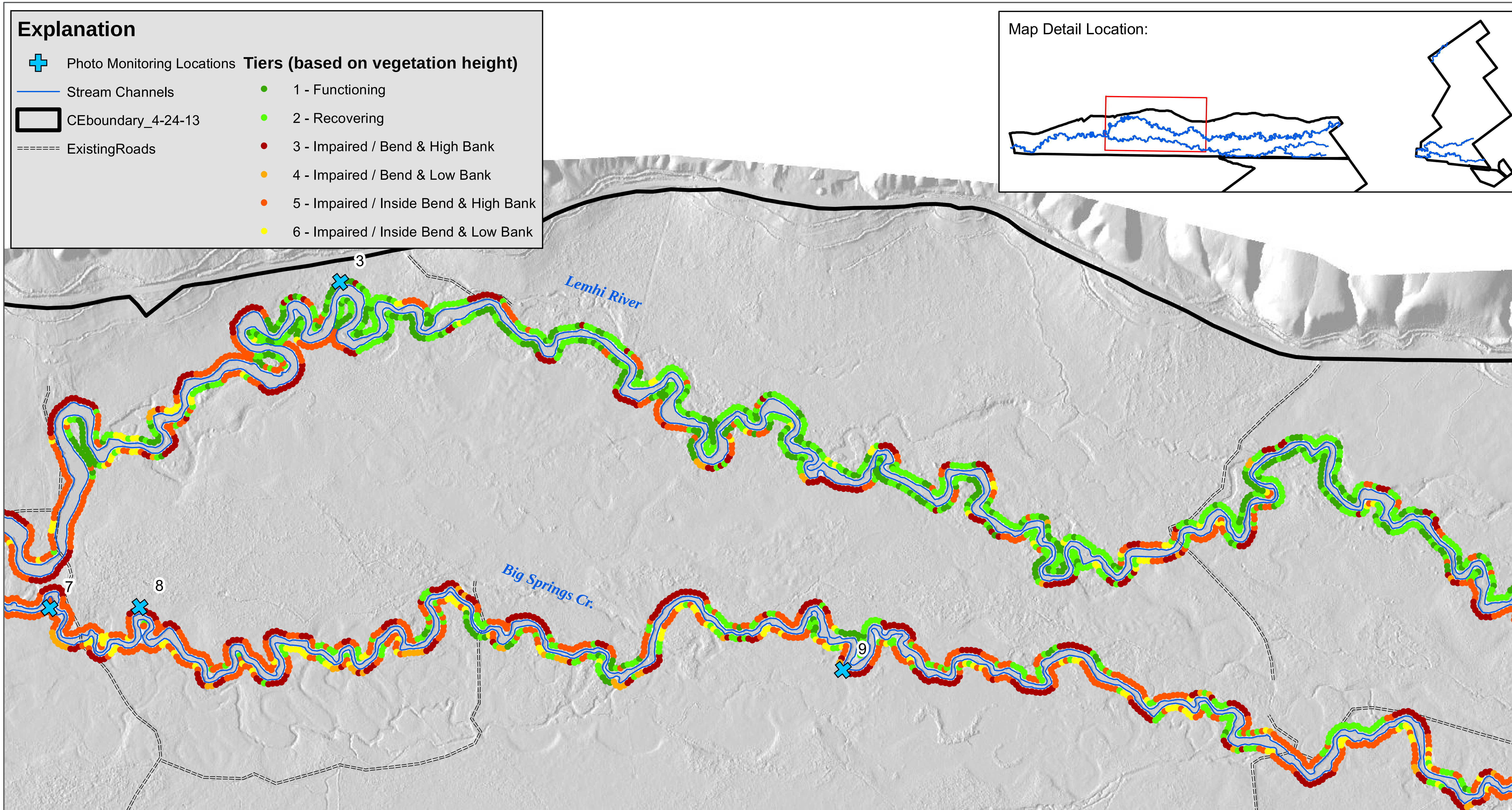
GIS Analyst: Rob.Richardson



Data Source:
2010 LiDAR from USBR

0 1,000 Feet

Appendix C-8
Bank Condition Tiers (1-6) -- Confluence; Lemhi & Big Springs Lower-Mid

Upper Lemhi River
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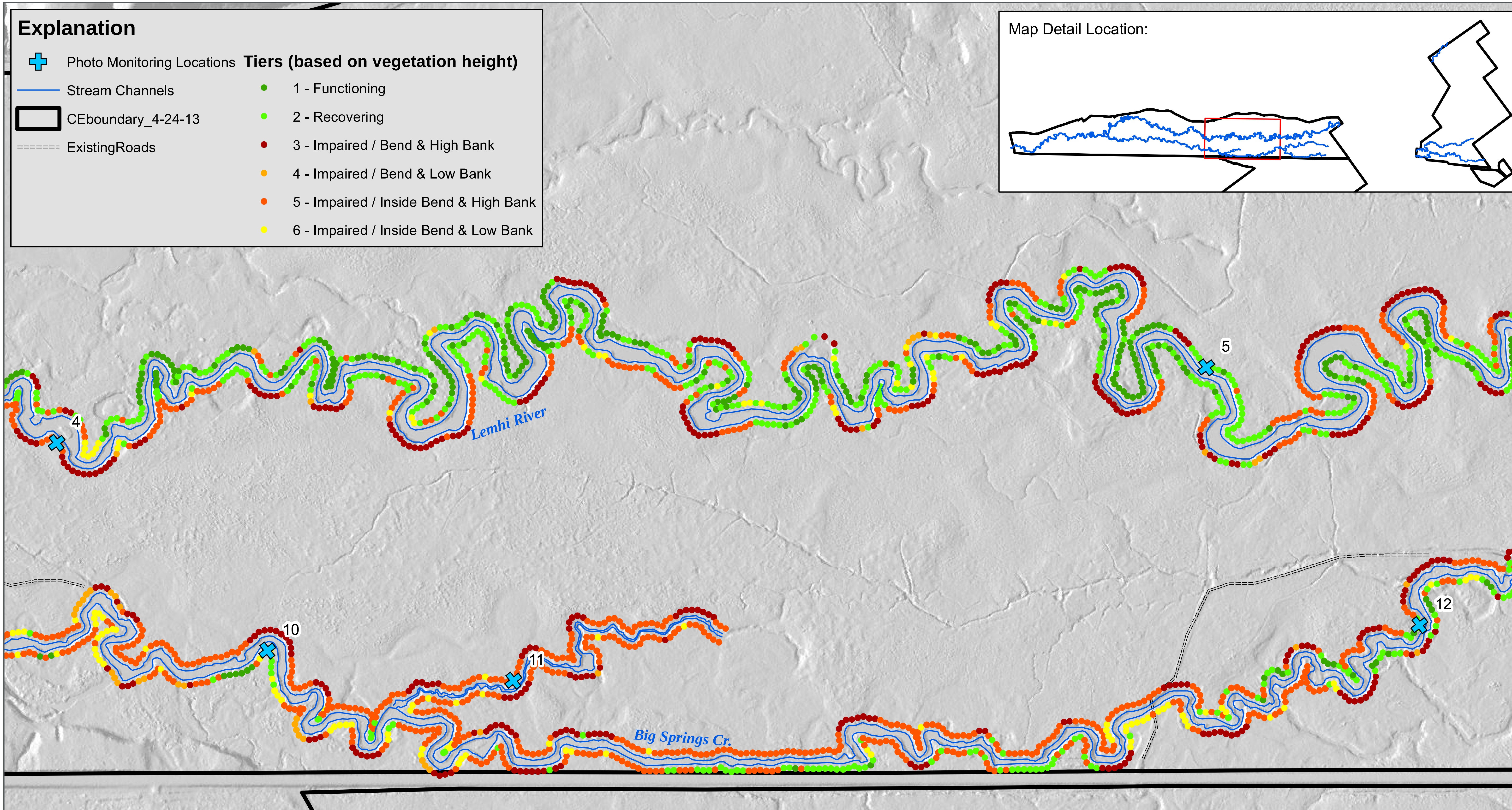
GIS Analyst: Rob.Richardson



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0 1,000 Feet

Appendix C-9
Bank Condition Tiers (1-6) -- Lemhi and Big Springs (Upper Mid)

Upper Lemhi River
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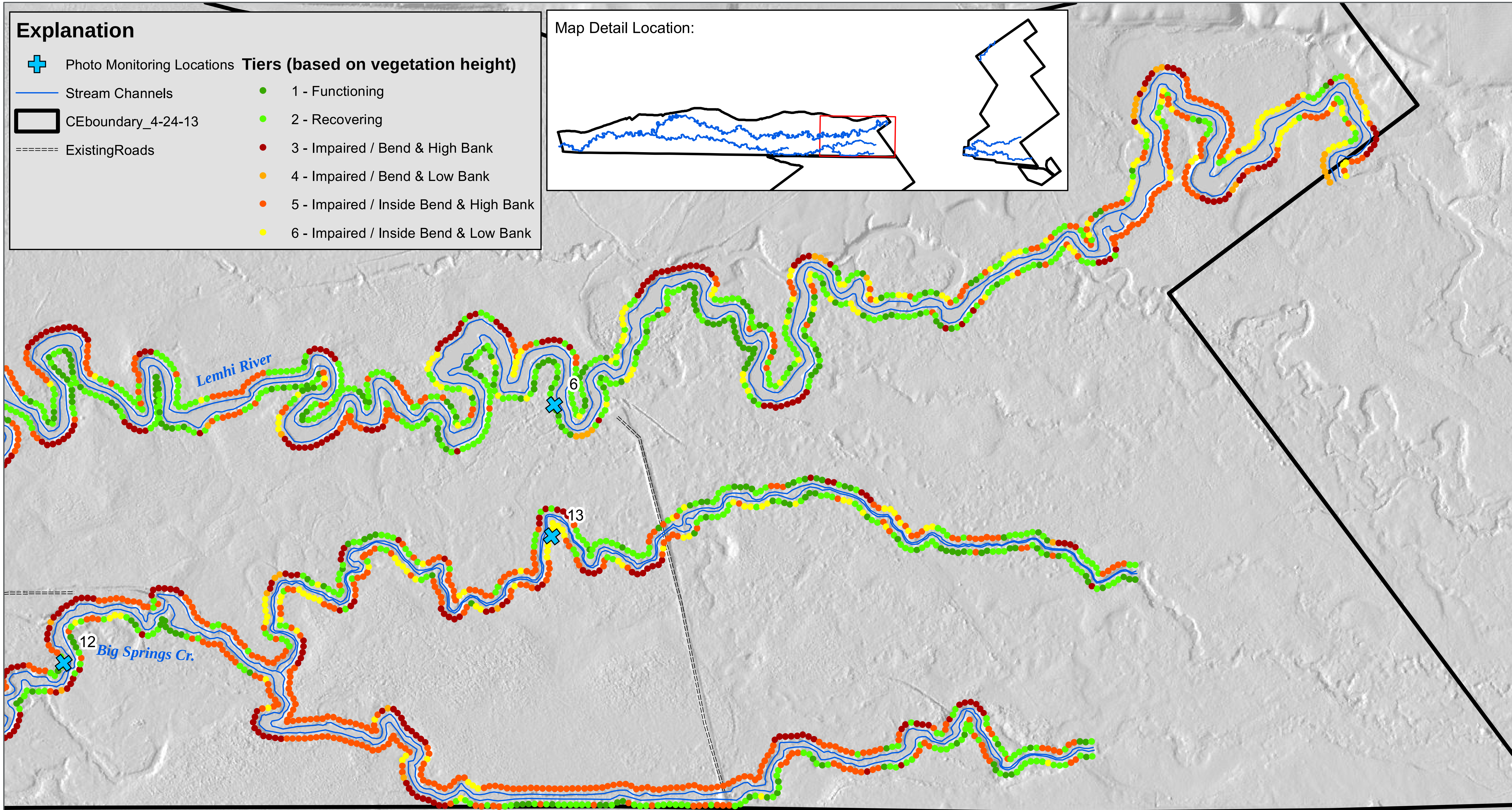
GIS Analyst: Rob.Richardson



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0 1,000 Feet

Appendix C-10
Bank Condition Tiers (1-6) -- Lemhi (Fayle); Big Springs (Headwaters)

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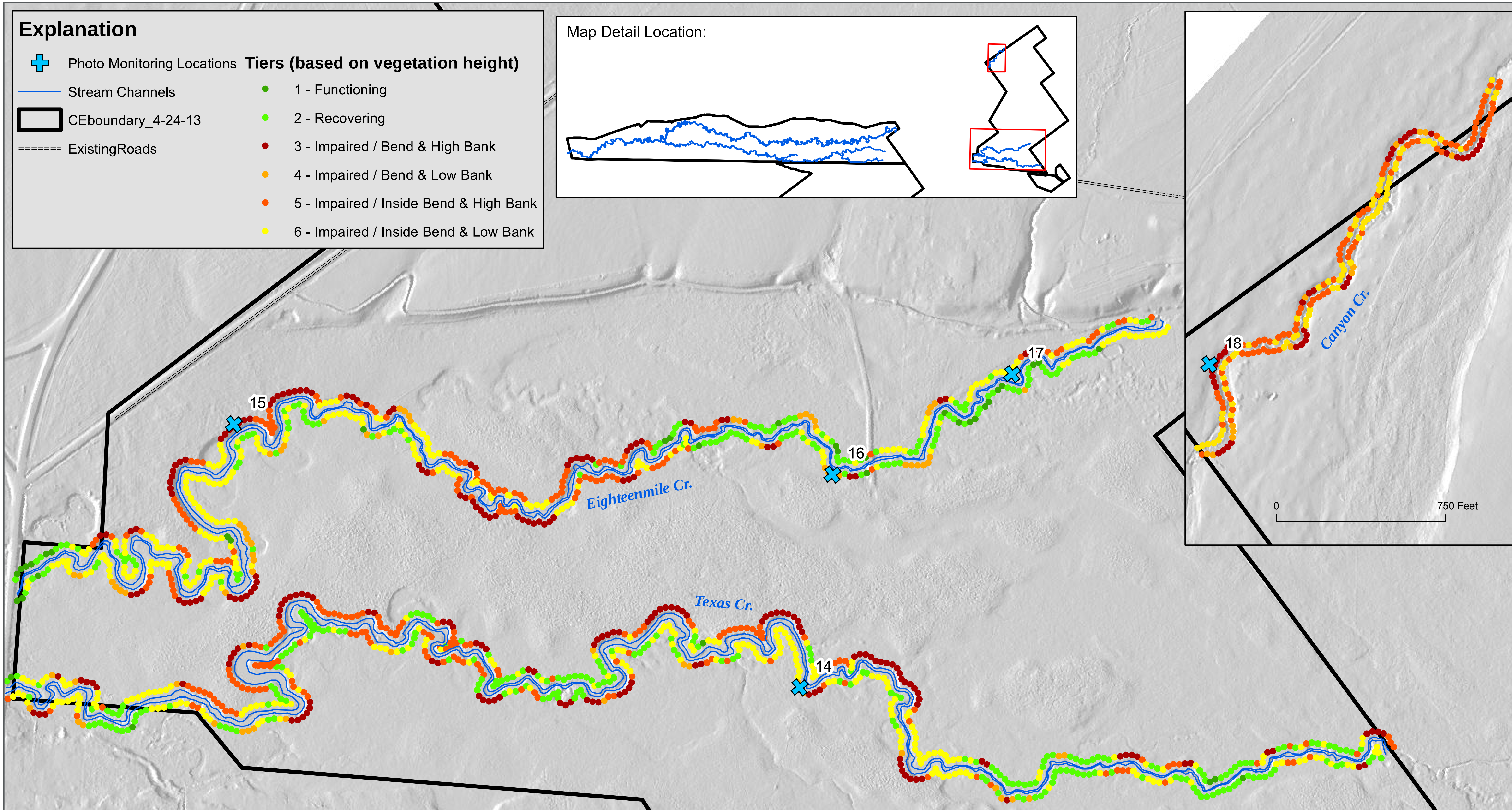
GIS Analyst: Rob.Richardson



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0 1,000 Feet

Appendix C-11
Bank Condition Tiers (1-6) -- Texas, Eighteenmile, and Canyon Creeks

Upper Lemhi River
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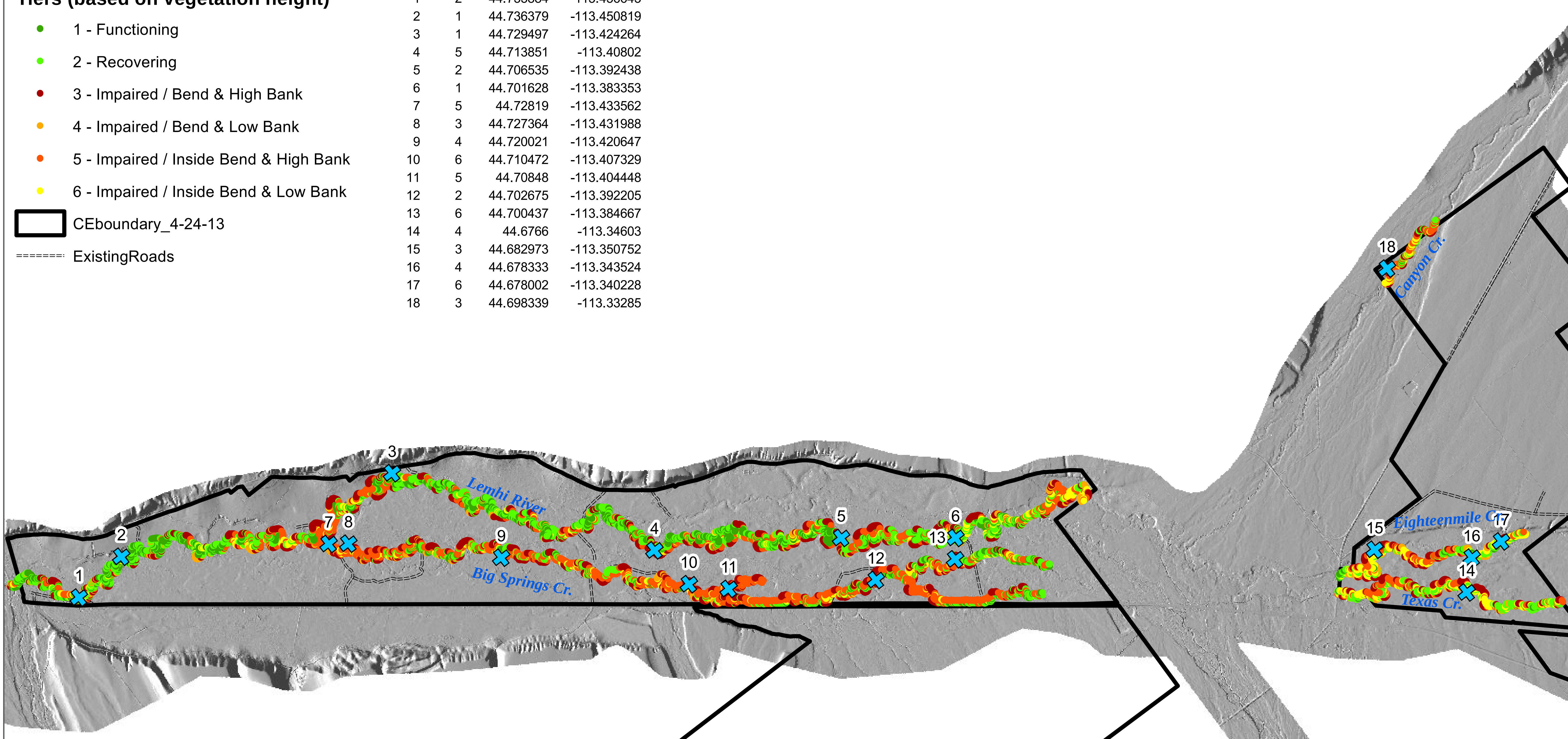
Date Created: 12/10/2015 Date Revised: 12/10/2015 File Path: E:_Cardno\Lemhi_Riparian_Mgt_Plan\GIS\MXD\Appendix C - Tiers5.mxd
GIS Analyst: Rob.Richardson



Explanation

Photo Monitoring Locations

Tiers (based on vegetation height)

- 1 - Functioning
- 2 - Recovering
- 3 - Impaired / Bend & High Bank
- 4 - Impaired / Bend & Low Bank
- 5 - Impaired / Inside Bend & High Bank
- 6 - Impaired / Inside Bend & Low Bank

CEboundary_4-24-13

ExistingRoads

Photo Monitoring Locations

Id	Tier	Lat	Long
1	2	44.735884	-113.456643
2	1	44.736379	-113.450819
3	1	44.729497	-113.424264
4	5	44.713851	-113.40802
5	2	44.706535	-113.392438
6	1	44.701628	-113.383353
7	5	44.72819	-113.433562
8	3	44.727364	-113.431988
9	4	44.720021	-113.420647
10	6	44.710472	-113.407329
11	5	44.70848	-113.404448
12	2	44.702675	-113.392205
13	6	44.700437	-113.384667
14	4	44.6766	-113.34603
15	3	44.682973	-113.350752
16	4	44.678333	-113.343524
17	6	44.678002	-113.340228
18	3	44.698339	-113.33285

Data Source:
2010 LiDAR from
USBR

0 1,000 2,000 3,000 4,000 Feet

0 500 1,000 Meters

Appendix C-12
Proposed Photo Monitoring Points

Upper Lemhi River
Leadore, ID

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Date Created: 12/10/2015 Date Revised: 12/10/2015 File Path: E:_Cardno\Lemhi_Riparian_Mgt_Plan\GIS\MXD\Monitoring_Locations.mxd
GIS Analyst: Rob.Richardson

Explanation

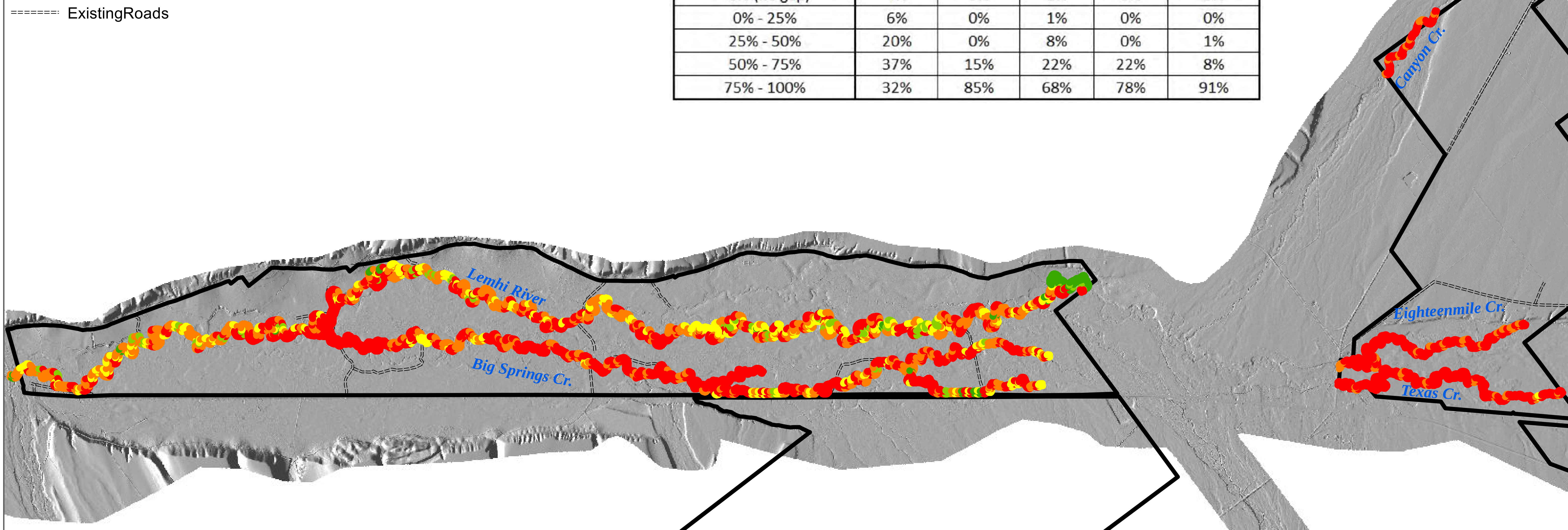
Gap Between Existing and Targeted Effective Shade

Gap (%) -- Version 8 of Heat Source Software

- < 0% (No Gap) Gap % = 1 - (Current Conditions / Target Conditions)
- 1% - 25%
- 26% - 50%
- 51% - 75%
- 76% - 100%
- CEboundary_4-24-13
- ExistingRoads

Effective shade has been calculated using software called Heat Source. There is a discrepency in results between Version 6 of Heat Source (used by DEQ to develop effective shade targets) and Version 8 of Heat Source (used in this document to assess current effective shade values). This figure illustrates the gap between the existing conditions and the targeted conditions as measured using Version 8 methodology which is believed to be the most up-to-date methodology. The figure in Appendix C14 illustrates the same gap between existing and targeted conditions using Version 6 methodology for a 1-to-1 comparison with DEQ's targets. Other that the map in C14, all effective shade values reported in this document reflect Version 8 methodology which is believed to be the most up-to-date methodology.

Effectiv Shade Gap (%) Version 8 of Heat Source Software	Lemhi	Eighteen-mile	Big Springs	Canyon	Texas
<0% (no gap)	4%	0%	1%	0%	0%
0% - 25%	6%	0%	1%	0%	0%
25% - 50%	20%	0%	8%	0%	1%
50% - 75%	37%	15%	22%	22%	8%
75% - 100%	32%	85%	68%	78%	91%



Data Source:
2010 LiDAR from USBR

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0 1,000 2,000 3,000 4,000 Feet

0 500 1,000 Meters

Appendix C-13
Gap Between Existing and Targeted Effective Shade (V8)

Upper Lemhi River
Leadore, ID

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Date Created: 1/4/2016 Date Revised: 1/4/2016 File Path: F:_Cardno\Lemhi_Riparian_Mgt_Plan\GIS\MXD\Appendix C - Gap_V8.mxd
GIS Analyst: Rob.Richardson

Explanation

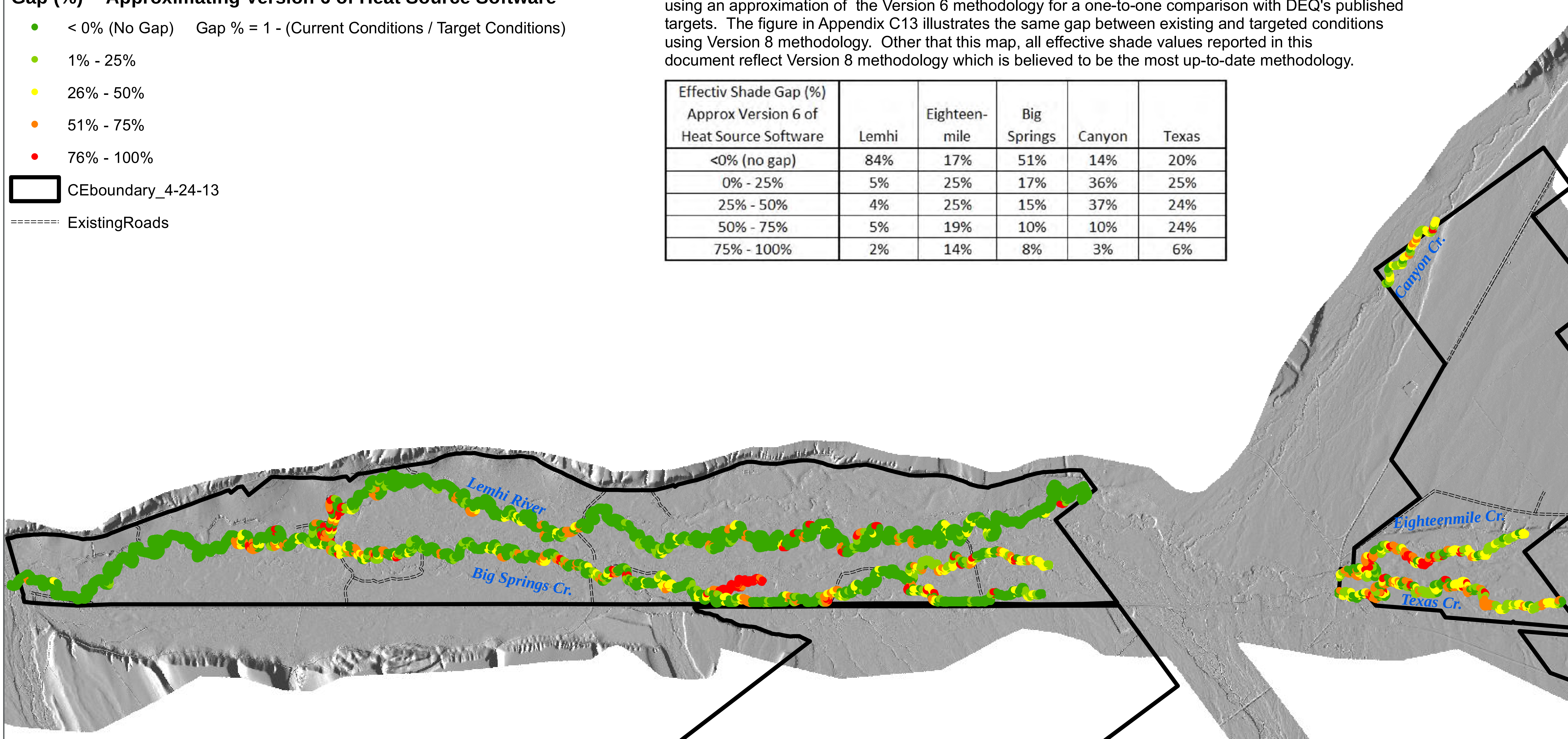
Gap Between Existing and Targeted Effective Shade

Gap (%) -- Approximating Version 6 of Heat Source Software

- < 0% (No Gap)   Gap % = 1 - (Current Conditions / Target Conditions)
- 1% - 25%
- 26% - 50%
- 51% - 75%
- 76% - 100%
- CEboundary_4-24-13
- ExistingRoads

Effective shade has been calculated using software called Heat Source. There is a discrepency in results between Version 6 of Heat Source (used by DEQ to develop effective shade targets) and Version 8 of Heat Source (used in this document to assess current effective shade values). This figure illustrates the gap between the existing conditions and the targeted conditions as measured using an approximation of the Version 6 methodology for a one-to-one comparison with DEQ's published targets. The figure in Appendix C13 illustrates the same gap between existing and targeted conditions using Version 8 methodology. Other that this map, all effective shade values reported in this document reflect Version 8 methodology which is believed to be the most up-to-date methodology.

Effectiv Shade Gap (%) Approx Version 6 of Heat Source Software	Lemhi	Eighteen-mile	Big Springs	Canyon	Texas
<0% (no gap)	84%	17%	51%	14%	20%
0% - 25%	5%	25%	17%	36%	25%
25% - 50%	4%	25%	15%	37%	24%
50% - 75%	5%	19%	10%	10%	24%
75% - 100%	2%	14%	8%	3%	6%



Data Source:
2010 LiDAR from USBR

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0 1,000 2,000 3,000 4,000 Feet
0 500 1,000 Meters

Appendix C-14
Gap Between Existing and Targeted Effective Shade (V6)

Upper Lemhi River
Leadore, ID

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