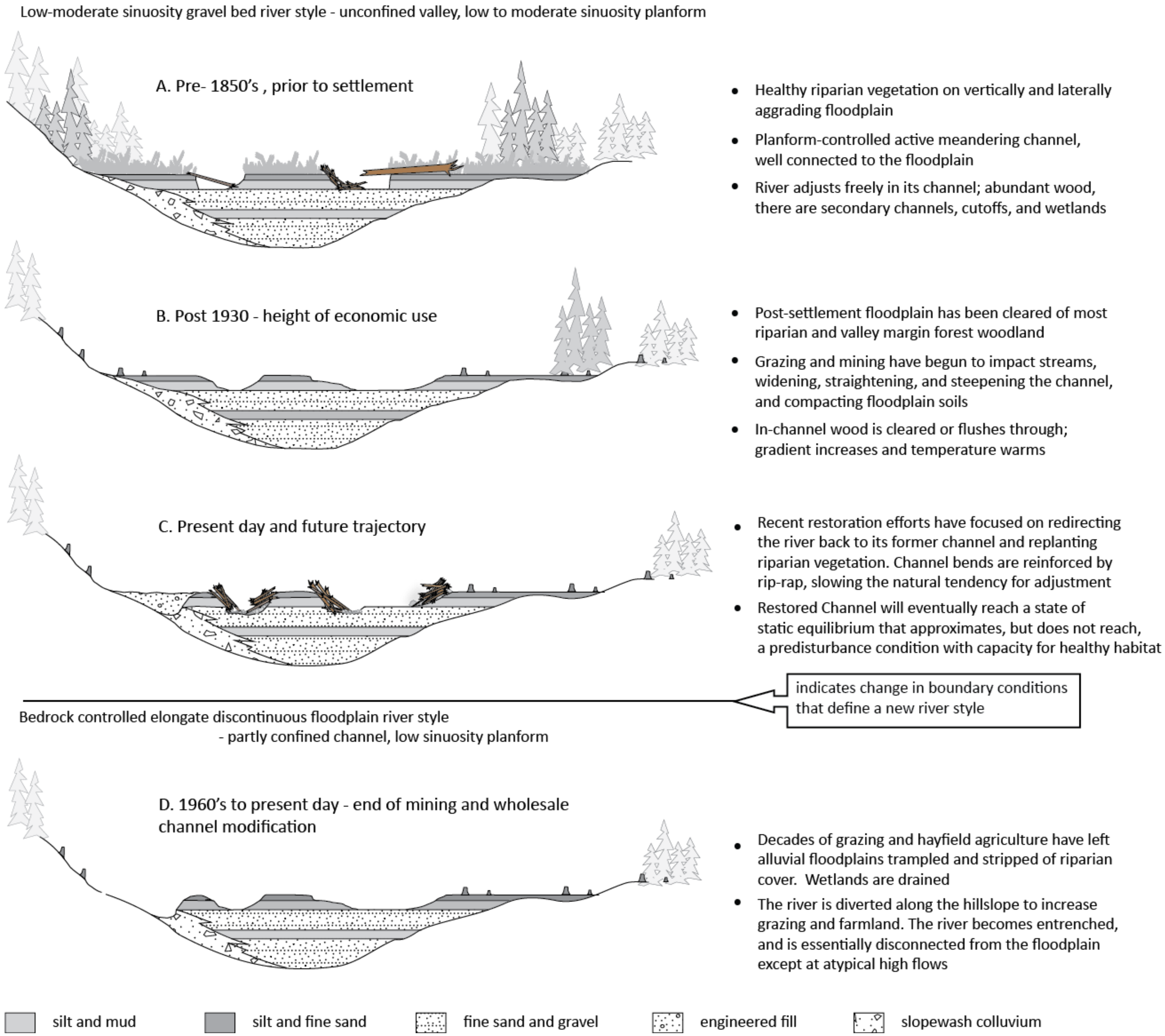

Figure 44. Evolutionary sequence for reaches of the Low-moderate sinuosity gravel bed river style. This river style has not incurred irreversible geomorphic change, but shows several variants based on its condition.

5.2.3 LEVERAGING GEOINDICATORS TO IDENTIFY GEOMORPHIC CONDITION AND A REFERENCE CONDITION FOR EACH REACH

The exercise of identifying geoindicators for each river style (Table 13 and Table 15) and the analysis of the evolutionary diagrams (Figure 44 and Appendix B) leads to the assignment of criteria aimed at producing a final determination of geomorphic condition of a reach. Determining geomorphic condition for individual reaches requires a baseline reference condition from which to compare variants of the same river style (i.e., Figure 14). The reference condition allows the standard to be set for the river style under study depending upon the degree of human impact and an understanding of how the river style should behave under its current boundary conditions. The decision tree shown in Figure 45 is used to aid in identifying a reference condition for each river style. In the MFJDW, reference conditions selected for each river style are good condition reaches because reaches of intact condition for important anadromous reaches do not exist in the watershed. The details for every non-ephemeral reference reach is explained in Appendix B.

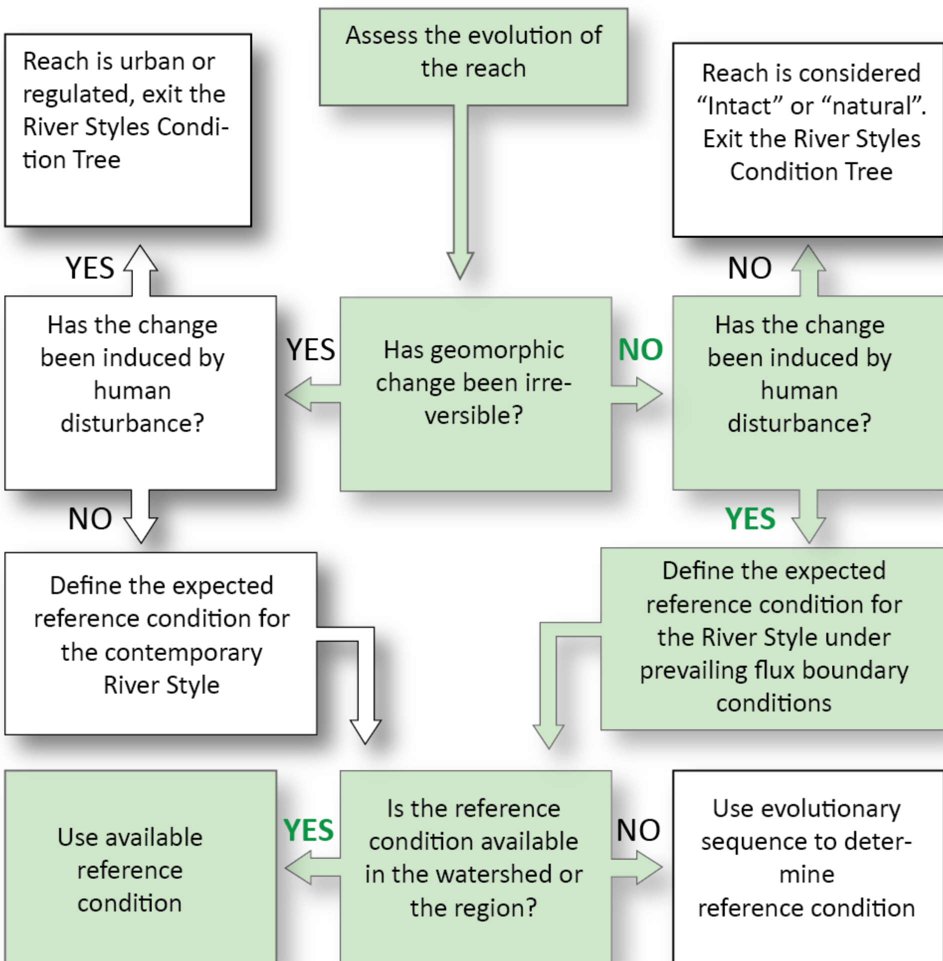

Figure 45. Decision tree for identifying a reference condition. Boxes in green show the pathway on this tree for the Low-moderate sinuosity gravel bed river River Style. Modified from Brierley and Fryirs (2005).

5.3 DESIGNATING AND MAPPING GEOMORPHIC CONDITION OF RIVER STYLE REACHES

The final step in designating and interpreting geomorphic condition of individual reaches is to compile responses to questions asked of relevant geoindicators (Table 15) into a "condition matrix". The condition matrix provides the basis for interpreting good, moderate and poor geomorphic condition for each variant of a river style. Details of this analysis for each river style is given in Appendix B. The section concludes with a watershed map of geomorphic condition and an explanation of its categories in the context of stream lengths.

5.3.1 EXPLANATION OF GEOMORPHIC CONDITION

Table 16 shows the degrees of freedom by which relevant geoindicators (those physical attributes of the river bed and floodplain capable of adjustment to fluctuations in flow or sediment flux) are assessed. For each, a series of questions are posed determine if a reach is in good, fair or poor condition as compared to the chosen reference condition. In this step, a positive response receives a "check" for each question answered affirmatively, and a negative response receives an "X". Added up, the positive and negative responses result in either good, moderate, or poor geomorphic condition for each specific river style variant (see also Appendix B). Table 17 provides data for assessing the geomorphic condition of each degrees of freedom and their attributes. Tables explaining geomorphic condition for each river style are in Appendix B. These tables provide the foundation for setting target conditions for improvement of poor or moderate reaches in the context of strategic process-based rehabilitation or restoration efforts. Table 18 describes how these tables should be used for assessing potential targets for rehabilitation work.

Continuing with the *Low-moderate Sinuosity Gravel Bed river style*, there are several reaches of along the mainstem MFJDR, Camp Creek, and Long Creek as discussed in Section 5.2.2. The first is a reach of upper Camp Creek that was assessed in good geomorphic condition and designated the Reference Reach. Here the stream and its floodplain possess all the defining attributes of its river style, and is in the best condition found in the MFJDW. The decision pathway for its designation as the reference reach is highlighted in Figure 45. We identified three additional variants, all on the MFJDR. These include an unprotected reach near the old township of Austin (Figure 8) where the floodplain is being actively grazed and ranched and a reach near the mouth of Vinegar Creek, where ongoing restoration is being implemented. Farther downstream, a reach at the mouth of Granite Boulder Creek (Oxbow reach; see (Reclamation, 2010)) where extensive restoration efforts are ongoing that include engineering volumes of large wood into the channel, and floodplain replanting. The final variant is near the town of Galena, where placer mining has resulted in extensive disruption to the channel and floodplain (Figure 14) We summarized the geomorphic attributes of good, fair and poor condition variants of the *Low-moderate Sinuosity Gravel Bed river style* during field visits and analysis of aerial photographs. The explanation of geomorphic condition highlights details of the channel, planform, and bed material. From these data we observed that:

- An Intact, pristine example of this river style does not exist in the MFJDW. Few if any reaches resemble their pre-settlement condition. This is true of all river styles in the MFJDW.

- Most of the reaches lay along the mainstem where wide, laterally unconfined valleys host fine-grained floodplains suitable for a variety of land uses. This river style possesses high adjustment capacity and is sensitive to disturbance. Consequently, reaches of the mainstem are in moderate geomorphic condition.

- Degrading effects include irregular erosion of the channel bed and banks, the overall lack of instream wood or wood placed only at bends of restored reaches, lack of well developed geomorphic units (long stretches of plane bed) near and downstream of restoration and previously mined reaches, and overgrazed floodplains affecting riparian vegetation and soil compaction. All of these factors influence the natural capacity of adjustment for this river style.

Table 16. Tables of "desirable" criteria and measures used to assess good condition reaches of the Low-moderate sinuosity gravel bed river style in laterally unconfined valley settings, MFJDW, Oregon (desirability criteria for all river styles are in Appendix B).

Degrees of freedom and their relevant geoindicators	Questions to be answered to assess geomorphic condition of each reach of the Low-moderate sinuosity gravel bed river River Style.	Clear Creek	MF John Day (near Bates)	MF John Day (Oxbow area)	MF John Day (near Galena)
Channel Attributes	**2 out of 3 questions must be answered YES For stream to be assessed in GOOD condition**				
Size	Is channel size appropriate given the catchment area, the prevailing sediment regime, and the vegetation character?	✓	X	X	X
Bank	Is the bank morphology consistent with caliber of sediment? Are banks eroding in the correct places?	✓	X	X	X
Woody debris Loading	Is there woody debris in the channel or potential for recruitment of woody debris?	✓	X	✓	X
		✓	X	X	X
Channel planform	**2 out of 3 questions must be answered YES**				
Number of channels	Is the channel single thread as appropriate for this river style? Are there signs of change such as avulsions or overbank channels forming on the floodplain?	✓	✓	✓	X
Geomorphic unit assemblage	Are the number, type and pattern of instream geomorphic units appropriate for the sediment regime, slope, bed material and valley setting? Are key units of *this* river style present (riffles, pools, plane bed runs & glides, cutbanks, point bars)?	✓	X	X	X
Riparian vegetation	Are the appropriate types and density of riparian vegetation present on the banks?	✓	X	✓	X
		✓	X	✓	X
Bed character	**3 out of 4 questions must be answered YES**				
Grain size and sorting	Is the range of sediment throughout the channel and floodplain organized and distributed appropriately?	✓	✓	✓	X
Bed stability	Is the bed vertically stable such that it is not incising or aggrading inappropriately for the channel slope, sediment caliber, and sinuosity?	✓	✓	✓	X
Sediment regime	Is the sediment storage and transport function of the reach appropriate for the catchment? position (i.e., is it a sediment transfer or accumulation zone?)?	✓	X	✓	X
Hydraulic diversity	Are roughness characteristics and the pattern of hydraulic diversity appropriate for the catchment position?	✓	✓	✓	X
		✓	✓	✓	X
		✓	X	X	X
Geomorphic Condition	Total checks and crosses are added for each stream reach	**Good**	**Moderate**	**Moderate**	**Poor**

Table 17. Explanation of geomorphic condition for variants of the Low-moderate sinuosity gravel bed river style. Check and "X" boxes are the same as those presented in Table 16.

Degree of Freedom	Good Condition	Moderate Condition	Poor Condition
Channel Attributes	Steep-sided asymmetrical cross section within a fine-grained sand to mud floodplain. Bank erosion is minimal. Channel bed is free of vegetation except for occasional tussock grasses. ✓	Steep-sided asymetric cross section within a fine-grained sand to mud floodplain. Bank erosion rate is correct for fine-grained floodplain and steep banks, but restoration projects have inserted large wood that is focused only at bends, to "prevent erosion" (will retard natural tendency to adjust). Channel shape and size are consistent, yet bank erosion is irregular as indicated by a greater abundance of channel margin tussock stands ✓	Original channel has been dredged in extensively, so width-depth ratio is uneven and shape inconsistent. Channel size is OK for catchment, but there are multiple channels and diversions. Banks have been armored with coarse bed material, creating uneven erosion rates and characteristics. X
Channel Planform	Irregular, moderate to high sinuosity planform, well-connected to floodplain, occasional overbank crevasse-splays and channel cutoffs developed. Riparian vegetation consists of scattered woody stands with rich grass cover on floodplain, partly influencing meander development. Abundant recruitment of woody debris plays role in channel shape and sinuosity as well as forcing bars and pools ✓	irregular, moderate to high sinuosity planform, adjustment is gradual on scale of decades, not years; well-connected to floodplain, channel cutoffs developed. Riparian vegetation is very scattered with few woody stands, but rich grass cover on floodplain. Emplaced wood is abundant through the restoration reach, but is distributed only at bends and not likely to play a role in channel shape and sinuosity as well as forcing bars and pools. Bed is stable. Geomorphic units are not well-developed, as restoration was recent. ✓	Planform has been truncated and straightened to accommodate placer mining activites. New channels were dug, making the number and shape of channels inappropriate for the catchment size. Sinuosity is correct where the natural channel trace is preserved, but flow characteristics are affected by multiple channels and ponds. Geomorphic units are appropriate in original channel, but are restricted to featureless plane bed where dredging has occurred. Channel-floodplain connectivity is impossible owing to levee of coarse, dredged bed material now placed on banks. Artificial backwaters and ponds produced by disruption of tributary access to mainstem Middle Fork John Day River. X
Bed Material	Segregated, bi-modal sediment mix, with channel bed composed of coarse gravel and cobble; coarse sediment projects beneath Floodplain composed of fine sand, silt and mud. ✓	Segregated, bi-modal sediment mix, with channel bed composed of coarse gravel and cobble; coarse sediment forms planar geomorphic units, with little diversity (pool-riffle sequences and cutbanks) X	Bed and bank material has been overturned and mixed except in places where original channel was not directly dredged. Integrated coarse gravel and cobble substrate. X

Camp Creek, Middle Fork John Day Watershed

Middle Fork John Day River

Middle Fork John Day River Near Galena, OR.

Table 17. How to use the Explanation of Geomorphic Condition Tables and to inform rehabilitation/restoration.

1. Each geomorphic attribute (channel, planform, and bed material) has a "check" or an "X", which refers to its condition, and whether it is operating as expected for that river style. 2. If the attribute has a "check" next to it, it is in GOOD geomorphic condition and should NOT be altered as part of a restoration or rehabilitation effort. 3. Only poor- or moderate-condition attributes (shown by an "X") should be the focus of strategic planning. This information provides the foundation for setting target conditions (see Stage Four, section 7) that will set the reach on a trajectory of poor to moderate to good condition. 4. This information provides a basis for *strategic process-based river restoration* – if attributes of a river style reach are already in good or moderate condition, they should be left alone or be the focus of only minimal intervention. A consequence of altering good-condition attributes as part of restoration is that deterioration could be triggered rather than improvement.

5.3.2 WATERSHED MAP OF GEOMORPHIC CONDITION

The product of a geomorphic condition assessment is a watershed map showing the distribution of intact, good, fair and poor condition reaches of every river style (**Figure 46**). For this study we divided the MFJDW into five 10-digit watersheds (HUC 10) for the purpose of reporting stream length summaries in each condition category (Figure 47).

Downstream patterns of river styles tend to reflect strong control by their valley settings and corresponding sensitivity to disturbances (see Figure 41 and Section 4.2 for explanation). The geomorphic condition of adjoining reaches reflects the overall limiting factors and pressures in the watershed, except where reach sensitivity differs across river styles and/or in areas of intense local land use. Higher elevation, upper watershed areas tend to have intact or good-condition reaches dominated by confined valley settings, except where clear cut logging operations have significantly changed patterns of sedimentation by destabilizing slopes and building road networks. The greatest share of land use pressure is focused on the mainstem MFJDR where all river styles—*Low-moderate sinuosity gravel bed river, Meandering gravel bed, Meandering planform-controlled discontinuous floodplain, and Bedrock-controlled discontinuous floodplain*—flow within laterally unconfined and partly confined valley settings. They are most sensitive to disturbances and have the highest capacity for adjustment. This is reflected in long sections of the mainstem with moderate or poor-condition reaches. Dominating every watershed, though, are areas where legacy land use has been localized and limited (e.g., isolated ranching operations or recovering clear-cut areas). Streams of these small basins flow in bedrock-controlled, confined or partly confined valleys and are generally in good geomorphic condition.

On balance, areas showing the greatest overall impact are near the mouths of Camp and Elk Creeks where placer mining of alluvial valleys and logging within tributaries north and south of the Middle Fork was extensive. Moreover, the uppermost MFJDR headwaters underlain by the volcanic Strawberry Formation (Figure 21) is a region where soils are less suitable for dense forest growth, and where intense land use (logging, road building, quarrying, canal building, grazing and ranching operations) has had a disproportionate and lasting impact on hillslopes, valleys and their streams.

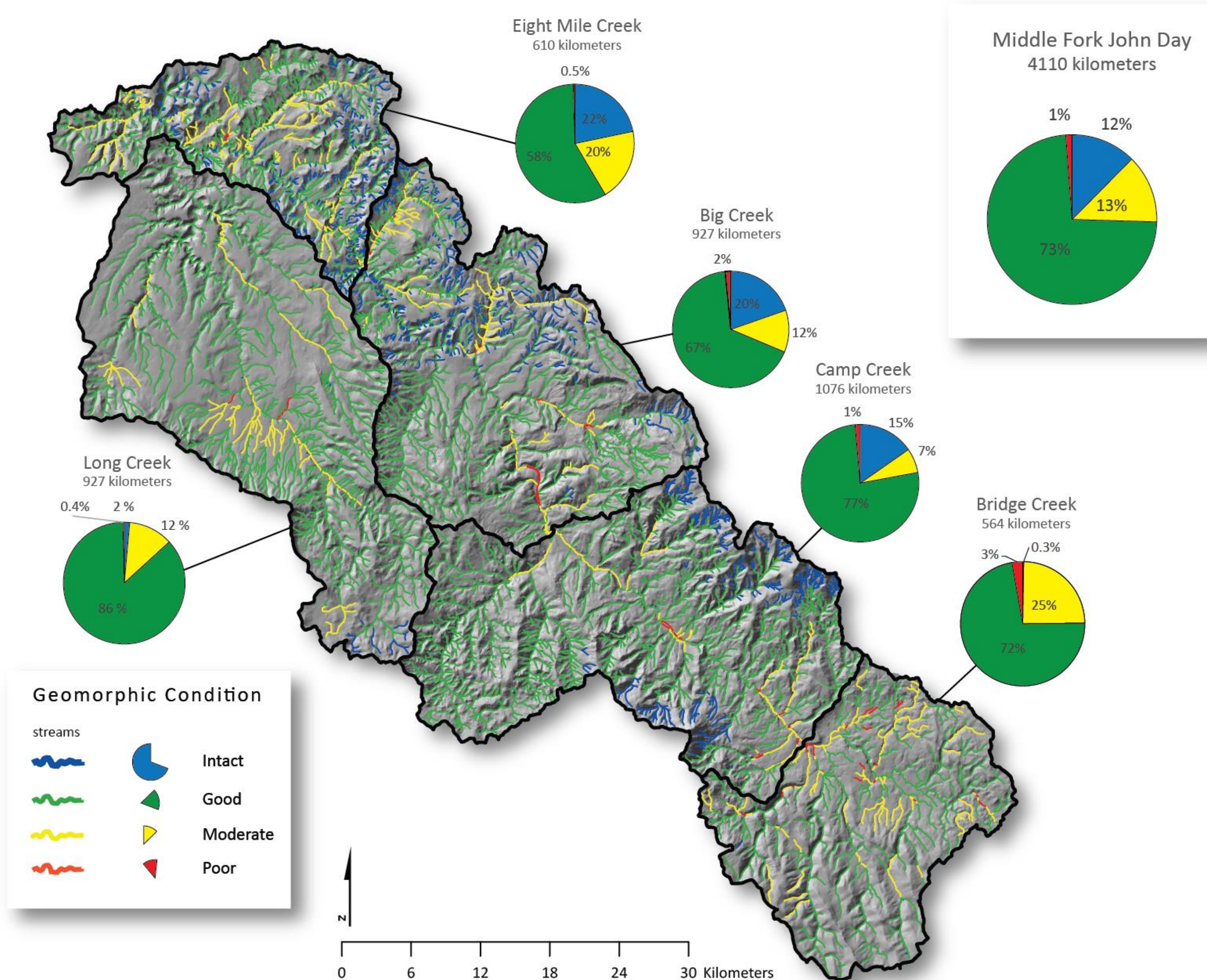

Figure 46. Geomorphic condition of all streams (intermittent, perennial and emphemeral) in the Middle Fork John Day Watershed in the context of HUC 10 subwatersheds.

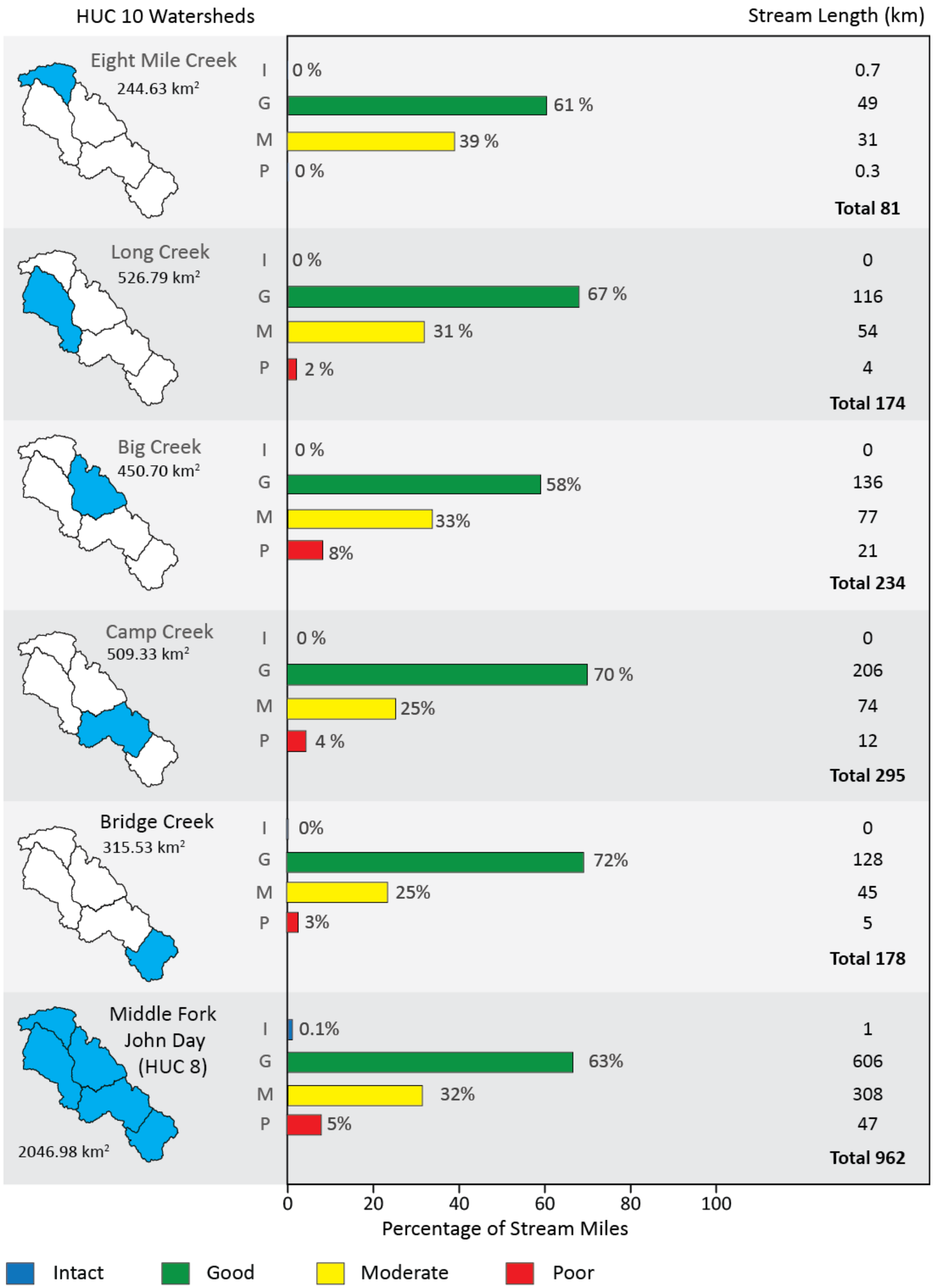

Figure 47. Geomorphic condition of perennial streams in HUC 10 subwatersheds of the Middle Fork John Day Watershed.

6 STAGE THREE: ASSESSMENT OF RECOVERY POTENTIAL

Geomorphic recovery potential is defined in the River Styles framework as "…the capacity for improvement of the geomorphic condition of a reach in the next 50-100 years" (Brierley and Fryirs, 2005). Geomorphic condition explains the contemporary state of reaches throughout a watershed and provides insight into their evolution, but does not examine or predict what changes may occur in the future. The ability to predict future change based on contemporary geomorphic condition is the subject of Stage Three of the River Styles framework. This is the process of assessing the geomorphic recovery potential of river style reaches by leveraging the information obtained in previous chapters (geomorphic river styles classification and geomorphic condition assessments), and is accomplished in two steps. First, the *trajectory of river change* is determined, whereby the *recovery trajectory* of each reach is determined—is the reach Intact, requiring restoration to improve, in a degraded state, or possibly poised to become a created river style (Section 6.1)? Secondly, river recovery potential is determined by assessing limiting factors in the watershed along with catchment position and proximity to intrinsic pressures (Section 6.2). The output from this effort is a watershed scale map of river recovery potential and is the last major analysis leading to development of a strategic management plan for the MFJDR (Section 6.2.2).

6.1 TRAJECTORY OF RIVER CHANGE FOR RIVER STYLES REACHES

The trajectory of river change for every river style reach is determined by plotting each study reach onto evolutionary diagrams created in river styles Stage Two (see Section 5.2 and Appendix B), and assessing each one through the decision tree shown in Figure 15. The most important trajectory of change diagram for the MFJDW is for the *Low-moderate sinuosity gravel bed* and *Bedrock-controlled discontinuous Floodplain river styles* (Figure 48). Reaches of these river styles possess the greatest adjustment potential, highest sensitivity to disturbance, and most intense land use pressures of all river style reaches in the MFJDW since onset of the settlement period.

To simplify this scenario, Figure 48 shows conceptual cross sections of five river styles variants placed along a "degradation pathway" between *Intact* and *degraded* geomorphic conditions. The intact variant of the Low-moderate sinuosity gravel bed river style is at top because it does not exist in the MFJDW. The five variants Plotted along the left-hand side represent gradually worsened geomorphic conditions. The one poor-condition variant is situated at the base, but not in the degraded position[1]. If watershed and management conditions are favorable and a reach begins to show signs of improvement, it may advance to a position on the right of the diagram. Two destinations are possible: toward a recovery condition naturally and with little intervention, or a restored or rehabilitated condition with applied restoration effort. On the other hand, if the stream cannot move laterally to an improved condition, it proceeds from a turning point downward to a more degraded position.

Analysis of these reaches through the decision tree (Figure 15B) shows that all have the potential to move to the right side of the diagram (rather than downward, progressively degrading), to a sustained or improved position. The Oxbow and Bates reaches are exhibiting signs of improvement with recent restoration efforts, so they have a

[1] The Middle Fork will never completely recover on its own from the mining era at Galena, nor will it likely be restored. However, it stands an excellent chance of becoming a "created" variant that could eventually serve as a functioning and connected part of the important anadromous reaches. For this reason it is not being rated a "degraded" reach despite the extensive damage that has occurred there.

recovery trajectory toward a restored—or at least rehabilitated—status, assuming that future flow and sediment regimes generally remain as they are, restoration structures create greater heterogeneity in terms of instream geomorphic units, and their current management status and protections (e.g., fenced off from cattle) remain in place.

Next to consider are several reaches along the mainstem whose channels were deliberately diverted around the laterally unconfined floodplain over which they meandered sometime during the midcentury (Figure 48). These reaches can move to the right side of the diagram in two ways: (1) by implementing a channel-reintroduction restoration design of a kind that has already been successfully implemented in the middle fork. This would constitute a "rehabilitated" condition as outlined in Section 7.5.1, because once reintroduced to its original bed, the MFJDR would be allowed to readjust to a meandering planform in an laterally unconfined valley setting (i.e., would again become the *Low-moderate sinuosity gravel bed river style*); and (2) by allowing the stream to remain in its diverted channel. In this case, the diverted reaches would remain as *Bedrock-controlled discontinuous floodplain river style*, and may evolve toward the good-condition characteristics of the naturally occurring variant.

Finally, the poor-condition reach near Galena is unique in the watershed as it is the only placer-mined reach along the MFJDR that still fully encompasses the trunk stream, and for which no attempts to improve its condition have been made. It currently represents a bottleneck through which fish must transit to access over half the entire watershed, and contains little refugia of any kind. However, given its strategic importance (the sole pathway for fish to reach the upper watershed and all its tributaries), this reach is a good candidate for a *created* variant that could eventually become a functioning and connected reach of the watershed and ecosystem. Trajectory of change diagrams for the remaining river styles are explained in Appendix B.

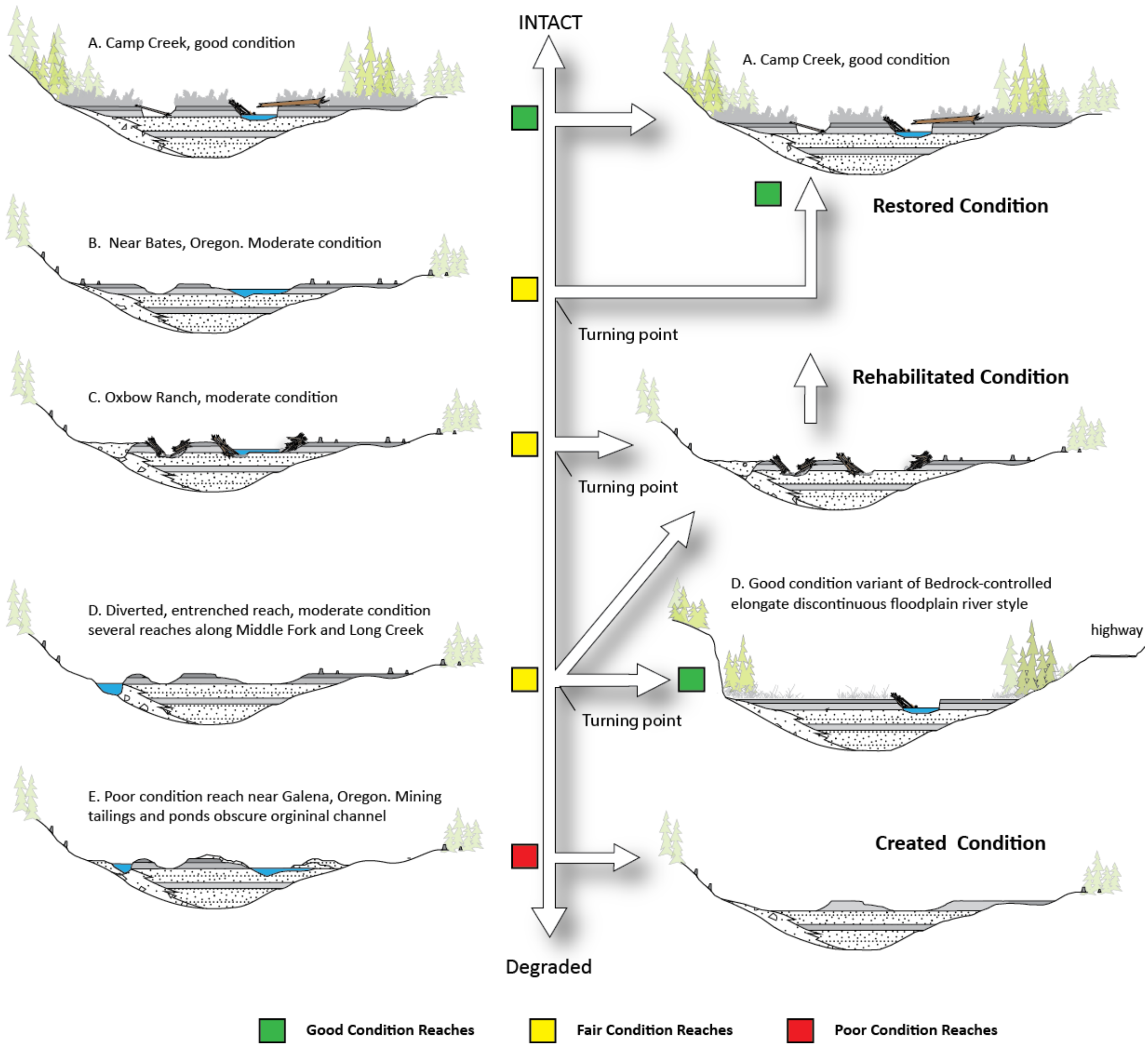

Figure 48. Chart showing trajectory of change for reaches of the *Low-moderate sinuosity gravel bed* and *Bedrock-controlled elongate discontinuous floodplain river styles*.

6.2 DETERMINING THE RECOVERY POTENTIAL OF RIVER STYLES REACHES

6.2.1 POSITION IN THE CATCHMENT AND LIMITING FACTORS AND PRESSURES

With the trajectories of river change determined for each river style and their variants, we now consider catchment-scale linkages that elucidate their recovery potentials. For a reach to continue along a recovery pathway (Figure 49), it must be subject to favorable conditions that are influenced by two factors: *position of the reach within the catchment,* and *limiting factors and pressures.*

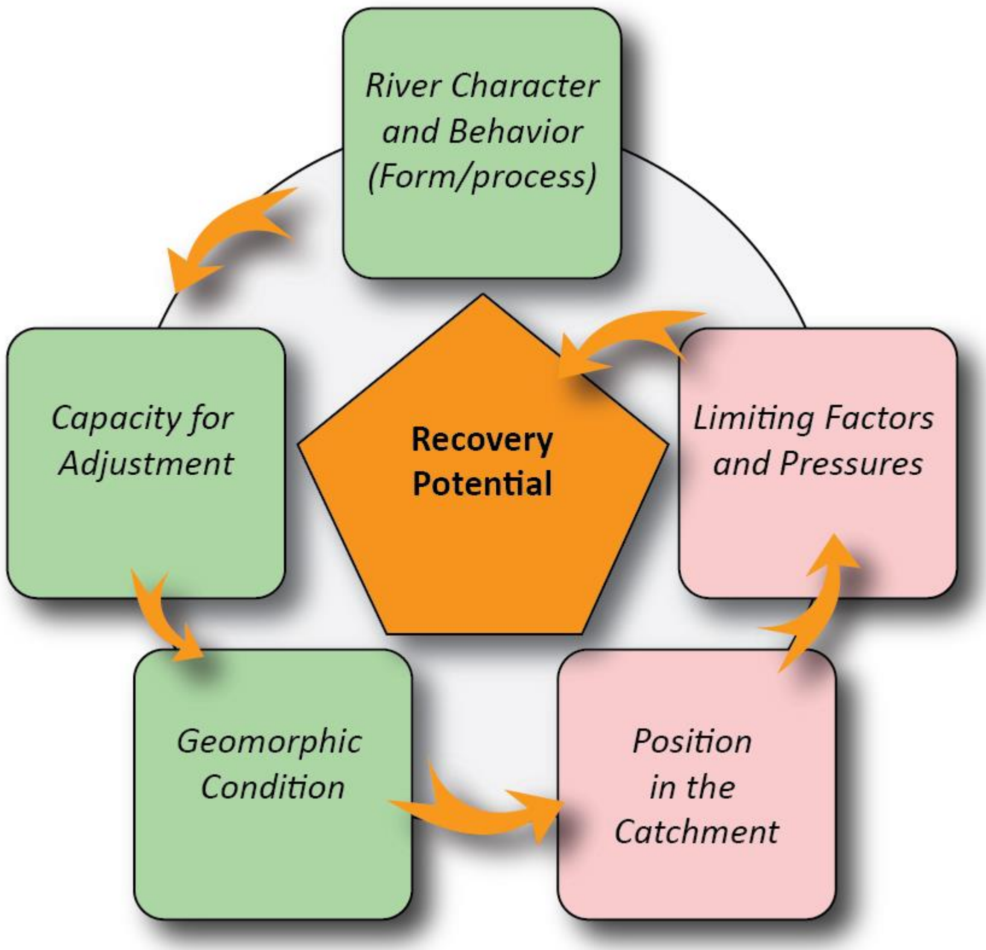

Figure 49. Flow chart showing factors influencing recovery potential of river styles Reaches. To this point, we have completed analyses shown in green. These feed the analyses posed by red boxes toward a determination of recovery potential for river style reaches.

We determined reach position by systematically mapping each river style reach using GIS and aerial imagery (Figure 39) and summarizing them in terms of downstream patterns (Figure 41). It is Important to consider linkages between subcatchments, and particularly between up and downstream reaches. Disturbance responses may be propagated to downstream reaches and become detrimental if good condition reaches lie downstream of degraded ones. These linkages were summarized in Figure 50 to observe how upstream reaches may affect those in downstream positions with respect to local land use issues and reach sensitivity. Information about limiting factors and pressures on individual reaches gained from the geomorphic condition assessment (Section 5 and Appendix B) were distilled through the recovery potential flowchart (Figure 17). The results are shown in the Geomorphic recovery potential Map (Figure 51).

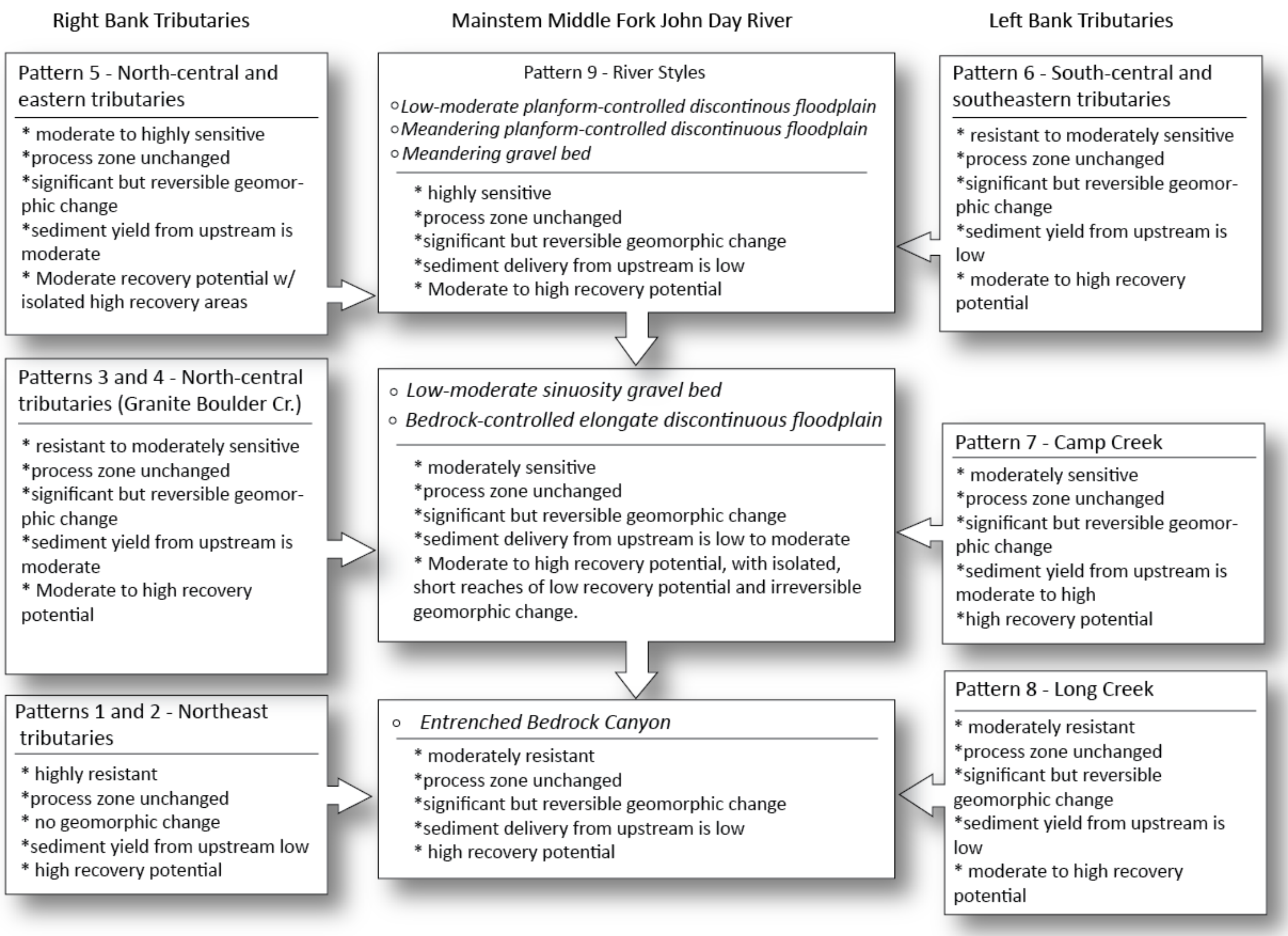

Figure 50. Catchment scale linkages and their impact on the geomorphic recovery potential of Middle Fork John Day Watershed river style reaches with different downstream patterns. Pattern labels and explanations are from Figure 41.

6.2.2 WATERSHED MAP OF RECOVERY POTENTIAL

The output of the recovery potential flow chart, and the whole geomorphic recovery potential assessment is a map showing the distribution of intact, high, moderate and low recovery potential throughout the watershed (Figure 51). In terms of products from stages 1-3 of this work (Sections 4-6), the analysis of Figure 50, Figure **51** and Figure 52 is an important synthesis of system-wide effects and will be a key tool in the development of a strategic plan covered in Chapter 7.

Results suggest that most of the streams have incurred significant but *reversible* Geomorphic Change and have moderate to high recovery potential. For the most part, there are few degraded reaches that lie *upstream* of good-condition or intact reaches. Aside from upper watershed logging and grazing operations, the highest concentration of human disturbances are along the main stem. One exeption is the uppermost tributaries of the southeast watershed, where the low-relief, accessible landscape has incurred multiple land uses including mining, logging and milling, grazing, current and past ranching operations, and widespread canal diversions. With intermittent streams throughout and ubiquitous impacts in the uppermost watersheds, many of these streams have only moderate recovery potential. Another exception is the mainstem MFJDR itself. The uppermost 40 km is characterized by river styles with high adjustment potential (e.g., *Meandering gravel bed*, *Meandering planform-controlled discontinuous floodplain,* and *Low-moderate sinuosity gravel bed river*) and wide alluvial floodplains. The lower watershed consists only of the *Entrenched Bedrock Canyon River Style,* which has low adjustment potential and high resistance to disturbances. The sediment regime was likely affected by a half-century of mining and upper tributary logging upstream, but that pressure has since been removed and the stream has adjusted to the consequent change in sediment yield and transport resulting from these disturbances. Otherwise, there is little expected long-term impact from upstream, and very little direct impact by farming and grazing operations downstream.

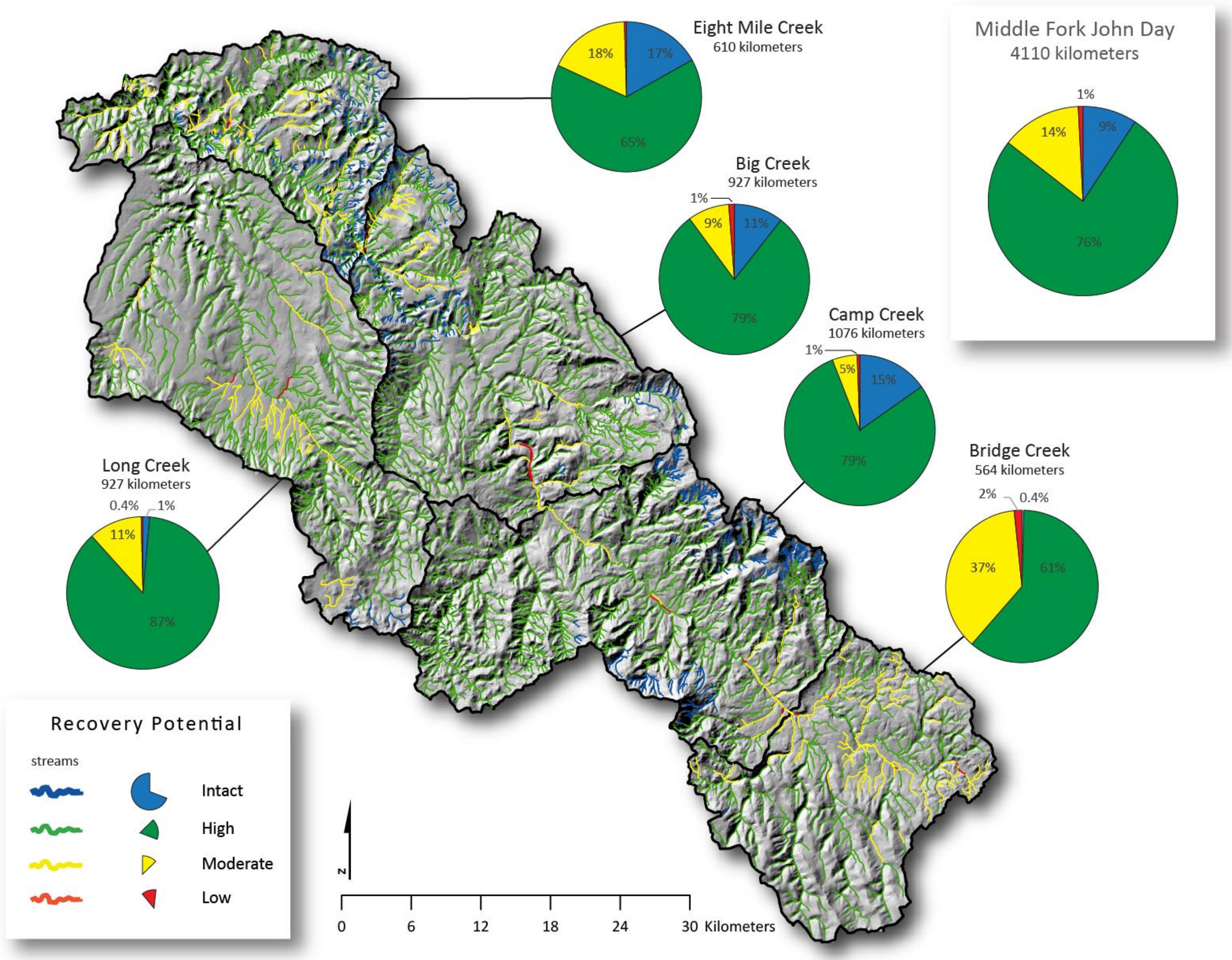

Figure 51**. Map of river recovery potential for the Middle Fork John Day River, Oregon**

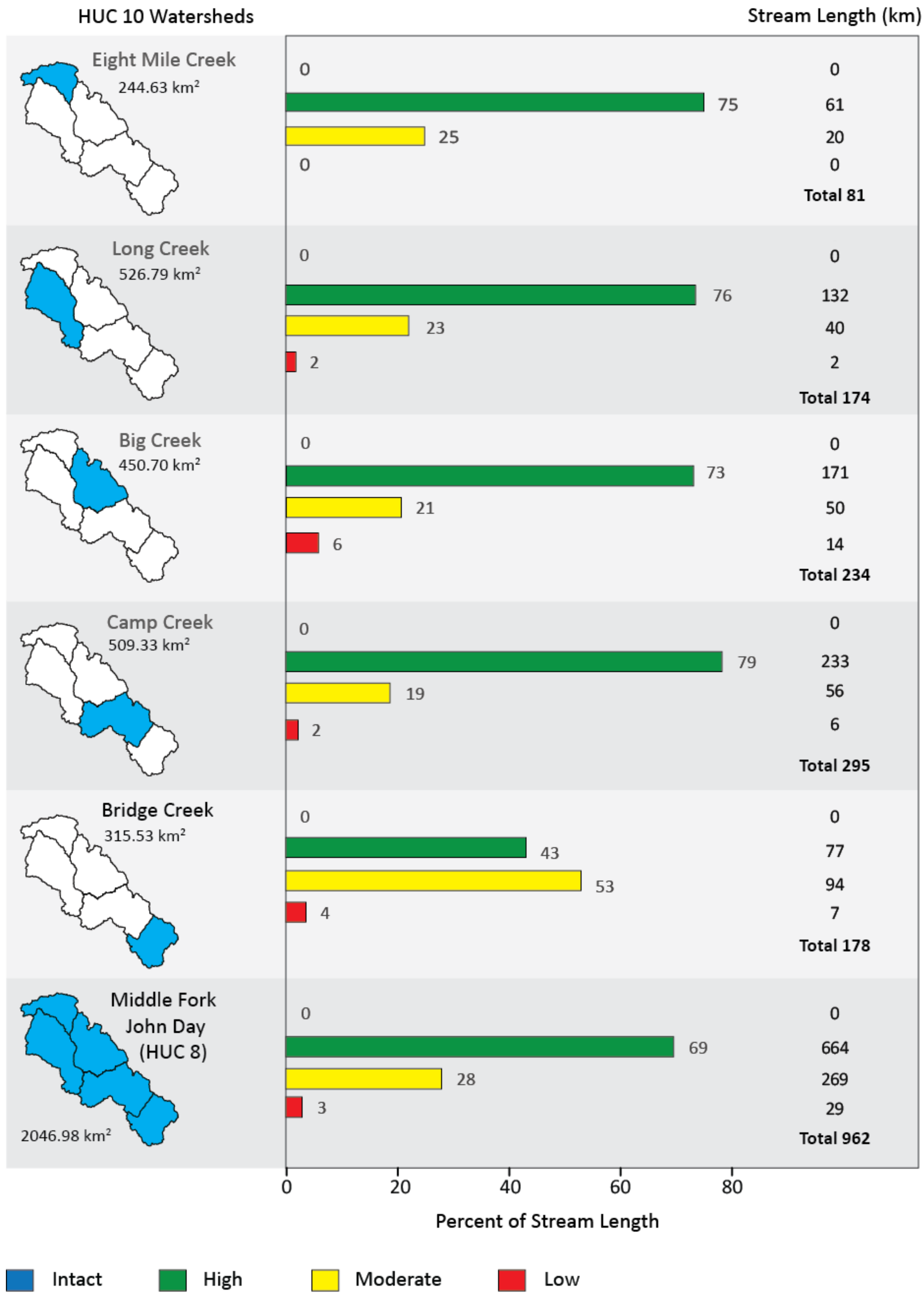

Figure 52. Recovery potential for perennial and connecting intermittent streams (excludes ephemeral streams) in HUC 10 subwatersheds of the Middle Fork John Day Watershed.

7 STAGE FOUR: POTENTIAL PRIORITIZATION OF MANAGEMENT ACTION

A potential strategic management plan for river restoration in the Middle Fork John Day basin is presented here and draws from the river styles, geomorphic condition, and restoration potential studies of Sections 4 through 6 (see Figure 16). The chapter concludes with presentation of a watershed scale map of suggested, potential prioritization of management reaches for the MFJDW. As the authors have no mandate to develop an actual management plan for the MFJD, we merely offer this plan for consideration based on the analyses using the River Styles framework. The creation and implementation of a watershed management plan following River Styles uses the following structure (i.e., Figure 18).

1. Creating a catchment-framed physical vision.
2. Prioritizing management efforts based on the geomorphic condition and recovery potential of each reach.
3. Identifying target conditions for river rehabilitation.
4. Monitoring improvement in geomorphic condition once a management plan has been adopted and implemented.

The actual adoption of a watershed management plan and/or strategic plan can only be done by the appropriate stakeholders (e.g. tribes, agencies, non-profits, land owners, etc.) with a stake in the watershed.

7.1 CATCHMENT FRAMED PHYSICAL VISION

For the MFJDW, the vision we propose here hinges on (a) maintaining the high quality habitat in existing good-condition reaches, and (b) restoring connectivity of the mainstem from the lower to upper MFJDW and c) increasing habitat quality through bolstering of diverse instream geomorphic units of the upper watershed. This vision can be realized with strategic, focused restoration efforts and continued public outreach to local landowners and collaboration with agency partners. Such strategic and targeted restoration efforts can be much more cost effective.

There are only a few reaches we recommend restoration for as part of strategic management for the MFJDW (Figure 53). The vast majority of the drainage network are in good geomorphic condition or are adjacent to intact or good condition reaches. However, the vast majority (77%) of the 4110 kilometer drainage network is also in intermittent and ephemeral drainages and so this assessment can be misleading. One of the primary management concerns in the MJFDW is for salmonids, and if we consider just the perennial fish-bearing portion of the watershed (962 km), over 63% are in good condition (Figure 47). Provided they are not subject to additional/increased land use pressure, most will be able to recover or improve with no active restoration intervention and just allowed to passively recover. The main goals of this management plan are:

1. Allow conservation areas to improve without active instream intervention. Monitor and manage existing land uses and their effects on streams of HUC 10 watersheds.
2. Restore heavily mined-out segments of the mainstem; create new conditions that support migration and needed refugia for transit through these areas.
3. Support and improve recent restoration projects along the mainstem and monitor restoration structures in appropriate tributaries (e.g., astride CHaMP reaches, etc.). Work with private landowners and with IMW, to coordinate restoration and design goals system-wide. Help focus existing efforts on more appropriate targets for fluvial behavior using the context of river styles.

4. Potentially restore diverted channels of the main stem MFJDR—create new habitat and restore the ecological and habitat diversity of the mainstem MFJDR where diversions occurred. Work with landowners to allow projects to proceed while addressing the issue of continued grazing of alluvial floodplains (prevent overgrazing, frequent rotation, etc).
5. Establish and enhance channel connectivity and habitat quality to tributaries of the upper watershed.

7.2 PRIORITIZATION OF MANAGEMENT REACHES

Each reach of every non-ephemeral river style or reach type was assessed for its geomorphic condition (i.e., sensitivity to impacts and disturbances, and condition compared to a near-pristine example in the watershed), and its recovery potential (the ability to retain the function of its characteristic river style and improve its geomorphic condition with time). Using this data, the final steps in preparing a strategic master plan for the MFJDW involves prioritizing the various recovery and restoration reaches according to the urgency for action and type of intervention required. The prioritization and rationale for them is structured as follows, and depicted as a flow chart in Figure 19.

1. First priority: *conserve unique, rare, or remnant intact reaches (conservation reaches).* This means, simply, preserve remaining habitat and refugia of intact and good-condition reaches.

Where they are in the watershed: Most highlands on both sides of the MFJDR are either intact, in good geomorphic condition, or are recovering from widespread logging operations that mostly ended in the late 1970's with the closure of the Bates Township Sawmill. The direct impacts of logging operations are difficult to measure, as are the effects of high country grazing, but in heavily impacted areas logging is certainly tied to modified patterns of hillslope-sourced sediment production which can affect stream ecology and fish habitat. This is most evident in some tributaries of the northcentral, eastern and southeastern watershed. In the absence of future clearcut operations, these streams (indeed a vast portion of the whole watershed) should be managed as conservation areas.

2. High priority: *strategic reaches.* *Regardless of the geomorphic condition, mitigate problem areas that will propagate negative affects to down-stream and special/high quality reaches*. This is where the bulk of restoration work may be focused, to address problem reaches that may impede the improvement of adjacent and downstream conservation reaches or act as a connectivity barrier for fish.

Where they are in the watershed: With the elongate plan view of the MFJDW, the mainstem is of great importance for transit, refugia, and access to tributaries for anadromous species along its length. Our analysis suggests that this critical series of reaches (in the upper watershed) is composed of river styles that are the most sensitive to human disturbance AND have seen the most intense and disruptive land use over time. Because many of these reaches are privately owned, efforts should be made to maximize beneficial treatments reaches where restoration is already underway (i.e., Tribal and Nature Conservancy allotments). Efforts should also include development and promotion of a stronger dialog with local landowners to promote ecologically sound land use practices and perhaps allow incremental restoration projects to proceed. In any case, the continuity of the MFJDR between the upper and lower watershed is threatened by the mined-out reach at Galena, and select other reaches where passage is critical, and these should be considered high priority, strategic reaches for future management action.

3. Important priority: ***connected Reaches with high recovery potential:*** *Maximize the positive effects of most extensive networks of intact and good condition reaches—particularly those connected to conservation areas or high quality habitat.* Connected reaches are those, which extend directly downstream from high quality, good condition reaches and are lacking problem areas along their lengths. By preserving and enhancing these as a priority, greater areas of the watershed are preserved intact and may aid the recovery of downstream reaches that have quality issues.

<u>*Where they are in the watershed:*</u> In the MFJDW, these are the distal extensions of good and intact condition reaches (e.g., Clear, Dry Clear, Vinegar, Camp, Granite Boulder, and others). Provided the current level of land use continues and does not escalate, these reaches can be preserved and improved largely by "hands off" management along with the conservation reaches they are connected to.

Next priority***: Isolated reaches with high recovery potential*****.** After ensuring the protection of high quality habitat and healthy, connected reaches, an effort is made to 'rescue" or sustain pockets of high quality habitat that are isolated between low-quality or poor condition reaches. These can have a positive downstream effect on lower-tiered, impacted reaches, especially if they are slated for rehabilitation or lie within a strategic reach. Existing high-quality habitat may be of future benefit, in any case.

<u>*Where they are in the watershed:*</u> Given that nearly all reaches with this designation lie along the mainstem MFJDR and its immediate headwater tributaries (e.g., Squaw, Summit and Crawford Creeks), these isolated, good-condition reaches will be critical to maintaining and improving the future connectivity and habitat quality of the entire Watershed (similar to the assessment of strategic reaches). Among possible restoration projects are the many remaining reaches where the MFJDR was intentionally diverted around its floodplain. many decades ago, resulting in loss of habitat and diversity of instream and floodplain geomorphic units. Initial project planning should prioritize reaches that are adjacent to existing, good condition reaches, or those recovering in the aftermath of successfully implemented restoration projects (i.e., Oxbow Reach).

4. Low priority: ***rehabilitate reaches of moderate or poor recovery potential*****.** Finally, we do what we can with reaches that show little recovery potential—these may be too heavily impacted to invest time and resources, except where the vision plan may designate a role in overall watershed recovery.

<u>*Where they are in the watershed:*</u> Many of the streams with this designation lie within the southeast portion of the MFJDW where the low-relief, accessible landscape has incurred multiple land uses including mining, clearcut logging and milling, grazing, current and past ranching operations, and widespread canal diversions. With intermittent streams throughout and ubiquitous impacts in the uppermost tributaries (small local stream impoundments, high road density, power lines, rampant grazing, etc.), many of these streams have only moderate recovery potential. Yet, many of them lie upstream of isolated good-condition reaches on federal land, so their importance in maintaining the quality of downstream resources should not be ruled out.

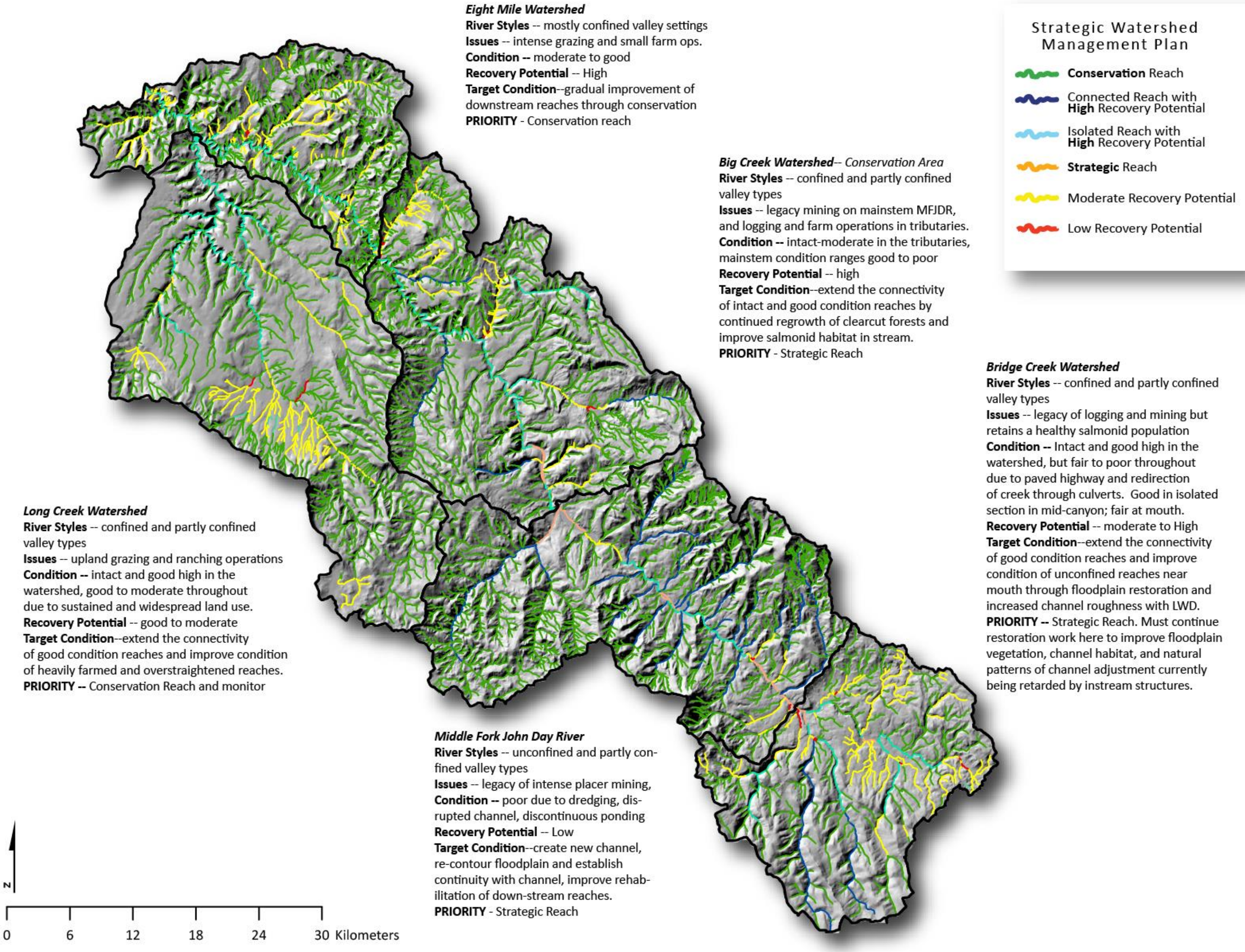

Figure 53. Watershed map showing prioritized Management reaches in the Upper MFJDW

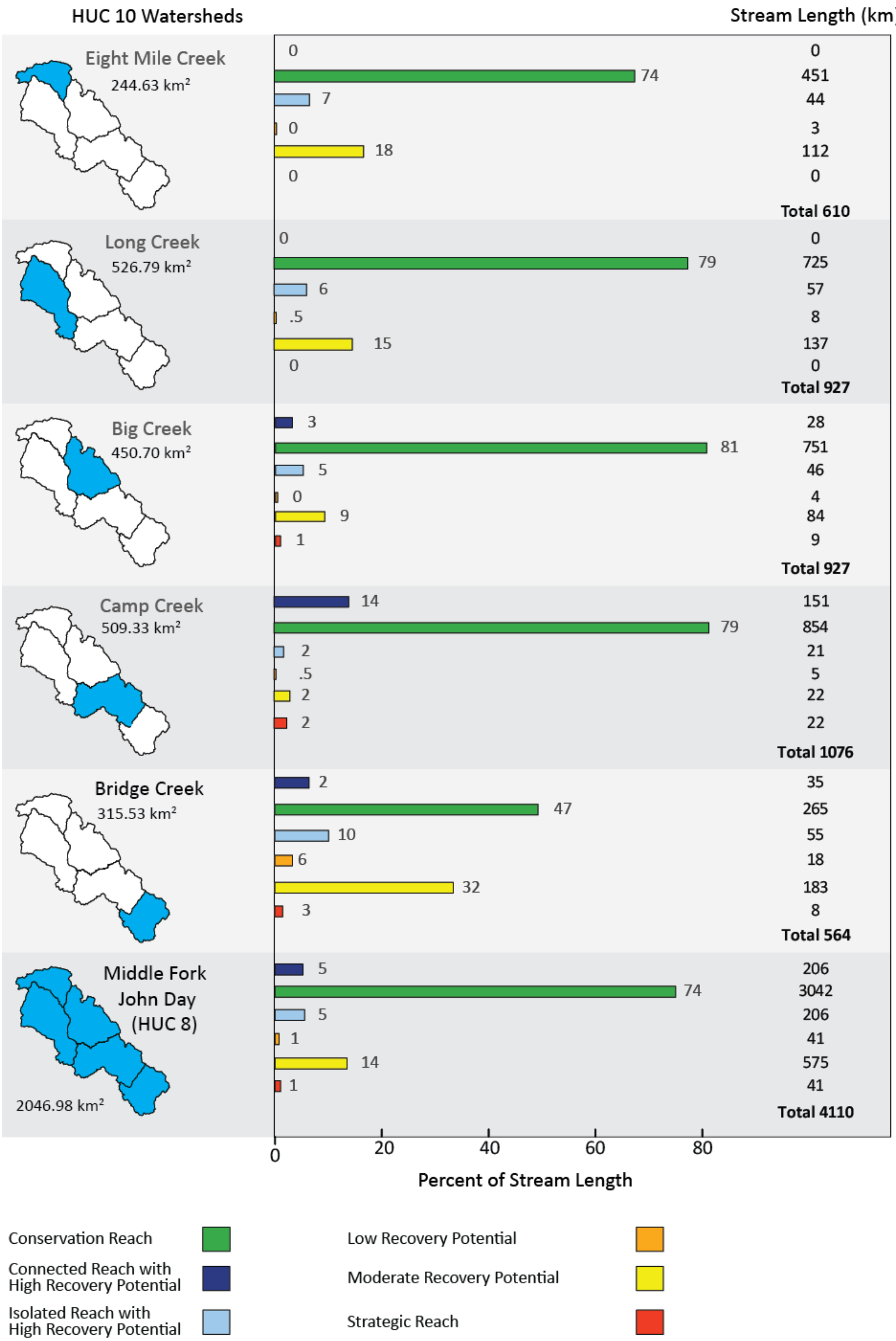

Figure 54**. Stream lengths per HUC 10 watersheds for Strategic Watershed Prioritized Management Reaches.**

7.3 TARGET CONDITIONS FOR RIVER REHABILITATION IN STRATEGIC REACHES

Target conditions for a watershed reflect an overall plan for river rehabilitation that is broken down to the needs of individual reaches. Each reach then becomes part of a strategy to implement the prioritized master plan (discussed above). We developed target conditions for each river style within a catchment perspective in order to enhance the recovery of reaches toward their reference conditions. Strategic reaches are those targeted for rehabilitation to improve connectivity with high quality conservation reaches, and to prevent the propagation of poor-quality effects to downstream reaches.

7.3.1 TARGET CONDITIONS FOR THE LOW-MODERATE SINUOSITY GRAVEL BED AND ALLUVIAL FAN RIVER STYLES

Reaches of this river style represent the most heavily impacted in the watershed and potentially a significant barrier to the passage and refugia for fish. The two target areas most in need of intervention are (a) MFJDR at the old Galena Town site, where the channel was intensively placer mined (Figure 55); and (b) the vicinity of the old Bates Mill site, at the mouths of Clear and Bridge Creeks. Both of these reaches are in poor geomorphic condition and cannot be restored to a natural function. The target for these projects would instead be "created" to improve conditions for integrated passage and survival of fish to the Camp Creek and Bridge Creek (HUC 10) watersheds. Similar tactics are being employed elsewhere in the CRB (c.f., Yankee Fork Tributary Habitat program:
http://www.usbr.gov/pn/fcrps/habitat/projects/uppersalmon/reports/uppersalmon/yfta/index.html).

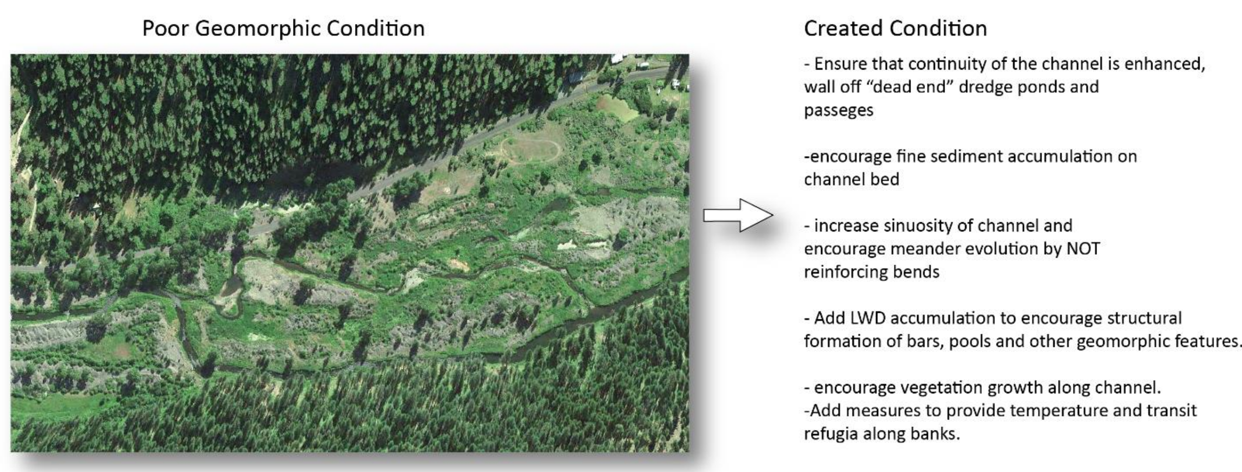

Figure 55. Target criteria for "created" condition in placer-mined reach of the Low-moderate sinuosity gravel bed river style, Middle Fork John Day River.

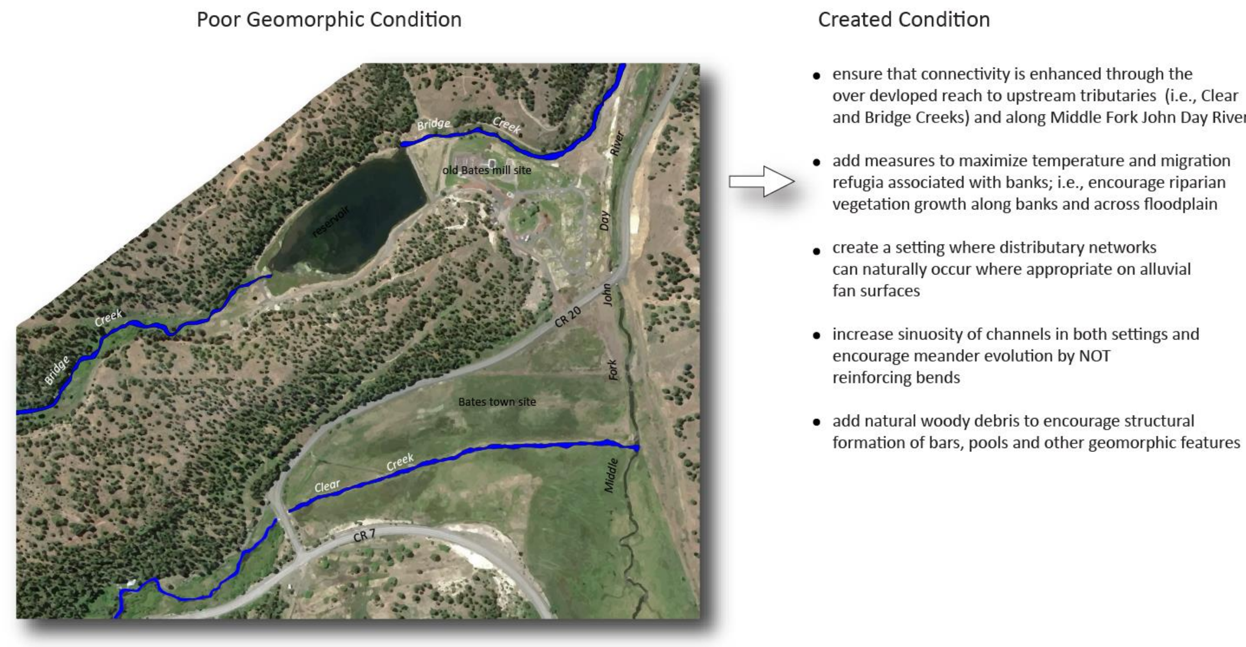

Figure 56. Target criteria for "created" condition in over-developed reaches of Middle Fork John Day River and of Clear and Bridge Creeks.

7.4 TARGET CONDITIONS FOR REACHES WITH HIGH RECOVERY POTENTIAL

Most streams within the MFJDW mapped as connected reaches with high recovery potential require no intervention. While some possess issues related to local development (farm operations, recovering timber harvest, road building and maintenance), they lie downstream of intact or good condition reaches (most form the headwaters of individual small basins) and would best be managed as closely associated with conservation reaches (Figure 53). This requires no specific action other than to monitor stream condition and current/future land management practices that affect them. Streams mapped as Isolated Reaches with high recovery potential are of critical importance to the overall health of the watershed, yet may face a more tenuous future in terms of improved condition. These reaches will, in all likelihood, continue on a recovery trajectory (see Section 6) if favorable land use practices are adopted for upstream reaches that isolate them in the watershed, but could just as easily degrade based on watershed position downstream of moderate and poor condition reaches. This is especially true of regions such as the Long Creek watershed, an immense area of nearly one-third of the MFJDW (e.g., Figure 10 and Figure 53).

7.4.1 TARGET CONDITIONS FOR REACHES OF THE LOW-MODERATE SINUOSITY GRAVEL BED AND MEANDERING GRAVEL BED RIVER STYLES

Some reaches of the MFJDR have already been partially treated e.g., immediately downstream of Bates, between Vinegar and Caribou Creeks (11T 376849 E, 4940814 N); and between Granite Boulder and Big Boulder Creeks (11T 367958 E, 4945083 N). These ongoing projects have greatly improved the outlook of improved habitat and geomorphic condition. They should be monitored, reappraised, and their target conditions adjusted over time (Brierley and Fryirs, 2005). Other reaches with high recovery potential remain untreated, but would benefit from mitigation with wooden structures (Abbe and Montgomery, 1996; Wheaton et al., In Prep), added wood, and revitalized riparian vegetation. One such example is several reaches of the MFJDR of the *Meandering gravel bed river style* (Figure 57). Although these are adjacent to roads and private inholdings, and are grazed on annual rotation, they nevertheless present an opportunity to improve the geomorphic condition of isolated reaches with high recovery potential. The figure illustrates that side-by-side land use practices can have contrasting effects on geomorphic condition and offer a way forward in terms of improving the outlook of a reach.

Figure 57. Target conditions for reaches of the Meandering gravel bed river style. A view of the Meandering gravel bed river style on Squaw Creek showing attributes of both good and moderate-condition variants. White dotted line shows a fence line with opposing management schemes on either side.

7.5 TARGET CONDITIONS FOR REACHES OF MODERATE RECOVERY POTENTIAL

Approximately 14% or ~600 km of streams in the MFJDW are in moderate or poor geomorphic condition. These are distributed more or less evenly throughout the five HUC 10 watersheds (Figure 47), but are primarily located in tributary basins, and in affected reaches of the main stem. Of the latter group, most are located on private inholdings, yet they could be rehabilitated by improving the in situ condition of instream and floodplain geomorphic settings.

7.5.1 LOW-MODERATE SINUOSITY GRAVEL BED AND BEDROCK-CONTROLLED DISCONTINUOUS FLOODPLAIN RIVER STYLE

Although in situ restoration is the preferred method of improving geomorphic condition of a reach, a more aggressive (and effective) approach to restoration has also been taken in the MFJDR. Figure 58 shows a restoration plan that was successfully implemented on the MFJDR in 2010, and is used here as an example that identifies the target condition for similar reaches along the mainstem and determines the required intervention. In this case, a reach of the MFJDR (11T 353762 E, 4955394 N) was degraded in the last century by diversion and channelization to free up the floodplain for grazing, hayfield cultivation and other uses. The plan to improve the geomorphic condition of this reach centers on redirecting the stream back into its original meandering channel, as seen in the upper photo panels. The outcome of this effort is focused on (a) improving habitat for fish; (b) improving overall stream function and streambed/floodplain rehabilitation; and (c) achieving the best results and return on investment. Habitat will likely improve once the channel is lengthened, its slope decreased, and sinuosity increased, all factors that will likely bolster the heterogeneity of instream and floodplain geomorphic units. This represents a best return on investment because the restoration is consistent with the boundary conditions (sediment availability and transport, basin hydrology, valley configuration and confinement, stream slope, etc.) under which the stream evolved in the first place. Thus, the solution works within the energy requirements for the type of river style being restored (represented by the graphic at bottom of Figure 58), leading to greater stability of the channel in its bed. Several reaches of this type remain untreated along the MFJDR and are designated as moderate recovery potential reaches.

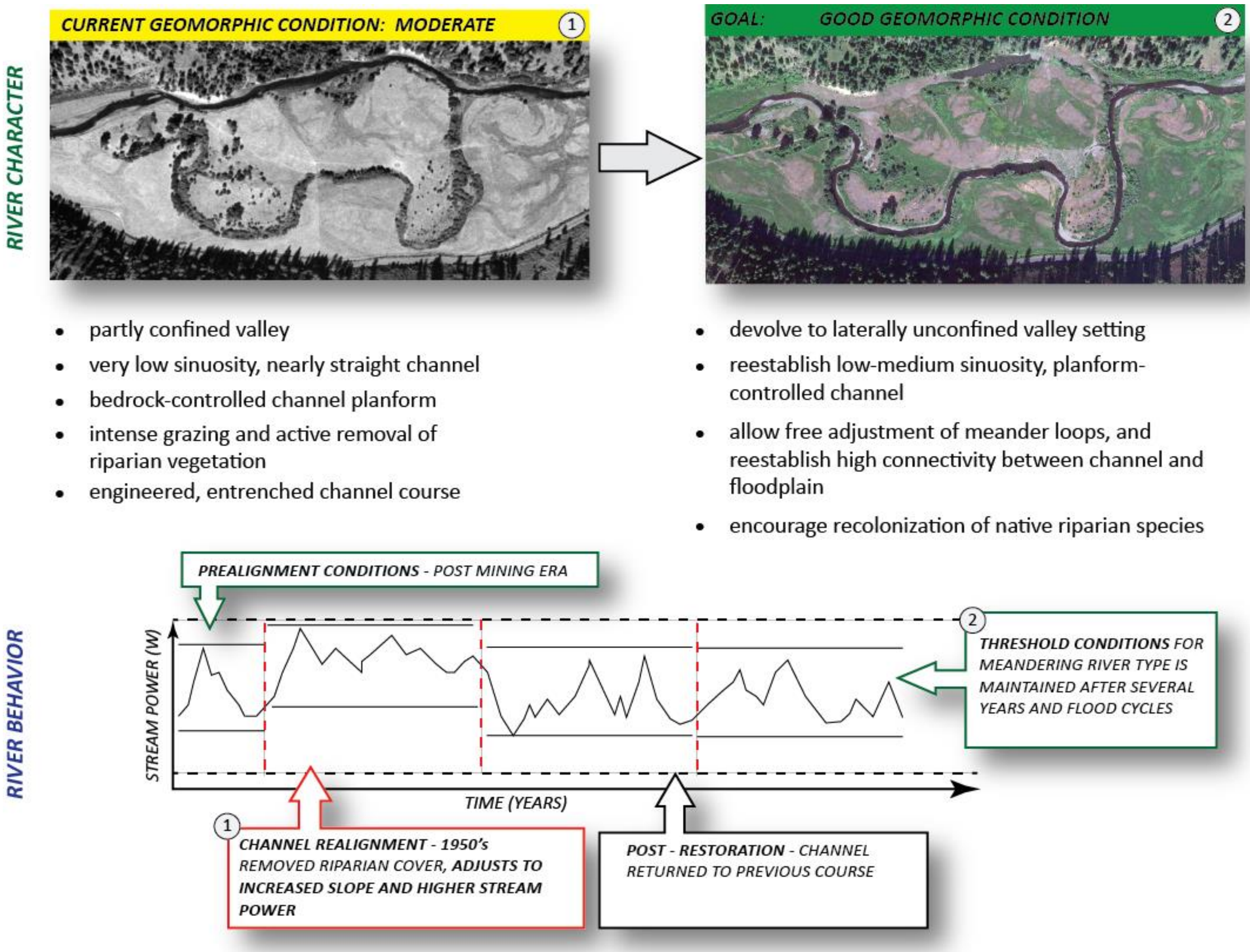

Figure 58. Conceptual Target conditions for restoration of Middle Fork John Day river where previously diverted from its original channel.

7.4 MONITOR AND AUDIT IMPROVEMENT TO GEOMORPHIC CONDITION FOLLOWING IMPLEMENTATION

The success of this recovery/restoration method program hinges upon identifying improvements in geomorphic condition in a study watershed over time and making adjustments that enhance the framework already in place. In this way, changing conditions and variable results can be accommodated within the overall management plan.

8 CONCLUSION

In this study, we undertook a complete River Styles Framework assessment for the Middle Fork John Day Watershed. There was not a pressing local need in the MFJD for additional geomorphic assessment, nor a lack of existing information in the MFJD hampering management decisions and prioritization of restoration actions. To the contrary, the MJFD has been a focal point of an Intensively Monitored Watershed, numerous restoration actions as well as strategic planning by the Bureau of Reclamation through Mainstem and Tributary Habitat Assessments (e.g. Reclamation, 2008, 2010). The reason we focused on the MFJD for a River Styles assessment is precisely because these other studies and pieces of information existed to compare with. The focus of this report was to provide a complete River Styles analysis without digressing into that comparison with these other approaches. That comparison is the focus of other ongoing efforts within ISEMP and collaborations with the Bureau of Reclamation. Efforts within ISEMP are underway to systematically implement stages 1 and 2 of the River Styles across the entire Columbia River Basin, as well as more detailed studies (like this) in specific CHaMP (Columbia Habitat Monitoring Program) Watersheds with an eye towards more fish-centric analyses of fish habitat conditions as informed by geomorphology (O'Brien and Wheaton, 2015). However, this study represents the first complete implementation (stages 1 through 4) of River Styles within the United States and will act as a benchmark for comparison. The report was thoroughly reviewed, vetted and included input in the field from the developers of the River Styles Framework, Gary Brierley and Kirstie Fryrirs. We felt it was important to complete this baseline work following the existing framework closely, before considering changes, extensions and adaptations to existing vetted methods like the River Styles Framework to make them more useful to addressing BPA’s key management questions as they relate to the Biological Opinion.

The development of prioritized management reaches presented in §7 for the MFJDW was the hypothetical summary-product of a complete geomorphic assessment using the River Styles framework involving months of office analysis and a few weeks of field-based work. Our results and those of others (Reclamation, 2008, 2010) show that the MFJDW has incurred a century and a half of disruptive land use and sustained pressure; yet in recent decades the worst of these have been curtailed in favor of more sustainable local economic uses (limited grazing and ranching versus placer mining and rampant clear-cut logging) and active restoration efforts such as the restoration effort shown in Figure 58. In light of this, the prognosis for gradual recovery and the success of well-applied restoration projects in the Middle Fork is very favorable, and could certainly result in improved status for salmonid populations and increased freshwater production benefits from healthier habitat into the future.

The end product of geomorphic condition and recovery potential studies are watershed-scale maps that provide the data, which can inform the prioritization of restoration and management actions. In addition to the six management priorities listed in the legend of Figure 53, the map also integrated key information about river styles, geomorphic condtion, limiting factors and pressures impacting key reaches, the geomorphic condition and recovery potentials, and target conditions and strategies for improvement if recommended. Strategic tributary habitat improvement plans should require input from a number of scientific sources reflecting biophysical and ecological principals that drive healthy ecosystems. However, it is ultimately stakeholders and decision makers with a remit to manage these rivers that have to decide how to use this information. An understanding of the geological, geomorphic, and landscape components of a study watershed provides the physical setting from which to assess them. The River Styles framework categorizes river types but does so on several scales of landscape interpretation from the regional setting down to channel units. But importantly, it also affords a pathway for assessing geomorphic condition and recovery potential of streams reaches, and thus feeds directly into a framework for building management recommendations and priorities with a geoscience foundation.

9 REFERENCES CITED

Abbe, T. B., and Montgomery, D. R., 1996, Large woody debris jams, channel hydraulics and habitat formation in large rivers: Regulated Rivers-Research & Management, v. 12, no. 2-3, p. 201-221.

Anderson, E. W., Borman, M. M., and Krueger, W. C., 1997, The Ecological Provinces of Oregon: a Treatise of the Basic Ecological Geography of the State, Volume 2013, Oregon State University Department of Rangeland Resouces and Management.

Bangen, S. G., Wheaton, J. M., and Bouwes, N., 2013, A methodological intercomparison of the relative quality of topographic survey techniques in for characterizing in-stream habitats: Geomorphology.

Beckham, S. D., and Lentz, F. K., 2000, Rocks & Hard Places: Historic Resources Study, National Park Service, United States Department of the Interior, Seattle, Washington.

Beechie, T. J., and Sibley, T. H., 1997, Relationships between channel characteristics, woody debris, and fish habitat in northwestern Washington streams Transactions of the American Fisheries Society, v. 126, p. 217-229.

Bestland, E. A., Hammond, P. E., Blackwell, D. L. S., Kays, M. A., Retallack, G. J., and Stimac, J., 1999, Geologic Framework of the Clarno Unit, John Day Fossil Beds National Monument, Central Oregon: Oregon Geology, v. 61, no. 1, p. 3-19.

Beyer, H. L., 2012, Geospatial Modelling Environment (Version 0.7.2.1)(software)

Bouwes, N., Moberg, J., Weber, N., Bouwes, B., Bennett, S., Beasley, C., Jordan, C. E., Nelle, P., Polino, S., Rentmeester, S., Semmens, B., Volk, C., Ward, M. B., and White, J., 2011, Scientific Protocol for Salmonid Habitat Surveys within the Columbia Habitat Monitoring Program: Prepared by the Integrated Status and Effectiveness Monitoring Program and published by Terraqua, Inc.

Brierley, G., and Fryirs, K., 2005, Geomorphology and River Management: Applications of the River Styles Framework, Victoria, Australia, Blackwell Publishing, 398 p.:

Buffington, J. M., and Montgomery, D. R., 2013, Geomorphic Classification of Rivers, Treatise on Geomorphology, Volume 9, Elseiver, p. 730-767.

Byron A. Steinmana, Mark B. Abbotta, Michael E. Mann, Nathan D. Stansell, and Finney, a. B. P., 2012, 1,500 year quantitative reconstruction of winter precipitation in the Pacific Northwest: Proceedings of the National Academy of Sciences of the United States of America, v. 109, no. 29, p. 11619-11623.

CHaMP, 2012, Scientific protocol for salmonid habitat surveys within the Columbia Habitat Monitoring Program: Prepared by the Integrated Status and Effectiveness Monitoring Program and published by Terraqua, Inc.

Conlon, T., and Wells, R., 2006, Columbia River Basalt Stratigraphy in the Pacific Northwest, US Geological Survey.

Cooper, R. M., 2006, Estimation of Peak Discharges for Rural, Unregulated Streams in Eastern Oregon: State of Oregon Water Resources Department.

Eaton, B. C., and Church, M., 2004, A graded stream response relation for bed load-dominated streams: Journal of Geophysical Research-Earth Surface, v. 109, no. F3.

Frissell, C. A., Liss, W. J., Warren, C. E., and Hurley, M. D., 1986, A hierarchical framework for stream habitat classification: Viewing streams in a watershed context: Environmental Management, v. 10, no. 2, p. 199-214.

Fryirs, K., and Brierley, G., 2013, Geomorphic Analysis of River Systems - An Approach To Reading The Landscape, Wiley-Blackwell, 345 p.:

Fryirs, K., and Brierley, G. J., 1999, Slope-channel decoupling in Wolumla catchment, New South Wales, Australia: the changing nature of sediment sources following European settlement: Catena, v. 35, no. 1, p. 41-63.

Fryirs, K., Brierley, G. J., and Erskine, W. D., 2012, Use of ergodic reasoning to reconstruct the historical range of variability and evolutionary trajectory of rivers: Earth Surface Processes and Landforms, v. 37, no. 7, p. 763-773.

Geist, J. M., and Strickler, G. S., 1978, Physical and chemical properties of some Blue Mountain soils in the northeastern Oregon / . Portland, Or. : .

Harris, D. D., and Hubbard, L. E., 1982, Magnitude and frequency of floods in eastern Oregon.

Hawkins, C. P., 1998, Livestock Grazing Impacts on Riparian and Aquatic Ecosystems in the Wilderness of the Western United States: Synthesis of Existing Knowledge and Recommendations for Research.

Holburn, E., Turner, T., Piety, L., and Klinger, R., 2009, Habitat Restoration on the Middle Fork John Day River, World Environmental and Water Resources Congress 2009, p. 1-12.

Hunt, R. M., and Stapleton, E., 2004, Geology and Paleontology of the Upper John Day Beds, John Day River Valley, Oregon: Lithostratigraphic and Biochronologic Revision in the Haystack Valley and Kimberly Areas (Kimberly and Mt. Misery Quadrangles): Bulletin of the American Museum of Natural History, no. 282, p. 90.

ISEMP, 2012, The Integrated Status and Effectiveness Monitoring Program: Lessons Learned Synthesis Report 2003-2011. .

Kasprak, A., and Wheaton, J., 2012, Development of a Rapid Geomorphic Assessment Procedure for Streams in the John Day River Watershed, Oregon: Prepared by Ecogeomorphology & Topographic Analysis Lab for Eco Logical Research, Inc.

Kauffman, J. B., Krueger, W. C., and Vavra, M., 1983, Impacts of Cattle on Streambanks in Northeastern Oregon: Journal of Range Management, v. 36, no. 6, p. 683-685.

Kellerhals, R., Church, M., and Bray, D. I., 1976, Classification and Analysis of River Processes: Journal of the Hydraulics Division-Asce, v. 102, no. 7, p. 813-829.

Klingeman, P., Bogavelli, V., Coles, D., and Wright, M., 2002, Streamflow Evaluations for River Restoration Planning and Design: Oregon State University.

Kondolf, G. M., 2000, Some suggested guidelines for geomorphic aspects of anadromous salmonid habitat restoration proposals: Restoration Ecology, v. 8, no. 1, p. 48-56.

Madin, I. P., 2009, Oregon: A Geologic History, [companion web page]. http://www.oregongeology.org/sub/publications/IMS/ims-028/index.htm (accessed Month Day, Year).

Madin, I. P., 2009 Oregon: A Geologic History: Oregon Department of Geology and Mineral Industries.

McKay, L., Bondeild, T., Dewald, T., Rea, A., Johnston, C., and Moore, R., 2012, NHDPlus Version 2: User Guide: U.S. Environmental Protection Agency.

Merriam, C. H., and Steineger, L., 1890, Results of a biological survey of the San Francisco mountain region and the desert of the Little Colorado, Arizona, *in* U.S. Department of Agriculture, D. o. O. a. M., ed., North American Fauna Report 3. : Washington, D.C., p. 136.

Moir, H. J., and Pasternack, G. B., 2008, Relationships between mesoscale morphological units, stream hydraulics and Chinook salmon (Oncorhynchus tshawytscha) spawning habitat on the Lower Yuba River, California: Geomorphology, v. 100, no. 3-4, p. 527-548.

Montgomery, D. R., 2004, Geology, geomorphology, and the restoration ecology of salmon: GSA Today, v. 14, no. 11, p. 4-12.

Montgomery, D. R., and Buffington, J. M., 1997, Channel-reach morphology in mountain drainage basins: Geological Society of America Bulletin, v. 109, no. 5, p. 596-611.

NOAA, 2013, Pacific Salmonids: Major Threats and Impacts, NOAA Fisheries Office of Protected Resources.

O'Brien, G., and Wheaton, J. M., 2015, Synthesis & Recommendations from Middle Fork John Day River Styles - Leveraging the River Styles Framework in Tributary Habitat Management for the Columbia River Basin: Fluvial Habitats Center, Utah State University, Prepared for Eco Logical Research and Bonneville Power Administration.

O'Connor, J. E., Webb, R. H., and Baker, V. R., 1986, Paleohydrology of pool-and-riffle pattern development: Boulder Creek, Utah: Geological Society of America Bulletin, v. 97, p. 410-420.

Pederson, J. L., and Tressler, C., 2012, Colorado River long-profile metrics, knickzones and their meaning: Earth and Planetary Science Letters, v. 345-348, p. 171-179.

Program), C. C. H. M., 2012, Scientific protocol for salmonid habitat surveys within the Columbia Habitat Monitoring Program: Prepared by the Integrated Status and Effectiveness Monitoring Program and published by Terraqua, Inc.

Reclamation, B. o., 2008, Middle Fork and Upper John Day Tributary Assessments, Grant County, Oregon: US Department of Interior, Bureau of Reclamation.

-, 2010, Oxbow Conservation Area Reach Assessment, Middle Fork John Day River, Grant County, Oregon: Bureau of Reclamation.

Ries, K. G., III, 2006, The National Streamflow Statistics Program: A computer program for estimating streamflow statistics for ungaged sites: : U.S. Geological Survey.

Rosgen, D. L., 1994, A Classification of Natural Rivers: Catena, v. 22, no. 3, p. 169-199.

Senkyr, K. L., 2012, The Role of Habitat Restoration and Conservation in the Changing Socio-economic Conditions of Grant County, Oregon [Master of Science: Portland State University, 123 p.

Strahler, A. N., 1952, Hypsometric (Area-Altitude) Analysis of Erosional Topography: Geological Society of America Bulletin, v. 63, no. 11, p. 1117-1142.

Thorson, T. D., Bryce, S. A., Lammers, D. A., Woods, A. J., Omernik, J. M., Kagan, J., Pater, D. E., and Comstock, J. A., 2003, Ecoregions of Oregon (color poster with map, descriptive text, summary tables, and photographs): U.S. Geological Survey, scale 1:1,500,000.

Trimble, S. W., and Mendel, A. C., 1995, The cow as a geomorphic agent — A critical review: Geomorphology, v. 13, no. 1–4, p. 233-253.

USDA, 1981, Soil Survey of Grant County, Oregon, Central Part. : United States Department of Agriculture.

USGS, 2007, National Hydrography Dataset, Volume 2013, United States Geological Survey (USGS), p. The National Hydrography Dataset (NHD) is the surface water component of The National Map. The NHD is a digital vector dataset used by geographic information systems (GIS). It contains features such as lakes, ponds, streams, rivers, canals, dams and streamgages. These data are designed to be used in general mapping and in the analysis of surface-water systems.

USGS, and NRCS, 2012, Federal Standards and Procedures for the National Watershed Boundary Dataset (WBD): U.S. Geological Survey.

Walker, G. W., and MacLeod, N. S., 1991, Geologic map of Oregon: U.S. Geological Survey, 2 plates, scale 1:500,000.

Weis, N. D., 1971, Ghost Towns of the Northwest, Caldwell, Idaho, Caxton Printers, LTD.

Wheaton, J., Bennett, S., Bouwes, N., and Camp, R., 2012, Asotin Creek Intensively Monitored Watershed: Restoration Plan for North Fork Asotin, South Fork Asotin and Charlie Creeks: Eco Logical Research, Inc.

Wheaton, J. M., Bennett, S. N., Bouwes, N., and Camp, R., In Prep, Designing Cheap and Effective Stream Restoration Projects - An Example of System Wide Woody Addition Treatment: Biological Conservation.

Wheaton, J. M., Brasington, J., Darby, S. E., Merz, J., Pasternack, G. B., Sear, D., and Vericat, D., 2010, Linking geomorphic changes to salmonid habitat at a scale relevant to fish: River Research and Applications, v. 26, no. 4, p. 469-486.

Wilson, W., Terra Schultz, James Ruzycki, Richard Carmichael, Julie Haire, Jaym'e, and Schricker, 2004-2005 Escapement and Productivity of Spring Chinook and Summer Steelhead in the John Day River Basin, BPA Report DOE/BP-00020364-1, p. 98 electronic pages.

Wolman, M. G., and Miller, J. P., 1960, Magnitude and frequency of forces in geomorphic processes: Journal of Geology, v. 68, p. 54-74.

Worthy, M., 2005, High-resolution total stream power estimates for the cotter river, namadgi national park, Australian capital territory, Regolith 2005 - Ten Years of the Centre for Resource and Environment Studies: Canberra, Australia, Australian National University, p. 338-343.

10 APPENDIX A- PROFORMA EVALUATIONS

Proforma evaluations and their accompanying figures provide the background and on-site data for each river style.

A1 PROFORMA EVALUATIONS FOR RIVERS OF LATERALLY UNCONFINED VALLEY SETTINGS

A1.1 PROFORMA – LOW-MODERATE SINUOSITY GRAVEL BED RIVER STYLE

The *Low-moderate sinuosity gravel bed river style* occurs in areas of the middle catchment where valley expansion or widening has locally created greater accommodation space, lowered gradient, and consequent deposition of a wide, uniform floodplain (Figure A 1). This river style is found in laterally unconfined valley settings, where the channel is free to adjust across the floodplain unimpeded. The channel interacts with relatively steep-sided canyon walls or low relief alluvial fans less than 10 % of the time along its length. The floodplain is composed of vertically accreted, fine-grained clay silt and fine sand deposited by successive overbank floods; at high flows, the Paleochannels and meander cutoffs are common and attest to a history of overbank flooding and meandering planform adjustment. The channel adopts a single thread, moderately sinuous, actively meandering planform, with occasional chute cutoffs at meander bends. The banks are stable and steep-sided, with a high width to depth ratio. Channel shape. The bed is underlain by gravel and cobbles; Instream geomorphic units include runs in straight sections, and pool-riffle-pool sequences developed at meander bends. Point bars are common, with occasional diagonal and lateral bars present. The proforma site for this river style is a moderate condition variant of the natural condition expected for this river style—it has been the target of heavy channel-wall reinforcements designed to dampen cutbank development, and extensive floodplain replanting of riparian species.

<u>Subwatersheds where this river style is observed:</u>
HUC 10: Long, Camp, Bridge and Big Creeks.
HUC 12: Six Mile Creek, Long Creek, Headwaters and Upper Long Creek, Upper Camp Creek, Lower Camp Creek, Balance Creek, Granite Boulder Creek, Little Boulder Creek, Mill Creek.

<u>Details of Analysis</u>
Representative Reach: MFJDR near Bates, Oregon
Map Sheets and Air Photographs Used: 2011 NAIP 1 m color aerial photos, Google Terrain Map (USGS 7.5' Quadrangle Derived)
Date of Proforma Draft: 10 July 2013
Date of Field Visit: 12-22 July 2013
Coordinates: DS: 376017.86 E 4941717.47 N, US: 377274.62 E 4940512.08 N (UTM 11N NAD 1983)

<u>River Character</u>
Valley Setting: laterally Unconfined
Channel Planform: low-moderate sinuosity
Bed Material Texture: gravel/cobble with similarly-sized bar deposits occurring on inside of meander bends.
Channel Geometry: Single thread trapezoidal channel generally ~15 m wide. Cross section contains coarser (gravel/cobble) sheets overlain by finer sand and gravel deposits composing contemporary floodplain.

Instream Geomorphic Units

Bank-attached Bars: composed of well-sorted and rounded gravels/cobbles deposited on the inside of meander bends. Bars are frequently vegetated with quickly-colonizing grasses, but generally lack larger shrubs or trees.

Pool-riffle Sequences: channel consists of pools located on the outside of meander bends, with bank-attached bars (see above) on the inside of bends; straighter, steeper riffles (slightly coarser with boulders occurring on active channel bed) and slow-water runs compose the majority of channel units.

Structural Elements: this proforma site is one of several reaches of this river style where restoration efforts are underway. Instream structural elements include rip-rap (mostly interlocked boulders) built up at channel bends, evidently to prevent further modification of cut banks by the river; and extended boulder berms placed along the channel for the same purpose. Channel-spanning logs have also been placed strategically to create plunge pools and bars in the channel.

Floodplain Geomorphic Units

Paleo/High-Flow Channels: distributed across the floodplain, marked by the presence of gravel and cobbles in a floodplain otherwise dominated by sand and small gravel.

Contemporary Floodplain Deposits: spanning the width of the valley floor, and topping contemporary channel deposits exposed in cutbanks of the current channel. Composed of a variety of grain sizes ranging from mud to sand to gravel, these are stratified, indicating deposition during individual flood events.

Terraces: flat-lying abandoned floodplain surfaces located ~1 m above active floodplain. Marked by smooth surfaces lacking paleo/high flow channels. Composed of similar mud/sand/gravel mixture as contemporary floodplain deposits. At the proforma site the relief between terrace and floodplain is subtle.

Alluvial Fans: several tributaries intersect the trunk stream valley along the length of the proforma site. At these junctions, an influx of fine-grained sediments interleave with the stratigraphy of the floodplain, influencing the lateral width and gradient of the valley bottom. While the trunk stream is planform-controlled and laterally unconfined, long-term progradation of alluvial fans tend to influence a stream's planform in the valley bottom.

Vegetation Associations

Instream: unvegetated aside from sparse colonization of several point bars by willow.

Floodplain: generally covered in grasses, active channel bounded by small willows and larger deciduous cottonwood trees. Noticeable vegetation density increase around paleo/high-flow channels, indicative of preferential subsurface flow.

River Behavior

Low Flow Stage: this river style is the product of local valley widening and the associated deposition and storage of sediment delivered from upstream and by local valley-margin drainages which source material to the valley floor via alluvial fan deposits. At low flows, the channel is well contained in a single-thread flow path, and the banks are generally stable. The assemblage of geomorphic units includes pools, bars, and riffles and runs; there appears to be little heterogeneity created by large woody debris or variation in channel-bed sediment size.

Bankfull Stage: higher flows are capable of reaching the finer-grained floodplain deposits which compose the steep banks found on the outside of channel bends, and at these flows bank erosion and translational and lateral meander adjustment may occur. The largely unvegetated channel bars have low cohesion and may be reworked at these stages. Additionally, free migration of the channel may be promoted by the lack of vegetation on channel banks and across the active floodplain. At bankfull and overbank stages, the planform is prone to floodplain accretion, as fines are deposited on the surface in zones of overbank sheetflow and deceleration.

Overbank Stage: at this stage, the high-flow channels crosscutting the valley floor may be activated, as these areas are generally located ~1 m or less above the active channel (see Figure 30). The high degree of connectivity between the active floodplain and the channel, coupled with the wide nature of the channel and its generally shallowly-sloping banks means that water and sediment may easily reach the floodplain, resulting in fresh deposits of finer mud, sand, and gravel across the valley bottom.

<u>Controls</u>

Upstream Drainage Area: 402 km^2

Landscape Unit and Position in Watershed: Alluvial valley bottom; found in lower watershed.

Process Zone: Sediment storage zone due to localized valley expansion.

Valley Morphology: wide (~200 m wall-to-wall) valley bottom with flat valley floor, consistent valley bottom width. Can be temporarily narrowed by occurrence of alluvial fans draining small watersheds on valley margins.

Valley Slope: On average, 0.6%

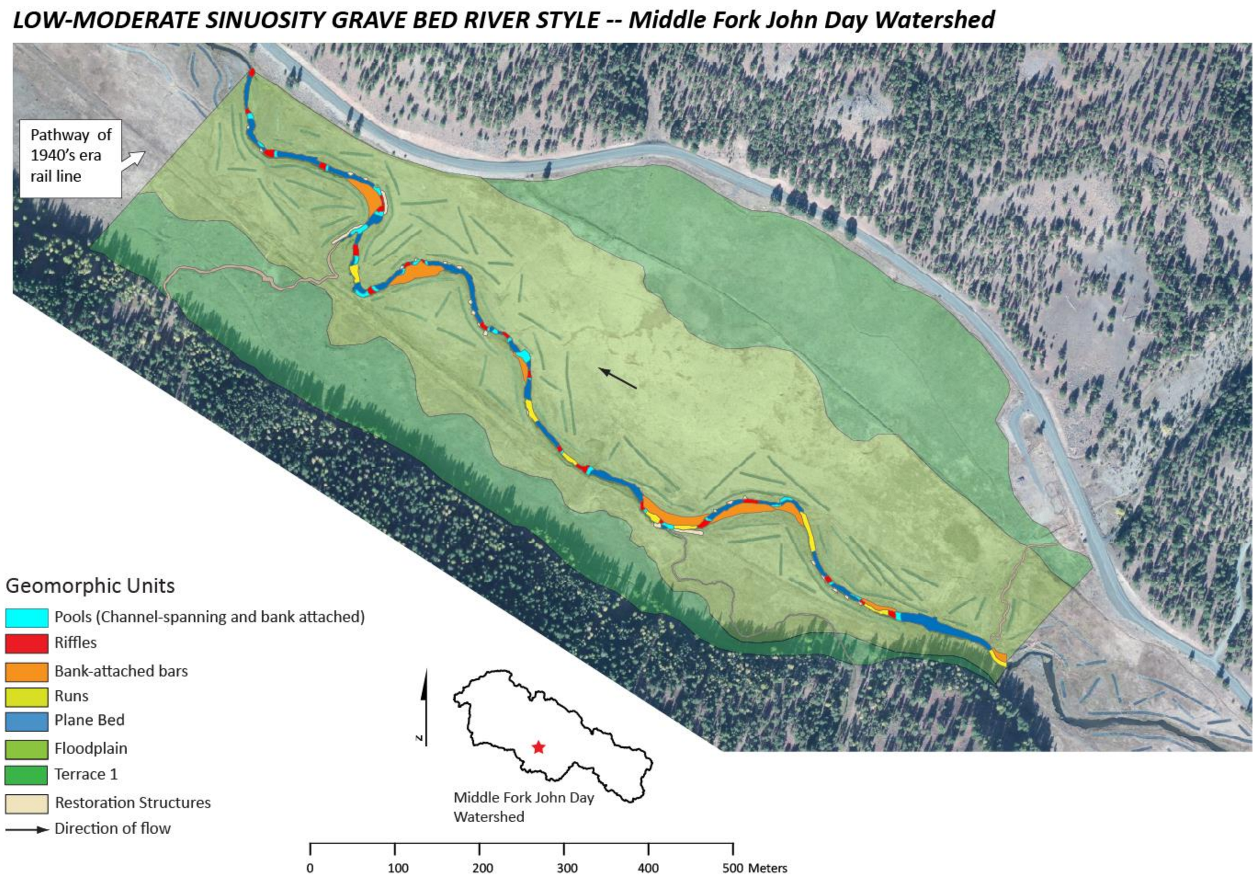

Figure A 1. Map of floodplain and instream geomorphic units associated with the low-moderate sinuosity gravel bed river style.

A1.2 PROFORMA – MEANDERING GRAVEL BED RIVER STYLE

The *Meandering gravel Bed river style* flows within open, laterally unconfined valley settings defined by meadow-like areas surrounded by low relief, rounded topography (Figure A 2). The floodplain is an extension of the fine-grained valley fill surface lacking terrace development, but is highlighted by ponds, meander cutoffs, and paleochannels demonstrating active channel adjustment. Floodplain and terrace deposits are finer than the streambed, typically composed of sand and gravel. The single thread, continuous channel has a high sinuosity, tortuous, irregular meandering planform and has active channels and groundwater seeps. The channel has steep-sided, stable banks, beset with pools, riffles, runs and glides. Cutbanks are situated at the base of riffles along bends. The channel bottom is fine bedded, primarily gravel with some sand and cobbles. This river style is found along the Middle Fork and several tributaries, some of which are intermittent streams. Along Squaw Creek in the SE part of the watershed, extensive channel-spanning restoration structures have been installed, resulting in formation of plunge-pools, undercut banks, and eddy bars. Channel adjustment is accomplished to a greater degree at bankfull stage, and overbank stages tend to force active side channels and ponds. The Proforma site chosen is good-condition variant of this river style (Figure 32). The channel contains little large woody debris due to the lack of floodplain colonization by upland species, presumably the result of a high groundwater table. In the case of the proforma site, the wide clearings have been accentuated by deliberate removal of floodplain vegetation. Cattle actively graze the floodplain.

<u>Subwatersheds where this river style is Observed</u>
HUC 10: Bridge, Big, Camp, and Long Creeks
HUC 12: Basin Creek, Big Creek, Granite Creek, Headwaters Long Creek, Little Boulder Creek, Mill Creek, Summit Creek, and Squaw Creek.

<u>Details of Analysis</u>
Representative Reach: MFJDR, upstream of USFS 2620 bridge
Map Sheets and Air Photographs Used: 2006 Leaf-off 15 cm aerial photographs, 1-m lidar DEM
Date of Proforma Draft: 13 July 2013
Date of Field Visit: 19-22 July 2013
Coordinates: 385587.78 m E, 4937660.13 m N (UTM 11N NAD 1983)

<u>River Character</u>
Valley Setting: laterally unconfined
Channel Planform: meandering with high sinuosity and active side channels
Bed Material Texture: predominantly gravel, with some sand and cobbles
Channel Geometry: narrow single thread trapezoidal channel generally ~3 m wide. Cross section contains coarser (gravel/cobble) channel bed, with banks composed of finer mud and deposits composing contemporary floodplain and terrace/valley fill surfaces found at higher elevations more distal from active channel.

<u>Instream Geomorphic Units</u>
Pool-riffle sequences: channel consists of pools located on the outside of meander bends; straighter, steeper riffles with slightly coarser gravel/cobbles connect these pools. There appears to be little accumulation of sediment in point bars along the inside of meander bends.
Active Side Channels: channel is marked by several side branches which contain water even at low flow; these are receiving water through subsurface flow; the occurrence of swamp/marsh like ponding along these channels may be indicative of very slow flow velocity.

Structural elements: reaches of this river style, including the proforma site, have been heavily augmented with channel-spanning logs (e.g., Figure 5 and Figure 6). Their purpose is to create heterogeneity of geomorphic units where channels have become dominated by plane bed features over time. Plunge pools, mid-channel bars, eddy bars, and cut banks result from placement of these simple structures.

Floodplain Geomorphic Units

Contemporary Floodplain Deposits: continuous deposits of mud and sand across the valley floor, vegetated only by small shrubs and grasses. Frequently dissected by paleo/high-flow channels that do not contain active flow at lower discharges.

Terraces: flat-lying abandoned floodplain surfaces located >1 m above active floodplain and below the steeply sloped valley margin walls. Marked by smooth surfaces lacking channelization, largely vegetated by sage, grasses and some sparse willow. Composed of similar mud/sand/gravel mixture as contemporary floodplain deposits.

Vegetation Associations

Instream: largely unvegetated, although small shrubs are encroaching on the stream in some sections and creating local flow constriction and roughness. Side channels are heavily vegetated by grasses, reeds, and other aquatic species, often having a marsh-like appearance in aerial photos.

Floodplain: active floodplain is generally marked by dense colonization by grasses, with rare shrubs visible.

River Behavior

Low Flow Stage: this river style results from a localized widening of the valley, which creates an accommodation space for sediment and a reduction in channel slope, giving rise to the highly sinuous channel planform. Given the semi-arid nature of the landscape, it is not surprising that the channel appears under-fit for the valley width, and the finer sediment sizes in the channel are indicative of a lack of transport power. It is likely that at low stages, much of the flow is conveyed in the subsurface; side channels and backswamps, likely the result of the emergence of groundwater springs, are common in this area. At low flow, the channel is confined to a single-thread sinuous course. While vegetation exists in some parts of the channel, its influence at this stage is minor.

Bankfull Stage: higher flows may scour channel banks and cause local avulsions, given the lack of vegetation along the channel. Additionally, numerous side channels may be activated at this stage, given the extremely flat nature of the valley bottom and small relief between the active channel and the relict side channels. A rise in the groundwater table during wet periods may result in these low areas being filled with water and acting as temporary side channels.

Overbank Stage: at this stage, infrequent high-flow channels crosscutting the active floodplain will be activated, as these areas are generally located ~1 m or less above the active channel. Fresh sediment will be deposited on the floodplain, and large-scale channel avulsions are likely, given the numerous abandoned channels visible on the active floodplain coupled with the lack of vegetation in these areas. The channel likely reaches overbank areas with some frequency (i.e. < 5 years recurrence), given the low relief of the landscape and the high groundwater table in this valley setting.

Controls

Upstream Drainage Area: 108 km^2

Landscape Unit and Position in Watershed: rounded Hills; generally found in low-slope reaches associated with local valley expansion, occurs in both lower and upper watershed

Process Zone: sediment storage zone

Valley Morphology: ellipsoid-shaped wide (~500 m wall-to-wall) valley bottom with flat floor and shallowly sloping valley walls.

Valley Slope: on average, 0.5%

MEANDERING GRAVEL BED RIVER STYLE -- Middle Fork John Day Watershed

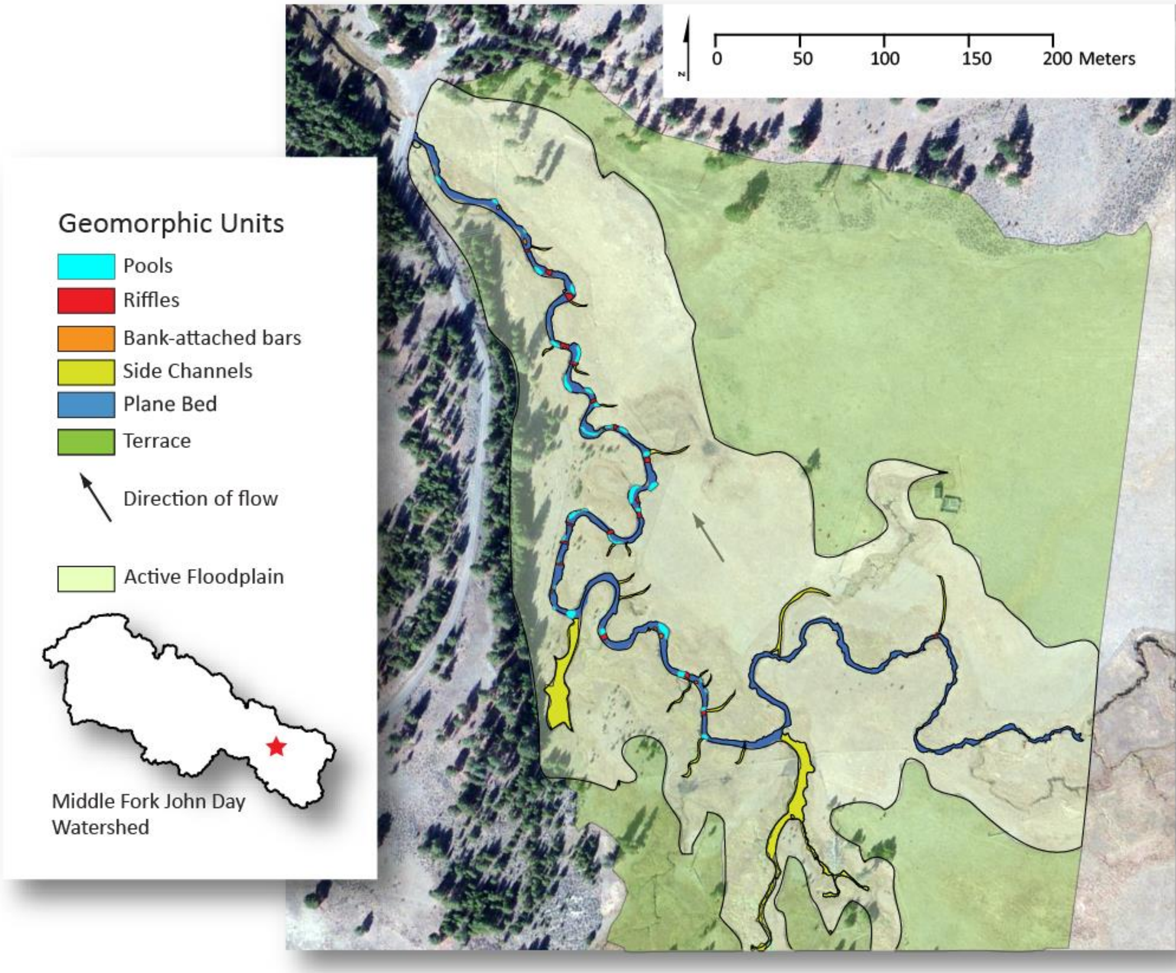

Figure A 2. Instream and floodplain geomorphic units associated with the Meandering gravel bed river style. Mapping of geomorphic units originally completed by Kasprak and Wheaton (2012).

A1.3 PROFORMA – INTACT VALLEY FILL RIVER STYLE

The *Intact valley fill river style* occurs in laterally unconfined valleys at the bottom of small upland basins, where the channel flows across open, meadow-like expanses. These shallow, smooth-sided discontinuous Channels consist of gently meandering swales terminating at intermittent ponds. The hallmark of this style is the absence of a continuous channel; rather, broken channels or an absence of visible flow paths across gently-sloping, wide-bottomed valleys give rise to the intact valley fill river style. Dense colonization by grasses and the absence of upland tree species mark these valley floors, which may also be littered with fallen trees from upslope. This river style may be the product of upstream drainages formed on less resistant marine sediments than the surrounding basalt lithology, or the result of high sediment delivery following upslope fires. The source of runoff for these discontinuous drainage systems are low relief, rounded uplands, and shallow subsurface throughflow from adjacent hillslopes. In the MFJDW, this river style is observed as a moderate to poor variant – it is associated with extensively grazed areas close to farming operations. Today, significant runoff is contained in ponds and existing channels. Paleochannels seen in plan view, however, suggest these muted channels may once have been integrated with tributaries of the MFJDR (Figure A 3).

<u>Subwatersheds in which this river style is Observed</u>
HUC 10: Big, Bridge, Camp and Long Creeks
HUC 12: Basin Creek, Big Creek, Bridge Creek, Clear Creek, Granite Creek, Granite Boulder Creek, Headwaters Long Creek, Indian Creek, Little Boulder Creek, Lower Camp Creek, Mill Creek, Summit Creek, Squaw Creek, and Upper Camp Creek.

<u>Details of Analysis</u>
Representative Reach: unnamed—2.3 km northeast of Bates town site and campground (private land)
Map Sheets and Air Photographs Used: 2011 1 m NAIP imagery, Google Terrain (7.5' USGS quadrangle-derived), aerial photographs from EcoFlight overflights
Date of Proforma Draft: 16 July 2012
Date of Field Visit: 19-28 July 2012
Coordinates: 381319.81 m E 4940661.07 m N (UTM 11N NAD 1983)

<u>River Character</u>
Valley Setting: laterally unconfined
Channel Planform: broken/discontinuous flow paths
Bed Material Texture: fine; predominantly sand with some gravel, often conspicuous white ash
Channel Geometry: channel is broken into segments separated by sections where subsurface flow is occurring. Sections with active flow are slow-moving and narrow (~3 m wide) and occur as flow paths.

<u>Instream Geomorphic Units</u>
Slow-Water Runs: channel takes the appearance of preferential flow paths, with slow-moving sand and-gravel bottomed sections. The large amount of woody debris littering the valley floor gives rise to occasional pools.
Gully headcuts and flow paths: many instances of this river style are the mid-sections of active stream channels; thus, intermittent channel flow appears to disperse and/or infiltrate, only to reemerge in downstream discontinuous channels. Overland flow and subsurface sapping, however, tend to scour channel headcuts and wide, shallow sheetflow channels. These disperse as discontinuous channels, or form the continuous channels that continue downstream.

Floodplain Geomorphic Units

Valley Floor Deposits: Rather than forming alluvial floodplain surfaces, the valley bottoms in this river style are dominated by the presence of hyporheic flow moving through quaternary surficial sediment. The source of this sediment is unclear, although it is likely a relict deposit from major up-basin erosional events such as wildfires. Valley floor deposits are fine, predominantly sand with some mud and gravel which are frequently stained white, presumably from the presence of ash in the surficial sediments.

Vegetation Associations

Instream: vegetated by grasses and small shrubs, which provide local roughness elements and force the location of pools and runs.

Valley Floor: thickly vegetated with grasses and small shrubs, notable absence of upland tree species indicates high groundwater table and active subsurface flow. Littered with fallen trees likely sourced from the valley margin.

River Behavior

Low Flow Stage: this river style is marked by the absence of a singular continuous channel, and rather exhibits a series of preferential flow paths, with active flow appearing where the groundwater table intersects the land surface. It is the result of a high sediment load being sourced from weak upslope sedimentary lithologies, although it is unclear at what interval sediment is delivered to valley bottoms; it is possible that the surficial sediment filling these valleys was delivered in a single pulse following a major erosional event. At low flow, the discontinuous channel lacks the necessary stream power to mobilize sediment coarser than sand and/or to erode banks or channel beds. At this stage, the local behavior of the channel (i.e. the distribution of geomorphic units) is highly influenced by the presence or absence of valley-bottom vegetation and large woody debris.

Higher Stages: given that this river style lacks a true floodplain and does not exhibit alluvial behavior (active meandering, bar building), bankfull and overbank stages are misnomers here. Rather, at higher stages the valley bottoms currently marked by discontinuous flow paths may become inundated, as a greater degree of subsurface and overland flow will connect these areas. Additionally, the very flat nature of the valley floor means that broad areas will be inundated, giving the appearance of a bog or marsh at higher stages. The highly vegetated valley floors and low slope of these systems means that they will be very resistant to lateral erosion or downcutting during higher stages. While the transport of sand and small gravels is possible at these higher stages, it appears that a) coarse sediment is not sourced from the weak lithologies in the upper basin and b) insufficient stream power exists to mobilize such grain sizes because of the low slope and shallow depths of the active channels.

Controls

Upstream Drainage area: 1.5 km^2

Landscape Unit and Position in Watershed: valley bottoms of small basins in upper watersheds, generally found in rounded uplands or alpine plateaus.

Process Zone: sediment accumulation zone (historical), sediment transport zone (net equilibrium at present)

Valley Morphology: flat valley floor of variable width (~50-70 m wall-to-wall)

Valley Slope: on average, 1-1.5%

INTACT VALLEY FILL RIVER STYLE --Middle Fork John Day Watershed

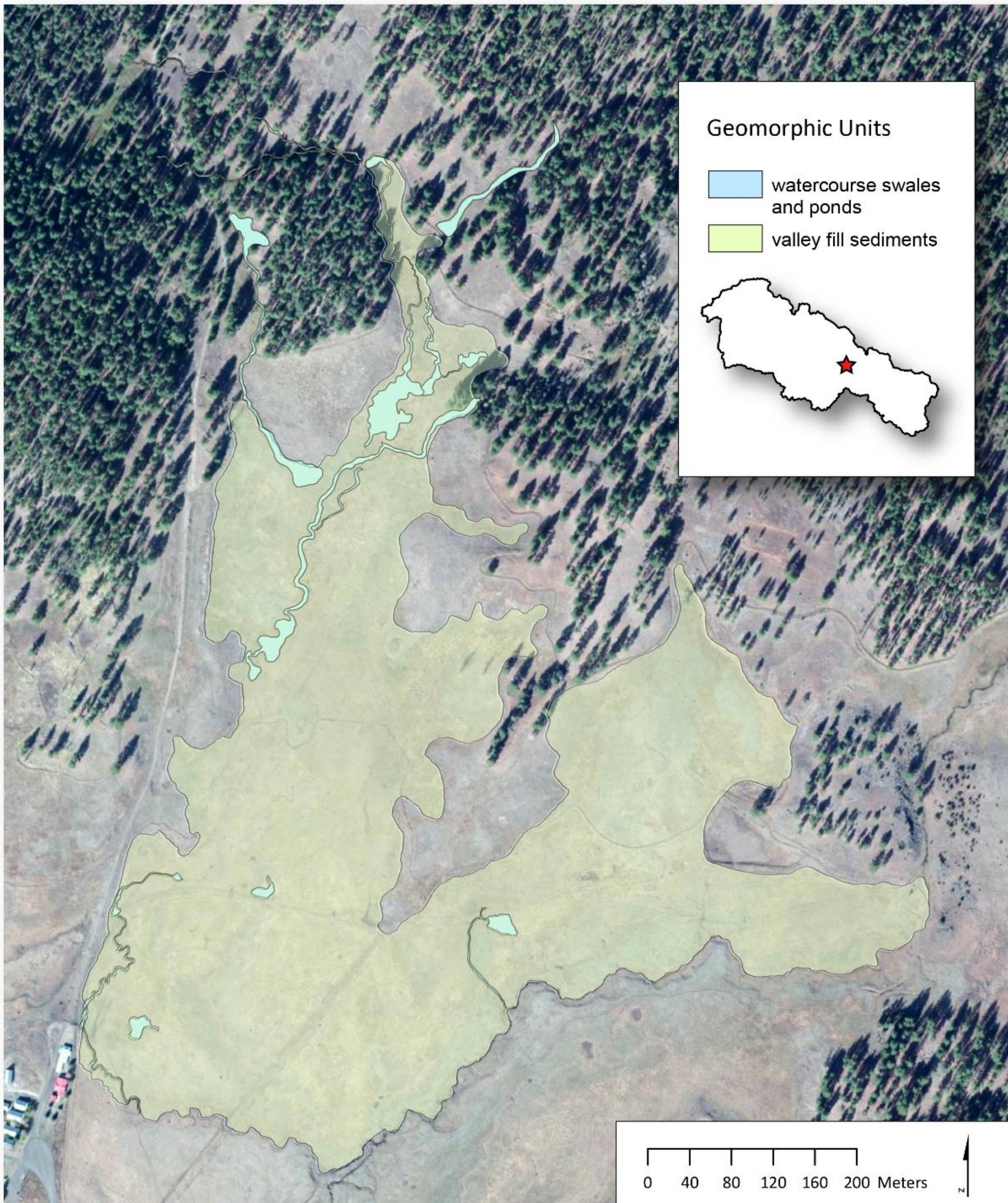

Figure A 3. Floodplain and instream geomorphic units associated with the Intact valley fill river style.

A1.4 PROFORMA – ALLUVIAL FAN RIVER STYLE

The *Alluvial fan river style* occurs in laterally unconfined valleys at the mouths of mainstem tributaries. Here the channel is generally a single thread flowing across a broad, fan- or arcuate-shaped surface where tributary valleys open or expand into the main trunk river floodplain. Thus this river style generally has two components: a tributary segment where the stream completes a transition from its upstream river style to the *Alluvial fan River Style*, and a down-fan segment where the stream emerges from the tributary valley and flows to a new base level into the trunk stream valley. Here the river loses energy and deposits its sediments across the fan surface. In the MFJDW where sediment flux from tributaries is not profuse, these fan systems generally have a single, somewhat stable channel, unlike sediment-rich fan systems where distributary systems are dynamic and change location with regularity. Likewise, the fan surface itself tends to be fine grained and of subtle relief in most cases. Fans are composed of coarser sediments than the mainstem floodplain. Episodes of tributary sediment deposition rarely synchronize with flood stage deposition of fine sediments on the mainstem, creating an interfingered stratigraphy where the landforms conjoin (Figure A 4).

Subwatersheds in which this river style is Observed
HUC 10: Big, Bridge, Camp, Eight-Mile, and Long Creeks
HUC 12: Three Mile Creek, Lower Long Creek, Slide Creek, Indian Creek, Bear Creek, Big Creek, Lower Camp Creek, Balance Creek, Granite Boulder Creek, Little Boulder Creek, Vinegar Creek, Mill Creek, and Clear Creek

Details of Analysis
Representative Reach: Granite Boulder Creek
Map Sheets and Air Photographs Used: 2011 1 m NAIP imagery, Google Terrain (7.5' USGS quadrangle-derived)
Date of Proforma Draft: 15 December 2013
Date of Field Visit: 11 October 2013
Coordinates: 364032.20 m E, 4947736.60 m N (UTM 11N NAD 1983)

River Character
Valley Setting: laterally unconfined
Channel Planform: slightly sinuous to straight
Bed Material Texture: cobble, gravel and sand
Channel Geometry: generally symmetrical, with high width/depth ratio. Banks are generally gently sloping and composed of coarse gravel and sand.

Instream Geomorphic Units
Riffles and Runs: a dominantly gravel substrate along the mostly straight stream planform provides runs punctuated by riffles that occur at bends.
Bars: transverse and diagonal bars, point bars.

Floodplain Geomorphic Units
Fan Surface Deposits: Fan surfaces are subtle in relief and tend to be coarse grained, dependent upon the sediment flux and geologic characteristics of the tributary watershed. In most cases, alluvial fans are difficult to discern from the mainstem floodplain; in others, the mound or fan-shaped landform is more pronounced, but in any case a classic "distributary" network of channels is absent across these surfaces, owing to the generally low energy and sediment yield from most tributary catchments.

Vegetation Associations

Instream: generally, little vegetation exists in the alluvial fan distributary channels.

Fan Surface: can be thickly vegetated with grasses and small shrubs, but a notable absence of upland tree species indicates a moderately active depositional environment. Generally colonized by species that lie at the margin of trunk stream valley.

River Behavior

Low Flow Stage: this river style is marked by the presence of a single straight channel that serves as connector between mainstem and tributary river styles. At low flow, the stream is confined within its shallow channel, which gradually decreases in gradient as the profile transitions between tributary and mainstem valleys.

Higher Stages: given that this river style occupies a unique laterally unconfined setting between tributary and mainstem valleys, high flows from tributaries will typically disperse across the fan, occupying a distributary channel pattern. This is typical of fan formation, and along with occasional debris flows or sediment-rich discharge, is the process responsible for building and maintaining the fan-shaped landform.

Controls

Upstream Drainage Area: 46.8 km^2

Landscape Unit and Position in Watershed: found at tributary junctions where local base level is reached, throughout the watershed. Generally found at the confluence of tributary streams and the main stem MFJDR, which intersects the Rounded Uplands, Dissected Tablelands, and Valley Alluvium landscape units.

Process Zone: alluvial Fans are depositional landforms, accumulating sediments at sink areas defined by local base levels.

Valley Morphology: alluvial fans occupy the distal portions of tributary valleys where they meet the laterally unconfined, open portions of adjoining valleys. Tributary valleys range from partly confined to confined bedrock canyons.

Valley Slope: on average, 1-1.5%

ALLUVIAL FAN RIVER STYLE- Middle Fork John Day Watershed

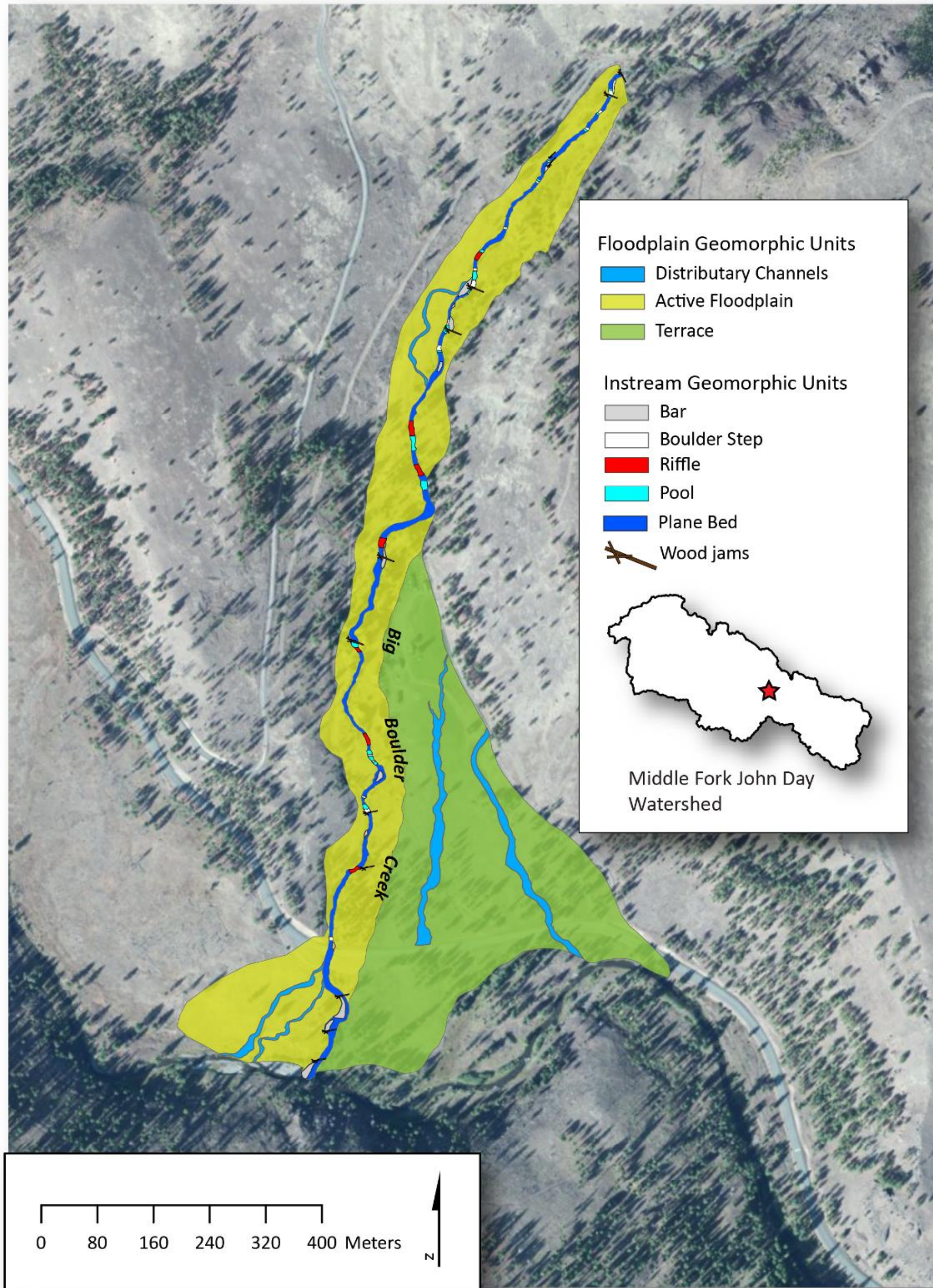

Figure A 4. Floodplain and instream geomorphic units associated with the Alluvial fan river style. The upstream, partly confined valley setting hosts the distal end of the Meandering Planform-controlled River Style.

A2 PROFORMA EVALUATIONS FOR RIVERS IN PARTLY CONFINED VALLEY SETTINGS

A2.1 PROFORMA – LOW-MODERATE PLANFORM-CONTROLLED DISCONTINUOUS FLOODPLAIN RIVER STYLE

The *Low-moderate sinuosity planform-controlled discontinuous floodplain river style* is typical of upper tributaries in the central and eastern Rounded Uplands and Dissected Uplands landscape units. Streams of this river style flow through partly confined valleys and exhibit dominantly single thread, moderate to low sinuosity planforms, although secondary channels exist in some configurations. Floodplains are discontinuous, 40-100 meters in width, and tend to have an irregular surface with overflow channels and occasional meander cutoffs. Instream geomorphic units are diverse and include riffles, runs, steps and pools, chute cutoffs, cutbanks, and a variety of bar forms (compound, point, mid-channel, and diagonal). Abundant wood loading tends to form jams and pour-offs, and create structurally forced bar forms. Floodplains are underlain by clay, silt and sand, and bed material is dominated by coarse gravel and cobble (Figure A 5).

Subwatersheds in which this river style is observed
HUC 10: Big, Bridge, Camp, Eight-Mile, and Long Creeks (see Figure 39 Figure 40).

Details of Analysis
Representative Reach: Vinegar Creek
Map Sheets and Air Photographs Used: 2011 1 m NAIP imagery, Google Terrain (7.5' USGS quadrangle-derived)
Date of Proforma Draft: 12 July 2013
Date of Field Visit: 19-28 July and 11 Oct 2013
Coordinates: 11T 380730 E, 4944391 N (UTM 10N NAD 1983)

River Character
Valley Setting: partly confined
Channel Planform: low to moderate sinuosity.
Bed Material Texture: gravel/cobble with similarly sized bar deposits occurring throughout the channel. Bimodal grain size distribution with abundant coarse bedload (cobbles and gravel), along with a high percentage of interstitial sand and fine gravel stored in bar forms.
Channel Geometry: single thread trapezoidal channel generally ~4 m wide. Cross section contains coarser (gravel/cobble) sheets overlain by fine sand and silt deposits composing contemporary floodplain surfaces.

In channel Geomorphic Units
Bank-attached Bars and Mid-channel Bars: composed of poorly sorted and rounded gravels/cobbles deposited on the inside of meander bends and mid-channel around bends; generally vegetated by grasses. The active channel is composed of the coarser fraction, while higher elevation bars and backwater areas between bars and banks tend to accumulate finer pebbles, gravel and sand.
Pool-riffle Sequences: channel consists of pools typically located on the outside of meander bends, with bank-attached bars (see above) on the inside of bends; straighter, steeper riffles (slightly coarser with small boulders occurring on active channel bed) connect these pools.
Coarse Gravel Runs: long sections between bends exhibit runs over coarse gravel and cobble channel substrate.
Secondary Channels: at this proforma site, the channel splits around islands underlain by gravel sheets and capped with floodplain fines (i.e., silt, sand and mud). These promote formation of confluence bars where channels meet, and headward-eroding backwater channels at meander bends.

Structural Elements: abundant LWD along Vinegar Creek and its secondary channels form wood jams that force pools below and accumulate gravels above. Typically, larger logs span the channel forming a plunge pool and channel-spanning, structural-forced bar farther downstream, while accumulating gravels and smaller woody debris upstream.

Floodplain Geomorphic Units
Contemporary Floodplain Deposits: generally continuous deposits of mud, sand, and gravel bordering the channel, densely vegetated by species of willow and numerous grasses. The pine forest occupying adjacent hillslopes has also colonized the floodplain. Found <0.25 to 0.5 m above current channel, the floodplain is an inset surface bounded by canyon walls that either crop out as resistant conglomerate (debris flow) erosional faces, or as more gentle forested slopes. In either case, the hillslopes and floodplains are strongly connected, and responsible for direct sediment input to the channel.

Vegetation Associations
Instream: grasses colonize all types of bars along the channel following the seasonal high flow stage.
Floodplain: active floodplain is generally marked by dense colonization by grasses, willows, and pine forest. Vegetation density is consistent between hillslope and floodplain, although some floodplain surfaces are devoid of larger riparian or conifer species.

River Behavior
Low Flow Stage: This river style results from the adjustment of its channel within the limited confines of steep-walled valleys, with the channel banks and floodplain composed of fine-grained mud, sand, and gravel, while the channel bed is composed of coarser gravels and cobbles. At low flows, the channel is well contained in a single-thread flow path, and the banks are generally stable as they are often armored by cobbles sourced from the contemporary channel bed or canyon walls. The assemblage of geomorphic units includes pools, bars, riffles, and runs. Large woody debris frequently acts to create localized hydraulic heterogeneity, leading to fine-scale sediment deposition and scour.
Bankfull Stage: higher flows are capable of reaching the finer-grained floodplain deposits, which often compose the steep banks found on the outside of channel bends, and at these flows bank erosion may occur. The largely unvegetated channel bars have low cohesion and may be reworked at these stages. Channel banks and the active floodplain have moderately dense vegetation, often colonized by thickets of willows and sparse stands of conifers that redirect flow over these uneven surfaces.
Overbank Stage: at this stage, infrequent high-flow channels crosscutting the active floodplain may be activated, as these areas are generally located ~1 m or less above the active channel. Overall, overbank flooding tends to increase recruitment of LWD, rework channel bars, and accentuate secondary channels; LWD lodged throughout the channel tends to create greater heterogeneity of instream geomorphic units.

Controls
Upstream Drainage Area: 148 km^2
Landscape Unit and Position in Watershed: Rounded Uplands; generally found in higher reaches of the watershed in steep-sloped, forested valleys.
Process Zone: Sediment transfer zone
Valley Morphology: Steep walled, narrow width (~50 m wall-to-wall) valley bottom with flat valley floor.
Valley Slope: On average, 1%

LOW-MODERATE SINUOSITY PLANFORM-CONTROLLED DISCONTINUOUS FLOODPLAIN RIVER STYLE- Middle Fork John Day Watershed

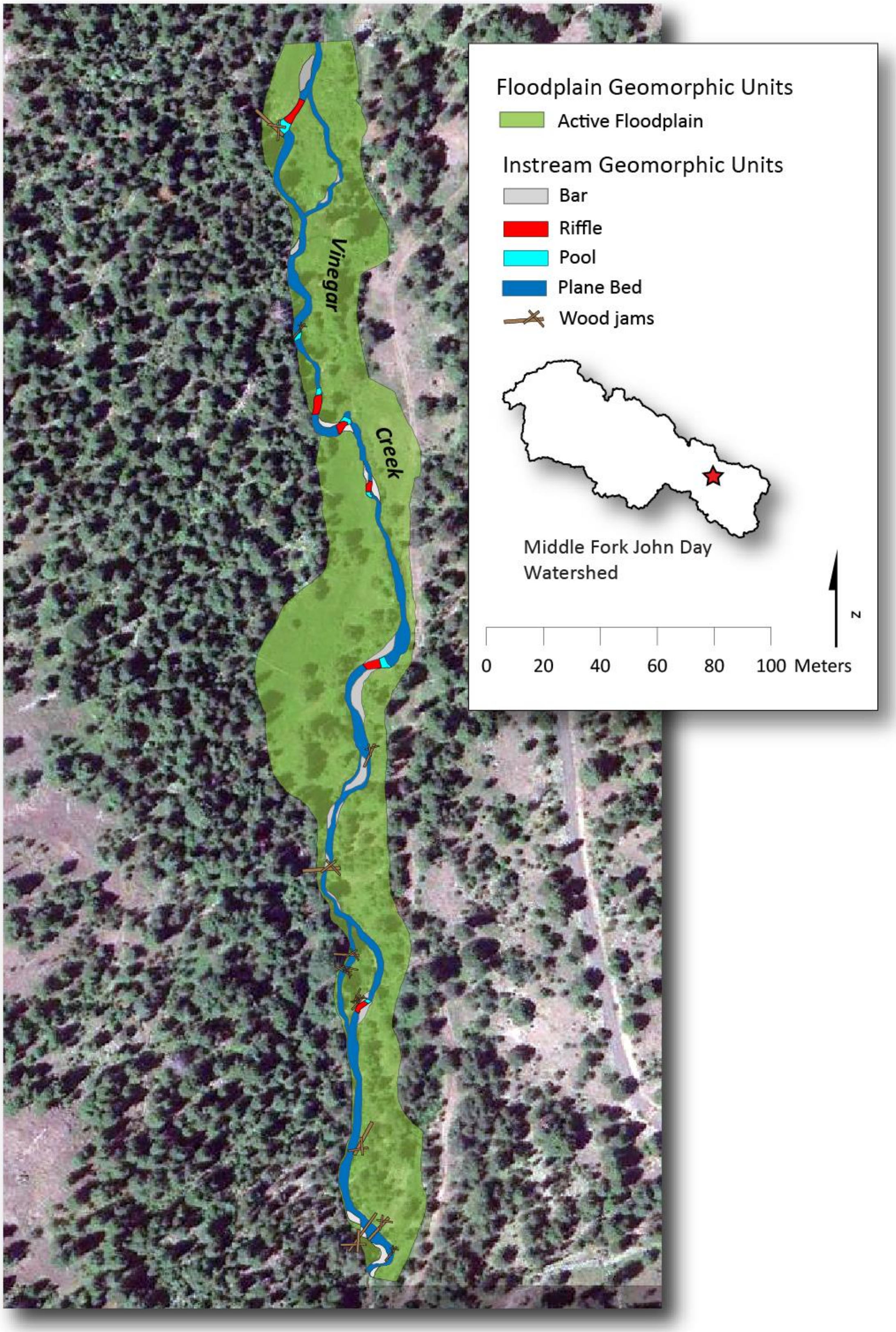

Figure A 5. In channel and out of channel geomorphic units associated with the Low-moderate sinuosity planform-controlled discontinuous floodplain river style shown at the Vinegar Creek proforma evaluation site.

A2.2 PROFORMA – BEDROCK-CONTROLLED ELONGATE DISCONTINUOUS FLOODPLAIN

The *Bedrock-controlled elongate discontinuous floodplain* river style occurs in partly confined valleys where the channel is generally routed against valley walls, and planform adjustment is controlled by proximity to bedrock cliffs or forested hillslopes. In general, the valley bottom is composed of flat-lying floodplain and terrace material, with a single-thread main channel system exhibiting low to moderate sinuosity. This river style has naturally occurring and human-created variants along the mainstem MFJDR (Figure A 6), and Long Creek subcatchments.

The hallmark of this river style is a channel course that takes on two forms: (a) a natural variant whose channel planform is largely controlled by proximity to bedrock walls; and (b) a variant whose stream course has been intentionally redirected against one valley wall to maximize the area available in the floodplain for grazing and hay growing (Section B2.3). The distribution of geomorphic units in this channel type is very homogenous, consisting mainly of long sections of plane bed punctuated by coarse riffles with few pools or slow-water areas. Little structure is added by the presence of natural woody debris as the balance between low upstream recruitment and discharge provides sufficient stream power to mobilize such roughness elements.

The naturally adjusting variant of this river style is found along the MFJDR between the historic towns of Bates in the upper watershed downstream to Galena at the head of the basalt bedrock canyon. These reaches alternate with the *Low-moderate sinuosity gravel bed* river style where reduced width of the bedrock canyon changes the behavior of the river from planform-controlled to bedrock-controlled (Figure A 1). The channel is single thread with the occasional anabranch, island and chute cutoff. The planform is bedrock-controlled and has low to moderate sinuosity. Floodplains can reach as much as 400 meters in width, with terraces, occasional meander cutoffs and paleochannels. Where the river is pinned against a single canyon wall, often for kilometers at a time, individual floodplain segments are elongate and narrow next to the closest wall, and elongate and very wide along the opposite side. The presence of scroll bars as well as wide uniform floodplains indicate a combination of vertical and lateral accretion processes are responsible for floodplain aggradation. Instream geomorphic units are dominated by riffles, runs, pools, point bars and scroll bars.

The human-altered variant occurs within the Long Creek subcatchment of the northwest region of the MFJDW along Basin, Pass, Pine and Long Creeks. These Tributaries of Long Creek initially flow from highlands to the west and south across shallow valleys carved into Dissected Tablelands of the Columbia River basalt. The Planform of these streams is bedrock-controlled (in the present day), and exhibits either straight or low sinuosity and are single threaded. Valley bottom alluvial floodplains are fine grained with a uniform surface, and are ~50 to over 200 meters in width. These floodplains are currently used for grazing and hay growing, given that most of the plateau landscape is basalt bedrock with little available cultivatable land. Thus, there is ample capacity for the stream to adjust in its floodplain, but at present flows for long distances pinned against one gently sloping valley wall or the other. Floodplain geomorphic units include paleochannels, ponds, and secondary channels, but in the present configuration these are probably relict features that predate manipulation of the stream bed. Instream geomorphic units include riffle and run sequences, pools, cutbanks, and point bars.

The same engineered variant exists across a large portion of the MFJDR between its headwaters and its boundary with the Entrenched Bedrock Canyon river style in the northwest watershed. Valley width varies significantly along this length, but the channel is confined by bedrock along the valley margin greater than 80% of the reach length where this river style occurs. Sections of this river style have been heavily treated with bank-attached restoration structures, and efforts have been made to restore the river to its original channel (Reclamation, 2010). Floodplain material ranges from fines to coarse gravel, and bed material consists of cobble, gravel and sand. To a large degree, the laterally unconfined (*Low-moderate sinuosity gravel bed river style*) and partly confined sections of the MFJDR are most impacted by human disturbance of the entire watershed through grazing, farming and mining activities.

Subwatersheds in which this river style is observed
HUC 10: Big, Bridge, Camp, Eight-Mile, and Long Creeks (see Figure 39 Figure 40).

Details of Analysis
Representative Reach: Middle Fork John Day near Oxbow Ranch
Map Sheets and Air Photographs Used: 1-m lidar DEM and derived slope raster, field-drawn sketches and notes from fieldwork in July 2013.
Date of Proforma Draft: 4 September 2013
Date of Field Visit: 19-28 July 2013
Coordinates: 375196.10 m E, 4942157.16 m N (UTM 10N NAD 1983)

River Character
Valley Setting: partly confined
Channel Planform: low to moderate sinuosity
Bed Material Texture: bimodal grain size distribution with abundant coarse bedload (cobbles and gravel).
Channel Geometry: single thread trapezoidal channel generally ~5 m wide. Floodplains are very broad, often 50 to 200 meters in width.

Instream Geomorphic Units
Bank-attached bars: composed of rounded gravels/cobbles deposited on the inside of meander bends. May be sparsely vegetated indicating a degree of stability, but are mainly barren.
Riffles: these are slightly steepened, planar sections of channels that are nearly featureless. Composed primarily of boulders and cobbles, riffles exhibit very little heterogeneity or local roughness elements which may provide refugia for aquatic organisms.
Pools: channel consists of rare pools typically located on the outside of meander bends. More subtle pools form upstream of riffles at the distal ends of runs.
Runs: frequent, long areas of straight channel are slightly deeper and flatter than riffles, and equally featureless in terms of variability in substrate size and/or roughness elements. The channel is marked by occasional boulders that break the otherwise homogeneous nature of the substrate. On the Long Creek plateau, runs are composed of coarse gravel and inclines tend to be somewhat steeper.
Structural Elements: natural wood exerts a relatively minor influence on the channel bed and banks because of low wood recruitment along the mainstem. However, along engineered variants of this river style and areas of active restoration, abundant wood has been pltced to improve habitat for fish, and could influence channel geomorphology in the future.

Floodplain Geomorphic Units:
Contemporary Floodplain Deposits: composed of fine sand, silt and clay, floodplains are vertically aggraded by overbank floods, and underlain by coarse gravel and cobble. They are colonized densely by willows and grasses and are composed of the same material as terraces.
Alluvial Fan Deposits: material sourced from steep tributary streams draining smaller watersheds along the valley margins. They are generally smooth-surfaced, but typically coarser than fine alluvium that forms the floodplain.
Terraces and Valley Fill: flat-lying surfaces located > 1 m above active floodplain and inset against sparsely forested bedrock slopes. These are smooth surfaces marked by few paleochannels and largely vegetated by grasses and sparse willow.

Vegetation Associations

Instream: unvegetated aside from sparse colonization of several point bars by grasses. However, tussock pedestals are common along both channel margins, and sometimes dense enough to form bank-attached, return-current channels and small islands.

Floodplain: active floodplain is generally marked by dense colonization by grasses and willows, but historic clearing of vegetation has left floodplains free of trees and dense riparian growth. Vegetation type shifts noticeably to pine forest on flanking canyon walls.

River Behavior

Bankfull Stage: higher flows are capable of reaching the finer-grained floodplain deposits which compose the steep banks found on the outside of channel bends, and at these flows bank erosion and translational and lateral meander adjustment may occur. The largely unvegetated channel bars have low cohesion and may be reworked at these stages. Additionally, free migration of the channel may be promoted by the lack of vegetation on channel banks and across the active floodplain. At bankfull and overbank stages, the planform is prone to floodplain accretion, as fines are deposited on the surface in zones of overbank sheetflow and deceleration.

Overbank Stage: at this stage, the high-flow channels crosscutting the valley floor may be activated, as these areas are generally located ~1 m or less above the active channel. The high degree of connectivity between the active floodplain and the channel, coupled with the wide nature of the channel and its generally shallowly sloping banks means that water and sediment may easily reach the floodplain, resulting in fresh deposits of finer mud, sand, and gravel across the valley bottom. Historic photographs reveal a high density of fine suspended load is conveyed at flood stage (i.e., Figure 30), which is the mode of both floodplain stripping, and of vertical accretion of fine sediments on the floodplain surface at seasonal high flows.

Controls

Landscape Unit and Position in Watershed: Generally found in valley bottoms, in the lower watershed.

Process Zone: Sediment transport zone

Valley Morphology: Valleys may be partly confined or laterally unconfined, but show little evidence of active channel migration over these surfaces. In this case, valley is flat-bottomed and channel is laterally unconfined in a wide valley (~200 m wall-to-wall), which is temporarily narrowed by the presence of alluvial fans draining small watersheds on the valley margins.

Valley Slope: On average, 1%