Appendix B

Reach-Based Ecosystem Indicators (REI)

Middle Twisp River (RM 7.8 – 18.12)

Contents

1 Introduction

1.1 BACKGROUND

The REI provides a consistent means of evaluating biological and physical conditions of a watershed in relation to regional standards and known habitat requirements for aquatic biota. These indicators, along with other scientific evaluations, describe the current quality of stream biophysical conditions and can help inform restoration targets and actions. The REI indicators used in this assessment are adaptations from previous efforts including the NMFS matrix of pathways and indicators (NMFS 1996) and the USFWS (1998). With a few exceptions, the REI are based on the USBR's latest adaptations and use of these indicators (USBR 2012).

The REI evaluation for the Middle Twisp River was conducted using field data, observations, previous studies, and available data for the study area. In particular, the rankings were developed based on: 1) quantitative inventory information from the Habitat Assessment performed as part of the Reach Assessment using USFS (2010) protocols, 2) assessment of geomorphic patterns and processes and how they have deviated, if at all, from historical conditions, and 3) analysis of existing watershed assessments and data (e.g. available ArcMap layers and shapefiles). Functional ratings include **adequate**, **at risk**, or **unacceptable**. The REI analysis helps to summarize habitat impairments and to distill the impairments down to a consistent value that can be compared among reaches.

1.2 SUMMARY OF RESULTS

Reaches in the downstream portion of the study area (Reaches 1-4) were the most impacted reaches, having the highest number of **at risk** and **unacceptable** ratings. Although Reach 4 has the highest at ten out of eleven indicators rated either **at risk** or **unacceptable**, Reach 2 is the least functional reach in the study area due to six **unacceptable** ratings (and two **at risk** ratings). Reaches 1 and 3 are close behind, each having 9 **unacceptable** or **at risk** ratings out of 11 categories. LWM was rated **unacceptable** in all reaches except Reach 5, in which the highest number of LWM was measured and from which the criteria for jams/mile was determined. The downstream reaches have more naturally confined channels, which results in less LWM retention throughout these reaches. Reaches 5 and 6 in the upstream portion of the study area were generally more functional overall. Reach 5 had no **unacceptable** ratings and Reach 6 had only one. For the study area as a whole, **at risk** was the most common rating (34), followed by **unacceptable** (16), then **adequate** (16).

2 Metrics & Indicators

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Scale					
Watershed Condition	Effective Drainage Network and Watershed Road Density	Increase in Drainage Network/Road Density	Zero or minimum increases in active channel length correlated with human caused disturbance. Road density <1 miles/miles2.	Low to moderate increase in active channel length correlated with human caused disturbances. Road density 1-2.4 miles/miles2.	Greater than moderate increase in active channel length correlated with human caused disturbances. Road density >2.4 miles/miles2.
	Disturbance Regime	Natural/Human Caused	Environmental disturbance is short-lived; predictable hydrograph, high quality habitat and watershed complexity providing refuge and rearing space for all life stages or multiple life-history forms. Natural processes are stable.	Scour events, debris torrents, or catastrophic fires are localized events that occur in several minor parts of the watershed. Resiliency of habitat to recover from environmental disturbances is moderate.	Frequent flood or drought producing highly variable and unpredictable flows, scour events, debris torrents, or high probability of catastrophic fire exists throughout a major portion of the watershed. The channel is simplified, providing little hydraulic complexity in the form of pools or side channels. Natural processes are unstable.
Flow/Hydrology	Streamflow	Change in Peak/Base Flows	Magnitude, timing, duration, and frequency of peak flows within a watershed are not altered relative to natural conditions of an undisturbed watershed of similar size, geology, and geography.	Some evidence of altered magnitude, timing, duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology, and geography.	Pronounced changes in magnitude, timing, duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology, and geography.
Water Quality	Temperature	Daily maximum and 7-day mean maximum temperatures	Bull Trout: Incubation 2-5°C, rearing 4-10°C, spawning 1-9°C. Salmon and Steelhead: June-Sept 15°C, Sept-May 12°C, rearing 15°C, migration 15°C, adult holding 15°C. OR 7-day daily maximum temperature performance standards: Salmon spawning 13°C, core summer salmonid habitat 16°C. Salmonid spawning, rearing and migration 17.5°C. Salmonid rearing and migration only 17.5°C.	MWMT in reach during the following life history stages: Incubation <2°C or <6°C; rearing <4°C or >13-15°C; spawning <4°C or >10°C. Temperatures in areas used by adults during the local spawning migration sometimes exceed 15°C. OR 7-day average daily maximum temperature standards are exceeded by ≤15%.	MWMT in reach during the following life history stages: Incubation <1°C or <6°C; rearing >15°C; spawning <4°C or >10°C. Temperatures in areas used by adults during the local spawning migration sometimes exceed 15°C. OR 7-day average daily maximum temperature standards are exceeded by ≤15%.
	Turbidity	Turbidity NTU's	Performance Standard: Acute <70 NTU, Chronic <50 NTU. For streams that naturally exceed these standards: Turbidity should not exceed natural baseline levels at the 95% CL <15% exceedance. OR Turbidity shall not exceed: 5 NTU over background when the background is 50 NTU or less; or a 10% increase in turbidity when the background turbidity is more than 50 NTU (WDOE 173-201A-200)	15-50% exceedance.	>50% exceedance.
	Chemical Contamination/ Nutrients	Metals/Pollutants, pH, DO, Nitrogen, Phosphorus	Low levels of chemical contamination from landuse sources, no excessive nutrients, no CWA 303d designated reaches. OR Washington State Department of Ecology standards 173-201A-200.	Moderate levels of chemical contamination from landuse sources, some excess nutrients, one CWA 303d designated reach.	High levels of chemical contamination from landuse sources, high levels of excess nutrients, more than one DWA 303d designated reach.

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Reach Scale					
Habitat Access	Physical Barriers	Main Channel Barriers	No man-made barriers present in the mainstem that limit upstream or downstream migration at any flow.	Man-made barriers present in the mainstem that prevent upstream or downstream migration at some flows that are biologically significant.	Man-made barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	Gravels or small cobbles make up >50% of the bed materials in spawning areas. ≤12%fines/sand (<2 mm) in spawning gravel.	Gravels or small cobbles make up 30-50% of the bed materials in spawning areas. 12-17% fines (<2 mm) in spawning gravel.	Gravels or small cobbles make up <30% of the bed materials in spawning areas. >17% fines (<2 mm) in spawning gravel.
	LWM	Pieces per Mile at Bankfull	>42.5 pieces/mile >12" diameter and >35 ft long (based on data from Fox and Bolton 2007); adequate sources of woody debris available for both long- and short-term recruitment. And, at least 3 jams/mile based on Reach 5 as a reference reach for jam quantities.	Current levels are able to maintain the minimum requirements for an "adequate" rating, but potential sources for long-term woody debris recruitment are lacking in order to maintain these current levels. And less than 3 jams/mile.	Current levels are not at meeting the minimum requirements for an "adequate" rating, and potential sources of woody debris for short- and/or long-term recruitment are lacking as well. And no jams/mile.
	Pools	Pool Frequency and Quality; presence of large pools.	Pool frequency: Number of pools/mile for a given channel width: Channel width of 65-100 ft = 4 pools/mile. Pools have good cover and cool water with only a minor reduction in pool volume from fine sediment. Each reach has many large pools >1 m (3 ft) deep with good fish cover.	Pool frequency is similar to the values for the "adequate" rating, but pools have inadequate cover/temperature and/or there has been a moderate reduction of pool volume by fine sediment. Reaches have few large pools (>1 m deep) present with good fish cover.	Pool frequency is considerably lower than the values for the "adequate" rating. Pools also have inadequate cover/temperature and there has been a major reduction of pool volume by fine sediment. Reaches have no large pools (>1 m deep) with good fish cover.
	Off-Channel Habitat	Connectivity with Main Channel	Reach has many ponds, oxbows, backwaters, and other off-channel areas with cover. Side channels are low energy areas. No man-made barriers present along the mainstem that prevent access to off-channel areas.	Reach has some ponds, oxbows, backwaters, and other off-channel areas with cover. Side channels are high energy areas. Man-made barriers are present that prevent access of off-channel habitat at some flows that are biologically significant.	Reach has few or no ponds, oxbows, backwaters, and other off-channel areas. Man-made barriers are present that prevent access to off-channel habitat at multiple or all flows.
Channel	Dynamics	Floodplain Connectivity	Floodplain areas are hydrologically linked to main channel within the context of the local process domain; overbank flows occur and maintain wetland functions, and riparian vegetation and succession. Naturally confined channels are considered adequate.	Reduced linkage of wetland, floodplains and riparian areas to main channel in reaches with historically strong connectivity; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function and riparian vegetation/succession.	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain, and riparian areas relative to historical connectivity; wetland extent drastically reduced and riparian vegetation/succession is altered significantly.
		Bank Stability/Channel Migration	Channel is migrating at or near natural rates.	Limited amount of channel migration is occurring at a faster/slower rate relative to natural rates, but significant change in channel width or planform is not detectable; large woody debris is still being recruited.	Little or no channel migration is occurring because of human actions preventing reworking of the floodplain and large woody debris recruitment; or channel migration is occurring at an accelerated rate such that channel width has at least doubled, possibly resulting in a channel planform change, and sediment supply has noticeably increased from bank erosion.
		Vertical Channel Stability	No measurable trend of aggradation or incision and	Measurable trend of aggradation of incision that has the potential to, but has not yet caused,	Enough incision has occurred that the floodplain and off-channel habitat areas have been

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
			no visible change in channel planform.	disconnection of the floodplain or a visible change in channel planform (e.g. single thread to braided.)	disconnected; or enough aggradation has occurred to create a visible change in channel planform (e.g. single thread to braided.)
Riparian Vegetation	Condition	Structure	>80% species composition, seral stage, and structural complexity are consistent with potential native community.	50-80% species composition, seral stage, and structural complexity are consistent with potential native community.	<50% species composition, seral stage, and structural complexity are consistent with potential native community.
		Disturbance (Human)	>80% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; <20% disturbance in the floodplain (e.g. agriculture, residential, roads, etc.); <2 miles/miles2 road density in the floodplain.	50-80% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; 20-50% disturbance in the floodplain (e.g. agriculture, residential, roads, etc.); 2-3 miles/miles2 road density in the floodplain.	<50% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; >50% disturbance in the floodplain (e.g. agriculture, residential, roads, etc.); >3 miles/miles2 road density in the floodplain.
		Canopy Cover	Trees and shrubs within one site potential tree height distance have >80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance have 50-80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance have <50% canopy cover that provides thermal shading to the river.

3 REI Ratings

This section discusses the results for each indicator, rated at either the reach-scale or watershed-scale for all six reaches.

3.1 WATERSHED-SCALE RATINGS

General Characteristics	General Indicators	Specific Indicators	Rating	Discussion
Watershed Scale				
Watershed Condition	Effective Drainage Network and Watershed Road Density	Increase in Drainage Network/Road Density	At Risk Condition	Road density was calculated using USFS roads and Chelan County roads shapefiles. Road density was calculated for the watershed area contributing to the study area as determined in the Streamstats online mapper application (USGS 2014). Areas of overlap in the data sets were removed to eliminate over overestimation of road density. Road density for the contributing watershed was 1.54 miles/mile2, which puts the study area within the At Risk category.
	Disturbance Regime	Natural/Human Caused	At Risk Condition	This disturbance history rating reflects historical accounts of riparian and hillslope timber harvest, mining, grazing, agriculture and roads and residential development. These activities have been shown to create channel instability and decrease the ability of the system to respond to natural disturbance regimes such as fire or flood. The watershed has a naturally frequent fire regime, annual snowmelt flooding and infrequent rain-on-snow floods, and active tributary alluvial fans. The channel has reduced complexity and floodplain connection, and is shown to be incising in some areas and aggrading in others. Furthermore, fire suppression within the basin has elevated the risk of potential catastrophic disturbance (e.g. stand-replacing fire) to the study area. These alterations include past human disturbance to which the system is still recovering from, or on-going "press" disturbances that have a persistent and long-lasting impact. Based on this information, the Twisp receives a rating of At Risk.
Flow/Hydrology	Streamflow	Change in Peak/Base Flows	At Risk Condition	The hydrology of the watershed contributing to the Middle Twisp study area on the Twisp River is driven by a combination of precipitation and snowmelt. Annual snowmelt flooding in the spring and early summer, with infrequent rain-on-snow floods dominates the season streamflow pattern in the basin. Snowmelt runoff is primarily driven by changes in ambient air temperature, snowpack mass, and the elevation distribution of the season's snowpack. Peak runoff usually occurs from April through July, with the highest rates typically in late June. The Twisp River typically returns to baseflow by late August. Many of the land-use activities and channel alterations affecting the Twisp River have been shown to change one or all of the above-mentioned attributes of peak flows in other basins. Climate change models indicate that rainfall is expected to increase one to two percent by 2040, and four percent by 2080 (e.g. Mote and Salanthe 2009) and likely result in an increase in winter stream flows, earlier and lower peak runoff, and lower summer baseflows. These analyses suggest that human-induced climate change is likely to have an effect on the magnitude, timing, duration, and frequency of streamflows. Based on the effects of past watershed management, and the potential effects of climate change, this indicator is rated At Risk for the middle Twisp River.
Water Quality	Temperature	Daily maximum and 7-day mean daily maximum temperatures	Unacceptable Risk Condition	Two excursions above temperature threshold limits in 1989 resulted in the original listing of the Twisp River on the 1996 Washington state 303(d) list (Andonaegui 2000). As of 2012, the Twisp River (measured at RM 26.096-28.154) is listed as a "waters of concern" by the Department of Ecology for temperature excursions beyond the criterion from measurements collected in 1999 at station 'Twisp River at War Creek CG'. Additional recent measurements show that the Lower Twisp River continues to have high temperatures throughout the summer months. Near the mouth of the Twisp the highest 7-day average daily maximum temperature recorded during the summer exceeded 16°C by about 26% in 2001 and 30% in 2005. Threshold criterion were also exceeded by over 15% at two other locations in those years (USBR 2008 App I). Temperature data from 2008 and 2009 show 7-day average daily maximum temperatures with over 15% exceedance of 16°C consistently from mid-July through mid-September. No more recent temperature data is available for the Middle Twisp study area at this time, although it is worth noting there are several natural springs around RM 16-18 and potentially RM 7-9.6 that contribute localized cooling and cool water recharge for the Middle Twisp River.
	Turbidity	Turbidity NTU's	N/A	Data was unavailable.
	Chemical Contamination/ Nutrients	Metals/Pollutants, pH, DO, Nitrogen, Phosphorus	N/A	Data was unavailable.

3.2 REACH-SCALE RATINGS

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
Habitat Access	Physical Barriers	Main Channel Barriers	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
			There are no anthropogenic barriers in the main channel in Reach 1.	There are no anthropogenic barriers in the main channel in Reach 2.	There are no anthropogenic barriers in the main channel in Reach 3.	There are no anthropogenic barriers in the main channel in Reach 4.	There are no anthropogenic barriers in the main channel in Reach 5.	There are no anthropogenic barriers in the main channel in Reach 6.
Habitat Quality	Substrate	Dominant Substrate/ Fine Sediment	Adequate	At Risk	Adequate	At Risk	Adequate	At Risk
			Two pebble counts: Gravel+Cobble: 76% + 65% Sand: 7% + 9% Ocular Average Gravel+Cobble: 76% Sand: 5%	Two pebble counts: Gravel+Cobble = 72% + 70% Sand = 14% + 13% Ocular Average Gravel+Cobble = 73% Sand = 7%	Two pebble counts: Gravel+Cobble = 90% + 85% Sand = 9% + 5% Ocular Average Gravel+Cobble = 86% Sand = 7%	Two pebble counts: Gravel+Cobble = 74% + 74% Sand = 13% + 12% Ocular Average Gravel+Cobble = 87% Sand = 5%	Two pebble counts: Gravel+Cobble = 87% + 90% Sand = 10% + 10% Ocular Average Gravel+Cobble = 94% Sand = 6%	Two pebble counts: Gravel+Cobble = 87% + 91% Sand = 13% + 4% Ocular Average Gravel+Cobble = 93% Sand = 4%
	LWM	Pieces per Mile at Bankfull	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Adequate	Unacceptable
			Total pieces = 55 M+L pieces/mi = 12 Jams/mi = 0 Limited availability of large wood for future recruitment.	Total pieces = 18 M+L pieces/mi = 11 Jams/mi = 0 Limited availability of large wood for future recruitment.	Total pieces = 131 M+L pieces/mi = 18 Jams/mi = 0.82 Minimal availability of large wood for future recruitment.	Total pieces = 89 M+L pieces/mi = 9 Jams/mi = 1.45 Minimal availability of large wood for future recruitment.	Total pieces = 537 M+L pieces/mi = 54 Jams/mi = 3.86 Only moderate large wood available for future recruitment due to the young seral stage of the riparian vegetation.	Total pieces = 169 M+L pieces/mi = 36 Jams/mi = 1.55 Moderate availability of large wood for future recruitment.
	Pools	Pool Frequency and Quality; presence of large pools.	At Risk	Unacceptable	At Risk	At Risk	Adequate	At Risk
			Total Pools = 5 Pools/mi = 3.7 Pools > 3 ft = 1 Pools had moderate cover	Total Pools = 1 Pools/mi = 1.54 Pools > 3 ft = 0	Total Pools = 11 Pools/mi = 4.5 Pools > 3 ft = 3 Only 3 pools deeper than 3 ft with less than adequate cover	Total Pools = 6 Pools/mi = 4.3 Pools > 3 ft = 2 Only two pools deeper than 3 ft with moderate cover	Total Pools = 34 Pools/mi = 13.2 Pools > 3 ft = 14 Pools had moderate cover	Total Pools = 15 Pools/mi = 7.7 Pools > 3 ft = 2 Only two pools deeper than 3 ft with moderate cover
	Off-Channel Habitat	Connectivity with Main Channel	At Risk	Adequate	At Risk	At Risk	Adequate	At Risk
			Total SC = 1 Fast water = 1 Slow water = N/A Cover = limited Is mostly a naturally	Total SC = 0 Fast water = N/A Slow water = N/A Cover = N/A Is a naturally confined	Total SC = 2 Fast water = N/A Slow water = 2 Cover = limited SC total 2% of the reach	Total SC = 4 Fast water = 3 Slow water = 1 Cover = limited SC total 2% of the reach	Total SC = 19 Fast water = 1 Slow water = 18 Cover = moderate-adequate	Total SC = 2 Fast water = N/A Slow water = 2 Cover = moderate

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
			confined channel, therefore would expect to have some, but not substantially greater amounts off-channel habitat.	channel . Would not expect to have off-channel habitat.	length. Historically more side channels would be expected in this reach.	length. Historically more side channels would be expected in this reach.	One side channel was approximately 1 mile long. Total length of side channels was 18% of the reach length.	SC total 1% of the reach length. Historically more side channels would be expected in this reach.
Riparian Vegetation	Condition	Structure	Unacceptable	Unacceptable	At risk	Unacceptable	At Risk	At Risk
			25% small tree 75% grass/forb Seral stage = should see more patches of mature trees Species composition is adequate Structural complexity is lacking 43.1% of 100 ft riparian buffer is cleared	100% small tree Seral stage = should see more patches of mature trees Species composition should be more varied coniferous over story and hardwood understory species Structural complexity is completely lacking 11.6% of 100 ft riparian buffer is cleared	29% small tree 29% grass/forb 14% shrub/seedlg 14% sapling/pole 14% M+L trees Seral stage = should see more patches of mature Cottonwoods, Douglas Fir, and Ponderosa Pine. Species composition is adequate Structural complexity is adequate 12.9% of 100 ft riparian buffer is cleared	60% small tree 20% grass/forb 20% no vegetation Seral stage = should see more patches of mature Cottonwoods, Douglas Fir, and Ponderosa Pine, which would contribute to a healthier structural complexity as well. Species composition is lacking 54.1% of 100 ft riparian buffer is cleared	21% small tree 7% no vegetation 43% shrub/seedlg 29% sapling/pole Seral stage = should see more patches of mature trees closer to the channel, since larger, older trees are present within reach, but outside of the 100 ft riparian buffer. This would contribute to a healthier structural complexity. Species composition is adequate 6.4% of 100 ft riparian buffer is cleared	63% small tree 12% no vegetation 25% shrub/seedlg Seral stage = should see slightly more patches of mature Cottonwoods, Douglas Fir, and Ponderosa Pine, which would contribute to a healthier structural complexity. Species composition is adequate. 4.2% of 100 ft riparian buffer is cleared
		Disturbance (Human)	Unacceptable	Unacceptable	At Risk	Unacceptable	At Risk	At Risk
			Disturbed floodplain = 70% Road Density = 3.45 miles/miles2 Very few medium-large trees within the riparian buffer available for recruitment of the river via channel migration	Disturbed floodplain = 60% Road Density = 0 miles/miles2 Very few medium-large trees in the riparian buffer available for recruitment of the river via channel migration	Disturbed floodplain = 50% Road Density = 1.80 miles/miles2 Moderate amounts of medium-large trees in the riparian buffer available for recruitment of the river via channel migration	Disturbed floodplain = 80% Road Density = 2.88 miles/miles2 Minimal amounts of medium-large trees in the riparian buffer available for recruitment of the river via channel migration	Disturbed floodplain = 30% Road Density = 1.33 miles/miles2 Moderate-to-high amounts of medium trees in the riparian buffer available for recruitment of the river via channel migration	Disturbed floodplain = 40% Road Density = 0.62 miles/miles2 Adequate amounts of medium-large trees in the riparian buffer available for recruitment of the river via channel migration

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
		Canopy Cover	Unacceptable Canopy Cover = 30% Thermal Shading = minimal Banks visible in patches in aerial photography.	Unacceptable Canopy Cover = 40% Thermal Shading = minimal Banks visible in patches in aerial photography.	Unacceptable Canopy Cover = 50% Thermal Shading = moderate Reach has some large expanses of development with no canopy cover at all. Banks visible at all times in aerial photography.	Unacceptable Canopy Cover = 20% Thermal Shading = minimal Stream and banks highly visible at several portions of the reach.	At Risk Canopy Cover = 70% Thermal Shading = moderate (patchy) Young-Middle age trees primarily provide thermal shading. Bank area and stream surface only visible in patches due to recent channel migrations.	At Risk Canopy Cover = 50% Thermal Shading = moderate (patchy) Lower portions of reach have highly visible stream surface and banks while upper portions are much more shaded with larger trees.
Channel	Dynamics	Floodplain Connectivity	At Risk Reach is naturally confined throughout most of its length. Where floodplains exist, there is reduced connectivity of the floodplain to the main channel. Roadways and push-up levees have a moderate impact on floodplain inundation rates in a few locations. Floodplain Road Density = 3.45 miles/miles^2 Given only an At Risk rating due to high natural confinement.	Adequate The channel is naturally confined by glacial terraces and alluvial fan deposits. The modeled flows (2-100 year event) were confined to the main channel and no floodplain or side channels were observed in this reach, which is additionally constrained by the road and residential alterations. Floodplain Road Density = 0 miles/miles^2 Given an Adequate rating due to natural confinement.	At Risk Reduced floodplain connectivity due to roads, bank armoring, and push-up levees. There has also been fill and grading in the floodplain, particularly in the upstream portion of the reach. Floodplain Road Density = 1.80 miles/miles^2	At Risk Floodplain connectivity is reduced by the two bridge crossings and associated fill on the approaches. There are also intermittent push-up levees and moderate amounts of past floodplain filling and grading. Floodplain Road Density = 2.88 miles/miles^2	At Risk Floodplain connectivity is high in the downstream half of the reach but is affected by levees, fill, and excavated ponds on river-left in the upstream half. These features reduce the extent, frequency, and patterns of floodplain inundation. Floodplain Road Density = 1.33 miles/miles^2	Adequate The bridge and approach fills at the upstream end impair floodplain inundation rates and patterns. On river-right at the downstream end, floodplain grading has impaired floodplain inundation patterns. Floodplains are relatively well-connected throughout the remainder of the reach. Floodplain Road Density = 0.62 miles/miles^2

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
		Bank Stability/ Channel Migration	At Risk	At Risk	At Risk	At Risk	At Risk	Adequate
			Many of the streambanks in the reach are affected by bank armoring, mostly riprap along the road embankment or used to protect residential property. However, the reach is naturally laterally constricted by terraces and hillslopes on both sides of the channel throughout much of the reach. Given only an At Risk rating due to high natural confinement.	Much of the river-left channel margin is affected by road embankments comprised of fill and riprap. There are also houses with access roads along the river and vegetation impacts up to the top of bank. Given only an At Risk rating due to high natural confinement.	Portions of the reach are affected by bank armoring, which impairs streambank complexity and reduces natural rates of channel migration. Push-up levees and riprap are present intermittently along river-left. Clearing and grading for residential and recreational uses has taken place in the active floodplain.	There is bank armoring associated with the two bridges but otherwise not extensive armoring. Floodplain grading and push-up levees have some impact on channel migration, as does the approach road fills at the two bridge crossings.	There are a few areas of riprap protecting houses and private property. These occur at the upstream end on river-left and at the downstream end on river-right. Bank migration is impaired at these locations. Much of the remainder of the reach is migrating near (or slightly above) natural rates.	The bridge at the upstream end of the reach has some impact on bank migration, but overall, there are minimal impacts on bank stability and channel migration processes.
		Vertical Channel Stability	At Risk	Adequate	At Risk	At Risk	At Risk	At Risk
			Floodplain alterations and channelization have likely resulted in some degree of vertical incision. Incision is likely limited by coarse substrate, including lag from glacial and tributary fan sources.	The channel is a single-thread boulder-step bed with a cobble/gravel/boulder substrate that limits vertical incision and provides vertical stability.	There are signs of vertical instability based on abandoned floodplain surfaces. Channelization and floodplain filling and grading appear to have caused incision in several locations, especially in the Jennings project area. Limited presence of gravel bars, even in very unconfined portions of the channel, suggest a general trend of incision.	The two bridge crossings create constrictions that have likely resulted in channel incision. Push-up levees and floodplain fill and grading have likely contributed to downcutting. Flood scars on the now-abandoned surface on river-left (mid-reach) suggests channel incision.	Due to its low gradient and wide floodprone width, this reach provides relatively high sediment storage capacity. It is highly dynamic, likely more than historical conditions due to loss of large trees in riparian areas and in log jams.	There is vertical instability at the upstream bridge crossing, which creates a constriction that has resulted in channel incision. The remainder of the reach is near the natural range of vertical stability.

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