APPENDICES

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APPENDIX A

Reach-based Ecosystem Indicators

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Appendix A

Reach-based Ecosystem Indicators (REI) Version 1.1

The reach-based ecosystem indicators table has been compiled from literature review, data contained in the *Methow Subbasin Geomorphic Assessment, Okanogan County, Washington* (Reclamation, 2008), *Geomorphology and Hydraulic Modeling for the Middle Methow River from Winthrop to Twisp* (Reclamation, 2010), and from new data collected for this reach assessment. The ranges of criteria presented here are not absolute and should be adjusted to each unique subbasin as data become available. Review and evaluation was performed through an iterative process by the interdisciplinary multi-agency team. Edward W. Lyon, Jr. was principal author in compiling data for the Reach-based Ecosystem Indicators (REI); and Jennifer Molesworth, Jennifer Bountry, David Hopkins, and Susan Prichard are acknowledged for providing selected input pertaining to their individual disciplines.

General Regional Characteristics

At the regional spatial scale, characteristics evaluated include the following information ecoregion, drainage basin, valley segments, and channel segments that inform planners and evaluators on the regional setting where the reach assessment occurred. These regional characteristics are recommended in the *Monitoring Strategy*, and by NOAA Fisheries and U.S. Fish and Wildlife Service (Skidmore and others 2009).

Watershed Characteristics

At the watershed/subwatershed spatial scales several reach-based ecosystem indicators are evaluated as general indicators to inform planners and evaluators on the condition of the watershed/subwatershed. At this scale an overall watershed/subwatershed condition can be addressed to determine if deficiencies at the reach-scale are symptomatic of a larger problem that should be addressed that impact the sustainability and effectiveness of implemented habitat actions.

Reach Characteristics

Physical Variables

At the reach spatial scale individual reach-based ecosystem indicators are evaluated to inform planners and evaluators on the indicators that are in an Adequate, At Risk, or Unacceptable Condition. These reach-based ecosystem indicators are typically the focus of implementation habitat actions.

GENERAL REGIONAL CHARACTERISTICS

REGIONAL SETTING

Ecoregion	Bailey Classification[1]	Domain - Humid Temperate Domain*	Division – Marine Regime Mountains Redwood Forest Province*	Province – Cascade Mixed Forest-Coniferous Forest-Alpine Meadow Province (M242C)*	Section – Eastern Cascades Section*
	Omernik Classification[1]	Okanogan Valley*		N/A	N/A
	Physiography[1]	Division – Pacific Mountain System*		Province – Cascade-Sierra Mountains (23)*	Section – Northern Cascade Mountains*
	Geology[2]	Parent Material – Metamorphic and Igneous Rocks[3]		Lithology – Alluvium*	N/A

Data from Morrison and Smith (2007).
[1] Bain and Stevenson (1990).
[2] Overton et al. (1997).
[3] Stoffel et al. (1991).

DRAINAGE BASIN CHARACTERISTICS

Geomorphic Features	Methow Basin Area	Basin Relief	Drainage Density	Hydrologic Unit Code	Strahler Stream Order	Stream Classification	Land Ownership
	1,208,746 acres (WRIA 48)	~8,500' - 800'	2.62*	170200080605	6	Class A (Excellent)	89% public 11% private

*Drainage density was calculated using the Washington/Oregon Hydrography Frameworks stream network at 1:24,000 and calculating against the National Hydrography's Subbasin HUC for the Methow Subbasin.

VALLEY SEGMENT CHARACTERISTICS

Valley Characteristics	Middle Methow Subwatershed	Valley Bottom Type	Valley Bottom Width (Avg.)	Valley Bottom Gradient (Avg.)	Valley Confinement			Channel Patterns
	162,834 acres	Wide mainstream valley *(F3)*	1400 ft	0.4%	RM 50.0-47.0 Moderately Confined	RM 47.0-41.3 Unconfined	RM 41.3-41.0 Confined	Variable

CHANNEL SEGMENT CHARACTERISTICS

Channel Characteristics	Valley Type	Elevation	Channel Type (Rosgen 1996)		Bed-form Type	Channel Gradient	Sinuosity
	Alluvial	1715' – 1580'	RM 50.0-49.1 (F)	RM 49.1-40.9 (C)	Pool-riffle	0.3%	1.2

WATERSHED CHARACTERISTICS

GENERAL INDICATOR: EFFECTIVE DRAINAGE NETWORK AND WATERSHED ROAD DENSITY

Criteria: The following criteria were developed by USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Watershed Condition	Effective Drainage Network and Watershed Road Density	Zero or minimum increases in active channel length correlated with human caused disturbance. And Road density <1 miles/miles^2.	Low to moderate increase in active channel length correlated with human caused disturbances. And Road density 1-2.4 miles/miles^2.	Greater than moderate increase in active channel length correlated with human caused disturbances. And Road density >2.4 miles/miles^2.

Data: Road classifications for the Methow subbasin (Morrison and Smith 2007).

HUC 6 Name	Total Road (miles)	Area of HUC 6 (mi^2)	Road Density (mi/mi^2)	Condition (based on criterion)
Andrews Creek	0.559 mi/mi^2 mi	34.236 mi^2	0.02 mi/mi^2	Adequate
Bear Creek	37.618 mi	16.834 mi^2	2.23 mi/mi^2	At Risk
Benson Creek	88.968 mi	39.738 mi^2	2.24 mi/mi^2	At Risk
Black Canyon Creek	25.942 mi	15.942 mi^2	1.63 mi/mi^2	At Risk
Boulder Creek	22.556 mi	20.460 mi^2	1.10 mi/mi^2	At Risk
Buttermilk Creek	55.488 mi	37.162 mi^2	1.49 mi/mi^2	At Risk
Cedar Creek	2.330 mi	30.807 mi^2	0.08 mi/mi^2	Adequate
Chewuch River/Kay Creek	1.628 mi	33.946 mi^2	0.05 mi/mi^2	Adequate
Chewuch River/Pearrygin Creek	100.736 mi	39.730 mi^2	2.54 mi/mi^2	Unacceptable
Cub Creek	75.559 mi	24.382 mi^2	3.10 mi/mi^2	Unacceptable
Davis Creek	84.966 mi	40.317 mi^2	2.11 mi/mi^2	At Risk
Eagle Creek	1.193 mi	13.440 mi^2	0.09 mi/mi^2	Adequate

HUC 6 Name	Total Road (miles)	Area of HUC 6 (mi^2)	Road Density (mi/mi^2)	Condition (based on criterion)
Early Winters Creek	28.192 mi	49.626 mi^2	0.57 mi/mi^2	Adequate
Eight Mile Creek	91.913 mi	46.487 mi^2	1.98 mi/mi^2	At Risk
Falls Creek	38.283 mi	26.730 mi^2	1.43 mi/mi^2	At Risk
Goat Creek	68.724 mi	35.977 mi^2	1.91 mi/mi^2	At Risk
Gold Creek	123.360 mi	73.583 mi^2	1.68 mi/mi^2	At Risk
Headwaters Chewuch River	0.00 mi	52.178 mi^2	0.00 mi/mi^2	Adequate
Lake Creek	3.834 mi	53.518 mi^2	0.07 mi/mi^2	Adequate
Libby Creek	76.895 mi	40.209 mi^2	1.91 mi/mi^2	At Risk
Little Bridge Creek	38.711 mi	24.417 mi^2	1.59 mi/mi^2	At Risk
Lower Beaver Creek	84.637 mi	49.811 mi^2	1.70 mi/mi^2	At Risk
Lower Lost River	7.332 mi	66.413 mi^2	0.11 mi/mi^2	Adequate
Lower Middle Methow River	114.45 mi	50.54 mi^2	2.26 mi/mi^2	At Risk
Mainstem Lower Chewuch River	94.815 mi	38.402 mi^2	2.47 mi/mi^2	Unacceptable
Mainstem Lower Methow River	77.603 mi	88.958 mi^2	0.87 mi/mi^2	Adequate
Mainstem Lower Twisp River	88.502 mi	43.965 mi^2	2.01 mi/mi^2	At Risk
Mainstem Upper Chewuch River	10.787 mi	27.660 mi^2	0.39 mi/mi^2	Adequate
Mainstem Upper Twisp River	61.615 mi	63.058 mi^2	0.98 mi/mi^2	Adequate
Methow River/Texas Creek	40.339 mi	31.657 mi^2	1.27 mi/mi^2	At Risk
Mouth of Methow River	38.674 mi	24.734 mi^2	1.56 mi/mi^2	At Risk
North Fork Boulder Creek	74.012 mi	60.533 mi^2	1.22 mi/mi^2	At Risk
Rattlesnake Creek	46.267 mi	38.402 mi^2	1.20 mi/mi^2	At Risk
Robinson Creek	1.150 mi	19.730 mi^2	0.06 mi/mi^2	Adequate
South Creek	0.410 mi	15.799 mi^2	0.03 mi/mi^2	Adequate
South Fork Lost River	0.00 mi	36.147 mi^2	0.00 mi/mi^2	Adequate
Squaw Creek	30.105 mi	33.301 mi^2	0.90 mi/mi^2	Adequate
Twenty Mile Creek	18.231 mi	42.228 mi^2	0.43 mi/mi^2	Adequate
Upper Beaver Creek	144.493 mi	62.614 mi^2	2.31 mi/mi^2	At Risk
Upper Lost River	0.00 mi	65.247 mi^2	0.00 mi/mi^2	Adequate
Upper Middle Methow River	84.606 mi	54.568 mi^2	1.55 mi/mi^2	At Risk
Upper Twisp River	2.169 mi	20.100 mi^2	0.11 mi/mi^2	Adequate
War Creek	3.337 mi	27.402 mi^2	0.12 mi/mi^2	Adequate
West Fork Methow River	4.710 mi	49.772 mi^2	0.09 mi/mi^2	Adequate
Windy Creek	11.868 mi	22.452 mi^2	0.53 mi/mi^2	Adequate
Wolf Creek	10.607 mi	40.363 mi^2	0.26 mi/mi^2	Adequate
Grand Total	**2018.176 mi**	**1823.579 mi^2**	**1.11 mi/mi^2**	**At Risk**

Narrative:

Road density for the Methow subbasin is 1.11 mi/mi2 which meets the At Risk Condition of the criterion. Road density for the Upper Middle Methow River is 1.55 mi/mi2 and the Lower Middle Methow River is 2.26 mi/mi2 which meet the At Risk Condition of the criterion. Higher road densities within the Upper Middle Methow River and Lower Middle Methow River watersheds negatively impact the routing of overland flows. This is primarily due to road embankments that re-direct or pond overland flows.

Overall, the effective drainage network and road density general indicators are qualitatively interpreted to be in an At Risk Condition primarily based on road densities and field observations.

GENERAL INDICATOR: DISTURBANCE REGIME (NATURAL/HUMAN)

Criteria: The following criteria were modified from USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Watershed Condition	Disturbance Regime	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 part of the watershed. The channel is simplified, providing little hydraulic complexity in the form of pools or side channels. Natural processes are unstable.

Narrative:
About 400 fires have been recorded in the Upper Methow Watershed with about 75% of them being caused by lightning (MVRD, 1996). In general, severe fires have burned in the Upper Methow Watershed every 100 to 300 years and fire frequency has not changed significantly since the 1920s. In the lower elevations of the Methow Valley fires were historically frequent with an estimated 2- to 18-year return interval between 1700 and 1900 (Ohlson 1996). The riparian forests in the Methow Valley are dominated by broadleaf deciduous trees and shrubs, which intrinsically are not as flammable as coniferous trees. Valley floor fires were occasionally set by native inhabitants; otherwise fires were probably episodic in the riparian forests, occasionally creeping into riparian zones from adjacent forests and grasslands.

Recent fires in the Methow subbasin include the Tripod Fire (2006), Quartz Mountain Fire (2004), Farewell Fire (2003), Needles Creek Fire (2003), Thirtymile Fire (2001), and Whiteface Fire (1994). Three recent fires have burned with varying intensities throughout about 70% of the Chewuch River watershed (primary tributary to the Middle Methow River): (1) Thirtymile fire burned approximately 9,300 acres; (2) Farewell fire perimeter included approximately 79,000 acres; and (3) Tripod fire burned approximately 175,000 acres. After an area burns there is generally an increase in soil erosion and mass wasting until soils are re-stabilized by vegetation. Burn areas may also increase water temperatures as the vegetative cover is removed and surface waters are exposed to direct sunlight. Fires are an integral part of the ecosystem. They rejuvenate vegetation, and provide coarse-fine sediment and large woody debris to the fluvial system.

Alpine and continental glacial advances have occurred several times in the Methow subbasin. The alpine glaciers were the most erosive and have carved U-shaped valleys leaving steep valley walls and hanging valleys upon their retreat. Steep headwater streams drain the mountainous terrane that is subject to naturally occurring, episodic debris flows and torrents, rockslides and landslides that deliver coarse sediment to the major tributaries and the Methow River.

The subbasin was settled by Euro-Americans in the late 19th century and established an economy based on agriculture, forestry and mining. The basin is now experiencing a demographic shift to tourism, recreation and general goods and services industries. This shift is resulting in the conversion of agricultural areas to residential and commercial development. Development along the floodplain and adjacent valley bottoms can increase the percentage of cleared and impervious areas that have a cumulative impact on streamflows, vegetation, and overall water quality.

The interpretation is that fire is a relatively short-term but frequent environmental disturbance. However, development in the valley bottoms is a long-term disturbance that could have adverse impacts. Overall, the disturbance regime general indicator is qualitatively interpreted to be in an **At Risk Condition** due to continued valley bottom development resulting in the disruption of floodplain processes and restricting lateral channel migration; and due to fire suppression that results in increased fire severity.

GENERAL INDICATOR: FLOW/HYDROLOGY

Criteria: The following criteria were developed by USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Watershed Condition	Flow/hydrology	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.

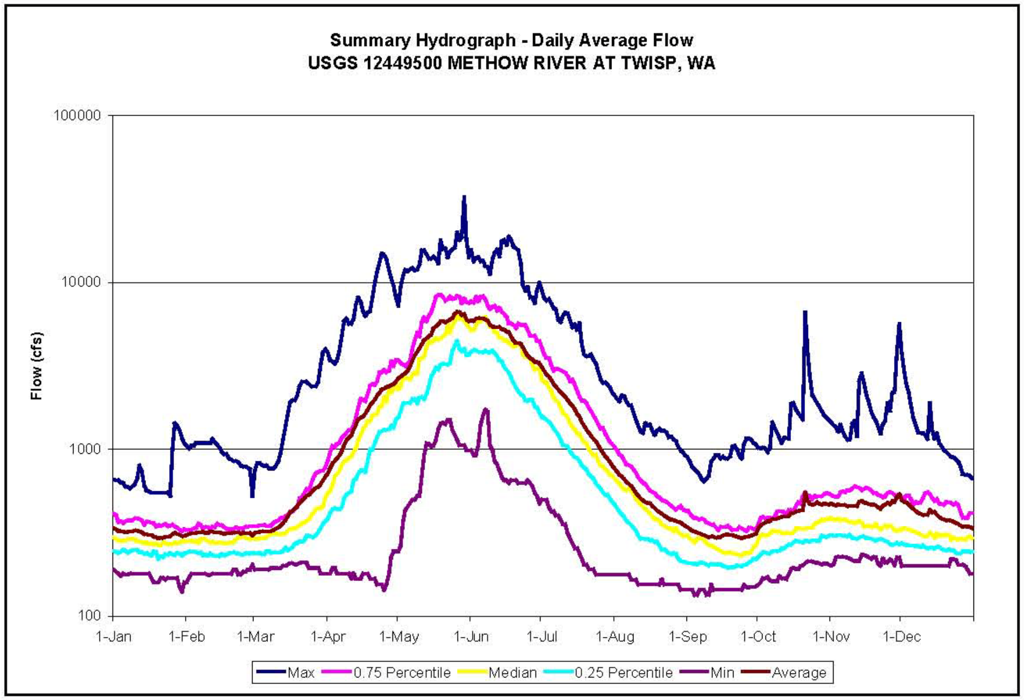

Figure 1. Mean daily flow statistics for Methow River at Twisp, WA. (Reclamation 2007).

Narrative:
In general, forestry practices in the upper areas of the Methow watershed can result in immediate and significant changes in the discharge, duration, and timing of flow events, especially if a dense road network accompanies the operations (Burton 1997). In addition, agricultural land use changes the watershed conditions that affect rates of precipitation interception, infiltration, and evapotranspiration; and surface water diversions for agriculture production reduce in-stream flows. When combined with associated changes in surface roughness, these alterations have multiple impacts on the rainfall-runoff relationship (Skidmore and others 2009).

The Methow River is a snowmelt dominated system that is characterized by a spring snowmelt runoff with low summer and winter flows, except for occasional rain-on-snow events that occur in late fall (November and December) and late winter (January and February) and occasional mid-summer severe thunderstorms or area-wide heavy rainfall events (Figure 1). Timber harvests still occur on Forest Service lands in the Methow subbasin, but practices have changed in that only partial cuts and thinning are used to promote forest health, and the existing road network is utilized for access. Much of the valley bottoms have been developed for agricultural and residential uses along the Middle and Lower Methow Rivers. Finally, urbanization converts significant areas of watershed land surfaces to an impermeable condition, reducing infiltration capacity and fundamentally changing the character of the runoff hydrograph from storm events. The severity of these impacts varies with development density and watershed size (Booth and Jackson 1997) There is currently not a lot of urbanization occurring throughout the Methow subbasin, with the exceptions of Mazama, Winthrop, and Twisp.

Ongoing climate change will likely affect the flow and hydrology within the Methow subbasin. The impacts are currently not known, however, the U.S. Geological Survey is initiating a pilot study in the Methow subbasin to address this issue.

Indirect impacts on the flow/hydrology regime in the Methow subbasin are pervasive, and include forest practices, floodplain development, irrigation diversions, urbanization, and the routing of flows caused by higher road densities. There are several channel segments along the Methow River and its tributaries that are listed by the Washington Department of Ecology as Category 4C for insufficient instream flows due primarily to irrigation diversions. Overall, the flow/hydrology general indicator is qualitatively interpreted to be in an **At Risk Condition**.

GENERAL INDICATOR: WATER QUALITY

Criteria: The following criteria were adapted and modified from the USFWS (1998) and Washington State Department of Ecology.

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Water Quality and Quantity	Quantity/Temperature/Chemical Contamination/ Nutrients	Adequate instream flows for habitat, low levels of water quality impairments from landuse sources, no excessive nutrients, no CWA 303d designated reaches. Or, Washington State Department of Ecology standards – 173-201A-200.	Inadequate instream flows for habitat, moderate levels of water quality impairments from landuse sources, some excess nutrients, CWA 303d designated reaches.	Inadequate instream flows for habitat, high levels of water quality impairments from landuse sources, high levels of excess nutrients, CWA 303d designated reaches.

Data: Methow River, Washington Department of Ecology website (http://apps.ecy.wa.gov/wats08/PrintListing.aspx?).

Listing ID	Parameter	Medium	Township Range Section	Monitoring Station	Location	2008 Category*	2004 Category*	1998 303(d) List?	1996 303(d) List?
3732	Temperature	Water	30.0N-23.0E-28	48A070	Near Pateros	5	5	Y	Y
6215	Instream Flow	Habitat	36.0N-20.0E-31	None	RM 59 (Weeman)	4C	4C	Y	Y
6216	Instream Flow	Habitat	36.0N-19.0E-26	None	RM 66.5 (Chokeberry)	4C	4C	Y	Y
6217	Instream Flow	Habitat	34.0N-21.0E-11	None	RM 49.0 (KOA)	4C	4C	Y	Y
6218	Instream Flow	Habitat	32.0N-22.0E-16	None	RM 31.5 (Walsh)	4C	4C	Y	N
8433	Temperature	Water	30.0N-23.0E-21	None	RM 5.0	2	2	N	Y

Listing ID	Parameter	Medium	Township Range Section	Monitoring Station	Location	2008 Category*	2004 Category*	1998 303(d) List?	1996 303(d) List?
11288	Ammonia-N	Water	30.0N-23.0E-28	48A070	Near Pateros	1	1	N	N
11290	pH	Water	30.0N-23.0E-28	48A070	Near Pateros	2	2	N	N
11291	Ammonia-N	Water	33.0N-22.0E-20	48A140	Near Pateros	1	1	N	N
11294	pH	Water	33.0N-22.0E-20	48A140	Near Pateros	2	2	N	N
16838	Fecal Coliform	Water	33.0N-22.0E-20	48A140	Near Pateros	1	1	N	N
16839	Fecal Coliform	Water	30.0N-23.0E-28	48A070	Near Pateros	1	1	N	N
40721	Arsenic	Water	33.0N-22.0E-20	48A140	Near Twisp	1	1	N	N
51562	2,3,7,8-TCDD	Tissue	34.0N-21.0E-13	None	Near Bear Creek	5		N	N
51615	2,3,7,8-TCDD TEQ	Tissue	34.0N-21.0E-13	None	Near Bear Creek	2		N	N
51675	4,4'-DDD	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
51736	4,4'-DDE	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
51796	4,4'-DDT	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
51918	Alpha-BHC	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
51979	Beta-BHC	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52094	Endosulfan I	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52140	Endosulfan II	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52192	Endosulfan Sulfate	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52252	Endrin	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52312	Endrin Aldehyd	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52372	Gamma-bhc (Lindane)	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52433	Heptachlor	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52494	Heptachlor Epoxide	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52554	Hexachlorobenzene	Tissue	34.0-21.0E-13	None	Near Bear Creek	1		N	N
52615	Mercury	Tissue	34.0-21.0E-13	None	Near Bear Creek	1		N	N
52672	PCB	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52735	Total Chlordane	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N

Data: Tributaries to the Methow River, Washington Department of Ecology website (http://apps.ecy.wa.gov/wats08/PrintListing.aspx?).

Tributary	Listing ID	Parameter	Medium	Township Range Section	Monitoring Station	Location	2008 Category*	2004 Category*	1998 303(d) List?	1996 303(d) List?
Early Winters Creek	6214	Instream Flow	Habitat	36.0N-19.0E-28	None	RM 1	4C	4C	Y	Y
Wolf Creek	6220	Instream Flow	Habitat	35.0N-21.0E-32	None	Mouth	4C	4C	Y	Y
Twisp River	6219	Instream Flow	Habitat	33.0N-21.0E-11	None	RM 1.8	4C	4C	Y	Y
	8435	Temperature	Water	33.0N-22.0E-08	None	Mouth	2	2	Y	Y
	39350	Temperature	Water	33.0N-20.0E-18	None	War Creek Campground	2	2	N	N
Alder Creek	17017	Temperature	Water	33.0N-21.0E-24	None	West Fork	2	2	N	N
	17030	pH	Water	33.0N-21.0E-25	None	West Fork	2	2	N	N
	17040	Zinc	Water	33.0N-21.0E-24	None	West Fork	2	2	N	N
Chewuch River	6213	Instream Flow	Habitat	35.0N-21.0E-35	None	RM 1.3	4C	4C	Y	Y
	39349	Temperature	Water	36.0N-21.0E-35	None	Near Okanogan NF Boundary	5	5	N	N

Tributary	Listing ID	Parameter	Medium	Township Range Section	Monitoring Station	Location	2008 Category*	2004 Category*	1998 303(d) List?	1996 303(d) List?
Andrews Creek	8432	Dissolved Oxygen	Water	38.0N-22.0E-06	None	East Fork	2	2	N	N
	8969	4,4'-DDE	Water	38.0N-22.0E-06	None	East Fork	2	2	N	N

*Water quality assessment categories (http://www.ecy.wa.gov/programs/wq/303d/WAAssessmentsCats.html).

- Category 1 – Meets tested standards for clean waters.
- Category 2 – Waters of concern.
- Category 3 – Insufficient data.
- Category 4 – Polluted waters that do not require a TMDL.
    - Category 4a – has a TMDL
    - Category 4b – has a pollution control program.
    - Category 4c – is impaired by a non-pollutant.
- Category 5 – Polluted waters that require a TMDL.

Narrative:
From Weeman Bridge to Mazama, the Methow River "naturally" dewaters in late summer and fall, but may be exacerbated by water use for irrigation (CCPUD, 1998). Dewatering in this stream segment is primarily due to the geology (depth of alluvial valley fill), but only limited studies have been conducted on the surface water and ground water interactions (Konrad, Drost, and Wagner, 2003). Several stream segments along the Methow River and its tributaries are listed as Category 4C for insufficient instream flows due primarily to irrigation diversions. Tributaries to the upper Methow River with stream segments that are listed as Category 4C for insufficient instream flows upstream of the confluence with the Chewuch River (RM 50.1) include Early Winters Creek and Wolf Creek. The Chewuch River, a primary tributary to the Methow River, has a stream segment at RM 1.3 that is listed as Category 4C for insufficient instream flow. The Twisp River, another primary tributary to the Methow River at RM 41.2, has a stream segment at RM 1.8 that is listed as Category 4C for insufficient instream flow. Along the Methow River there are four stream segments at about RM 66.5, RM 59.0, RM 49.0 and RM 31.5 that are listed as Category 4C for instream flow.

Water quality of the lower Methow River (RM 50.1 to 0.0) is classified as Class A (excellent) below the Chewuch River confluence, and upstream of the confluence is classified as Class AA (extraordinary) (WDOE 1990). Warm water conditions may occur in the Methow River and its tributaries during summer months, and may be exacerbated by decreased instream flows, floodplain connectivity, and removal of riparian vegetation along the river for development. The Chewuch River, a primary tributary, has a stream segment listed as Category 5 for temperature at the Okanogan National Forest boundary near Boulder Creek. The Twisp River has two stream segments listed as Category 2 for temperature near War Creek and near its mouth. Alder Creek (West Fork), which flows into the Methow River downstream of Twisp, is listed as Category 2 for temperature. The lower Methow River near monitoring station 48A070 (near Pateros) is listed as Category 5 for water temperature, however, the Middle Methow River is not listed for water temperature.

Other water quality issues include (1) Andrews Creek (East Fork), a tributary to the Chewuch River is listed as Category 2 for Dissolved Oxygen and 4,4'-DDE, (2) the Methow River within the Middle Methow reach assessment area near Bear Creek is listed as Category 5 for 2,3,7,8-TCDD and Category 2 for 2,3,7,8-TCDD TEQ, (3) Alder Creek (West Fork), a tributary to Methow River below Twisp, listed as a Category 2 for pH and Zinc and (4) the lower Methow River near monitoring station 48A070 (near Pateros) is listed as Category 2 for pH.

The water quality and quantity general indicators are interpreted to be in an **At Risk Condition** due to warm water temperatures mainly in certain tributaries (Category 5 and 2 listings), low levels of chemical contamination (Category 5 and 2 listings), and insufficient instream flows (Category 4C listings).

GENERAL INDICATOR: HABITAT ACCESS

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Habitat Access	Main Channel Physical Barriers	No manmade barriers present in the mainstem that limit upstream or downstream migration at any flow.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at some flows that are biologically significant.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.

Narrative:
The Methow River main channel diversion dams are Foghorn dam near RM 53 and Barkley dam near RM 49. Foghorn diversion dam most likely is impeding juvenile fish passage at some biologically significant flows (i.e., low-flows). Barkley diversion dam is pushed up annually in late July or August. The push-up dam spans about 70 percent of the wetted main channel. This may increase the entrainment of fish into the Barkley ditch. Many fish including juvenile steelhead/rainbow trout, juvenile spring Chinook salmon, cutthroat, Pacific lamprey, and some adult bull trout are residing in the Barkley ditch upstream of the fish screen during irrigation season. Despite fish salvage efforts many of these fish are lost when the ditch is turned off in the fall (fish salvage report is in the Habitat Assessment; Appendix D). The Methow Valley Irrigation District's east diversion dam has been mostly removed and is no longer a hazard to fish.

Other physical barriers within the tributaries were considered in the interpretation of this general indicator. Although the criterion only addresses mainstem, physical barriers, there are several barriers that impact access to the upper watersheds. In the last ten years fish passage to the upper watershed has vastly improved as many of the barriers have been modified. The Fulton diversion dam near RM 1 on the Chewuch River has been modified and is no longer a low flow fish passage barrier. The Chewuch diversion dam near RM 8 on the Chewuch River most likely prevents upstream migration of juvenile Chinook salmon and juvenile steelhead at higher flows. The Methow Valley Irrigation District's west canal diversion on the Twisp River near RM 4 does not appear to be a fish passage barrier but is modified annually. There are some small diversion dams and culverts within the tributaries that may be fish passage barriers, but nearly all of the culverts have been replaced to improve fish passage on USFS managed land and many small diversion dams have been modified to improve fish passage on privately owned lands.

Due to manmade barriers on the mainstem Methow River and other man-made barriers within its primary tributaries the main channel physical barriers general indicator is interpreted to be in an **At Risk Condition**.

REACH CHARACTERISTICS

GENERAL INDICATOR: WATER TEMPERATURE

Criteria: The following criteria were developed by Hillman and Giorgi (2002) and USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Water Quality	Water Temperature	MWMT/ MDMT/ 7-DADMax	Bull Trout: Incubation: 2-5°C Rearing: 4-10°C Spawning: 1-9°C Salmon and Steelhead: Spawning: June-Sept 15°C Sept-May 12°C Rearing: 15°C Migration: 15°C Adult holding: 15°C Or, 7-DADMax performance standards (WDOE): 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-DADMax performance standards 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 regularly exceed 15°C. Or 7-DADMax performance standards exceeded by >15%

Data: Washington Department of Ecology, Environmental Monitoring and Trends Section Methow River at Twisp, Station 48A140, Lat. 48.3593 Long. 120.1143, Waterbody: WA-48-1020 (http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=final_data&scrolly=0&sta=48A140)

Year	Constituent	Criterion	Deployment		Max 7-day Mean		ITS*
			Max °C	Date/Time	Max °C	Date	
2007	Air Temp	NA	32.8	7/12/2007 3:00:00 PM	31.2	7/13/2007	0
2007	Water Temp	18	19.3	8/2/2007 6:00:00 PM	18.9	7/31/2007	0
2006	Air Temp	NA	36.2	7/23/2006 3:30:00 PM	34	7/24/2006	NA
2006	Water Temp	18	20.4	7/24/2006 6:30:00 PM	19.8	7/25/2006	4.3
2005	Air Temp	NA	35.8	8/6/2005 5:30:00 PM	33.3	8/6/2005	0
2005	Water Temp	18	21.6	8/8/2005 4:30:00 PM	21.1	8/8/2005	0
2004	Air Temp	NA	36.2	8/14/2004 3:00: PM	34.7	8/13/2004	NA
2004	Water Temp	18	21.5	8/15/2004 6:00:00 PM	20.3	8/13/2004	14.6
2003	Air Temp	NA	36.6	8/15/2003 4:30:00 PM	35.3	7/29/2003	0
2003	Water Temp	18	20.4	7/31/2003 6:00:00 PM	20.1	7/29/2003	0
2002	Air Temp	NA	35.85	8/13/2002 4:00:00 PM	32.2	7/14/2002	NA
2002	Water Temp	18	20.02	8/23/2002 6:00:00 PM	18.8	8/26/2002	1.5
2001	Air Temp	NA	40.7	7/10/2001 6:00:29 PM	36.8	8/9/2001	NA
2001	Water Temp	18	21.1	8/11/2001 5:30:15 PM	20.6	8/9/2001	11.1

Data: The source of the following information is the 2005 temperature summary for the Middle Methow River from above the confluence of Chewuch River to below the confluence of Twisp River collected by the Methow Ranger Valley District (information received from D. Hopkins, Methow Valley Ranger District) and the *Geomorphic Assessment – Appendix I* (Reclamation, 2008).

	RM 41.1	RM 41.3	RM 43.4	RM 46.3	RM 48.7	RM 51.2	RM 52.0
Highest Temperature (Date)	20.14° C (8-07-2005)	19.80° C (8-07-2005)	20.68° C (8-08-2005)	22.24° C (8-08-2005)	20.64° C (8-08-2005)	21.62° C (8-08-2005)	20.17° C (8-08-2005)
Highest 7-day Max. Temp. (Date)	19.44° C (8-03-2005)	19.35° C (8-05-2005)	20.00° C (8-05-2005)	21.55° C (8-04-2005)	19.94° C (8-04-2005)	20.84° C (8-08-2005)	19.50° C (8-05-2005)
Highest 7-day Avg. Temp. (Date)	16.88° C (8-05-2005)	16.78° C (8-05-2005)	17.79° C (8-05-2005)	18.17° C (8-05-2005)	17.04° C (8-05-2005)	17.60° C (8-05-2005)	15.62° C (8-05-2005)

Data: Temperature profile of the Middle Methow River for summer 2008 showing the highest water temperature, highest 7-day maximum temperature, and the 7-day average maximum temperature at each monitor site in the Habitat Assessment area (Appendix D).

River Mile	RM 41.4	RM 46.3	RM 49.6
Highest Recorded Water Temperature (°C)	19.85°C	19.53°C	19.03°C
Date	08-17-2008	08-16-2008	08-16-2008
Highest Recorded 7-day Max Temp (°C)	18.83°C	18.58°C	18.13°C
Date	08-18-2008	08-18-2008	08-18-2008
Days Exceeding State DOE Standard of 16°C	41 days (2008)	43 days (2008)	35 days (2008)

Date: Summary of cold water upwelling sites based on 2009 TIR imagery.

River Mile	Location	Comments
RM 48.6	Bird side channel	Groundwater upwelling at downstream end
RM 48.2	Gilbertson springs	Cold water spring
RM 47.9	River right	Cold water upwelling in channel
RM 47.0	River Rock side channel	Cold water upwelling at downstream end

River Mile	Location	Comments
RM 46.5	River left	Cool spring
RM 45.6	McNae side channel	Water is slightly warmer than river at downstream end
RM 45.1	Side channel	Cool water from side channel along river left
RM 44.3	Habermehl side channel	Cool water upwelling in downstream end of side channel

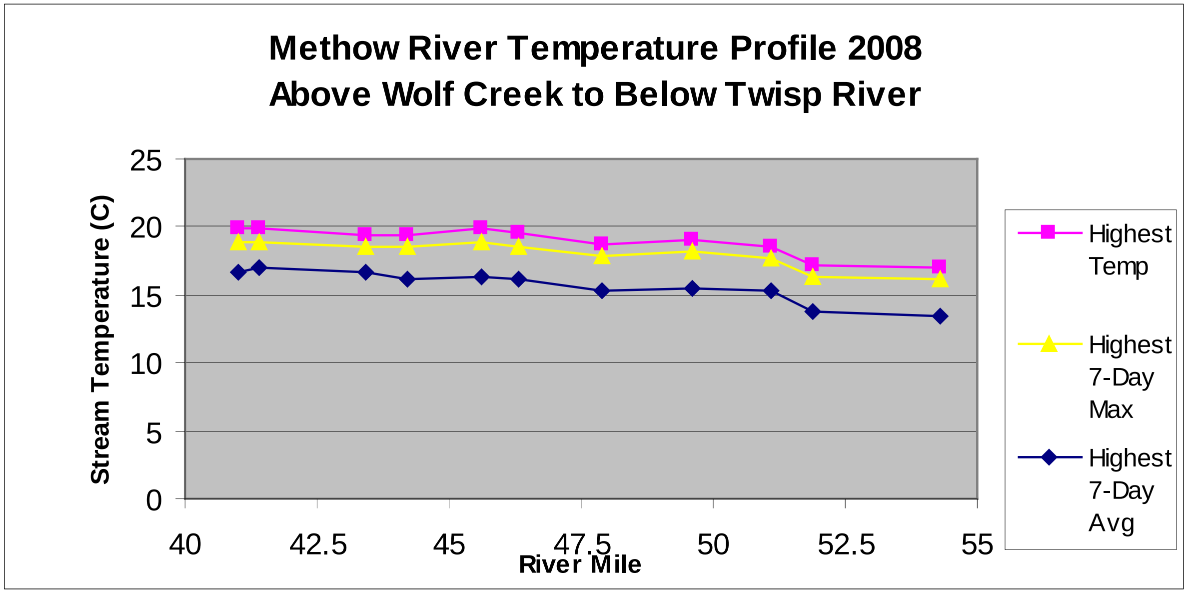

Figure 2. Summary chart of Methow River water temperature profile for 2008.

Narrative:
The Yakama Indian Nation funded the collection of thermal infra-red (TIR) imagery in 2009 (imagery is also available from Reclamation's Pacific Northwest Regional Office in Boise, Idaho: contact Kristin Swoboda at kswoboda@usbr.gov). Cold water sources were identified from the TIR imagery. These cold water sources are located at RM 48.2 (Gilbertson springs), RM 47.9 (in-channel cold water upwelling), RM 47.7 (River Rock side channel), RM 46.5 (unnamed side channel), RM 45.1 (unnamed side channel), and RM 44.3 (Habermehl side channel).

Temperature monitors were installed on the mainstem Methow River at RM 41.0 (below Twisp River confluence), RM 41.4, RM 43.4, RM 44.2, RM 45.6, RM 46.3, RM 47.9 (just below Gilbertson Springs), RM 49.6 (at the Barkley Diversion Dam), RM 51.9 (above Chewuch River confluence), and RM 54.3 (above Wolf Creek) during the summer of 2008. A water temperature profile chart (Figure 2) for the Methow River was generated using recorded data from the summer 2008 by U.S. Forest Service as part of a habitat assessment completed between RM 54.2 and 40.3 (for further information see Appendix D). The summary chart above shows a general trend of increasing water temperature through the Middle

Methow River reach. The number of days water temperatures exceeded Washington State Department of Ecology water standards for core summer salmonid habitat (16°C) ranged from 35 days at RM 49.6, 43 days at RM 46.3, and 41 days at RM 41.4. Areas where water temperatures cooled were between RM 45.6 and RM 44.2, and RM 47.9 below Gilbertson Springs, due to the cold water input from springs into the Methow River which is supported by TIR imagery. From RM 45.6 to 44.2 water temperatures cooled by about 0.5°C. The warm water temperatures may be exacerbated by riparian vegetation clearing (see Specific Indicator: Vegetation Condition (Canopy Cover)); reduced floodplain connectivity caused by development and associated infrastructure; reduced instream flows due to irrigation diversions; and irrigation returns. Therefore, the water temperature general indicator is interpreted to be in an At Risk Condition based on the number of days water temperatures exceeded Washington State Department of Ecology water standards.

GENERAL INDICATOR: TURBIDITY

Criteria: The performance standard for this indicator is from Hillman and Giorgi (2002), and Washington State Department of Ecology.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Water Quality	Turbidity	Nephelometric Turbidity Units (NTU)	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 percent increase in turbidity when the background turbidity is more than 50 NTU (WDOE – 173-201A-200).	15-50% exceedance.	>50% exceedance.

Data: Results that exceeded water quality standards criteria or the usual range of data (since October, 1996) on the Methow River at Twisp, Station 48A140, Lat. 48.3593 Long. 120.1143, Waterbody: WA-48-1020
(http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=final_data&scrolly=0&sta=48A140)

Date	Time	Units	Result	QMEAN	QSD	QDP
3/2/2009	11:30	NTU	1.9	0.6777778	0.2016274	18
12/5/2007	12:40	NTU	1.2	0.5944445	0.176476	18
6/5/2007	11:10	NTU	40	4.438889	6.807188	18
11/13/2006	11:05	NTU	0.7	0.5176471	6.359338E-02	17
2/7/2005	10:30	NTU	1.1	0.6055555	0.1830211	18

Date	Time	Units	Result	QMEAN	QSD	QDP
12/6/2004	11:00	NTU	0.9	0.5176471	6.359338E-02	17
11/1/2004	11:10	NTU	1.1	0.5235294	6.642111E-02	17
10/4/2004	10:11	NTU	0.8	0.5235294	6.642111E-02	17
8/10/2004	13:22	NTU	6.3	1.088889	1.502112	18
8/3/1999	09:45	NTU	6.5	0.633	0.352	12
7/6/1999	9:40	NTU	3.2	0.633	0.352	12
12/10/1996	09:50	NTU	1	0.527	0.2	11

Note: QMEAN, QSD, and QDP are the quarterly mean, standard deviation, and number of data points for the last six years, where available, for the station.

Narrative:
Turbidity is measured in Nephelometric Turbidity Units (NTU) which is a measure of the cloudiness of the water caused by suspended solids. Exceeding a criterion does not necessarily mean the water quality standard has been violated according to the Environmental Protection Agency. In the data table, the timing (date) of the turbidity exceedences predominantly occurred in October through December when there is a good potential for rain-on-snow events; and in July and August when thunderstorms usually occur. The turbidity exceedances are interpreted to be natural occurrences within the Methow watershed. At water monitoring station 48A150 (Methow River at Winthrop) the Water Quality Index (WQI) for turbidity in 2008 was 81 or in good condition and the overall water quality met or exceeded expectation. At water monitoring station 48A130 (Methow River at Twisp) the WQI for turbidity in 2008 was 81 or in good condition and the overall water quality met or exceeded expectation (data available on Washington Department of Ecology's water quality website). Based on this information the turbidity specific indicator is interpreted to be in an Adequate Condition.

GENERAL INDICATOR: CHEMICAL CONTAMINATION/NUTRIENTS

Criteria: The following criteria were developed by USFWS (1998) and Washington State Department of Ecology.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Water Quality	Chemical Contamination/ Nutrients	Metals/ Pollutants, pH, DO, Nitrogen, Phosphorous	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 CWA 303d designated reach.

Data: Washington State Department of Ecology, Environmental Monitoring and Trends Section Methow River at Winthrop, Station 48A150, Lat. 48.4735 Long. 120.1776, Waterbody: WA-48-1020 (http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=final_data&scrolly=0&sta=48A150)

date	time	ALK (mg/L)	COND (umhos/	FC (#/100	FLOW (CFS)	HARD (mg/L)	NH3_N (mg/L)	NO2_NO3 (mg/L)	OP_DIS (mg/L)	OXYGEN (mg/L)	PH (pH)	PRESS (mm/Hg)	SUSSOL (mg/L)	TEMP (deg C)	TP_P (mg/L)	TPN (mg/L)	TURB (NTU)
10/8/2007	11:40	58.6	134	3	300	58.3	0.01 U	0.054	0.0036	11.61	8.31	712.724	1	7.5	0.005 U	0.1	0.8
11/5/2007	11:00		136	1	300		0.01 U	0.106	0.0045	12.6	8.32	719.328	2	4.5	0.005 U	0.14	0.5 U
12/5/2007	11:40	61.2	129	1	385	60.9	0.01 U	0.135	0.003 U	12.52	8.16	705.358		4.1	0.005 U	0.16	0.7
1/7/2008	12:05		131	6	281		0.01 U	0.173	0.004	13.03	8.22	701.04	4	1.3	0.005 U	0.2	0.7
2/11/2008	11:50	59.8	133	6	241	59	0.01 U	0.16	0.003 U	13.29	8.31	711.454	2	1.8	0.005 U	0.19	0.8
3/3/2008	11:25		131	1	255		0.01 U	0.123	0.0034	12.56	8.1	713.994	2	3.9	0.005 U	0.17	0.5 U
4/7/2008	12:10	60.6	133	1 U	354	56.9	0.01 U	0.094	0.004	11.83	8.14	705.612	2	6	0.005 U	0.145	0.5 U
5/5/2008	11:55		85	3	2110		0.01 U	0.325	0.0072	11.53	7.78	711.708	86	6.6	0.0621 J	0.434	25
6/2/2008	13:45	23	54	6	7280	23.9	0.01 U	0.069	0.0041	10.65	7.53	706.374	19 J	8.8	0.011	0.13	4.6
7/7/2008	12:30		78	7	1910		0.01 U	0.025	0.003 U	9.74	7.87	707.136	6	11.5* J	0.0088	0.069	2.4
8/4/2008	12:30	53.2	114	7	477	51.6	0.01 U	0.04	0.0033	9.69	8.1	716.534	1	15* J	0.005 U	0.078	0.5
9/8/2008	11:25		128	7	255		0.01 U	0.082	0.0039	10.65	8.19	688.848	1	11.4* J	0.0062 J	0.12	0.5

Common data qualifiers: U - not detected at the reported level, J - estimated value

Colored background

indicates that result exceeded water quality standards -OR- contrasted strongly with historical results.

November 2006 amendment to water quality standards (excluding supplemental temperature criteria) was incorporated beginning in January 2009.

Asterisk * indicates possible quality problem for the result. You may wish to discuss the result with the station contact person.

Data: Washington Department of Ecology, Environmental Monitoring and Trends Section Methow River at Twisp, Station 48A140, Lat. 48.3593 Long. 120.1143, Waterbody: WA-48-1020 (http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=final_data&scrolly=0&sta=48A140)

date	time	COND (umhos/	FC (#/100	FLOW (CFS)	NH3_N (mg/L)	NO2_NO3 (mg/L)	OP_DIS (mg/L)	OXYGEN (mg/L)	PH (pH)	PRESS (mm/Hg)	SUSSOL (mg/L)	TEMP (deg C)	TP_P (mg/L)	TP_PInLin (mg/L)	TP_P_ICP (mg/L)	TPN (mg/L)	TURB (NTU)	Turb-JTU (JTU)
10/11/1988	10:20	155	7	266	0.01 U	0.16	0.01	11.4	8.2	715	3	5.3	0.01 U				1 U	
11/15/1988	11:15	138	1 U	360	0.01	0.13	0.01 U	12.9	8.4	716	1 U	3.2					1 U	
12/13/1988	11:45	141	1 U	370	0.01 U	0.11	0.01	13	7.8	718	6	3.4					1 U	
1/10/1989	11:10	153	1 U	240	0.01	0.14	0.01 U	13.7	8.9	718	1 U	0	0.08				4	
2/14/1989	10:00	150	4	266	0.01 U	0.14	0.002	12.9	8.1	730	1	0	0.002 U				1	
3/14/1989	10:45	150	1 U	287	0.01 U	0.12	0.01	12.3	8.5	717	1 U	4.6	0.008				1	
4/11/1989	10:30	140	3	990	0.01	0.11	0.01 U	11.8	8.4	720	4	6.8	0.01				1	
5/9/1989	10:30	64	29	7300	0.01	0.05	0.01 U	11.3	7.8	715	39	6.2	0.03				10	
6/13/1989	9:45	68	16	5150	0.01 U	0.02	0.01 U	11.3	7.7	713.7	5	9.2	0.01 U				1.3	
7/11/1989	10:25	138	8	980	0.01 U	0.06	0.01 U	10.2	8	722.9	4	11.7	0.02				1.2	
8/15/1989	10:35	151	9	272	0.03	0.13	0.01 U	9.9	8.4	716.5	4	12.6	0.006				0.4	
9/12/1989	10:50	160	7	215	0.01 U	0.21	0.01 U	10.3	8.3	719.8	1 U	11.5	0.01 U				0.5	
10/10/1989	11:00	175	3	193	0.01	0.19	0.01 U	11.8	7.8	711.2	1 U	9.5	0.01				0.4	
11/14/1989	10:55	128	2	462	0.01 U	0.09	0.01 U	13	8.4	723.4	1	3.4	0.01 U				1.2	
12/5/1989	11:20	122	5	660	0.02	0.09	0.01 U	12.9	7.8	720.9	4	3.6	0.01 U				0.9	
1/16/1990	11:15	140	7	318	0.01 U	0.12	0.01 U	13.3	8.6	717.8	1	3	0.01 U				0.3	
2/20/1990	11:30	145	1 U	256	0.01 U	0.14	0.01 U	13.8	8.5	722.1	2	1.2	0.01 U				1.9	
3/13/1990	10:55	150	1 U	310	0.01 U	0.11	0.01 U	12.7	8.8	721.1	3	4.2	0.01 U				0.5	
4/10/1990	10:10	139	4	2040	0.01 U	0.06	0.01 U	12.6	7.8	730.5	5	5.2	0.01 U				1	
5/15/1990	10:30	85	1 U	2400	0.01 U	0.04	0.01 U	11.8	7.9	720.9	3	7.2	0.02				1 U	
6/12/1990	9:45	60	10	5300	0.01 U	0.02	0.01 U	11.3	8	716.8	8	6.1	0.01				1	
7/17/1990	10:05	110	9	1750	0.01 U	0.03	0.01 U	10.2	8	721.4	3	12.8	0.01 U				1 U	
8/14/1990	9:15	134	19	1630	0.01 U	0.09	0.01 U	9.7	8.1	713.5	1	15.5	0.01 U				1 U	
9/11/1990	11:00	151	8	343	0.04	0.14	0.01 U	10.3	8.5	715	1	13.4	0.01 U				1 U	
10/16/1990	10:10	145	1	409	0.01	0.1	0.01 U	12	8	721.6	1	6.1	0.01 U				1 U	
11/13/1990	10:00	89	4	1740	0.01 U	0.07	0.01 U	12.1	7.8	715	2	5.3	0.01 U				1 U	
12/4/1990	12:00	97	1 U	1270	0.01 U	0.08	0.01 U	14.1	8.3	710.4	1	2.9	0.01 U				1 U	
1/15/1991	10:50	137	1 U		0.01 U	0.09	0.01 U	12.7	8.6	726.4	2	3.1	0.01 U				1 U	
2/12/1991	12:30	140	2	429	0.01 U	0.08	0.01 U	12.3	8.7	723.1	2	4.8	0.01				1 U	
3/12/1991	10:45	150	1	640	0.01 U	0.09	0.01 U	12.1	8.7	723.1	1	5.2	0.01				0.3	
4/9/1991	10:50	150	12	1180	0.01 U	0.06	0.01 U	11.8	8.4	718.8	2	5.9	0.01 U				1	
5/14/1991	10:40	92	7	4480	0.02	0.04	0.01 U	11.5	8.1	718.1	18	6.4	0.012				3.1	
6/11/1991	11:05	62	43	7600	0.01 U	0.02	0.01 U	11.4	7.4	715	26	7.1	0.01 U				3.1	
7/16/1991	10:35	73	7	3490	0.01 U	0.02	0.01 U	7.9	7.4	722.1	2	8.8	0.01 U				0.3	
8/13/1991	10:15	107	15	1210	0.01 U	0.03	0.01 U	10.2	7.3	724.4	1	11.4	0.01 U				0.5	
9/10/1991	11:30	140	4	381	0.01 U	0.13	0.01 U	10.5	8.1	719.6	1 U	14.4	0.01 U				0.2	
10/13/1992	10:15	138	15	277	0.01 U	0.145	0.01 U	11.1	8.1	722.1	1	8.5	0.01 U				0.4	
11/10/1992	10:40	155	1 U	277	0.01 U	0.133	0.01 U	12.9	8.2	728.5	1	3.2	0.01 U				0.4	
12/8/1992	11:30	114	5	252	0.01 U	0.172		13.1	8.4	713	1 U	1.1	0.01 U				0.2	
1/12/1993	11:10	129	2	278 J?	0.014	0.169	0.01 U	13.1	7.4	730.5	2	0	0.01 U				0.3	
2/9/1993	9:55	128	1	221	0.012	0.144	0.01 U	12.2	8	719.8	1	4	0.01 U				0.4	

3/8/1993	10:45	130		1	U	209		0.017		0.12		0.01	U	12.1		8.4		725.9		3		5.5		0.01	U							0.3			
4/12/1993	10:20	127		2		324		0.011		0.119		0.01	U	11.8		7.7		725.7		2		6.7		0.01	U							0.5			
5/11/1993	11:25	75		68		2630		0.01		0.07		0.01	U	11		7.8		719.1		35		8.7		0.015								6			
6/14/1993	10:55	75		5		2080		0.01	U	0.035		0.01	U	10.8		8		724.9		2		9.8		0.01	U							0.3			
7/13/1993	10:30	98		51		870		0.01	U	0.067		0.01	U	10.3		8.2		724.4		1		12.9		0.01	U							0.3			
8/10/1993	11:20	99		2		828		0.01	U	0.074		0.01	U	9.8		8.2		722.6		1		14.4		0.01	U							0.2			
9/14/1993	10:10	130		5		304		0.01	U	0.145		0.01	U	10.8		8.3		720.9		1		10.4		0.01	U							0.4			
10/5/1994	11:00			5		215		0.01	U	0.23		0.01	U	11.2		8.1		716.3		1		7.2		0.01	U					0.2		0.5	U		
11/22/1994	11:30			1		192		0.01	U	0.193		0.01	U	13.7		8.2		734.1		2		0.3		0.01	U					0.2		0.6			
12/14/1994	10:40			3		284		0.01	U	0.144		0.005	U	13.2				723.9		1		0.5		0.01	U					0.2		0.5	U		
1/4/1995	10:30			1		252		0.014		0.19		0.005	U	13.7		7.8		724.9		1		0		0.01	U					0.3		0.5	U		
2/15/1995	10:50			3		240		0.01	U	0.161		0.005	U	13.5		8.1		713.7		1		0.1		0.01	U					0.2		0.5	U		
3/14/1995	10:20			5		623		0.01	U	0.114		0.005	U	12		8.1		716.3		3		4.7		0.01	U					0.2		1.4			
4/12/1995	9:15			7		1800		0.01	U	0.14		0.005	U	12		7.8		719.8		3		4.8		0.01	U					0.2		2			
5/10/1995	10:20			59		7610		0.01	U	0.053		0.005	U	11.4		7.8		721.4		103		5.9		0.101						0.3		40			
6/14/1995	9:40			4		6000		0.01		0.033		0.005	U	11.2		7.7		721.4		6		7.2		0.01	U					0.1		2.4			
7/12/1995	11:20			5		2330		0.011		0.056		0.005	U	10.5		8.2		721.4		1	U	11.3		0.01	U					0.1		0.8			
8/16/1995	8:40			17		535		0.01	U	0.188		0.005	U	10.3		8.5		725.4		1	U	10.7		0.01	U					0.2		0.5	U		
9/13/1995	8:45			14		334		0.01	U	0.287		0.005	U	10.1		8.2		736.1		2		12.1		0.01	U					0.3		0.5	U		
10/9/1995	13:45					375		0.01	U	0.21		0.005	U	11.3		8.3		720.6		1	U	9.7		0.01	U					0.2		0.5	U		
11/13/1995	12:40			2		633		0.01	U	0.136		0.005	U	12.9		7.9		736.6		1	U	5.4		0.01	U					0.2		0.5	U		
1/17/1996	14:00			1	U	518		0.01	U	0.108		0.005	U	13.8		8		723.9		3		1.3		0.01	U					0.1		0.5	U		
2/12/1996	14:50			1		436		0.01	U	0.137		0.005	U	13.6		8.1		731.5		1	U	2.5		0.01	U					0.2		0.5	U		
3/11/1996	13:50			1		578		0.01	U	0.103		0.005	U	12		8.2		721.4		1		7.2		0.01	U					0.1		0.5	U		
4/15/1996	14:40			4		3480		0.01	U	0.046		0.005	U	11.9		8		713.7		4		6.8		0.01	U					0.1		2.3			
5/14/1996	14:00			2		3000		0.01	U	0.034		0.005	U	11.1		8.2		711.2		5		9		0.022						0.1		2			
6/11/1996	14:30			4		7650		0.01	U	0.016		0.005	U	11.2		7.9		718.8		11		9		0.012						0.1		5.4			
7/15/1996	11:20			6		3780		0.01	U	0.012		0.005*	U	10.3		7.7		711.2		3		11.9		0.01	U					0		1.5*			
8/13/1996	13:20			3		767		0.01	U	0.101		0.005	U	10		8.3		718.8		1	U	15.4		0.021						0.1		0.8			
9/10/1996	14:40			2		382		0.01	U	0.198		0.005	U	10.4		8.5		716.3		1	U	14.9		0.01						0.2		0.6			
10/15/1996	11:50			5		397		0.01	U	0.172		0.005	U	11.5		8.1		721.4		2		6.4		0.01	U					0.2		0.5	U		
11/12/1996	10:00			1	U	390		0.01	U	0.151		0.005	U	11.4		7.9		727.7		2		6		0.01	U					0.2		0.7			
12/10/1996	9:50			4		367		0.01	U	0.159		0.005	U	12.5		8.1		698.5		1		1								0.2		1			
1/14/1997	10:00			27		290		0.01	U	0.209		0.005	U	15.2		7.7		723.9		1		0		0.01	U					0.2		1.1			
2/11/1997	9:40			5		428		0.01	U	0.117		0.005	U	13.7		7.9		725.9		1		0.6		0.033						0.2		0.5	U		
3/11/1997	8:45			12		353		0.015		0.154		0.005	U	12.2		8.2		722.9		31		3.6		0.033						0.2		1.5	J		
4/15/1997	9:55			2		1320		0.01	U	0.228*		0.005	U	11.7		8.2		726.9		3		5.7		0.037						0.2		1.4			
5/13/1997	10:10			11		10000		0.021		0.041		0.005	U	11.8		8		718.8		85		5.9		0.11						0.2		26			
6/10/1997	9:35			9		8590		0.01	UJ	0.01	UJ	0.005	U	10.8		7.9		719.3		15		7.2		0.068	J					0	J	5.9			
7/15/1997	9:00					2710		0.01	U	0.086		0.005	U	10.4		8		723.9		2		11		0.01	U					0.1		1			
8/12/1997	10:10			11		767		0.01	U	0.159		0.005	U	10.2		7.9		726.4		2		13.5		0.015						0.2		0.5	U		
9/16/1997	9:25			8		412		0.01	U	0.205		0.005	U	10.8		8.2		718.8		1	U	9.4		0.032						0.2		0.5			
10/14/1997	11:15			2		642		0.01	U	0.126		0.005	U	11.7		8.1		726.4		2		7.1		0.039						0.2		0.5	U		

11/4/1997	9:30			1	U	708		0.01	U	0.119		0.005	U	11.6		8.2		728.5		1	U	5.3		0.026						0.3		0.5	U		
12/9/1997	9:55			4		420		0.01	U	0.177		0.005	U	13.5		8		732		3		-0.7		0.022						0.2		0.6			
1/13/1998	9:35			3		297		0.01	U	0.21		0.005	U	13.4				743.7		3		-1.2		0.014						0.2		0.5	U		
2/10/1998	9:55			6		390		0.01	U	0.155		0.005	U	12.6		7.9		716.3		2		1.8		0.02						0.2		0.5	U		
3/10/1998	9:20			9		367		0.01	U	0.186		0.005	U	12.4		8.2		724.7		2		2.9		0.021						0.2		0.6			
4/7/1998	9:40			6		1380		0.01	U	0.087		0.005	U	11.6		8.2		714.8		5		4.4		0.021						0.2		3.9			
5/12/1998	10:10			3		10600		0.01	U	0.022		0.005	U	11.7		7.7		708.7		17		5.1		0.023						0.1		7.3			
6/16/1998	10:30			6		3740		0.01	U	0.028		0.005	U	11.4		8		716.3		4		7.4		0.03						0.1		1.7			
7/14/1998	10:05			13		1530		0.01	U	0.043		0.005	U	10.2		8.2		720.1		4	U	11.1		0.02						0.1		0.6			
8/11/1998	9:45			1		501		0.01	U	0.141		0.005	U	9.5		8.2		715.8		4	U	13.8		0.01	U					0.2		0.7			
9/8/1998	11:30			13		245		0.01	U	0.264		0.005	U	10				708.7		1		16.6		0.034						0.3		0.5	U		
10/13/1998	10:05			33		297				0.217		0.005	U	11		8.1		715		1	U	7.8		0.01	U					0.3		0.6			
11/3/1998	10:00			2		277		0.01	U	0.188		0.005	U	11.6		8.6		726.4		1		6		0.01	U					0.2		0.5	U		
12/15/1998	11:00			2		284		0.012		0.2		0.005	U	13.3		7.4		729.2		2		1.2		0.01	U					0.2		0.5			
1/12/1999	10:35			19		311		0.01	U	0.211		0.005	U	12.8		7.6		715.8		1	U	1.5		0.005	U					0.2		1.1			
2/2/1999	11:00			1	U	284		0.01	U	0.195		0.005	U	12.8		7.9		708.7		1	U	2.2				0.01*	U			0.2		0.6			
3/16/1999	10:20			1	U	311		0.01	U	0.147		0.009		12.5		7.8		714.2		3		2.4				0.014				0.2		0.8			
4/13/1999	10:35			3		989		0.01	U	0.031		0.015		12.1		8.5		729.5		4		4.5				0.026				0.2		1.9			
5/11/1999	11:05			2		2590		0.021		0.045		0.005	U	12.6		8.2		721.4		4		4.7				0.017				0.1		1.9			
6/15/1999	10:10			120		12700		0.017		0.033		0.006		11.3		7.7		713.7		70		5.4				0.095				0.2		30			
7/6/1999	9:40			6		4550		0.026		0.027		0.005	U	11.4		7.4		723.9		8		7				0.015				0.1		3.2			
8/3/1999	9:45			4		1985		0.027		0.035		0.005	U	10.2		8		726.4		3		10.9				0.014				0.1		6.5			
9/7/1999	10:00			5		552		0.031		0.155		0.005	U	10.9		7.9		721.4		1		8.5				0.015				0.2		0.6			
10/5/1999	11:50			1		420		0.022		0.172		0.005	U	10.8		8.5		715		1		7.3				0.011				0.2		0.6			
11/2/1999	12:00			1	U	375		0.01	U	0.14		0.005	U	12.3		8		720.9				3				0.017				0.2					
12/7/1999	13:30			3		747		0.01	U	0.083		0.005	U	13.1		7.9		717		1		1.1				0.012				0.1		0.5	U		
1/4/2000	15:00			1	U	587		0.01	U	0.103		0.005	U	13		8		714.8		1		0.2				0.01*				0.1		0.5	U		
2/8/2000	14:50					390		0.01	U	0.117		0.005	U	12.4		8		715.8		2		3.1				0.017				0.1		0.6			
3/7/2000	15:12			1	U	360		0.01	U	0.113		0.005	U	12.1		8.2		719.1		1		4.7				0.01*	U			0.1		0.5	U		
4/4/2000	15:10			6		1650		0.01	U	0.072		0.005	U	11.3		8.5		712.5		11		6.5				0.012				0.1		6.2			
5/2/2000	14:50			1		3040		0.01	U	0.025		0.005	U	11.3				712.5		4		7.1				0.01*	U			0.1		2.4			
6/6/2000	17:45			4		5460		0.01	U	0.023		0.005	U	10.9				716.5		16		7.5				0.01*	U			0.1		6			
7/11/2000	17:00			1		1830		0.01	U	0.048		0.005	U	9.8		8.3		715.8		2		12.8				0.01*	U			0.1		1			
8/15/2000	15:20			2		428		0.01	U	0.138		0.005	U	10.3		7.85		714.25		1		15.2				0.013				0.2		0.5			
9/5/2000	15:50			2		271		0.01	U	0.186		0.005	U	9.69		8.2		718.31		2		11.5				0.012				0.2		0.5	U		
10/4/2000	11:35			3		290		0.01	U	0.194		0.005	U	11.41		8.14		720.09		1	U	6.5				0.011				0.2		0.4			
11/8/2000	11:35			2		311		0.01*	U	0.159*		0.005	U	12.5		8.15		708.91		1		2.7				0.012				0.13		0.5	U		
12/6/2000	12:30			1		245		0.01	U	0.192		0.005	U	13.09		7.87		728.98		1	U	2.8	J			0.015				0.2		0.5	U		
1/17/2001	11:50					220		0.01	U	0.21		0.005	U	13.13		7.86		733.55		1	U	0.7				0.01*	U			0.2		0.5	U		
2/7/2001	12:35			1	U	188		0.01	U	0.213		0.005	U	13.87		7.54		721.61		2		0				0.012				0.2		0.5	U		
3/7/2001	11:52			1	U	202		0.01	U	0.171		0.005	U	12.12		8.29		776.73		2		6				0.011				0.2		0.5			
4/4/2001	11:30			1	U	215		0.01	U	0.169		0.005	U	12.32		8.06	J	720.6		3		6.4				0.012				0.2		0.6			
5/9/2001	11:55			6		820		0.01	U	0.075		0.005	U	11		8.22		718.06		7		10.3				0.01*	U			0.1		2.4			

6/6/2001	11:45			1		1900		0.01	U	0.047		0.005	U	11.21		7.92		730.76		2		9.6				0.015				0.1		0.8			
7/11/2001	10:00			190	J	599		0.01	U	0.085		0.005	U	9.66		8.31		711.71		2		15.7				0.01*	U			0.1		0.5			
8/15/2001	9:20			29		228		0.01	U	0.187		0.005	U	9.79		8.09		725.42		1	U	15.1				0.01*	U			0.3		0.5	U		
9/5/2001	9:35			12		184		0.01	U	0.241		0.005	U	10		8.24		721.87		1	U	12.3				0.013				0.3		0.5	U		
10/9/2001	13:30	161		2		224		0.01	UJ	0.185	J	0.003	U	11.71		8.26		719.07		1	U	9.3				0.01*	UJ			0.2	J	0.5	UJ		
11/13/2001	13:05	155		1	U	215		0.01	U	0.167		0.0046		12.02		8		728.73	J	1	U	6.8				0.015				0.2		0.5	U		
12/4/2001	13:40	152		1	U	259		0.01	U	0.156		0.0036		13.1		7.96		714.5		1	U	2.7				0.01*	U			0.2		0.5	U		
1/8/2002	13:15	146	J	2		242		0.01	UJ	0.147		0.003	U	12.66		7.89		719.33		2		4.8				0.01*	UJ			0.2	J	1			
2/5/2002	12:58	150		1	U	228		0.01	U	0.138		0.003	U	13.23		8.13		721.61		2		3				0.01*	U			0.2		0.7			
3/5/2002	13:15	139		1		322		0.01	U	0.097		0.0032		13.23		8.22		716.79		2		4.5				0.01*	U			0.1		0.5			
4/2/2002	13:10	133		1		599		0.01	U	0.101		0.003	U	12.3		8.27		726.44		5		7.7				0.01*	U			0.2		1.1	J		
5/7/2002	11:33	99		1	U	2240		0.01	U	0.04		0.003	U	12.8		8.04		722.12	J	2		5.5				0.01*	U			0.1		1.1			
6/11/2002	11:25	61		6		5210		0.01	U	0.026		0.003	U	11.4		7.92		716.28		14		8.4				0.01*	U			0.1		3.8			
7/9/2002	12:57	63		10		3190		0.01	U	0.025		0.003	U	11.3		8.15		727.46		5		10.9				0.01*	U			0.1		1.5			
8/6/2002	12:50	117		3		610		0.01	U	0.123		0.004		10.4		8.13		721.36		1		12.9				0.014				0.2		0.5	U		
9/10/2002	12:40	129		5		284		0.01	U	0.193		0.003	U	10.1		8.22		717.8		1	U	14.1				0.012				0.2		0.5	U		
10/8/2002	12:40	147		1		290		0.01	U	0.196		0.0036		11		8.21		694.94	J	1		10.7				0.012				0.2		0.7			
11/5/2002	12:15	146		1	U	237		0.01	U	0.201		0.0039		13.1		8.14		697.48	J	1	U	3.5				0.017				0.2		0.5	U		
12/3/2002	12:25	145		3		228		0.01	U	0.208		0.0035		12.6		8.24		701.8	J	1		3.9				0.011				0.2		0.5	U		
1/7/2003	12:35	147		2		211		0.01	U	0.184		0.003	U	13.4		8.2		736.09		1		3.3				0.01*	U			0.2		0.5	U		
2/4/2003	13:20	145		1	U	220		0.01	U	0.164		0.003	U	13.8		8.46		740.41	J	1	U	2.8				0.01*	U			0.2		0.5	U		
3/4/2003	12:30	134		1		220		0.01	U	0.16		0.0052		12.9		8.21		713.99		1		5.1				0.01*	U			0.2		0.5			
4/8/2003	12:57	133		1	U	658		0.01	U	0.127		0.004		11.7		8.18		719.84		2		8.5				0.012				0.2		0.8			
5/6/2003	12:25	103		1		2240		0.01	U	0.057		0.0039		12.28		8.02		719.58		3		6.4				0.012				0.1		1.6			
6/3/2003	14:06	57		5		6330		0.01	U	0.028		0.003	U	11.37		7.67		725.17		11		8.4				0.019				0.1		3.8			
7/8/2003	13:45	142		8		1220		0.01	U	0.065		0.0033		10.45		8.17		723.65		1	U	14.2				0.01*	U			0.1		0.5	U		
8/5/2003	12:08	142		9		376		0.01	U	0.176		0.003		10.05		8.23		723.14		1		16.7				0.01*	U			0.2		0.5	U		
9/9/2003	12:45	161		9		211		0.01	U	0.269		0.0032		10.55		8.31		717.8		1	U	13.5				0.01*	U			0.3		0.5	U		
10/7/2003	14:33	143		4		248		0.01	U	0.211		0.003	U	10.72		8.68		720.09		1		12.5						0.002		0.3		0.5	U		
11/4/2003	14:06	114		1		795		0.01	U	0.079		0.003	U	13.8		7.97		728.47		1	U	3.2						0.001		0.1		0.5	U		
12/8/2003	16:02	125				558		0.01	U	0.083		0.003	U	13.87		8.14		709.93		1	U	2						0.001		0.1		0.5	U		
1/13/2004	14:12	134				385	J	0.01	U	0.108		0.0035		13.67		8.32		728.98		1		3.5						0.001	U	0.1		0.5	U		
2/10/2004	14:34	145		1	U	315		0.01	U	0.138		0.003	U	13.67		8.14		734.31		1	U	2.7						0.001		0.2		0.5	U		
3/9/2004	14:45	145		1	U	412		0.01	U	0.114		0.003	U	11.6		8.19		727.96		2		8.5						0.001		0.2		0.6			
4/13/2004	14:22	81		9		4200		0.01	U	0.085		0.0031		11.61		7.82		720.34		30		7						0.01		0.2		9.2			
5/4/2004	14:20	65		6		5710		0.01	U	0.032		0.003	U	11.21		7.71		718.06		33		8.5						0.008		0.1		5.3			
6/8/2004	14:27	74		2		3070		0.01	U	0.034		0.003	U	10.8		7.75		740.66		5		11.6						0.002		0.1		1			
7/13/2004	15:14	102		13		995		0.01	U	0.058		0.0036		10.5		8.45		742.19		2		15.6						0.005		0.1		1.7			
8/10/2004	13:22	114		62		502		0.01	U	0.132		0.0093		9.89		8.25		727.71		15		18						0.019		0.2		6.3			
9/14/2004	13:35	134		17		390		0.01	U	0.126		0.003	U	10.46		8.35		722.38		3		12.8						0.004		0.2		1			
10/4/2004	10:11	131		5		412		0.01	U	0.119		0.003	U	11.37		8.1		726.44		3		8.6						0.003		0.2		0.8			
11/1/2004	11:10	136		4		383		0.018		0.129		0.003	U	12.77		7.63		734.06	J	6		4.1						0.002		0.2		1.1			
12/6/2004	11:00	125	J	2		383		0.01	U	0.165		0.003		12.99		8.13		700.53		1		2						0.002		0.2		0.9			

1/3/2005	10:45	139		2		376		0.01	U	0.153		0.0067		13.75		7.88		719.07		1		0.5						0.002		0.2		0.8			
2/7/2005	10:30	120		2		778		0.01	U	0.117		0.003	U	14.14		7.99		717.55		4		2.2						0.002		0.1		1.1			
3/14/2005	10:05	123		1	U	730		0.01	U	0.126		0.003	U	12.52		8.12		720.6		4		4.2						0.002		0.2		1			
4/4/2005	10:15	132		1	U	537		0.01	U	0.133		0.003	U	12		8.05		707.39		3		5.9						0.002		0.2		1			
5/2/2005	9:05	82		8	J	2640		0.01	U	0.193		0.0041	J	11.63		7.6		720.09		22		6.4						0.009		0.2		4.6			
6/6/2005	10:00	83		4		1970		0.01	U	0.051		0.003	U	11.53		7.76		710.18		6		8.1						0.003		0.1		1.1			
7/11/2005	10:25	110		10		712		0.01	U	0.01	U	0.003	U	10.51		8.21		722.88		3		12.9						0.003		0.1		0.7			
8/1/2005	9:40	142		23	J	343		0.01	U	0.159		0.003	U	9.59		8.23		727.96		2		15.7						0.004		0.2		0.5	U		
9/12/2005	9:35	160		25		206		0.01	U	0.229		0.003	U	10.27		8.14		721.61		1		11.7						0.002		0.3		0.5	U		
10/3/2005	12:10	155		49		242		0.01	U	0.2		0.003	U	10.96		8.3		713.49	J	2		8.9						0.002		0.3		0.5	U		
11/7/2005	11:55	164		1	U	312		0.01	U	0.155		0.003	U	12.2		8.3		710.69		2		4						0.002		0.2		0.5	U		
12/5/2005	11:15	164		1				0.01	U	0.216		0.003	U			8.21		721.87		1		0.3						0.002		0.3		0.5	U		
1/9/2006	11:00	133		4		306		0.01	U	0.172		0.0031		12.7		8.08		713.74		2		3.1						0.002		0.3		0.6			
2/6/2006	10:10	144		4		289		0.01	U	0.175		0.0031		13.1		8.27		719.33		2		2.5						0.002		0.2		0.6			
3/6/2006	10:15	160		2		278		0.01	U	0.163		0.003	U	12.47		8.34		708.66		2		4.3						0.003		0.2		0.5	U		
4/10/2006	10:30	150		11		1290		0.01	UJ	0.21		0.0035		11.7		8.12		711.2		17	J	6.5						0.006		0.3		3.6			
5/1/2006	10:10	93		6		5510		0.01	U	0.231		0.0053		11.8		8.08		716.53		68	J	5						0.017		0.3		16			
6/5/2006	10:15	60		5		8360		0.01	U	0.072		0.0046		11.2		7.83		715.01		47	J	7.2						0.01		0.1		9.8	J		
7/10/2006	10:05	96		16		1770		0.01	U	0.064		0.003	U	10.1		8.15		717.55		4		13.8						0.003		0.1		1.7			
8/7/2006	10:25	142		23		460		0.01	U	0.18		0.0031		9.68		8.17		725.93		1		14.5						0.002		0.2		0.5	U		
9/11/2006	9:50	166		12				0.01	U	0.286		0.003	U	10.2		8.21		731.01		1	U	12						0.003		0.4		0.5	U		
10/2/2006	11:25	164		6				0.01	U	0.24		0.0031		10.8				714.5		1		9.7						0.003		0.3		0.5	U		
11/13/2006	11:05	102		6		1390		0.035		0.12		0.0035		12.12		7.96		703.58		2		3.3						0.003		0.2		0.7			
12/4/2006	10:45	138		2		570		0.01	U	0.157		0.0036		13.43		8.21		722.38		1	U	1						0.001		0.2		0.5			
1/8/2007	10:25	140		110		544		0.01	U	0.142		0.003	U	13.73	J	8.39		724.92		1		1.5						0.001	U	0.2		0.7			
2/12/2007	10:45	149		12				0.01	U	0.154		0.003	U	12.55		8.52		712.47		2		3.7						0.003		0.2		0.9			
3/5/2007	11:30	155		1	U	468		0.01	U	0.158		0.003	U	12.32		8.36		720.6		2		4.9						0.002		0.2		0.7			
4/2/2007	10:40	123		1	U	2690		0.01	U	0.144		0.003	U	12.24		8.12		714.5		5		4.1						0.005		0.2		1.9			
5/7/2007	10:50	93		8		4300		0.01	U	0.076		0.0033		11.51		8.12		717.55		10		7.2						0.005		0.1		2.6			
6/5/2007	11:10	57		35		10100		0.01	U	0.047		0.0035		10.39		7.63		721.36		85		7.9						0.028		0.1		40			
7/9/2007	11:00	91		8				0.01	U	0.065		0.003	U	10.19		8.17		720.6		3		13.3						0.003		0.1		1			
8/6/2007	11:40	133		7		561		0.01	U	0.107		0.0035		9.84		8.34		714.76		2		16.2						0.003		0.2		0.7			
9/10/2007	11:15	162		17		282		0.01	U	0.242		0.003	U	10.3		8.3		723.9		1		12.3						0.002		0.3		0.6			
10/8/2007	12:30	154		2		352		0.01	U	0.194		0.0032		11.11		8.29		716.53		2		8.9		0.005	U					0.2		0.8			
11/5/2007	11:45	148		1	U	374		0.01	U	0.178		0.0032		12.1		8.31		722.88		2		5.2		0.005	U					0.2		0.5			
12/5/2007	12:40	138		3		506		0.01	U	0.156		0.003	U	13.23		8.19		708.41		7		2.5		0.005	U					0.2		1.2			
1/7/2008	12:40	158		1		331		0.01	U	0.214		0.0033		13.33		8.15		703.58		1	U	1.4		0.005	U					0.3		0.5			
2/11/2008	12:25	162		3		303		0.01	U	0.205		0.003	U	13.7		8.46		714.76		2		2.6		0.005	U					0.2		0.6			
3/3/2008	12:00	158		1	U	312		0.01	U	0.18		0.003	U	12.46		8.25		716.28		3		5.1		0.005	U					0.2		0.5			
4/7/2008	12:45	154		1	U	409		0.01	U	0.164		0.0038		11.83		8.29		710.69		5		6.9		0.0051						0.2		1			
5/5/2008	12:25	102		16		2300		0.01	U	0.219		0.0044		10.91		7.04		714.25		69		7.8		0.048	J					0.3		18			
6/2/2008	14:20	58		12		8790		0.01	U	0.062		0.0041		10.75		7.52		710.69		22	J	8.9		0.013						0.1		6.1			
7/7/2008	13:15	82		4		2470		0.01	U	0.029		0.003	U	10.15		8.19		708.91		6		11.9*	J	0.0059						0.1		2.4			

8/4/2008	13:30	128		6		545		0.01	U	0.109		0.0031		9.8		8.19		716.53		2		16.3*	J	0.005	U					0.2		0.6			
9/8/2008	12:00	148		6		292	J	0.01	U	0.202		0.0031		10.45		8.22		691.13		1		13*	J	0.005	U					0.2		0.5	U		

Common data qualifiers: U - not detected at the reported level, J - estimated value

Colored background

indicates that result exceeded water quality standards -OR- contrasted strongly with historical results.

November 2006 amendment to water quality standards (excluding supplemental temperature criteria) was incorporated beginning in January 2009.

Asterisk * indicates possible quality problem for the result. You may wish to discuss the result with the station contact person.

Data: Water Quality Index (WQI) for year 2008 at monitoring stations 48A150 and 48A140 from Washington State Department of Ecology website (http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?).

Station 48A150 (2008) Methow River @ Winthrop	Parameter	WQI*	Condition
	Fecal coliform bacteria	100	Good
	Oxygen	82	Good
	pH	85	Good
	Suspended solids	76	Moderate
	Temperature	83	Good
	Total persulf nitrogen	97	Good
	Total phosphorus	94	Good
	Turbidity	81	Good
	Overall	**88**	**Good**

Station 48A140 (2008) Methow River @ Twisp	Parameter	WQI*	Condition
	Fecal coliform bacteria	98	Good
	Oxygen	93	Good
	pH	81	Good
	Suspended solids	75	Moderate
	Temperature	84	Good
	Total persulf nitrogen	97	Good
	Total phosphorus	95	Good
	Turbidity	81	Good
	Overall	**89**	**Good**

The Water Quality Index is designed to rate general water quality based on monitoring conducted by Ecology's Freshwater Monitoring Unit. Monitoring results from monthly grab samples have been converted to scores ranging from 1 to 100 following a fairly complex methodology. In general, scores less than 40 indicate water quality did not meet expectations or was poor. Scores of 40 through 79 indicate moderate quality, and scores of 80 and greater indicate water quality met expectations and is good.

For temperature, pH, fecal coliform bacteria, and dissolved oxygen, the index expresses results relative to levels required to maintain beneficial uses (based on criteria in Washington's Water Quality Standards, WAC 173-201A). For nutrient and sediment measures, where standards are not specific, results are expressed relative to expected conditions in a given region (http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?).

Narrative:
The Washington State Department of Ecology determined that the overall water quality at the Winthrop station (48A150) and Twisp station (48A140) met or exceeded expectations and is of lowest concern. Therefore, the chemical contamination/nutrients general indicator is interpreted to be in an Adequate Condition.

GENERAL INDICATOR: MAIN CHANNEL PHYSICAL BARRIERS (NATURAL/HUMAN)

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Habitat Access	Main Channel Physical Barriers	Barriers (Natural/Human)	No manmade barriers present in the mainstem that limit upstream or downstream migration at any flow.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at some flows that are biologically significant.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.

Narrative:
There are two irrigation diversion structures within the Middle Methow reach. The Barkley diversion dam near RM 49 is a push-up dam that during low summer flows is created to maintain irrigation flows. In addition, the Barkley diversion dam is modified annually which causes major disturbances in the stream channel that negatively impact the channel processes and creates an entrainment hazard for juvenile salmonids and Pacific lamprey. The Methow Valley Irrigation District's (MVID) east irrigation diversion dam near RM 46 has been mostly removed and is no longer a fish passage barrier or impingement hazard.

The main channel physical barriers general indicator is interpreted to be in an At Risk Condition because during very low flows (drought years) the Barkley diversion dam may be pushed-up almost completely across the river which causes an entrainment hazard and possibly a velocity barrier for smaller fish.

GENERAL INDICATOR: CHANNEL SUBSTRATE

Criteria: Performance standards for these criteria are from Hillman and Giorgi (2002).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Habitat Quality	Substrate	Dominant Substrate/ Fine Sediment	Gravels or small cobbles make-up >50% of the bed materials in spawning areas. Reach embeddedness in rearing areas <20%. <12% fines (<0.85mm) in spawning gravel or ≤12% surface fines of ≤6mm.	Gravels or small cobbles make-up 30-50% of the bed materials in spawning areas. Reach embeddedness in rearing areas 20-30%. 12-17% fines (<0.85mm) in spawning gravel or 12-20% surface fines of ≤6mm.	Gravels or small cobbles make-up <30% of the bed materials in spawning areas. Reach embeddedness in rearing areas >30%. >17% fines (<0.85mm) in spawning gravel or >20% surface fines of ≤6mm.

Data: Middle Methow River Habitat Assessment (Appendix D).

Substrate	RM 41.2-47.0	RM 47.0-50.0
Habitat reach	Reach 2	Reach 3
Channel Type (Rosgen 1996)	C	C/F
Substrate (Pebble Counts):		
Surface fines (<6mm)	8%	5%
D50 (mm)	85.8	132.0
D84 (mm)	156.9	230.4
Sand (<2mm)	6%	5%
Gravel (2-64mm)	28%	11%
Cobble (64-256mm)	61%	72%
Boulder (>256mm)	5%	12%
Bedrock	-	-

Narrative:
The channel substrate indicator describes the dominant material that makes up the composition of material along the streambed in spawning and rearing areas (Hillman 2006). Cobble and gravel are the dominant substrate types for moderately confined habitat reach 3 and unconfined habitat reach 2 (Appendix D). Embeddedness is a measure of the degree to which fine sediments surround or bury larger particles and is an indicator of the quality of over-wintering habitat for juvenile salmonids (Hillman 2006). Substrate embeddedness does not appear to be excessive within the Middle Methow reach. Percent of fine sediments in spawning gravels appears to be a localized problem between RM 45.0 and RM 45.5 because cobble and coarse gravel substrate at the pool crests of the two pools in this section were embedded due to high amounts of fine sediments. This could be related to a pulse of sediment transported from the Chewuch River after landslides in 2004 (personal communication from David Hopkins, April 5, 2010), bank erosion, sediment suspended in irrigation return flows, unimproved roads, and road sanding. The surface fine sediments (< 6 mm) for the Middle Methow reach averaged about 7.5% with a range of 4% to 11% (Appendix D). Fine sediment is being contributed to the Middle Methow reach from fires that have burned in the upper watershed and in tributaries. The Middle Methow reach is interpreted to be in an **Adequate Condition** for dominant substrate and fine sediment specific indicators.

GENERAL INDICATOR: LARGE WOOD

Criteria: The following criteria were developed by USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Habitat Quality	Large Wood	Pieces Per Mile at Bankfull	>20 pieces/mile >12" diameter >35 ft length; and adequate sources of woody debris available for both long- and short-term recruitment.	Currently levels are being maintained at minimum levels desired for "adequate", but potential sources for long-term woody debris recruitment is lacking to maintain these minimum values.	Current levels are not at those desired values for "adequate", and potential sources of woody debris for short- and/or long-term recruitment are lacking.

Data: Middle Methow River Habitat Assessment (Appendix D).

River Mile	RM 41.2-47.0	RM 47.0-50.0
Habitat Reach	Reach 2	Reach 3
Channel Type (Rosgen 1996)	C	C/F
Large wood per mile (in-channel only):		
Large (>35' long, >20" diameter)	3.3/mile	2.1/mile
Medium (>35' long, 12-20" diameter)	12.7/mile	7.8/mile
Total large and medium	16.0/mile	9.9/mile
Small (>20' long, >6" diameter)	30.0/mile	15.6/mile

Narrative:
Amounts of large wood in the channel are at low levels for a moderately confined (habitat reach 3) and unconfined (habitat reach 2) valley segments based on data recorded in the habitat assessment (Appendix D). Large wood has been anecdotally noted to have been historically removed from the channel both within the reach and in the upper portions of the Methow River (Reclamation 2007). Only about 10 pieces of large wood (greater than 35-feet long with a diameter of at least 12-inches per mile) was surveyed along the main channel between RM 47.0 to 50.0, and 16 pieces of large wood was surveyed between RM 41.2 to 47.0. Most of the wood was observed high on the bars and in jams at the confluence with side channels which is expected for a large river. About 10 pieces of large wood per mile were counted in several wetted side channels.

Large wood recruitment potential is considered poor to fair due to the removal of vegetation in the floodplain for agriculture and residential development (refer to Specific Indicator: Vegetation Condition (Disturbance)). Technically, the Middle Methow reach is functioning in an unacceptable condition, but due to the large size of the stream which transports wood at high flows the Middle Methow reach is interpreted to be in an **At Risk Condition** for the large wood general indicator.

GENERAL INDICATOR: POOLS

Criteria: The following criteria were adapted from USFWS (1998) and Montgomery and Buffington (1993).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Habitat Quality	Pools	Pool Frequency and Quality Large Pools (in adult holding, juvenile rearing, and over-wintering reaches where streams are >3 m in wetted width at base flow)	Pool frequency: Channel width No. pools/mile 0-5 ft 39 5-10 ft 60 10-15 ft 48 15-20 ft 39 20-30 ft 23 30-35 ft 18 35-40 ft 10 40-65 ft 9 65-100 ft 4 For channel widths greater than 100 feet, pool spacing for an alluvial valley type that are moderately confined to unconfined with a channel slope <2% is generally a pool for every 5-7 channel widths (Montgomery and Buffington (1993). Pools have good cover and cool water and only minor reduction of pool volume by fine sediment. Each reach has many large pools >1 m deep with good fish cover.	Pool frequency is similar to values in "functioning adequately", 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) present with good fish cover.	Pool frequency is considerably lower than values for "functioning adequately", also cover/temperature is inadequate, and there has been a major reduction of pool volume by fine sediment. Reaches have no deep pools (>1 m) with good fish cover.

Data: Middle Methow River Habitat Survey (Appendix D).

River Mile	**RM 41.2-47.0**	**RM 47.0-50.0**
Habitat reach	Reach 2	Reach 3
Total number of survey pools in reach	19	12
Survey pools per mile	3.3	4.3
Survey pools >5 feet deep per mile	1.7	3.6
Average maximum pool depth	6.32 feet	7.81 feet
Average pool residual depth	4.59 feet	6.03 feet
Pool Form:		
Number of bedrock pools	4	8
Number of lateral scour pools	13	4
Number formed by large wood	0	0
Number of other pool form	2	0
Channel Morphology:		
Average wetted channel width	120 feet	132 feet
Bankfull width	207 feet	190 feet
Width/depth ratio	68.0	72.2
Floodplain width	>1000 feet	400 feet
Entrenchment ratio	>5.0	2.10
Sinuosity	1.35	1.15
Gradient	0.3%	0.3%
Channel types (Rosgen 1996)	C3	C/F
Required number of pools per mile to meet criteria	4	4

Narrative:
Pool depth was interpreted to provide cover from predators, buffers against wide fluctuations in water temperatures, and acts as a refuge during fire, drought and cold water temperatures in the Middle Methow reach. About 3.3 pools per mile were documented between RM 41.2 to 47.0, and about 4.3 pools per mile between RM 47.0 to 50.0 that were greater than 1 meter depth (Appendix D). Based on the Montgomery and Buffington (1993) criteria there should be about 3.7 pools per mile, suggesting pool habitat area is functioning adequately. Bedrock was the primary pool forming agent of the deep pool habitat with depths ranging from 6-feet to 17-feet and provides good fish hiding cover. Although there are adequate numbers of deep bedrock pools that provide fish cover, there are shallow lateral scour pools along the channel margins that appropriate vegetation and lack large wood which would provide adequate fish cover. Therefore, the pools general indicator is interpreted to be in an **At Risk Condition**.

GENERAL INDICATOR: OFF-CHANNEL HABITAT

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Habitat Quality	Off-channel Habitat	Connectivity with Main Channel	Reach has many ponds, oxbows, backwaters, and other off-channel areas with cover, and side channels are low energy areas. No manmade 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, and side channels are generally high energy areas. Manmade barriers present that prevent access to off-channel habitat at some flows that are biologically significant.	Reach has few or no ponds, oxbows, backwaters, and other off-channel areas. Manmade barriers present that prevent access to off-channel habitat at multiple or all flows.

Data: Middle Methow River Habitat Assessment (Appendix D).

River Mile	**RM 41.2-47.0**	**RM 47.0-50.0**
Habitat Reach	Reach 2	Reach 3
Pool	40.7%	50.5%
Riffle	33.0%	27.2%
Run	18.0%	19.2%
Side channel/off-channel	8.3%	3.1%

Mapped Side Channels - Data: Middle Methow River Habitat Assessment (Appendix D).

Identifier[1]	River Mile	Bank	Length	Width	Avg/Max Depths	Date Dewatered	% Pool Habitat	% Riffle Habitat	Max Water Temp.	Notes
SC_41.70_L	41.2[2]	Left	1,500'[2]	Dry	-	?	-	-	n/m	Connects to wetlands
SC_42.30_R	42.0	Right	1,350'	Dry	-	07-11-08	-	-	n/m	Located below dike
SC_42.85_R	42.5	Right	>1,000'	Dry	-	06-09-08	-	-	n/m	Channel not walked
SC_42.90_L	42.7	Left	n/m	Dry	-	07-07-08	-	-	n/m	Lehman side channel.
SC_43.10_L	42.9	Left	1,100'	15'	0.6' / 3.0'	-	n/m	n/m	n/m	3.0' pool in channel
SC_45.30_R	44.2	Right	1,250'	70-100'	n/m	-	100%	0	23.23◦C	Beaver ponds
SC_45.10_R	44.5[3]	Right	2,600'	Dry	-	09-20-08	-	-	19.37◦C	State land above ponds
SC_46.04_R	45.6	Right	1,585'	70'	1.0' / 4.0'	-	63%	37%	18.72◦C	McNae Side Channel
SC_46.70_L	46.7	Left	1,255'	80'	1.2' / 5.0'	-	66%	34%	n/m	At end of reach
SC_47.90_R	47.7	Right	1,150'[2]	Dry	-	06-09-08	-	-	n/m	Nancy Farr property.
SC_48.37_L	48.1	Left	950'	15'	1.0' / 2.0'	-	n/m	n/m	11.60◦C	Gilbertson Springs
SC_49.00_R	48.6	Right	1,700'	Dry	0	Midsummer	-	-	-	Large, up to 140' wide
SC_49.63_L	49.3	Left	1,225'	39'	2' / 6'	-	70%	30%	n/m	Barkley side channel

n/m = not measured.

1Geographical information system (GIS) side channel identification.

2Two dry side channels, total length 1,500'. One of the side channels connects to a series of wetland ponds. On 10-02-08 (low flow), the six ponds had a total area of about 22,500 sq. ft., with depths ranging from 0.4' to 3.0'.

3There were a few disconnected, wetted pools in the lower part of the channel at the time of the habitat survey.

Narrative:

At low flow, there is about 8 percent of off-channel habitat from RM 41.2 to 47.0 and 3 percent of off-channel habitat from RM 47.0 to 50.0 based on all available aquatic habitat (Appendix D). Based on the Two-Dimensional Hydraulic Model results, many of the larger side channels become inundated and have the potential to provide high water refugia at 11,000 cfs and greater flows (Reclamation 2010). However, recent Methow Salmon Recovery Foundation (MSRF) staff gage monitoring shows all the primary side channels receiving flow at much less than the 11,000 cfs. A large portion of the side channels dewater in late summer, with the exception of areas that have groundwater input (Appendix D). Although bank protection and levees have reduced the amount of side channel and off-channel habitat, man-made off-channel rearing habitat exists that is used by large numbers of fish (i.e., Barkley irrigation ditch provides rearing habitat until shut-off in the fall which is a hazard to all fish species due to the mortality associated with the shut-off, despite salvage efforts). There are also 6 perennial ponds ranging in size from 180 square feet to 15,000 square feet on river left at about RM 42.1 in subreach MM-OZ-18 (also called Anderson side channel area), and backwater pool habitat (alcoves) at many of the river bends.

Beaver (*Castor canadensis*) and other fur-bearing animals were trapped extensively throughout the Methow Valley. Because trapping predated any historic records, there is no clear reference on how numerous beavers were along the Middle Methow or how they influenced riparian forests and hydrology. Beaver are slowly recovering along the Methow River but may be at only a small fraction of their original population (Kent Woodruff, Methow Valley Ranger District, personal communication). The cumulative anthropogenic impacts affecting the creation of floodplain-type side channels and reduction in beaver populations are qualitatively interpreted to have resulted in a reduction of complex off-channel habitats produced by beaver activities, a reduction in groundwater recharge, and potentially a contraction in the size of the hyporheic zone.

Floodplain development (see Specific Indicator: Vegetation Condition (Disturbance)), and large wood removal from the channel, based on anecdotal accounts (Reclamation 2007), have most likely reduced the instream complexity and fish cover of the off-channel habitat areas. Manmade barriers are present that disconnect several of the off-channel areas (Appendix C). In addition, while beavers are active in some areas of the reach their populations have greatly diminished and this is also a cause of reduced off-channel habitat quantity and quality. Therefore, the off-channel habitat general indicator is interpreted to be in an **At Risk Condition**.

SPECIFIC INDICATOR: FLOODPLAIN CONNECTIVITY

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Channel Condition	Channel Dynamics	Floodplain Connectivity	Floodplain areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession.	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced and riparian vegetation/succession altered significantly.

Data: Initial site assessment (Appendix C) and geographic information system (GIS) analysis (Appendix F).

River Miles	RM 40.90-41.15	RM 41.15-43.10	RM 43.10-44.10	RM 44.10-45.50	RM 45.50-46.25	RM 46.25-48.10	RM 48.10-49.25	RM 49.25-50.00
Subreach	MM-IZ-8	MM-IZ-7	MM-IZ-6	MM-IZ-5	MM-IZ-4	MM-IZ-3	MM-IZ-2	MM-IZ-1
Channel gradient	0.18%	0.35%	0.18%	0.38%	0.32%	0.28%	0.35%	0.25%
Average bankfull width[1]	190 feet	250 feet	200 feet	200 feet	200 feet	220 feet	200 feet	150 feet
Channel units (percentage):								
Rapid	15%	4%	1%	3%	10%	4%	4%	3%
Run	45%	16%	43%	38%	42%	49%	30%	33%
Riffle	0%	3%	6%	1%	12%	3%	7%	17%
Pool	0%	14%	12%	11%	8%	15%	29%	18%
Bar	40%	45%	35%	42%	21%	25%	23%	15%

River Miles	RM 40.90-41.15	RM 41.15-43.10	RM 43.10-44.10	RM 44.10-45.50	RM 45.50-46.25	RM 46.25-48.10	RM 48.10-49.25	RM 49.25-50.00
Side channel	0%	18%	3%	5%	7%	4%	7%	14%
Anthropogenic features:								
Riprap (linear feet)	~670 ft	~1,290 ft	~2,330 ft	~3,120 ft	~370 ft	~80 ft	~3,000 ft	~1,900 ft
Diversion dam	None	None	None	None	MVID East	None	None	Barkley
Levee	None	~1,110 ft	None	~440 ft	~1,210 ft	None	None	None
Road embankment	None	~5,400 ft disconnecting parcels MM-DOZ-20c and MM-DOZ-20e	None	None	None	None	~640 ft	None
Potential channel impacts (causal factors):	Localized incision (primarily natural)	Localized incision (riprap and levee)	Localized incision (riprap)	Localized incision (riprap and levee)	Actively adjusting to dam modifications; potential for localized incision (levee)	Localized scour (cars, etc.)	Localized incision (riprap)	Localized deposition (dam) and incision (riprap)

[1] Bankfull widths measured from LiDAR hillshade model.

Data: Geomorphology and hydraulic modeling (Reclamation 2010).

Geomorphic Unit	Flood Event	Discharge	Comment
Active Floodplain (Qa3)	10-year flood	16,600 cfs	The active floodplain (Qa3) is overtopped at a discharge of about 16,600 cfs (about a 10-year flood) and the variability of inundation reflects the irregular topography
Side Channels in Active Floodplain (Qa3)	2-year flood	10,900 cfs	Side channels within the active channel (Qa4) have the most potential to be inundated during low-flow periods and prominent side channels within the active floodplain (Qa3) are not generally inundated by the 2-year flood
Overflow Channels in Active Floodplain (Qa3) and Higher Floodplain (Qa2)	5-to-10-year flood	>10,900 cfs to 16,600 cfs	Overflow channels within the active floodplain (Qa3) and higher floodplain (Qa2) are only inundated by larger floods greater than 5-to-10-year events

Narrative:
Much of the main channel in the Middle Methow reach is in active adjustment (transition) due to dams and riprap. The Barkley diversion dam is modified annually by pushing up a levee for the diversion from an active gravel bar. The Methow Valley Irrigation District's east canal diversion has been modified (main channel dam has been removed) and the channel is actively adjusting to this disturbance.

Reclamation (2010) predicted that the active floodplain (Qa3) is overtopped at a discharge of about 16,600 cfs (10-year flood) based on the two-dimensional hydraulic model results. It also concluded there was no reach scale incision and that riprap could potentially cause local scour pools, but would not lower hydraulic controls that would lower flood stages and reduce floodplain access. This was based on comparison of historical and existing channel data and high water flood stage, geomorphic dating and mapping of surfaces and modeling results.

However, the riprap (~12,760 linear feet) and levees (~2,760 linear feet; lined with riprap) are the primary anthropogenic causal factors for vertical channel adjustments in the Middle Methow reach. In addition, the highway embankment (~5,400 linear feet) disconnects about 85 acres of floodplain (MM-DOZ-20c and MM-DOZ-20e) from being accessed during high water events. Bank protection (i.e. riprap) placed on a streambank constrains lateral channel adjustment, thereby exaggerating adjustment in the vertical dimension. Additionally, riprap often has a lower roughness coefficient than a naturally vegetated streambank and consequently, near bank velocities may be higher, resulting in increased boundary shear stress that may result in scouring of the bed next to the riprap revetment (i.e. localized incision) (Skidmore and others 2009). An "active" floodplain is typically accessed during channel forming flows (about 2-year flood), and where there are long sections of bank protection along the Middle Methow River there are floodplain areas that are not being activated until the 10-year flood. Areas of localized incision negatively impact the channel and floodplain interactions as the channel is lowered and unable to access the floodplain except at much higher flows (i.e. 10-year flood versus 2-year flood). Other causal factors include floodplain development, improved roads, and unimproved roads that artificially route flows on the floodplain. Therefore, the floodplain connectivity specific indicator is interpreted to be in an **At Risk Condition**.

SPECIFIC INDICATOR: BANK STABILITY/CHANNEL MIGRATION

Criteria: The criteria for bank stability/channel migration are a relative condition of the specific indicator developed by Reclamation.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Channel Condition	Channel Dynamics	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.	Little or no channel migration is occurring because of human actions preventing reworking of the floodplain; 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.

Data: The following information was gathered by Reclamation during the initial site assessment (Appendix C). The table contains the anthropogenic features that are within the inner zone and interact with the river.

River Mile	RM 41.20-40.85	RM 43.10-41.15	RM 44.15-43.10	RM 45.50-44.10	RM 46.25-45.50	RM 48.10-46.25	RM 49.25-48.10	RM 50.00-49.25
Subreach	MM-IZ-8	MM-IZ-7	MM-IZ-6	MM-IZ-5	MM-IZ-4	MM-IZ-3	MM-IZ-2	MM-IZ-1
Riprap (linear feet)	~670 ft	~1,290 ft	~2,330 ft	~3,120 ft	~370 ft	~80 ft	~3,000 ft	~1,900 ft
Diversion dam	None	None	None	None	MVID East	None	None	Barkley
Levee	None	~1,110 ft	None	~440 ft	~1,210 ft	None	None	None
Road embankment	None	None	None	None	None	None	~640 ft	None
Cars, gabions, and other debris	None	None	None	None	3 cars	13 cars	None	None

Data: Geographic information System (GIS) analysis of eroding streambanks (Appendix F).

River Mile	Bank	Length	Vegetation Condition
RM 47.70 – 47.60	Right	422 ft	Grass/forbs
RM 47.30 – 47.20	Right	703 ft	Grass/forbs
RM 47.00 - 46.70	Left	1,185 ft	Grass/forbs-to-small tree
RM 43.40 – 43.10	Left	1,554 ft	Grass/forbs
RM 43.20 – 43.10	Right	528 ft	Small tree
RM 42.25 – 42.20	Left	612 ft	Small tree
RM 41.85 – 41.60	Right	1,490 ft	Small tree

Data: Habitat Assessment (Appendix D).

River Mile	RM 41.2-47.0	RM 47.0-50.0
Habitat Reach	HR 2	HR 3
Linear feet of erosion per mile	1,748 ft/mile	827 ft/mile
Percent eroding banks (total both banks)	16.6%	7.8%

Narrative:

Riprap (~12,760 ft) and levees (~2,760 ft) are the primary causal factors preventing (or inhibiting) lateral channel migration in the Middle Methow reach. Bank protection (i.e. riprap) has been placed along about 16 percent of the streambanks (both banks) that restricts lateral channel adjustment, thereby increasing potential for exaggerating adjustment in the vertical dimension (Skidmore and others 2009). However, much of the riprap is placed in areas where the channel would not migrate significantly due to juxtaposition with older non-erodible or only slightly erodible materials such as high glacial outwash terraces and bedrock.

About 6,500 linear feet of bank erosion was documented on field maps and redrawn in GIS (Appendix F). More accurate documentation of streambank erosion was measured and recorded in the Habitat Assessment (Appendix D). Measured erosion from RM 41.2 to RM 47.0 was

1,748 ft/mile (about 17 percent), and from RM 47.0 to 50.0 was 827 ft/mile (about 8 percent). About 30 percent of the riparian buffer zone is in a grass/forbs-to-shrub/seedling condition primarily due to removal for agriculture and residential development. Eroding streambanks downstream of RM 43.50 appear to be a translocation issue related to riprap. Flow velocities and shear stresses are not dissipated along the riprap, but are transferred downstream and directed at the opposing bank.

Based on historical maps and aerial photography, the upper portion of the Middle Methow reach is migrating at natural rates from about RM 50 to RM 43. Downstream of RM 43 to the constriction near the mouth of the Twisp River the river is unconfined and historically had larger and more frequent lateral channel migration (Reclamation 2010).

It is difficult to discern whether the observed streambank erosion is occurring at a normal, accelerated or slower than natural rate since a trend analysis (i.e. time series) has not been completed for the Middle Methow reach. Depending on the location of the bank, composition, and vegetation, the primary impact of bank protection may be an alteration of bank roughness and increased shear stresses along the streambed (scour).

Channel migration has been documented using historic aerial photographs to be fairly active between RM 43 to 40 in recent decades. Lateral channel migration has historically occurred, to a lesser degree, between RM 50 and 45 than between RM 45 to 40 (Reclamation, 2010).

Overall, the bank stability and channel migration specific indicators are interpreted to be in an **At Risk Condition** due to bank protection that may alter bank roughness and increase streambed shear stresses; erosion along disturbed streambanks; and levees and riprap that limit lateral channel migration from historical levels.

SPECIFIC INDICATOR: VERTICAL CHANNEL STABILITY

Criteria: The criteria for bank stability/channel migration are a relative condition of the specific indicator developed by Reclamation.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Channel Condition	Channel Dynamics	Vertical Channel Stability	No measurable or observable trend of aggradation or incision and no visible change in channel planform.	Measurable or observable trend of aggradation or incision that has the potential to, but not yet caused, disconnect the floodplain or a visible change in channel planform (e.g. single thread to braided).	Enough incision that the floodplain and off-channel habitat areas have been disconnected; or, enough aggradation that a visible change in channel planform has occurred (e.g. single thread to braided).

Data: The following information was gathered during the habitat assessment conducted by the Methow Valley Ranger District for this reach assessment (Appendix D).

River Mile	RM 41.2-47.0	RM 47.0-50.0
Habitat Reach	HR 2	HR 3
Bankfull data (main channel):		
Bankfull width	207 ft	190 ft
W/D ratio	68.0	72.2
Entrenchment ratio	>5	2.10
Floodplain width	>1,000 ft	400 ft

Data: The following information was gathered by Reclamation during the initial site assessments (Appendix C).

River Mile	RM 41.20-40.85	RM 43.10-41.15	RM 44.15-43.10	RM 45.50-44.10	RM 46.25-45.50	RM 48.10-46.25	RM 49.25-48.10	RM 50.00-49.25
Subreach	MM-IZ-8	MM-IZ-7	MM-IZ-6	MM-IZ-5	MM-IZ-4	MM-IZ-3	MM-IZ-2	MM-IZ-1
Riprap (linear feet)	~670 ft	~1,290 ft	~2,330 ft	~3,120 ft	~370 ft	~80 ft	~3,000 ft	~1,900 ft
Diversion dam	None	None	None	None	MVID East	None	None	Barkley
Levee	None	~1,110 ft	None	~440 ft	~1,210 ft	None	None	None
Road embankment	None	None	None	None	None	None	~640 ft	None
Cars, gabions, and other debris	None	None	None	None	3 cars	13 cars	None	None

Data: Summary of channel unit percentages at subreach-scale (Appendix C).

River Mile	RM 40.90-41.15	RM 41.15-43.10	RM 43.10-44.10	RM 44.10-45.50	RM 45.50-46.25	RM 46.25-48.10	RM 48.10-49.25	RM 49.25-50.00
Subreach	MM-IZ-8	MM-IZ-7	MM-IZ-6	MM-IZ-5	MM-IZ-4	MM-IZ-3	MM-IZ-2	MM-IZ-1
Total Acres	6 acres	96 acres	29 acres	52 acres	26 acres	56 acres	36 acres	21 acres
Percent Pools	0%	3%	6%	1%	12%	3%	7%	17%
Percent Rapids	15%	4%	1%	3%	10%	4%	4%	3%
Percent Riffles	0%	14%	12%	11%	8%	15%	29%	18%
Percent Runs	45%	16%	43%	38%	42%	49%	30%	33%
Percent Bars	40%	45%	35%	42%	21%	25%	23%	15%
Percent Side Channels	0%	18%	3%	5%	7%	4%	7%	14%

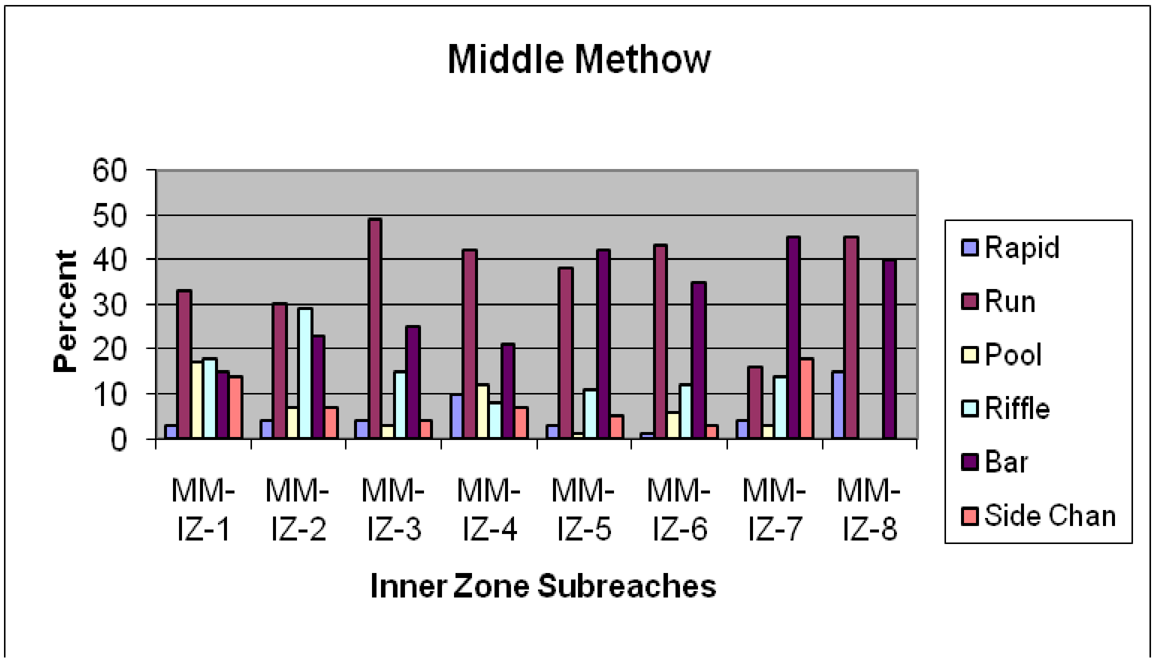

Figure 3. Bar graph of the percent based on acreage of channel units and exposed gravel bars within each subreach as mapped during the initial site assessment (Appendix C).

Narrative:
Hydraulic modeling results, comparison of historical data and flood stages, geomorphic mapping of channel migration and the presence of depositional gravel bars indicate no measurable reach-scale trend of channel incision has occurred over the last several decades (Reclamation, 2010). Fill or scour on the channel bed associated with diversion dams, bedrock, riprap, meanders, or other features results in localized effects but does not indicate a trend of reach-wide vertical instability.

Riprap (~12,760 ft), levees (~2,760 ft) and two diversion dams are the primary anthropogenic causal factors for localized active channel adjustments. Bank protection (i.e. riprap) placed on a streambank constrains lateral channel adjustment, thereby exaggerating potential for adjustment in the vertical dimension (Skidmore and others 2009). Additionally, riprap often has a lower roughness coefficient than a naturally vegetated streambank and consequently, near bank velocities may be higher, resulting in increased boundary shear stress that may result in scouring of the bed next to the riprap revetment (i.e. localized incision). Some common indicators of localized incision include (1) abrupt break in channel profile of the primary channel; however, in a coarse-bedded stream like the Methow this is only discernable from a surveyed profile, (2) lack of pool channel units in an otherwise pool/riffle dominated system, and (3) a transition of vegetative composition in channel banks from moisture dependent species to drought tolerant species as the depth to channel bed and associated groundwater table exceeds rooting depth (Skidmore and others 2009).

Channel unit mapping was conducted for the Middle Methow reach assessment (Appendix C). Channel unit mapping is a useful tool in interpreting subreach scale hydraulic conditions in addition to sediment movement through a given reach or channel segment at channel forming flows. Channel units are mapped in the field based on observed physical characteristics and then each unit is redrawn on rectified aerial photographs in ArcGIS. “Channel units” should not be confused with “habitat units” that are a measure of habitat type and quantity available at low flows. For example, the habitat assessment includes the long pool tail-out in the glide-pools (usually lateral scour pools) as pool habitat even though this area of the pool is functioning as a run hydraulically. For the channel unit mapping the pools (area of pool scour) and runs are spatially defined and mapped separately as geomorphic channel units. The channel units were charted using the percent of total area occupied by each unit to graphically illustrate the existing condition and to help interpret current trends in sediment transport and deposition (Figure 2). The Middle Methow reach includes a combination of channel types including moderately confined plane-bed to pool-riffle and unconfined pool-riffle segments. Conceptually, confined channel segments should have more pools and runs (scour and transport channel units); moderately confined segments should have a balance of runs (transport channel unit) with riffles and bars (depositional channel units); and unconfined segments should also have a balance of different types of channel units but with increasing area of riffles and bars (depositional channel units).

Moderately confined channels with higher gradients and more plan-bed type morphology do not typically form pools except where forced by significant hydraulic structures such as bedrock outcrops. In the moderately confined section of the reach (subreaches MM-IZ-1, MM-IZ-2, and MM-IZ-3) the reduction in lateral channel migration capability combined with the effect this has on sediment transport may be the most important factor since pool formation is typically associated with energy concentration at the meander bend apex. A balance of transport and depositional channel units would be expected in this plane-bed/pool-riffle system. In subreaches MM-IZ-1 and MM-IZ-2 there is an adequate balance of runs and pools (transport units) with riffles, rapids and bars (depositional units). However, in subreach MM-IZ-3 runs significantly increase most likely due to bedrock controls that restrict lateral and vertical channel migration.

In the unconfined section of the reach (subreaches MM-IZ-4, MM-IZ-5, MM-IZ-6, and MM-IZ-7) depositional channel units would be expected to increase in the downstream direction in this pool-riffle type system as the channel gradient decreases and large wood becomes more mobile. In these types of unconfined sections wood becomes less important as a channel control and functions more like sediment. Riffles and bars increase from MM-IZ-4 through MM-IZ-7, but there are also a high percentage of runs in MM-IZ-4, MM-IZ-5, and MM-IZ-6. This is most likely due to bank protection (i.e., riprap and levees) that has reduced lateral channel migration resulting in vertical channel instability (scour and localized channel incision). The impact on channel processes caused by the bank protection is interpreted to be a reduction in the sediment supply due to artificially stable streambanks and an increase in channel transport capacity at channel forming flows due to a change in channel geometry caused by scour.

In the moderately confined section of the Middle Methow reach there is an adequate number of pools for this plane-bed to pool-riffle system. However, in the unconfined section pools are underrepresented compared to what is expected for a pool-riffle type system. Even though the pool indicator is rated adequate for the reach based on pool frequency (total number per mile) and spacing for alluvial valley types that are unconfined with widths greater than 100 feet and channel slope <2% is generally a pool for every 5-7 channel widths (Montgomery and Buffington 1993). This implies that pools should comprise about 14-20% of the channel units in these unconfined low-gradient river channels. Pool, riffle, run, and rapid channel units (bars excluded) were analyzed for the entire Middle Methow reach and the pool channel units were found to comprise about 8 percent of the active channel area.

A reduction of in-stream and boundary roughness elements caused by the removal of large wood from the system, removal of riparian vegetation along the channel corridor, placement of hydraulically smooth bank protection, and reduction in floodplain connectivity are interpreted to have increased sediment transport capacity and reduced hydraulic complexity during channel forming discharges, While the magnitude of the changes are not known, it is hypothesized that these anthropogenic causal factors have resulted in a simplification of the channel processes and form.

Annual in-channel and gravel bar modifications to maintain the Barkley diversion dam causes the river to actively adjust (transition) to changing channel geometries. The removal of the Methow Valley Irrigation District east canal diversion dam is allowing the river to vertically adjust as it can now transport the accumulated sediment that was captured behind the dam downstream.

The vertical channel stability specific indicator is interpreted to be in an Adequate Condition for the potential of reach-scale channel incision or aggradation. However, the overall vertical channel stability is ranked as an At Risk Condition primarily due to the potential cumulative effects of localized active channel adjustments along bank protection (localized incision); annual manipulation of the Barkley diversion; and the removal of the Methow Valley Irrigation District's east canal diversion dam.

SPECIFIC INDICATOR: VEGETATION CONDITION (STRUCTURE)

Criteria: The criteria for riparian vegetation structure are a "relative" indication to the functionality of the specific indicator.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Riparian/Upland Vegetation	Vegetation Condition	Vegetation 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.

Data: The following vegetation structure was computed utilizing the geographic information system (GIS) vegetation mapping from Appendix E.

Code	Successional Stage	Acres	Percentage
NV	No Vegetation	23.3 acres	2%
GF	Grass/Forbs	546.1 acres	46%
SS	Shrub/Seedling	16.5 acres	1%
SP	Sapling/Pole	21.5 acres	2%
ST	Small Tree	266.9 acres	22%
LT	Large Tree	319.2 acres	27%
Total		1,193.5 acrea	100%

Data: The following vegetation structure was computed utilizing the geographic information system (GIS) vegetation mapping from Appendix E.

Vegetation Code	Vegetation Type	Acres	Percentage
1	Quaking aspen	49.4 acres	4%
1a	Quaking aspen with deciduous shrubs	5.2 acres	<1%
2	Black cottonwood	73.9 acres	6%
2a	Black cottonwood with mixed conifers and deciduous trees	265.8 acres	23%
2b	Black cottonwood with mixed deciduous shrubs	58.8 acres	5%
3	Other broadleaf deciduous trees	6.6 acres	<1%
4	Wetlands, water other than river	8.1 acres	<1%
5	Bars with deciduous shrubs	1.7 acres	<1%
5a	Bars with regenerating cottonwood	8.2 acres	<1%
6	Bars with forbs or no vegetation	2.4 acres	<1%
7	Mixed deciduous shrubs (not on bars)	8.3 acres	<1%
7a	Shrub steppe	0.1 acres	<1%
8a	Upland forest	1.2 acres	<1%
9	Mixed coniferous/deciduous	74.3 acres	6%
10	Agricultural areas (current and fallow)	504.4 acres	43%
11	Residential areas	84.0 acres	7%
12	Other use areas (runway, golf course, etc.)	0.7 acres	<1%
14	Road	13.8 acres	1%
Total		1,166.9 acres	100%

Narrative:

About 51 percent of the riparian and floodplain area of the Middle Methow reach has been disturbed by agriculture, residential, and commercial development. About 49 percent of the reach is currently in a small tree/large tree condition, with very few mature ponderosa pine trees. The large-diameter cottonwood component is reduced with most cottonwood trees relatively young, probably regenerated from the 1948 flood. The overall species composition, seral stage structural complexity is less than 80 percent of the potential native community, but greater than 50 percent. Based on the vegetation condition (structure) specific indicator criteria, this indicator is in an **At Risk Condition**.

SPECIFIC INDICATOR: VEGETATION CONDITION (DISTURBANCE)

Criteria: The criteria for riparian vegetation disturbance are a “relative” indication to the functionality of the specific indicator.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Riparian/Upland Vegetation	Vegetation Condition	Vegetation Disturbance (Natural/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 mi/mi^2 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 mi/mi^2 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 mi/mi^2 road density in the floodplain.

Data: The following 30 meter riparian buffer zone information was computed utilizing the geographic information system (GIS) vegetation mapping from Appendix E.

Code	Successional Stage	Acres	Percentage
--	Unknown	21.5 acres	9%
GF	Grass/Forbs	44.4 acres	19%
LT	Large Tree	37.4 acres	16%
SP	Sapling/Pole	16.1 acres	7%
SS	Shrub/Seedling	9.9 acres	4%
ST	Small Tree	106.9 acres	45%

Data: The following floodplain disturbance area information was computed utilizing the geographic information system (GIS) vegetation mapping from Appendix E.

Disturbance	Acres	Percent of Outer Zone
Agriculture	504.4 acres	43%
Residential	84.0 acres	7%
Other use areas	0.7 acres	<1%

Disturbance	Acres	Percent of Outer Zone
Roads	13.8 acres	1%
Outer Zone	Total Area of Outer Zone = 1184.1 acres	Total Percent Disturbed = 51%

Data: The following road density information was computed from the Middle Methow reach geodatabase (Appendix F).

Improved Roads	2.67 miles
Unimproved Roads	6.51 miles
Outer Zone	1.80 $miles^2$
Inner Zone	0.54 $miles^2$
Total Road Density (Improved and Unimproved Roads)	9.18 miles/2.34 $miles^2$

Interpretation:

Riparian Buffer Zone (30 meters)	Large Tree Condition = 16%	Unacceptable Condition
Floodplain Disturbance:	Agriculture & Residential & Roads = 51%	Unacceptable Condition
Road Density in Floodplain:	3.92 miles/1.00 $miles^2$	Unacceptable Condition

Narrative:
There are about 16 percent large trees and about 45 percent small trees available for recruitment by the river along the 30 meter riparian buffer zone. Most of the trees within the buffer zone were probably recruited from the 1948 flood event and have not had the time to reach a large tree condition. About 51 percent of the floodplain has been disturbed by agriculture, residential, and commercial development, and the total road density within the floodplain is about 3.92 miles/1.00 $miles^2$. Overall, the vegetation condition (disturbance) specific indicator is interpreted to be in an **Unacceptable Condition**.

SPECIFIC INDICATOR: VEGETATION CONDITION (CANOPY COVER)

Criteria: The criteria for riparian vegetation canopy cover are a "relative" indication to the functionality of the specific indicator.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Riparian/Upland Vegetation	Vegetation Condition	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.

Data: Geographic information system (GIS) analysis was used to determine the percent of small-to-mature trees are present in riparian buffer (10 meters) which is used as a surrogate to interpret the percent canopy cover.

Code	Successional Stage	Acres	Percentage
--	Unknown	5.3 acres	7%

Code	Successional Stage	Acres	Percentage
GF	Grass/Forbs	9.3 acres	12%
SS	Shrub/Seedling	3.6 acres	4%
SP	Sapling/Pole	6.2 acres	8%
ST	Small Tree	41.2 acres	52%
LT	Large Tree	13.4 acres	17%

Narrative:

Densiometers were not used during the reach assessment to determine canopy cover. As a surrogate the percent of small-to-large trees along a 10 meter riparian buffer zone (both banks) was used to assess the potential canopy cover. About 67 percent of the riparian vegetation is in a small-to-large tree condition, suggesting the canopy cover specific indicator is in an At Risk Condition, primarily due to removal of riparian vegetation for agriculture and residential development and secondarily by beavers in isolated locations.

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APPENDIX B

Monitoring Inventory

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METHOW SUBBASIN MONITORING INVENTORY

Prepared By: John Crandall
Wild Fish Conservancy
Methow Restoration Council
10 May 2009

Table of Contents

List of Acronyms

AREMP	Aquatic Resources Effectiveness Monitoring Plan
BACI	Before-After Control-Impact
DC PUD	Douglas County Public Utility District
DOE	Washington Department of Ecology
EMAP	Environmental Monitoring and Assessment Program
ESA	Endangered Species Act
HUC	Hydrologic Unit Code
ISEMP	Integrated Status and Effectiveness Monitoring Program
MRC	Methow Restoration Council
OBMEP	Okanogan Basin Monitoring and Evaluation Program
PIBO	PACFISH/INFISH Biological Opinion
QA/QC	Quality Assurance/Quality Control
R&E	Research and Evaluation
REI	Reach-based Ecosystem Indicators
SRFB	Salmon Recovery Funding Board
UCSRB	Upper Columbia Salmon Recovery Board
USBR	United States Bureau of Reclamation
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VSP	Viable Salmonid Population
WDFW	Washington Department of Fish and Wildlife
WFC	Wild Fish Conservancy
YN	Yakama Nation

1. Background

This assessment reflects an effort by the Wild Fish Conservancy, working in conjunction with the Methow Restoration Council (MRC), to develop an inventory of current salmonid fish population and aquatic habitat monitoring activities in the Methow Subbasin. We employ this inventory to assess the consistency of monitoring efforts in the Methow with the regional population and habitat monitoring criteria contained in the *Monitoring Strategy for the Upper Columbia Basin* (*'Monitoring Strategy'*, Hillman, 2006) and the *Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan* (*'Recovery Plan'*, UCSRB 2007). Results of this effort, including the identification of monitoring data gaps, will assist the alignment of monitoring in the Methow with other monitoring efforts in Upper Columbia (primarily OBMEP and ISEMP) and provide a basis for the creation of a comprehensive Methow Subbasin Monitoring Plan that can be amended into the *Recovery Plan*.

In the Methow subbasin, numerous agencies, tribes and non-governmental organizations are monitoring the status and trends of salmonid fish populations and their habitat and initiating restoration projects aimed at restoring viable populations throughout the Upper Columbia Basin. The listing of spring Chinook, steelhead and bull trout populations under the Endangered Species Act required the development of recovery plans that require comprehensive monitoring to assist in recovery assessment. Coordination of monitoring effort provides several benefits including consistent protocols, data collection and reporting, reduction of redundant monitoring, and efficient use of resources. Previous efforts in the Upper Columbia to coordinate monitoring have focused on areas where funded monitoring programs were in place, such as the Wenatchee, Entiat, and Okanogan subbasins. In 2005, the MRC was assembled in an initial attempt to coordinate restoration efforts within the Methow Subbasin and the role of this group has expanded to include monitoring coordination. The MRC includes representatives from local, state, tribal, federal and non-profit groups actively involved in planning, restoration, protection projects and monitoring in the subbasin.

In the Methow Subbasin, over ten entities are actively engaged in monitoring. They each collect data to meet their unique objectives or agency missions, and much of that data can be used for measuring the status, trend and response of habitat, water quality, or fish populations for recovery purposes.

Many, but not all, of these monitoring and restoration actions have been developed in response to individual Biological Opinions and Habitat Conservation Plans issued by the Federal Services. To date, monitoring has proceeded along several tracks with variable levels of coordination among the entities to ensure consistency. Each entity has its own monitoring program designed to meet the goals and objectives of their respective programs. In some cases, different monitoring procedures and protocols have been used by different groups to collect similar kinds of data. This can make summarizing or sharing of results difficult or impossible when trying to use the existing information to meet new or expanded objectives. Matters can be complicated further by the lack of standardized protocols for data storage and reporting of the monitoring results.

Additionally, different entities may be monitoring and measuring similar variables within close proximity, risking duplication of effort. A lack of coordinated and standardized subbasin monitoring could result in an inefficient use of resources or missed opportunities for information sharing. Efforts to streamline data collection, processing and storage are underway in the Upper Columbia Region, but these efforts have not yet been undertaken on a large scale in the Methow subbasin.

The inefficiencies of the current situation have been noted by the MRC. It was agreed that the development of a coordinated monitoring plan for the Methow subbasin that meets the goals and objectives of the various monitoring efforts while simultaneously increasing efficiency and reducing redundancy is necessary to align Methow monitoring with broader salmon recovery efforts. The MRC concluded that the first step in developing a monitoring plan for the basin should be a baseline inventory and analysis of current monitoring activities.

2. Methods

The development of a monitoring baseline assessment for the Methow began with the identification of current monitoring entities and programs (see Attachment 1). This list was developed through the MRC and with conversations with regional monitoring personnel. Only programs that were closely linked to monitoring of ESA-listed spring Chinook salmon, steelhead and bull trout populations and their associated habitats were considered. Past monitoring efforts, hatchery programs, or efforts related to other salmonid and anadromous species (especially coho and summer Chinook salmon, Pacific lamprey, rainbow trout and cutthroat trout) were noted where encountered, but were not included in the inventory. It is noted, however, that data from these efforts may provide valuable contributions to current and future monitoring programs and they will likely be addressed or integrated into a future Methow Subbasin Monitoring Plan.

Once identified, lead personnel for each monitoring program were interviewed either in person or via e-mail. The interview was based upon a questionnaire developed through the MRC to obtain information related to the what (type of monitoring, species, projects), where (location), why (plans followed, goals, questions), and how (protocols, frequency, duration, data collection and storage, reporting) of the particular monitoring program. If completed via e-mail, a follow-up conversation was had in order to establish contact and clarify responses. Interviews were conducted and collected by John Crandall of the Wild Fish Conservancy and results were entered into Excel.

Discreet data collected by each monitoring program were identified through an examination of the monitoring plans, protocols and interview notes. This analysis was compared to the core list of biological (Table 8) and physical (Table 9) indicators from the *Monitoring Strategy*, elements of *Recovery Plan* Appendices P (Monitoring and Evaluation Plan), H (Biological Strategy), and G (Habitat Matrices/Limiting Factors). Monitoring protocols and sampling frequencies from Tables 12 and 13 of the *Monitoring Strategy* were also compared to Methow data to assess consistency with regional recommendations. Key management questions and limiting factors identified in the

Appendix P of the *Recovery Plan* were examined and compared to how they are being addressed by monitoring in the Methow.

Results from the above comparisons formed the basis for the assessment as well as for the identification of data gaps, redundancies, and recommendations to align Methow monitoring with regional efforts and assist in the creation of a coordinated and comprehensive Methow Subbasin Monitoring Plan.

3. Results

3.1 Biological and Physical Indicators

Interviews were conducted with 12 program lead personnel representing eight federal, state and tribal entities including the U.S. Forest Service (USFS - 3 programs), U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (USBR), U.S. Geological Survey (USGS - 3 programs), Washington Department of Fish and Wildlife (WDFW), Washington Department of Ecology (DOE), Salmon Recovery Funding Board (SRFB) and the Yakama Nation (YN – 2 programs). All programs were currently active in some form and response to interview questions was 100%.

In total, 12 entities were identified that encompass 34 monitoring programs that are on-going in the Methow subbasin (see Attachment 1 and the *Methow Subbasin Monitoring Programmatic Worksheet*). These programs extend some sort of monitoring to most fish-bearing HUC 6 watersheds in the Methow (Figure 1). The Twisp, Chewuch and Methow Rivers are the most intensely monitored streams because of their important habitat for spawning and rearing of spring Chinook and steelhead. Several important partnerships in data collection were revealed. For example, USFWS collaborates with USFS, USGS, WDFW and Wild Fish Conservancy to complete annual redd surveys for bull trout. Similarly, USBR contracts USFS to collect temperature and habitat data for restoration related projects and reach assessments on private lands. These partnerships use the same protocol to complete their monitoring, illustrating an example of coordinated monitoring in the Methow.

3.1.1 Biological Indicators

Methow monitoring coverage of the core biological indicators and variables identified in Table 8 of the *Monitoring Strategy* is presented in Attachment 2 (spring Chinook), Attachment 3 (steelhead) and Attachment 4 (bull trout).

Monitoring by WDFW under the Douglas County PUD Hatchery Monitoring and Evaluation Plan (DC PUD 2005) was designed to evaluate population status, trend, and various hatchery effectiveness parameters. Many of the same metrics and protocols are needed to complete status assessments for evaluating the four Viable Salmonid Population (VSP) parameters (adult abundance, population status, spatial structure and diversity). Due to previous efforts for coordinating monitoring in the Upper Columbia Region, these make up the majority of metrics of core variables called for in the *Monitoring Strategy*. It is believed that monitoring these variables will provide valuable

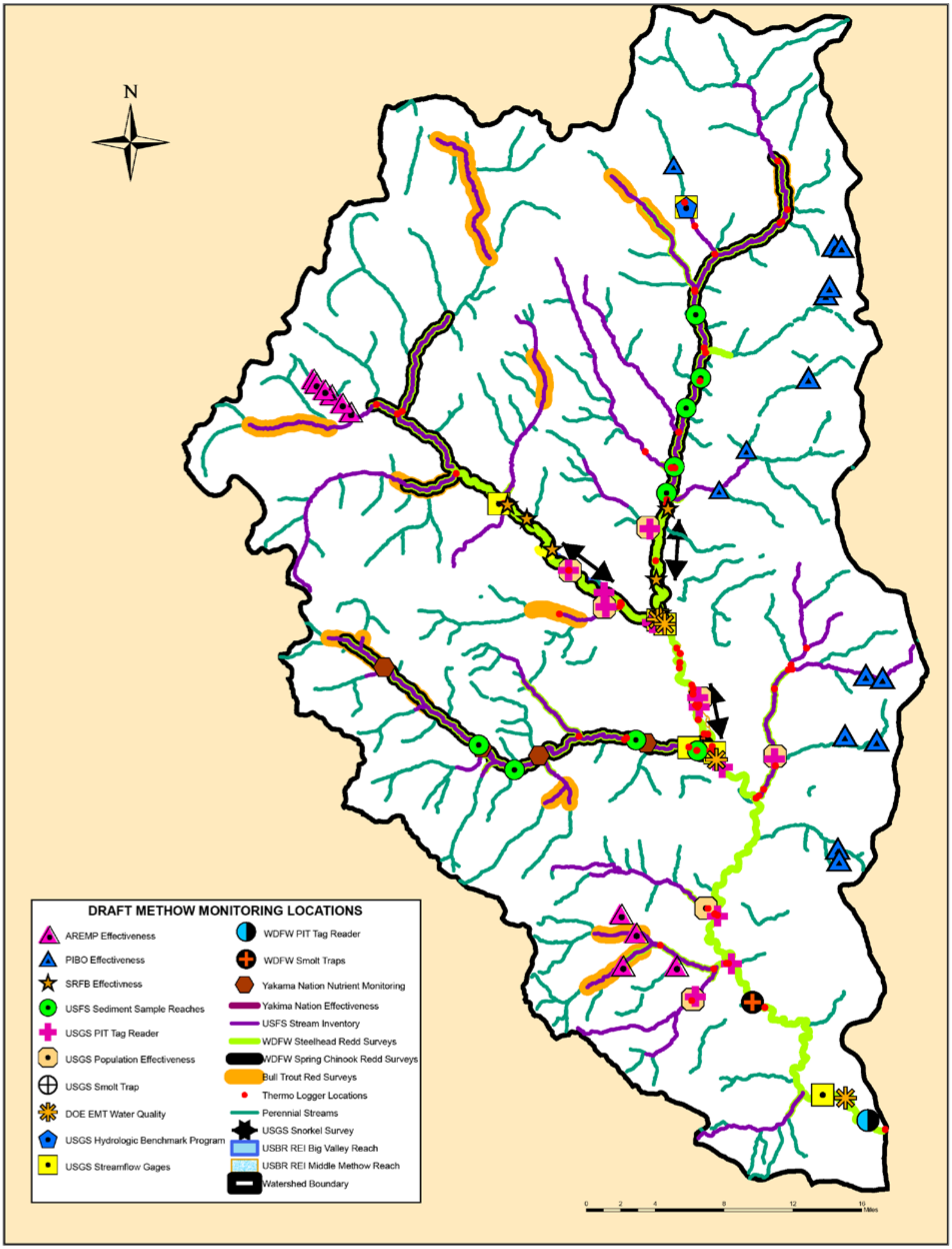

Figure 1. Draft Methow Monitoring Locations.

information in the determination of fish population recovery. Monitoring by WDFW is focused primarily on adults and smolts and this monitoring addresses all of the current core indicators for these life stages. Monitoring for resident/transitory juveniles is somewhat less comprehensive and species specific. Monitoring this life stage and is partially covered by several effectiveness monitoring programs, including USGS and SRFB, but these programs are not specifically targeted at the status and trend aspects of the juveniles and do not cover the full range of occurrence. The USFS Stream Inventory program collects juvenile data from numerous HUC 6 watersheds on a 10 year rotation, but this program is focused primarily on presence/absence (distribution) rather than abundance and size and the sampling interval is likely too long to effectively assess trends. Combined, these monitoring efforts are collecting juvenile data but at this time the results are not combined into a single database or report for potential analysis and use in recovery planning. This provides and example of where individual programs are meeting their own objectives, but where coordination might allow them to meet additional objectives.

Macroinvertebrates are being collected by four effectiveness monitoring programs (SRFB, PIBO, AREMP, and Yakama Nation). These sampling efforts cover a broad geographic area and collect repeat samples, but do not collect data in the Chewuch or Twisp Rivers. Macroinvertebrates are only monitored specifically for status and trend by the Yakama Nation Nutrient Monitoring Program (at six locations in the Twisp River). All monitoring is for benthic forms and none collect drift samples which represents a data gap.

Overall, monitoring the status and trend of bull trout in the Methow is not fully addressing the core indicators. Several monitoring programs (USGS, SRFB, USFS Stream Inventory) collect distribution and size data, and redd surveys and genetic analyses (coordinated by the USFWS) represent the only on-going monitoring programs that specifically target bull trout. These efforts yield critical information about bull trout populations in the Methow. Overall, it appears bull trout distribution has been ascertained (and monitored) through various efforts, but monitoring data detailing adult and juvenile abundance, age, sex, size and interactions between life histories has been sporadic and this represents a data gap.

3.1.2 Physical Indicators

Physical habitat core indicators (Table 9, *Monitoring Strategy*) currently monitored in the Methow are presented in Attachment 5. Combined, six entities representing 11 programs [DOE, USGS (3 programs), Yakama Nation (2 programs), USFS (4 programs), USBR and SRFB] monitor habitat and water quality. Overall, spatial coverage of these efforts is extensive, although the sampling period for some areas is large (i.e. ten years for the USFS Stream Inventory). The physical monitoring effort consists of both status and trend (DOE, USGS, USFS) and effectiveness monitoring (PIBO, AREMP, USGS, SRFB, YN and USBR) programs. Physical habitat is not currently monitored under a systematic, randomized sampling design such as EMAP.

Water quality parameters are monitored by several programs in the Methow and with a large degree of spatial coverage. Three programs (DOE Environmental Monitoring and Trends, USGS Hydrologic Benchmark, USFS Temperature Monitoring) are focused solely on water quality and the Yakama Nation initiated a nutrient monitoring program at six locations in the Twisp River in 2008. Temperature is the most intensively monitored parameter with nine separate programs collecting spring-fall hourly temperature. With the exception of continuous temperature, water quality monitoring in the Methow is instantaneous and projects collect data once during a site visit (monthly, annually or longer). As a result, only phosphorus and nitrogen (and temperature) are monitored with the frequency called for in the *Monitoring Strategy*. Seven programs collect non-core indicator data, including metals, several Phosphorous parameters, chlorophyll a, hardness, chloride and silica.

Habitat access indicators are monitored by only two programs, the USBR REI and USFS Stream Inventory. These programs are closely coordinated and USBR contracts with the USFS to conduct a portion of the REI. Currently, the REI is focused on the valley reaches of the middle Methow Rivers. The Stream Inventory works on a 10 year rotating panel in fish bearing HUC 6 watersheds. This monitoring effort also collects data on culverts, but based on previous work (USFS, WDFW), a comprehensive culvert inventory exists in the Methow. Overall, it does not appear that current monitoring frequency meets the annual criteria set forth in the *Monitoring Strategy*, but these indicators are not believed to be increasing in number in the Methow. Indeed, a significant habitat access improvement effort is underway in the Methow which is likely improving habitat access conditions basinwide.

Habitat quality and channel condition indicators are monitored by several entities and, for the most part, these indicators are monitored for change over time as a component of effectiveness monitoring programs. The spatial coverage of these efforts is extensive, yet very few of the monitoring reaches are visited annually as recommended in the *Monitoring Strategy*. In general, variation exists in terms of methods (at least five different protocols are in use) and also for specific metrics used to describe the indicators.

The USBR REI is monitoring the majority of habitat quality and channel condition indicators in several reaches (Big Valley and Middle Methow) of the Methow River. The USFS is also monitoring these indictors through three separate efforts (Stream Inventory, PIBO, and AREMP). While the protocols and locations for each of these efforts vary, they collect similar data. These three efforts also monitor the non-core indicators of sinuosity and entrenchment. Additionally, a fourth USFS program (Sediment Surveys) specifically monitors substrate/sediment at four locations in both the Chewuch and Twisp Rivers.

Both the SRFB at the Fender Mill site in the mainstem Methow and the Yakama Nation at the nearby Hancock Spring site obtain thalweg profiles (a non-core indicator) as a portion of two separate effectiveness monitoring programs.

Riparian condition is monitored by three entities (USBR, USFS, SRFB) with only the USBR REI monitoring all three core indicators of riparian structure, riparian disturbance, and canopy cover. Presently, this monitoring follows the protocols outlined in the *Monitoring Strategy*, but is limited to only the three reach assessments and is not slated to be repeated in the short-term. The USFS collects data on riparian structure in fish bearing HUC 6 watersheds on a ten year rotation, while the SRFB effectiveness monitoring collects only canopy cover information at the Fender Mill restoration site in the mainstem Methow.

Streamflow monitoring is conducted by USGS and USFS. USGS monitors daily discharge and gauge height continuously at seven stations in the Twisp (1 site), Chewuch (2 sites) and mainstem Methow (4 sites) rivers. Six of these sites stem from the streamflow monitoring program and the remaining site, Andrews Creek (a tributary to the Chewuch), is monitored under the Hydrologic Benchmark Program. Both programs use internal USGS protocols.

The USFS measures instantaneous discharge under the Stream Inventory program (fish bearing HUC 6 watersheds on a ten year rotation) and also annually at several irrigation diversions (Early Winters Creek, Wolf Creek, Little Bridge Creek) that were sites formerly monitored by USGS.

Watershed Condition is currently monitored only by USBR REI and AREMP. Each of these programs monitors the location, length and density of watershed and riparian roads. These indexes were collected on only one occasion and for only a few sub-watersheds in the basin. At this time, no planning exists to monitor these parameters every five years, although the USBR REI will continue to develop road indices with future reach assessments. It should be noted that the Pacific Biodiversity Institute did complete a basin-wide study of roads and land use in 2005 and this effort likely represents the most comprehensive dataset currently available. Yet, at this time, there are no plans to repeat this study every five years as called for in the *Monitoring Strategy*.

Land ownership is tracked by Okanogan County, and although this is not part of an on-going monitoring effort, these data are available.

3.2 Management Questions and Limiting Factors

The *Upper Columbia Monitoring and Evaluation Plan* (Appendix P of the *Recovery Plan*) provides the foundation for this portion of the Methow monitoring inventory. Three of the five key management questions presented in Appendix P were cross referenced with current Methow monitoring efforts to determine how current monitoring is addressing the questions needed to assess and adaptively manage salmonid recovery efforts in the Upper Columbia. We selected only the questions that were directly linked to biological and physical habitat monitoring (questions 1, 2 and 4).The two questions related to implementation and data management (questions 3 and 5) were not considered for this assessment. The *Upper Columbia Monitoring and Evaluation Plan* provides additional details and perspective, especially for spring Chinook and steelhead, and should be considered as a foundation for this assessment as well as a valuable resource in monitoring coordination efforts in the Methow.

Responses to the questions below are not extensively detailed. Rather, they highlight the monitoring program that addresses the question and/or limiting factor as detailed information on individual monitoring efforts can be found in other sections of this document (Tables 1-4). The management questions and relevant portions of the accompanying text from Appendix P were copied into the boxes below and italicized to distinguish them from responses pertaining to Methow monitoring which appear in plain text below the boxes. For question 1, sub-questions were lumped in some instances because related monitoring efforts addressed them simultaneously.

Question 1: ***Is the status of the population/ESU/DPS improving?***

The status of a population is determined by measuring (or estimating) the four Viable Salmonid Population (VSP) parameters described in Section 4 of the recovery plan. Those parameters are adult abundance, population productivity or growth rate, population spatial structure, and diversity. The status of these parameters is compared to the population-specific recovery criteria (identified in Section 4) to arrive at an overall conclusion on the status of the population/ESU/DPS. The specific questions associated with VSP are:

1.1 Is the abundance of naturally produced adult fish trending to the recovery criteria for each population?

This question deals with the number of naturally produced fish that spawn within the population. Recovery criteria in the recovery plan are based on the 12-year geometric mean (GM) of naturally produced spawners.

Current monitoring:

Spring Chinook: WDFW broodstock program and redd surveys annually monitor the total number of potential spawners (Wells dam passage) and spawners (redds) per all four major and the one minor spawning areas. Redd surveys are total counts. Additionally, the SRFB monitors four 500m reaches in the lower Chewuch for redds (total) as a portion of an effectiveness monitoring program. These overlap with reaches sampled by WDFW.

Steelhead: WDFW broodstock program (Wells Dam passage in conjunction with data derived from a radio telemetry study) provides the primary assessment of adult abundance. It should be noted that redd surveys using the index expansion method monitor the total number of spawners and spawners (redds) per four major and four minor spawning areas on an annual basis, but these data are not employed to estimate annual abundance.

Bull trout: USFWS, WDFW, USGS, USFS and WFC partner to annually monitor redds in 12 of 21 identified bull trout spawning areas (within 10 local populations). However, it is important to note that these surveys cover the largest known populations and >80% of the total known bull trout distribution. Redd surveys obtain total counts for each spawning area. Spawning and abundance data from the remaining nine systems is occasionally produced but has no consistent funding source. Fish abundance surveys take place in most other streams on a 10-year rotating panel (USFS stream inventory) but this program is not specifically designed to assess the status and trend of bull trout abundance in these systems. Thus, it should not be considered as fully addressing the question of bull trout abundance within the ten local populations.

1.2 Is the population productivity of naturally produced fish trending to the recovery criteria for each population?

This question addressed population productivity, which is the ratio of naturally produced recruits to naturally produced spawners. Recovery criteria in the recovery plan are based on the 12-year GM of recruits per spawner.

1.2.1 Is juvenile productivity of naturally produced fish increasing within each population?

This question deals with freshwater productivity. It is calculated as number of juveniles or smolts per redd. It provides an index of productivity within spawning and rearing areas and is not influenced by factors outside the population, ESU, or DPS. This index should be more sensitive to tributary actions than recruits per spawner.

Current Monitoring:

Spring Chinook: Combined, WDFW's smolt trapping (Methow and Twisp rivers) and adult abundance monitoring programs represent the most intensive effort to estimate production. Monitoring is annual and data analysis includes production estimates, CPUE (trapping), and smolts/redd. Four SRFB effectiveness projects (located on the lower Chewuch and upper Methow rivers) monitor habitat use by juvenile Chinook in 500m stream reaches. These sites will be visited on four occasions over 12 years and may not have enough resolution to effectively address this question. Monitoring by USGS (Middle Methow and lower tributaries) will likely contribute valuable data for use in production estimates in the near future. Additionally, USFS (stream inventory) may encounter juvenile Chinook in several locations throughout the subbasin and although this program is not specifically target spring Chinook, these data could potentially be used for production estimates.

Steelhead: Combined, WDFW's smolt trapping (Methow and Twisp rivers) and adult abundance monitoring programs address this question. Monitoring is annual and specific data analysis includes production estimates, CPUE (trapping) and egg to smolt survival. Similar to efforts for spring Chinook, these efforts represent the most intensive effort to estimate production. USGS lower tributary effectiveness study monitors juvenile steelhead use in one major spawning area (Beaver Creek) and two minor spawning areas (Libby and Gold creeks). This monitoring will expand into major spawning areas of middle Methow and several more tributaries to the mainstem and Chewuch Rivers in 2008 and will then likely contribute to production estimates. SRFB and USFS monitoring may encounter steelhead in several locations, but these are not steelhead production specific monitoring programs.

Bull Trout: USFWS sporadically (i.e. when funding allows) monitors resident adult and juvenile bull trout abundance with snorkel surveys. Yet, no established monitoring program specifically monitors the abundance and production of juvenile bull trout. Several monitoring efforts (USGS, USFS, SRFB) may encounter bull trout and these data could be useful in the development of a more comprehensive monitoring plan for this species.

1.3 Is the spatial structure of the populations trending to the recovery criteria for each population?

This question deals with factors that affect the distribution and spatial complexity of the population. Spatial structure of a population is maintained by not destroying habitat (or their functions) at rates faster than they are created or restored, by maintaining suitable habitats (major and minor spawning areas) even if they contain no listed species, and by addressing man-made barriers to fish migration and movement. This question is answered by addressing each of the following questions.

1.3.1 Does the number and spatial arrangement of spawning areas meet recovery criteria for each population?

This question deals with the number and spatial arrangement of major and minor spawning areas that are occupied within the geographic area of the population. Spatial arrangement refers to the distribution of spawning areas (e.g., linear structure, dendritic, trellis, etc.).

Current Monitoring:

Spring Chinook: WDFW conducts redd surveys annually in all (four major and one minor) of the spawning areas in the Methow. Counts are total redds and location.

Steelhead: WDFW monitors four major and four minor spawning areas in the Methow for redds on an annual basis. Data include expansion counts and locations. However, with the reach expansion method not all minor area streams are surveyed every year.

Bull Trout: Of the 21 known bull trout spawning areas (within ten local populations), twelve are monitored (by USFWS, USGS, WDFW, USFS, and WFC) for redds on an annual basis. The status and trend of the remaining sites represent a data gap. Wild Fish Conservancy began an effort to address this by surveying redds in the upper Lost River in 2008.

1.3.2 Does the spatial extent or range of the population meet recovery criteria for each population?

This question deals with the proportion of the historical range that is currently occupied and the presence of spawners in major spawning areas.

Current Monitoring:

Spring Chinook: WDFW conducts annual redd surveys in the four major (and one minor) spawning areas in the Methow.

Steelhead: WDFW monitors all four major (and four of six minor) spawning areas in the Methow for redds on an annual basis.

Bull Trout: Of the 21 known bull trout spawning areas (within ten local populations), twelve are monitored (by USFWS, USGS, WDFW and USFS) for redds on an annual basis. The status and trend of the remaining sites are a data gap. Wild Fish Conservancy has begun to address this by conducting redd surveys in the upper Lost River in 2008.

1.3.3 Do the gaps or continuities between spawning area meet recovery criteria for each population?

This question is concerned with the distance (stream km) between spawning areas.

Current Monitoring:

Spring Chinook: WDFW conducts annual redd surveys in the four major (and one minor) spawning areas in the Methow.

Steelhead: WDFW monitors all four major (and four of six minor) spawning areas in the Methow for redds on an annual basis.

Bull Trout: Of the 21 known bull trout spawning areas (within ten local populations), twelve are monitored (by USFWS, USGS, WDFW, USFS and WFC) for redds on an annual basis. The status and trend of the remaining sites are a data gap.

1.4 ***Is the phenotypic and genotypic diversity of the population trending to the recovery criteria for each population?***

This question deals with factors that affect both phenotypic (morphology, behavior, and life-history traits) and genotypic (genetic) within-population diversity. Diversity is maintained by managing or minimizing factors that alter variation in traits such as run timing, age structure, size fecundity, morphology, behavior, and molecular genetic characteristics. The following questions capture these traits.

The information gained from hatchery monitoring and evaluation programs management is vital to addressing question 1.4. Yet, for recovery purposes this topic is more conducive to addressing at the ESU level. As such, only portions of current monitoring activities in the Methow subbasin that provide information relative to this question will be provided. Several questions will be lumped below as they are addressed by the same monitoring efforts.

1.4.1 Are all the major life-history strategies that occurred historically still expressed within the population?

Major life-history strategies include adult run timing, juvenile migration patterns, and resident or anadromous life-history forms. This question addresses the occurrence of these strategies within the population and their distribution.

1.4.2 Is there morphological, life history, and/or behavioral differentiation within and between populations consistent with historic condition or a suitable reference condition?

This question deals with the average condition, amount of variability, and presence or absence of phenotypic traits. The focus is on spawn timing, size at age, and fecundity.

1.4.3 Is the genetic differentiation within and between populations consistent with historic condition or a suitable reference condition?

This question is concerned with the amount of molecular genetic variation within the population and whether it changes over time.

1.4.4 Is the proportion of natural spawners within the population that is derived from a local (within population) hatchery brood-stock program, which is using best management practices, trending to the recovery criteria for each population?

This question deals with the number (or fraction) of natural spawners that are made up of hatchery fish derived from within the population. There is less risk to the population if the hatchery fish were raised in a program using local (within populations) broodstock and best hatchery management practices.

1.4.5 Is the proportion of natural spawners within the population that is derived from a local brood-stock program, which is not using best management practices, trending to the recovery criteria for each population?

Like the last question, this one deals with the number (or fraction) of natural spawners that are made up of hatchery fish derived from within the population. However, this question is concerned with the number of hatchery fish from programs that do not use best hatchery management practices.

1.4.6 Is the proportion of natural spawners within the population that is derived from a within-MPG brood-stock program trending to the recovery criteria for each population?

This question deals with the number (or fraction) of natural spawners that are made up of hatchery fish derived from outside the population, but within the major population grouping.

1.4.7 Is the proportion of natural spawners within the population that is made up of exogenous, out-of-MGP strays trending to the recovery criteria for each population?

This question deals with the number (or fraction) of natural spawners that are made up of hatchery or naturally produced fish derived from outside the major population grouping, but within the ESU.

1.4.8 Is the proportion of natural spawners within the population that is made up of exogenous, out-of-ESU strays trending to the recovery criteria for each population?

This question deals with the number (or fraction) of natural spawners that are made up of hatchery or naturally produced fish derived from outside the ESU.

1.4.9 Is the distributed of spawners across naturally occurring habitat types within the geographic area of the population trending to the recovery criteria for each population?

This question deals with the presence of spawners in all ecoregions (Level IV; Omernick 1987) that were used by the population historically.

Current Monitoring:

Spring Chinook: The phenotypic and genotypic diversity of the population is monitored annually and to address specific R&E questions through genetic analysis of fish captured by WDFW (and partners) in the Methow subbasin and at Wells Dam (under the assumption they are Methow origin fish). Spent adults are captured during carcass monitoring in spawning ground surveys in major and minor spawning areas. Adults are sampled as they pass through Wells Dam fish ladder. Juveniles are obtained via fish capture during smolt trapping. Genetic composition, adult run timing, juvenile migration timing and patterns, life history type (ocean or resident), fish condition metrics, sex, origin, stray rates, spawn timing, size at age, and fecundity information is obtained from this monitoring. All genetic analysis is done by the WDFW lab in Olympia, WA.

Steelhead: Genetic monitoring of steelhead in the Methow occurs through sampling of juveniles captured during smolt trapping and adults sampled as they pass through Wells Dam fish ladder. Combined data include: genetic composition, adult run timing, juvenile migration timing and patterns, life history type (ocean or resident), fish condition metrics, sex, origin, stray rates, spawn timing, size at age, and fecundity information is obtained from this monitoring. All genetic analysis is done by the WDFW lab in Olympia, WA.

Bull Trout: USFWS coordinates a bull trout population structure study that has obtained genetic samples from most local populations and has a target of collecting genetic samples from all local populations by 2009. Genetic analysis is conducted by the USFWS lab in Abernathy, WA.

1.4.10 Are there ongoing anthropogenic activities that are causing selective mortality or habitat change within or outside the boundaries of the population?

This question is concerned with the factors that intentionally or unintentionally affect natural levels of variation within the population. We will provide no specific monitoring plan for determining if anthropogenic activities have a selective mortality on Upper Columbia populations. The Board will rely on information collected by various entities within the different sectors (habitat, harvest, hatcheries, and hydropower) and on information compiled during the monitoring of statutory listing factors (Question 2 below). This information will be reviewed annually by the Board.

Collecting data that can be used to answer these specific questions will help federal agencies determine if the populations are moving toward and ultimately achieve recovery criteria.

Current Monitoring:

Spring Chinook/Steelhead/Bull Trout: Although USBR and AREMP monitor road densities which may cause mortality or habitat change, this question is not specifically addressed for any species through current monitoring efforts in the Methow. Although not addressed in this assessment, tracking take through state and federal permitting reports would provide information that could be used to determine how activities, including scientific monitoring, are causing mortality or habitat change in the basin.

Question 2: ***Are the primary factors limiting the status of the population/ESU/DPS increasing or decreasing?***

Before the populations/ESU/DPS can be reclassified or de-listed, the federal agencies must evaluate if the existing and ongoing institutional measures are sufficient to address the threats and ensure that the populations/ESU/DPS remain viable. This will be accomplished by monitoring the status and trend of factors limiting the viability of the populations/ESU/DPS. Answers to the following questions will help the federal agencies determine if the institutional measures are sufficient to address the threats.

2.1 Are the limiting factors associated with habitat being ameliorated such that they do not limit the desired status of the population?

This question addresses NMFS Statutory Listing Factor 1 (the presence or threatened destruction, modification, or curtailment of its habitat or range). The recovery plan identifies specific habitat limiting factors for each population. Where these limiting factors occur, they need to be monitoring for status and trend.

Methow Limiting Factors, Associated Threats and Areas of Occurrence (from Appendix G)

Limiting Factor	Threats	Assessment Unit (N=13)
1. Habitat diversity and quantity	Roads, riprap, residential development, agriculture, diking, channelization, fires, mining	LM, MM, UMM, UM, BCSC, GCLC, BCBC, LT, UT, LC, UC, WCHC, GCBC
2. Excessive artificial channel stability	Riprap, roads, channelization	LM, MM, BCSC, GCLC, BCBC, LT, LC, WCHC, GCBC
3. Water quantity	Agriculture, residential development, forest management	MM, UMM, UM, BCSC, GCLC, CBC, LT, LC, WCHC, GCBC
4. Obstructions	Diversions, culverts	GCLC, BCBC, LT, WCHC, GCBC
5. Sediment	Fires, timber harvest, roads, agriculture, residential development	UM, BCBC, UT, LC, UC
6. Water quality	Agriculture, fires, roads, timber harvest, residential development	LC

LM=lower Methow, MM=middle Methow, UMM=upper middle Methow, UM=upper Methow (includes Lost River and Early Winters creek), BCSC=Black Canyon Creek/Squaw Creek, GCLC=Gold Creek/Libby Creek, BCBC=Beaver Creek/Bear Creek, LT=lower Twisp, UT=upper Twisp, LC=lower Chewuch, UC=upper Chewuch, WCHC=Wolf Creek/Hancock Springs, GCBC=Goat Creek/Little Boulder Creek

Habitat diversity and quantity

Habitat diversity and quantity has been identified as a limiting factor in all 13 assessment units in the Methow subbasin. It has been assigned eight threats (the most of any limiting factor) combined from all of the assessment units. Core indicators that address this limiting factor lay within the habitat quality, channel condition, riparian condition and watershed condition categories in Table 9 of the *Monitoring Strategy*. Monitoring of indicator variables that address habitat quality will be included in this analysis due to their close relationship to diversity and quantity of habitat.

Current Status and Trend Monitoring:

1. USFS Stream Inventory
2. USBR Reach-based Ecosystem Indicators (REI)

Other Related Monitoring:

1. PIBO Effectiveness
2. AREMP Effectiveness
3. SRFB Effectiveness
4. USGS lower Tributary and middle Methow Effectiveness
5. Yakama Nation Hancock Springs Effectiveness

The Stream Inventory program conducted by the USFS is the longest running and most extensive status and trend monitoring effort addressing habitat diversity, quantity and quality in the Methow. Monitoring occurs within all assessment units on a 10 year rotating panel with some units sampled more frequently depending on needs to address specific management actions. USBR REI monitoring began in 2006 in the Big Valley reach and is expanding to the middle Methow and lower Chewuch assessment units beginning in 2008. While not specifically a status and trend monitoring program, the REI could form a baseline for subsequent status and trend (as well as effectiveness) monitoring. Combined, the USFS and USBR efforts address the entire suite of core habitat indicator variables (except for fish cover, which is likely indirectly measured) outlined in the *Monitoring Strategy*.

Five other effectiveness monitoring programs collect data that could be incorporated into a habitat diversity and quantity status and trend monitoring program. Within these programs there is a large degree of spatial coverage from the mainstem to several tributary basins. Most, if not all, would have to be modified to some degree in order to address the core indicators for habitat.

At present, only USBR REI and AREMP collect data related to roads in terms of watershed and riparian presence and density although this information may be available from other sources.

Excessive artificial channel stability

The liming factor of excessive artificial channel stability was identified as present in 9 of 13 assessment units and was absent in the upper portions Methow, Twisp and Chewuch Rivers. Conversely, it was present in all of the smaller tributary assessment units. Roads, riprap and channelization are primary threats.

Current Status and Trend Monitoring:

1. USBR Reach-based Ecosystem Indicators (REI)

Monitoring for excessive artificial channel stability currently occurs only within one monitoring program and is also being monitored in only two assessment units (middle and upper middle Methow) from which it has been identified as a limiting factor. The REI collects detailed data related to artificial channel stability under the core indicators of bank stability (bank protection length) and riparian disturbance (% disturbance and human influences). Currently, this limiting factor is being monitored in the Big Valley (2006) and Middle Methow (Twisp to Winthrop) in 2008. Additional reach assessments are likely to be initiated beginning in 2009-2010, but it should be noted that unless these assessments (or portions thereof) are repeated they will not represent specific status and trend monitoring efforts.

Water Quantity

Water quantity has been identified as a limiting factor in the majority of assessment units (11 of 13) and is absent only from the upper Twisp and upper Chewuch Rivers. Water quantity can directly influence habitat quality and quantity and also water quality but these have been categorized as separate limiting factors and will be reviewed elsewhere. Agricultural and residential development and forest management have been identified as primary threats.

Current Status and Trend Monitoring:
1. USGS Streamflow
2. USGS Hydrologic Benchmark Program
3. USFS Stream Inventory
4. USFS agricultural diversion flow monitoring

Other related monitoring:
1. USBR Reach-based Ecosystem Indicators (REI)

USGS continuously monitors daily discharge and gauge height at seven stations including Andrews Creek (upper Chewuch), Twisp River (lower Twisp), Chewuch River (lower Chewuch), and the Methow River at Goat Creek (upper middle Methow), Winthrop (middle Methow), Twisp (middle Methow) and Pateros (lower Methow).

Additionally, the USFS collects discharge data associated with its Stream Inventory program in over 30 tributaries. USFS also collects discharge data at diversion intakes on Early Winters (upper Methow), Wolf (Wolf Creek/Hancock Springs) and Little Bridge Creeks (tributary to upper Twisp). These measurements are instantaneous and not continuous as called for in the *Monitoring Strategy*.

The USBR REI program, in partnership with USGS Middle Methow program, will collect instantaneous streamflow data at a number of to be determined sites within the middle Methow assessment unit staring in 2008.

Within this monitoring framework, 5 of 11 assessment units have a continuous water quantity monitoring (at one location) as called for in the *Monitoring Strategy* (all via USGS programs).

Obstructions

Diversions and culverts are two primary causal agents influencing the limiting factor of obstructions in the Methow. Obstructions have been deemed limiting in many of the smaller tributary assessment units as well as the lower Twisp River. The sole management objective associated with this limiting factor is increasing habitat connectivity. To date, numerous restoration actions, primarily culvert replacement and improved dam passage, have addressed this limiting factor.

Current Status and Trend Monitoring:
1. USFS Stream Inventory
2. USBR Reach-based Ecosystem Indicators (REI)

Both USFS Stream Inventory and USBR REI monitoring programs address obstructions. Specifically, both collect data related to the type, number and distribution of road crossings, diversions and culverts. Monitoring occurs in all six identified assessment units, as well as in the remaining seven assessment units where it was not identified as limiting. Currently, it is unlikely that new obstructions are being created and the trend in the Methow for this limiting factor is likely decreasing in light of the numerous restoration actions targeted at removing obstructions and improving connectivity. A primary monitoring question is how effective are the actions at improving connectivity (effectiveness monitoring). This question was addressed in Beaver Creek (and to some extent in Gold and Libby Creeks) by the USGS lower tributaries monitoring program.

Sediment

Sediment is identified as a limiting factor in the upper Methow and upper Twisp Rivers, both the upper and lower Chewuch and in Beaver/Bear Creek assessment units. The primary threats are roads, fires, agriculture, residential development and forest management. Reducing sediment load to streams is the primary management objective to ameliorate sediment as a limiting factor.

Current Status and Trend Monitoring:

1. USFS Sediment Surveys
2. USBR Reach-based Ecosystem Indicators (REI)

Other related monitoring:

1. USFS Stream Inventory
2. PIBO Effectiveness Monitoring
3. AREMP Effectiveness Monitoring

The USFS conducts annual sediment surveys using McNeil core sampling in four locations in the upper assessment units in both the Twisp and Chewuch Rivers. This monitoring has been on-going since 2000 (Chewuch) and 2002 (Twisp). The USBR REI program is slated to begin McNeil core sampling with the Middle Methow reach assessment in 2008. Both programs will monitor percent/depth fines and substrate composition in spawning habitats.

Three other monitoring programs collect data related to stream substrates using Woman pebble counts and two of these (PIBO and AREMP) collect data on percent of pooltail fines. Both of the latter programs are effectiveness monitoring, but their data could be used with future status and trend monitoring.

Water Quality

Water quality was identified as a limiting factor only in the lower Chewuch assessment unit. It is threatened by agriculture, fires, roads, timber harvest and residential development. Decreasing summer temperatures through restoration is the primary management objective. The Methow River (and the lower Chewuch) is currently 303(d) listed for temperature, thus the extent of this limiting factor may currently extend beyond the lower reaches of the Chewuch River.

Current Status and Trend Monitoring:
1. DOE Environmental Monitoring and Trends
2. USGS Hydrologic Benchmark Program (Andrews Creek)
3. USGS Gauging Stations (data current and archival)
4. USFS Temperature Monitoring
5. Yakama Nation Nutrient Monitoring (Twisp River)

Other related monitoring:
5. Yakama Nation- Hancock Springs
6. USBR Reach-based Ecosystem Indicators
7. PIBO Reach-based Effectiveness Monitoring
8. AREMP Reach-based Effectiveness Monitoring
9. USGS Middle Methow Effectiveness Monitoring

There are several monitoring programs that collect status and trend temperature data. Of all of the habitat core variables, temperature is the most intensively monitored variable with basinwide deployment through nine monitoring efforts. DOE environmental monitoring and trends program collects monthly temperature (and other water quality) data from four sites (Methow River at Winthrop, Twisp and Pateros and the lower Chewuch River). USGS Hydrologic Benchmark Program collects continuous temperature data on Andrews Creek (a tributary to the upper Chewuch) and other USGS streamflow monitoring stations have monitored temperature at several locations over the past 20 years. However, at this time many of the locations are not being monitored. The USFS temperature monitoring program takes place in conjunction with the habitat inventory monitoring and temperature is continuously recorded from June through September at the mouths of numerous fish bearing HUC 6 watersheds in the basin.

Five effectiveness monitoring programs collect continuous hourly temperature (seasonal) data at various locations throughout the Methow subbasin. While not specifically status and trend monitoring, these data will be collected over time and could be incorporated into future status and trend monitoring efforts.

Several of the above programs, including DOE, USGS, PIBO, YN, USBR and AREMP also collect related water quality data at the locations of the temperature monitoring. Parameters include turbidity, conductivity, pH, dissolved oxygen, nitrogen, phosphorous, chlorophyll a, metals and alkalinity. Overall, these monitoring efforts are likely providing the spatial coverage needed to address these other water quality parameters. However, for the most part they are not capturing data at the frequencies outlined in the Monitoring Strategy.

2.5 Are the limiting factors associated with disease and predation being ameliorated such that they do not limit the desired status of the population?

This question addresses Statutory Listing Factor 3 (disease or predation; Figure 1). Disease and predation by birds, fish, and mammals are limiting factors addressed in this question. Bird predation is an important limiting factor on the status of Upper Columbia salmon and steelhead. Predation by introduced fish species (e.g., bass and walleye) and northern pikeminnow (native species) also affects the viability of listed species in the Upper Columbia basin. These factors need to be monitored for status and trend.

Current Monitoring

A monitoring program associated with hatchery programs at Wells and Winthrop fish hatcheries is on-going. Full analysis of hatchery disease research and monitoring is beyond the scope of this assessment. However, it does not appear that habitat or fish population monitoring is specifically addressing this question in terms of how it may be affecting or limiting fish populations in the Methow.

Currently, there is no active status and trend monitoring addressing predation and/or predators and their affects on spring Chinook, steelhead and bull trout in the Methow subbasin.

2.7 What natural factors limit the desired status of the population?

This question addresses Statutory Listing Factor 5 (other natural or manmade factors affecting continued existence; Figure 1). Drought and poor ocean conditions are natural factors that limit populations in the Upper Columbia. The status of these factors needs to be monitored over time.

Current Monitoring

The affects of drought and ocean conditions on fish populations are not currently or directly monitored within the Methow subbasin. Likely, these are factors that are more appropriately addressed at the regional level, or at least coordinated regionally.

Question 4: *Which actions are effective and should be continued?*

Of all the questions, this one is the most difficult to answer. This is because it is very difficult to tease out the effects of a given action or suite of actions from among all the factors affecting a population, including the effects of other recovery actions (an issue of multiple treatment effects). Actions within all sectors (harvest, hatcheries, hydro, and habitat) are needed to recover the populations/ESU/DPS. This means that different actions within all sectors, all intending to affect VSP parameters of the populations, will be implemented within a relatively short time period. Trying to assess the effects of different actions on VSP parameters will require well designed studies with long-term control over the experiments. Answers to the following questions will aid in the selection and design of effectiveness monitoring plans.

4. 1 Which actions are most important to managers and funding entities?

There are several types of actions that will be implemented within and outside the Upper Columbia Basin. Not all of these actions can or should be monitored for effectiveness at the population scale. However, a representative suite of actions should be monitored for effectiveness. Some harvest, hydro, and hatchery actions will be monitored for effectiveness because monitoring is required through regulatory mandates (e.g., U.S. v OR, HCPs, BiOps, Relicensing Agreements, etc.). Monitoring plans have already been developed for most of these actions. Other actions, such as specific habitat actions, will be selected for monitoring based on assurance of implementation (including adequate funding, landowner acceptance, possession of required permits, and favorable scientific review), the assumed size of their treatment effect (large signal-to-noise ratio), and the presence of adequate controls/references that can be maintained for the life of the monitoring study. At this time, there are few proposed projects that meet these requirements (examples include the Entiat Bridge-Bridge Project and Nason Creek Off-Channel Reconnection Project).

4.1 What exactly do managers and funding entities need to know?

Before one designs effectiveness monitoring plans, it is important to know exactly what managers and funding entities need to know to make informed decisions. This plan recognizes three basic needs, each requiring a different monitoring approach:

4.1.1Did the project affect the environmental parameters (physical/chemical variables) that were the target of the action?

This question requires the most basic type of effectiveness monitoring (what Hillman (2005) called Level 1 Effectiveness Monitoring or Project Monitoring). It simply documents the changes in habitat conditions (environmental variables) before and after implementation of the project. Measuring changes in biological variables (e.g., fish abundance and survival) is not emphasized at this level of monitoring. This question is primarily answered through analyses of photographs (before-after photographs taken from fixed locations), count data, and presence/absence surveys. It is inexpensive and does not require a high level of scientific expertise.

Current Monitoring:

Currently, several effectiveness monitoring efforts (PIBO, AREMP, SRFB Yakama Nation and USGS) address question *4.1.1*, but they also monitor biological variables and, as such, are discussed in more detail with the response to question *4.1.2*. Additionally, USBR collects photos and other construction related data in conjunction with its support of restoration projects. At this time, however, the full extent of this information is undetermined.

4.1.2 Did the project affect environmental <u>and</u> biological parameters at a reach or habitat scale?

This question requires a monitoring plan that collects more detailed information on changes in environmental <u>and</u> biological variables. Hillman (2005) called this Level 2 Effectiveness Monitoring. It is also referred to as the "Bottom-Up" approach (Jordan et al. 2003) and focuses efforts on measuring desired environmental and biological effects at small spatial scales (reach or habitat scale). It is designed to assess the effects of specific projects in isolation of other restoration actions. That is, results from this type of effectiveness monitoring would not be confounded by actions occurring elsewhere in the basin.

<u>Current Monitoring</u>

1. PIBO Effectiveness
2. AREMP Effectiveness
3. SRFB Effectiveness
4. USGS lower Tributary Effectiveness
5. Yakama Nation Hancock Springs Effectiveness
6. Yakama Nation Nutrient Monitoring

This is the most common type of effectiveness monitoring currently being undertaken in the Methow with six on-going programs. These efforts vary widely in their overall goals and scope, but all collect both habitat and biological data. The USGS lower tributary effort examining the effectiveness of passage improvements is the most intensive. After 2008 it will likely be integrated into the larger Middle Methow Effectiveness Monitoring Program (see *4.1.3*) that seeks to monitor the effects of reach scale restoration activities. PIBO and AREMP are regional USFS effectiveness monitoring efforts and collect data from an array of sites throughout the Methow. These monitoring efforts are fairly similar in terms of data collected. Monitoring sites and habitat data collected by these efforts will likely be valuable in the development of a basinwide status and trend monitoring program. The SRFB effectiveness monitoring occurs in three sites in the Methow and Chewuch rivers and is focused on the effectiveness of passage and habitat improvements as well as habitat protection efforts. The Yakama Nation monitors the effectiveness of restoration actions in Hancock Springs and also monitors the status and trends of various water quality parameters in preparation for a nutrient enrichment study. This project will serve to provide both status and trend and effectiveness monitoring data.

4.1.3 Did the project affect the biological parameters at a population scale?

This question requires the most intensive monitoring at larger spatial scales (e.g., watershed subbasin) over longer time periods. Hillman (2005) called this Level 3 Effectiveness Monitoring. It has also been referred to as the "Top-Down" approach (Jordan et al. 2003). If a single type of action is implemented within the geographic area of the population, the approach for assessing the effects on the population are straightforward (the assessment is not confounded by multiple treatment effects). However, if several different types of actions are implemented, the assessment becomes much more complex. This scenario requires intensive and extensive sampling of several environmental and biological parameters within the geographic area of the population.

Current Monitoring:

1. USGS Middle Methow Effectiveness

Currently, only the USGS Middle Methow Effectiveness Monitoring is attempting level 3 effectiveness monitoring. It will rely heavily on USBR REI monitoring to provide physical habitat data. Several years of baseline data will be collected prior to the implementation of several restoration actions within the Middle Methow reach after which several more years post-project data will be collected. The monitoring uses reference sites in the Chewuch and upper Methow and will incorporate other monitoring efforts (i.e. WDFW smolt trapping, USGS Streamflow) in its analyses. Additionally, data from the USGS lower tributaries effectiveness monitoring will likely be integrated into the Middle Methow effort thus expanding the scope of the monitoring.

3.3. Monitoring Gaps

Monitoring gaps in the Methow were identified during the assessment process through several means. All core indicators from the *Monitoring Strategy* that are not currently monitored, or indictors that are currently monitored but at a level (i.e. frequency, spatial coverage, metrics) that may not adequately address the overall needs for that particular indicator, were included. Data gaps were also assigned to aspects of key management questions and limiting factors that current monitoring efforts do not directly or adequately address. Recommended goals and protocols for the data gaps rely on information presented in the *Recovery Plan* and *Monitoring Strategy*.

It must be noted that the list of data gaps generated through this process represent only those closely related to this monitoring assessment and are not prioritized in the list below. Assuredly, they do not represent the entire suite of potential data gaps that currently exist in the Methow. The identification and development of informational needs and required monitoring is an on-going, fluid process in the Upper Columbia and should be viewed as such. Other efforts to identify data gaps, such as the UCSRB Regional Technical Team’s tiered data gaps assessment and the Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) strengths and weaknesses review provide detailed and valuable insight into the data gaps, and hence, research and monitoring needs in the Methow.

1**. Continuous water quality –** Except for temperature, none of the numerous water quality monitoring programs collects continuous water quality data for DO, pH, conductivity and turbidity – all core indicators in the *Monitoring Strategy*. These water quality parameters are important components of overall habitat quality and continuous monitoring is essential to capturing acute changes and for the examination of seasonal and annual trends.

Goal: Establish a network of continuous water quality monitoring stations across the Methow subbasin as a portion of an overall status and trend water quality monitoring program. Stations could be developed to monitor major and minor spawning areas as well as areas of more intensive restoration.

Protocol: Oregon Plan for Salmon and Watersheds. 1999. Water quality monitoring, technical guide book. Version 2.0. Corvallis, OR. Coordination with DOE, USGS and YN water quality monitoring programs would be beneficial.

2. **Population and age structure of bull trout –** Little population size and age structure data exist, especially for resident/juvenile fish, for characterizing this aspect of the ten identified bull trout local populations in the Methow. It is a core indicator in the *Monitoring Strategy* and the data is necessary to inform bull trout management and conservation efforts. Potential gaps in distributional knowledge may also be filled via this monitoring.

Goal: Increase the frequency and scope of bull trout population/age structure monitoring to develop a status and trend monitoring program for all ten local populations. Populations could be sampled on a multi-year rotation to minimize impacts of handling.

Protocol: Population surveys likely through existing USFWS and USFS protocols (Haskins, J. 200X. Okanogan – Wenatchee N.F. Aquatic Biota Survey Protocol) Also, USBR Borgerson (1992) as recommended in the *Monitoring Strategy* for scale analysis but possibly others due to challenges with scale reading in bull trout. Fin ray analysis may be more applicable.

3. **Fecundity and sex ratios of bull trout –** Scant data exist for fecundity and sex ratios of bull trout populations in the Methow. This core indicator informs important aspects of bull trout population ecology, especially production.

Goal: Develop a plan to monitor the fecundity and sex ratios of bull trout which could be integrated in population/age structure monitoring. Methods to minimize lethal sampling should be explored and data from other upper Columbia River basins should be reviewed for relevance. Explore potential for the development of condition factor/fecundity relationship. On larger individuals, sex data could potentially be informed from snorkel, or other, survey techniques.

Protocol: TBD, but may include Strange, R.J. 1996. Field examination of fishes. Pages 433-446 *in* B.R. Murphy and D.W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

4. **Chinook and steelhead juvenile/parr monitoring –** While there is a great deal of monitoring related to adults and egg to smolt survival in the Methow, monitoring that specifically addresses juvenile (resident parr) salmonid population dynamics and ecology is less intensive. While several programs currently address this core indicator on some level (USGS, SRFB, USFS), there is a need for expanding effort and intensity especially in the Twisp, Chewuch and upper/lower Methow. Data gaps include distribution, abundance, size, condition, seasonal habitat use, habitat availability, and survival. Currently, the USGS Middle Methow Effectiveness monitoring is likely collecting the most relevant data on which to base future monitoring.

Goal: Develop a status and trend monitoring program to specifically address the core indicators of abundance, distribution, and size of resident juveniles. Additional metrics listed above could also be included. Integrating existing effectiveness monitoring sites from both USGS and SRFB monitoring efforts would likely be possible.

Protocol: Likely Thurow, R.F. 1994. Underwater methods for study of salmonids in the Intermountain West. USDA Forest Service, General Technical Report INT-GTR-307, Ogden, UT. Also, Haskins, J. 200X. Okanogan – Wenatchee N.F. Aquatic Biota Survey Protocol. 5 p.

5. **Sediment –** Expand habitat quality monitoring through an increase in the scope and intensity of sediment monitoring. A more detailed sediment monitoring program may be of value to understand how and where sediment is being transported through the Methow (i.e. sediment budget – sources, sinks and pathways). Data may also inform effectiveness monitoring programs. This could be accomplished partially through expanding the spatial coverage of current USFS sediment monitoring efforts (McNeil core sampling in Twisp and Chewuch) to other locations. Turbidity monitoring associated with several programs (DOE and USBR) is occurring and could be potentially be incorporated into a broader sediment monitoring effort.

Goal: Using existing monitoring programs, expand/initiate a sediment transport (budget) status and trend monitoring program and/or develop a detailed study plan for a targeted research project to address this topic.

Protocol: TBD

6. **Lower mainstem Methow habitat surveys –** Habitat structure, availability and condition of the lower Methow (below Gold Creek) has not been fully surveyed. In the past, information has relied primarily on professional judgment. All anadromous fish must, at the very least, pass through this reach at least twice in their lifetime and there is a need to more fully understand the habitat features and quality and their relationship to salmonid populations. It would also be important to examine exotic species interactions in this reach.

Goal: Conduct a reach assessment of the lower Methow River. Develop a fish status and trend monitoring program.

Protocol: Bureau of Reclamations REI for habitat. Fish portion TBD depending on extent and wadability of some sections, but likely similar to USGS effectiveness monitoring.

7. **Invertebrate drift –** Only the Yakama Nation Nutrient Monitoring program is examining drift and this began in 2008 and is restricted to the Twisp River. Invertebrate drift (transport) is an important metric of stream productivity and a *Monitoring Strategy* core indicator and should be addressed at a wider scale. Invertebrate drift influences fish population dynamics and overall stream productivity.

Goal: Establish a status and trend invertebrate drift monitoring program throughout the Methow subbasin. Key basins include Chewuch and Methow rivers. This could be accomplished through coordination with habitat monitoring efforts.

Protocol: Wipfli and Gregovich. 2002. Export of invertebrates and detritus from fishless headwater streams in southeastern Alaska: implications for downstream salmonid production. Freshwater Biology 47:957-969.

8. **Fish Cover –** There is no current monitoring for fish cover which is *Monitoring Strategy* core indicator. Fish cover is various and includes, rocks, logs, overhanging banks and vegetation, bubble curtain, aquatic macrophytes, algal mats, etc. It is a measure of channel complexity. Data that is currently collected by the USFS Stream Inventory and USBR REI is closely related and could be used as a potential baseline, but at this time no specific fish cover work is underway.

Goal: Develop a fish cover monitoring program. Likely, this could easily incorporated into several on-going survey efforts (USBR REI and USFS stream inventory) with little additional effort.

Protocol: Peck, D.V., J.M. Lazorchak, and D.J. Klemm. 2001. Environmental monitoring and assessment program-surface waters: western pilot study field operations manual for wadeable streams. Draft report. U.S. Environmental Protection Agency, Washington, D.C. (do not cite report, check on current status).

3.4 Monitoring Redundancies

Overall in the Methow, redundant monitoring efforts appear to be uncommon. One reason for this is due to the specific nature and location of many of the effectiveness monitoring programs (AREMP, PIBO, SRFB, USGS). These efforts are largely reach based and rely on site specific data collection sites and methods to inform project objectives. As such, data from nearby locations may not be specific enough, or collected in the proper fashion, to meet goals. Further analysis is necessary to determine if data collected from the various programs represents a redundancy or if it could be incorporated (i.e. serving as a baseline or control site) into the analyses of other programs.

Coordination of monitoring efforts between the various entities has also been important in reducing redundancy, even though no formal coordination forum exists. Several monitoring partnerships currently exist and it appears that more will be strengthened or formed in the near future. However, there may be several areas where coordination may assist in reducing redundancy.

1. **Water Quality –** Water quality, especially temperature, is the most intensively monitored suite of indictors in the Methow. A map of the location of all temperature loggers is under development and should help clarify where redundant monitoring is occurring. For other water quality parameters, although numerous programs collect the

same variables, it does not appear a great deal of redundant effort exists. Yet, there may be several pathways for sharing data that could be beneficial. Currently, the DOE environmental monitoring and trends program collects several variables that may be of use to other programs such as the USBR REI program. Similarly, USFS temperature monitoring may assist USGS and USBR efforts. A coordination effort is needed to disseminate the nature and location of water quality data collection and decisions can then be made to determine strategies for data sharing and coordination.

2. **Spring Chinook Redd Surveys –** Currently, WDFW collects the majority of spring Chinook redd data and strives to count all visible redds for this species. The SRFB is also engaged in redd surveys for spring Chinook in four 500m reaches in the Chewuch River. It appears this is redundant sampling and coordination of monitoring could be useful.

3. **Habitat Surveys –** There are several locations where USFS Stream Inventory efforts overlap with several effectiveness monitoring efforts, primarily PIBO (Beaver and Boulder Creeks), AREMP (Gold Creek). It is possible that data sharing from the effectiveness monitoring efforts to USFS could reduce redundant sampling. Overall, habitat surveys in the Methow occur under several different plans and increased coordination under an overarching habitat status and trend program could provide valuable data.

4. Summary

Presently, there is a substantial effort on the part of numerous entities to monitor spring Chinook, steelhead and bull trout populations and their associated habitats and limiting factors in the Methow subbasin. In total, 12 monitoring programs (originating form eight federal, state, tribal entities) are monitoring the Methow subbasin via 34 separate monitoring projects (Appendix A). The combined monitoring effort is broad in geographic scope and encompasses numerous status and trend and effectiveness monitoring programs. Even without an extensive effort to coordinate monitoring at both the local and regional level, monitoring in the Methow is addressing many aspects of recovery planning set forth in the *Recovery Plan* as well as nearly all of the core indicators recommended by the *Monitoring Strategy*.

Methow monitoring was not designed under a single holistic monitoring plan and current monitoring is proceeding under several different and project specific monitoring plans. The majority of monitoring relies on monitoring plans and/or protocols that were developed and/or initiated prior to the publication of the *Recovery Plan* and the *Monitoring Strategy*, and to date only the Bureau of Reclamation's REI program has developed a specific monitoring project based on elements of the *Monitoring Strategy*. As such, most of the current monitoring, both status and trend and effectiveness, effort is not based upon the *Monitoring Strategy* in terms of sampling design and recommended protocols. This is not to state that current monitoring is not collecting valid, scientifically sound data, indeed it is, but if alignment is desired, then changes to protocols (and likely data management including QA/QC) are needed by a number of projects to fully engage with the *Recovery Plan* and *Monitoring Strategy*. This situation presents both challenges and opportunities depending on the desired degree of alignment.

To align with the *Recovery Plan* and *Monitoring Strategy*, current Methow monitoring projects would need to be transitioned to incorporate various elements of the overall monitoring framework. In some cases, a transition may not be justified or necessary, or could occur with only slight modifications, as the monitoring is similar to what is recommended in the *Monitoring Strategy.* In others, where the differences are potentially more distinct, transition may be needed to more fully address the needs of regional monitoring needs. What is certain is that any modifications to current monitoring programs will only occur with the full cooperation of the monitoring entities and through a concerted coordination effort aimed at regional alignment. Overall, decisions need to made concerning the ultimate goals of any modifications to existing programs and a more detailed analysis of individual monitoring plans (likely on a case by case basis) and protocols is needed to fully address the above situation. From this a discussion could occur on how to proceed, and specifics of this transition can be addressed with the development of a Methow Subbasin Monitoring Plan. Certainly, current efforts will likely, and should, form a significant portion of future monitoring efforts in the Methow, yet it has not been decided weather or not these need to be coordinated through a single plan.

Monitoring of the status and trend of fish populations in the Methow currently addresses the majority of variables and management questions (see question 1, Appendix P) associated with current VSP parameters. This is especially true for spring Chinook and steelhead, where monitoring efforts led by WDFW are collecting data that can be used to measure and assess the abundance, productivity, spatial structure and diversity of these fish populations. This monitoring occurs under the guidance of the *Conceptual Approach to Monitoring and Evaluation for Hatchery Programs* (Douglas County PUD, 2005) and was designed to address VSP criteria. However, this monitoring is focused on adults and smolts (and to some extent eggs) and does not directly address parr/resident juveniles. This data gap could be addressed through integration of data from other projects such as USFS and USGS. These programs collect data from a variety of species and their salmon and steelhead data could be used to assess the abundance, distribution and size of juvenile life stage.

Monitoring of bull trout populations is less robust than for both spring Chinook and steelhead. Knowledge of the status and trend of bull trout populations and VSP parameters relies heavily on redd surveys that have been on-going (in some form) since 1995. This monitoring yields data related to the abundance and spatial structure of adult bull trout populations, yet this relies on several assumptions and information related to production is not directly monitored. Scant data exists related to the overall abundance, age structure, sex ratios, juveniles (abundance, distribution and size) and life history types/interactions of bull trout. While some data related to these metrics exist (USFS, USGS, primarily), these should be considered data gaps that should be filled.

Current status and trend monitoring of physical/environmental (habitat) variables covers virtually all of the core indicators recommended by the *Monitoring Strategy* with at least ten entities monitoring habitat in some fashion. Water quality, streamflow, habitat quality, channel condition, and riparian condition are specifically monitored for status and trend, primarily through USFS, USGS and DOE. Several effectiveness monitoring programs (USBR REI, AREMP, PIBO) also collect data that could be used to assess status and trends, but these programs have not been designed specifically for this purpose. Combined, habitat monitoring in the Methow has extensive spatial coverage on both public (and to some extent, private lands) throughout the basin. However, there is no current effort to integrate data from the various entities into one location or analysis, so it is unclear how effectively habitat conditions are being comprehensively assessed over time. Additionally, the USBR REI represents the most intensive effort to monitor habitat on private land, but at this time this monitoring has only occurred in each of the two reaches (Big Valley and middle Methow) on one occasion thus no trend information is available. Thus, additional monitoring of these reaches is needed to address a gap for status and trend habitat monitoring on private lands.

Frequency of monitoring is one aspect of habitat monitoring that does not appear to be in close alignment with the *Monitoring Strategy*. Aside from temperature and streamflow monitoring, which are monitored hourly and continuously, respectively, few core habitat variables are monitored at the recommended frequency. Habitat quality and condition indicators are recommended to be monitored annually. In most cases, the intervals between data collection for these indicators could be several years (via several effectiveness monitoring programs) or even ten years for fish bearing HUC watersheds monitored via USFS Stream Inventory. It could be possible to incorporate some of the sites within these projects into a rotating panel of status and trend sites to reduce the sampling frequencies to recommended levels.

Several monitoring programs in the Methow are focused on monitoring the effectiveness of restoration (SRFB, REI USBR, USGS lower tributaries) or national forest management activities (PIBO and AREMP). These efforts monitor biological and environmental indicators at the reach scale (level 2, and generally encompassing level 1). All of these efforts rely on relatively recently developed plans and protocols that are not specifically tied to the *Monitoring Strategy*, although there appears to be a large degree of similarity (i.e. BACI designs) between these efforts and the monitoring framework outlined in the *Monitoring Strategy* and in Appendix P. Given that effectiveness monitoring needs to take place where the specific actions occur, there is a good deal of spatial and habitat coverage under the current monitoring effort. In the future, these effectiveness monitoring sites could potentially comprise a portion of an on-going status and trend monitoring program.

Currently, only the USGS Middle Methow project is attempting level 3 effectiveness monitoring. This project is aimed at assessing population level effects of several restoration actions slated to occur on the mainstem Methow between Twisp and Winthrop. The USGS effort will rely on physical habitat data generated through the USBR REI to assist in the overall assessment. Interestingly, it is difficult to categorize the USBR REI as either strictly status and trend or effectiveness monitoring. In this example, however, the REI projects should be considered effectiveness monitoring, but the data they collect, if repeated over time, could form a foundation for status and trend monitoring on private lands in the Methow. At this time, no other level 3 effectiveness monitoring projects are slated for the Methow.

All limiting factors in the Methow identified in the *Recovery Plan* are being monitored to some extent by both status and trend and effectiveness monitoring programs, yet only one monitoring effort (USBR REI) has been implemented to specifically address (on the reach scale) the status and trend of any of the six limiting factors identified for the Methow which include: habitat diversity and quantity, excessive artificial channel stability, water quantity, water quality, obstructions and sediment. For the limiting factors we have considered the USBR REI as status and trend monitoring because present monitoring has set a baseline condition of the Big Valley and Middle Methow reaches and repeat monitoring is planned for at least a portion of these reaches.

The limiting factors of habitat diversity and quantity, water quantity and quality and sediment are currently monitored for status and trend and several effectiveness monitoring projects also collect data that, if repeated over time, could be used to assess status and trends. The combined spatial coverage of this monitoring is extensive. Excessive artificial channel stability and obstructions are much less intensively monitored and currently only data collected by the USFS Stream Inventory and USBR REI (and associated USBR geomorphic assessments) addresses these two limiting factors. Overall, it appears that future pathways for limiting factors monitoring in the Methow should be mapped out to determine the extent of monitoring required to align with *Monitoring Strategy* recommendations and to fully assess their distribution, status and trends. Important data is likely embedded in several monitoring efforts and is not being fully utilized to assess limiting factors.

5. Recommendations

It is recognized that monitoring coordination will continue to be a complex and fluid process in the Methow. Until recently, there has been minimal progress made towards aligning the suite of monitoring programs under one comprehensive plan or strategy. Most monitoring programs are focused on only a subset of questions or goals related to the overall regional monitoring framework that is linked to the recovery of ESA listed populations of spring Chinook, steelhead and bull trout. It is likely that future monitoring will rely heavily on the baselines and logistical networks forged by current monitoring efforts. It will take a concerted effort on the parts of at least 12 separate monitoring programs in order to comprehensively coordinate monitoring in the Methow and to develop a monitoring strategy that is scientifically based, efficient and logistically feasible. As such, recommendations below have not been prioritized and are not intended to be a detailed roadmap on how best to comprehensively coordinate monitoring. Rather, they are general in nature and it is intended that they serve as starting points for discussions related to the specific recommendations. Working towards addressing these recommendations should bring the monitoring efforts in the Methow towards alignment with regional efforts.

1. Convene a meeting of local and regional monitoring entities to disseminate assessment findings and to begin discussion to determine future directions of monitoring and its

coordination in the Methow. Regularly scheduled meetings of Methow monitoring entities to receive local, and disseminate regional, updates and monitoring related information should be on-going (several meetings have already occurred). This will likely entail Methow specific representation at UCSRB RTT and MaDMC and other regional monitoring forums.

2. Coordinate monitoring in the Methow through the development of a comprehensive, peer- reviewed Methow Subbasin Monitoring Plan that presents a statement of Methow specific monitoring questions and objectives and the work that will be done to address them. Such a plan should strive to involve all monitoring entities and incorporate this assessment, multiple elements of regional recovery planning, and existing monitoring efforts in order to best adapt the regional monitoring perspective outlined in the *Monitoring Strategy*. This effort should originate via the MRC.

3. Develop strategy to fill identified data gaps. Reference this report and the tiered data gaps analysis completed by UC RTT.

4. Determine future pathways and extent of limiting factors research and monitoring. The USBR REI could form a starting point for future efforts. The *Biological Strategy to Protect and Restore Salmonid Habitat* (*Recovery Plan* – Appendix H) and the tiered data gaps analysis completed by UC RTT provide important information related to this topic and should be incorporated into this effort.

5. Determine the needs and potential for additional effectiveness monitoring efforts (at all levels) to address the full suite of restoration project types across a variety of locations.

6. In response to recommendations #5 and #6, develop a list of completed and planned restoration actions (specific and by class) and limiting factors, threats, VSP parameters they address. Reference information presented in Table 3 and Table 5.9 of the *Recovery Plan.*

7. Develop a Methow specific, web-based monitoring portal (housing maps, schedules, plans, protocols and data) that is formatted to be seamlessly interactive with the STEM databank.

8. Develop data sharing agreement for Methow monitoring entities (likely a necessity for recommendation #5). This could be contained in a regional agreement.

9. Convene workshops for Methow monitoring entities to standardize data collection, QA/QC, data management and to disseminate new and/or innovative protocols/methods. Develop strategy to complete the above data management efforts which should include the creation of a Methow specific data steward.

10. Foster current, and forge new, monitoring partnerships.

6. Literature Cited

Borgerson, L.A. 1992. Scale Analysis. Oregon Department of Fish and Wildlife, Fish Research Project F-144-R-4, Annual Progress Report, Portland, OR.

Douglas County PUD. 2005. Conceptual Approach to Monitoring and Evaluation for Hatchery Programs. Prepared for: Douglas PUD Habitat Conservation Plan Hatchery Committee. Douglas PUD, Wenatchee, WA.

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Hillman, T. 2006. Monitoring Strategy for the Upper Columbia Basin. Prepared for the Upper Columbia Salmon Recovery Board, Bonneville Power Administration and National Marine Fisheries Service. 98p.

Oregon Plan for Salmon and Watersheds. 1999. Water quality monitoring, technical guide book. Version 2.0. Corvallis, OR.

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Strange, R.J. 1996. Field examination of fishes. Pages 433-446 *in* B.R. Murphy and D.W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

Thurow, R.F. 1994. Underwater methods for study of salmonids in the Intermountain West. USDA Forest Service, General Technical Report INT-GTR-307, Ogden, UT.

Upper Columbia Salmon Recovery Board. 2003. A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region. 88p. Appendix H of the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. Available at http://www.ucsrb.com/plan.asp.

Upper Columbia Salmon Recovery Board. 2007. Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. UCSRB, Wenatchee, WA. Available at http://www.ucsrb.com/plan.asp.

Upper Columbia Salmon Recovery Board. 2007. Designing a Monitoring and Evaluation Program to Support Adaptive Management. 165p. Appendix P of the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. Available at http://www.ucsrb.com/plan.asp.

Wipfli and Gregovich. 2002. Export of invertebrates and detritus from fishless headwater streams in southeastern Alaska: implications for downstream salmonid production. Freshwater Biology 47:957-969.

Attachment 1. Methow Subbasin Monitoring Program Information, May 2009.

Program	Entity	Protocols	Data Management	Contact
Spring Chinook Broodstock Program Spring Chinook Basinwide Redd Surveys Steelhead Basinwide Redd Surveys (includes Hancock Springs) Spring Chinook and Steelhead Smolt Trapping	WDFW	Conceptual Approach to Monitoring and Evaluation for Hatchery Programs. *Prepared for:* Douglas PUD Habitat Conservation Plan Hatchery Committee. 2005. Douglas PUD, Wenatchee, WA.	By hand into Access, reviewed and stored in-house. Smolt data into DART. Annual reports to Douglas County PUD.	Charlie Snow 509.997.0048 snowcgs@dfw.wa.gov
SRFB Chewuch Dam Barrier Removal SRFB Fulton Dam Barrier Removal	Tetra Tech	Crawford, B.A. 2004. Protocol for monitoring effectiveness of fish passage projects (Culverts, Bridges, Fishways, Logjams, Dam Removal, Debris removal). MC-1. Washington Salmon Recovery Funding Board, Olympia, WA. 27 p.	Field collection by Trimble handheld into Access, reviewed and stored in-house. Summary data in PRISM Reports on-line at www.rco.wa.gov	Jennifer O'Neal 425.785.0510 Jennifer.ONeal@tteci.c
SRFB Fender Mill Channel Connectivity Restoration	Tetra Tech	Crawford, B.A. 2004. Protocol for monitoring effectiveness of channel connectivity, off channel habitat, and wetland restoration projects. MC-6. Washington Salmon Recovery Funding Board, Olympia, WA. 32 p.	Field collection by Trimble handheld into Access, reviewed and stored in-house. Summary data in PRISM Reports on-line at www.rco.wa.gov	Jennifer O'Neal 425.785.0510 Jennifer.ONeal@tteci.c
SRFB Fender Mill Constrained Channel Restoration	Tetra Tech	Crawford, B.A. 2004. Protocol for monitoring effectiveness of constrained channels (Dike Removal/Setback, Riprap Removal, Road Removal/Setback, and Landfill Removal). MC-5.	Field collection by Trimble handheld into Access, reviewed and stored in-house. Summary data in PRISM	Jennifer O'Neal 425.785.0510 Jennifer.ONeal@tteci.c

Program	Entity	Protocols	Data Management	Contact
		Washington Salmon Recovery Funding Board, Olympia, WA. 20 p.	Reports on-line at www.rco.wa.gov	
SRFB Critical Riparian Habitat Acquisition	Tetra Tech	Crawford, B.A. and Arnett, J. 2004. Protocol for monitoring effectiveness of habitat protection (Land Parcel Biodiversity Health). MC-10.Washington Salmon Recovery Funding Board, Olympia, WA. 64 p.	Field collection by Trimble handheld into Access, reviewed and stored in-house. Summary data in PRISM Reports on-line at www.rco.wa.gov	Jennifer O'Neal 425.785.0510 Jennifer.ONeal@tteci.c
Lower Tributaries Effectiveness Monitoring Middle Methow Effectiveness Monitoring	USGS	USGS. 2008. Beaver Creek weir standard operating procedure. GEN000.0. Columbia River Research Lab, Cook, WA. 4 p. USGS. 2008. Removal technique for small streams using a backpack electroshocker. FIE522.0. Columbia River Research Lab, Cook, WA. 5 p. USGS. 2008. Protocol for conducting point-abundance estimates in the Methow River. Columbia River Research Lab, Cook, WA. 1 p. USGS. 2008. Snorkeling protocol for the Methow River. Columbia River Research Lab, Cook, WA. 1 p. Columbia Basin Fish and Wildlife Authority, PIT Tag Steering Committee. 1999. PIT Tag Marking Procedures Manual. Portland, Oregon. Martens, K.D. and Connolly, P.J. 2008. Lower Methow tributaries intensive effectiveness monitoring study. Interim Report. U.S.G.S., Cook,	By hand into Excel, reviewed and stored in-house. PIT tag data into PITAGIS.	Pat Connolly 509.538.2299 x269 pconnolly@usgs.gov

Program	Entity	Protocols	Data Management	Contact
		WA. 71 p. Connolly, P.J., I.G. Jezorek, K. Martens, and E.F. Prentice. *In press*. Measuring performance of two stationary interrogation systems for detecting downstream and upstream movement of PIT-tagged salmonids. North American Journal of Fisheries Management.		
Stream Inventory	USFS	USFS. 2006. Stream Inventory Handbook. Level I and II. Version 2.6. Pacific Northwest Region, Region 6. 117 p. (Habitat Inventory) Haskins, J. 200X. Okanogan – Wenatchee N.F. Aquatic Biota Survey Protocol. 5 p. (Snorkel Survey, modified)	By hand into Access, reviewed and stored in-house and some into ENRIS. Annual report.	Gene Shull 509.996.4005 gshull@fs.fed.us
Temperature Monitoring	USFS	USFS. 2006. Stream Inventory Handbook. Level I and II. Version 2.6. Pacific Northwest Region, Region 6. 117 p. (Habitat Inventory)	By datalogger in Access, reviewed and stored in-house and some into ENRIS. Annual report.	Gene Shull 509.996.4005 gshull@fs.fed.us
Water Diversion Flow Measurements	USFS	Swafford Flow meter publication.	Electronic data collection (Swafford 3000) into specific database. Data sent to NMFS.	Gene Shull 509.996.4005 gshull@fs.fed.us
Sediment Surveys	USFS WCC	Schuett-Hames, D., B. Conrad, M. McHenry, P. Peterson, and A. Pleus. 1993. Salmonid spawning gravel composition module. NWIFC Ambient Monitoring Program Manual, TFW AM9-93-001.	By hand into project specific Excel workbook for analysis, reviewed and stored in-house. Annual report.	Gene Shull 509.996.4005 gshull@fs.fed.us
Effectiveness Monitoring for Streams and Riparian Areas	PIBO	Heitke, Jeremiah D.; Archer, Erik J.: Dugaw, Dax D.: Bouwes, Boyd A.; Archer Eric A.; Henderson, Richard C.; Kershner, Jeffrey L. 2007. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel	By handheld into PIBO database. Annual reports and data available on-line at www.fs.fed.us/biology/fishecol ogy/emp/index.html	Eric Archer 435.755.3565 earcher@fs.fed.us

Program	Entity	Protocols	Data Management	Contact
		attributes. PACFISH/INFISH Biological Opinion (PIBO) Effectiveness Monitoring Program, Logan, UT. 100 p. (Habitat) Hawkins, C.P., J. Ostermiller, J., M. Vinson, R.J. Stevenson, and J. Olsen, J. 2003. Stream algae, invertebrate, and environmental sampling associated with biological water quality assessments: filed protocols. Department of Aquatic, Watershed, and Earth Resources, Utah State University, Logan, UT 84322-5210. (BMI)		
Aquatic and Riparian Effectiveness Monitoring	AREMP	AREMP. 2007. Field protocol manual aquatic and riparian effectiveness monitoring program regional interagency monitoring for the northwest forest plan. Hawkins, C.P., J. Ostermiller, J., M. Vinson, R.J. Stevenson, and J. Olsen, J. 2003. Stream algae, invertebrate, and environmental sampling associated with biological water quality assessments: filed protocols. Department of Aquatic, Watershed, and Earth Resources, Utah State University, Logan, UT 84322-5210. (BMI)	By handheld into AREMP database, reviewed and stored at AREMP and on-line at www.reo.gov/monitoring. Future posting with ENRIS and AREMS.	Kirsten Gallo 541.750.7021 kgallo@fs.fed.us Chris Moyer 541.750.7017 cmoyer@fs.fed.us
Environmental Monitoring and Trends (Water Quality)	DOE	Cusimano, R., Merritt, G. Plotnikoff, R., Wiseman, C. Smith, C and WDFW. 2006. Status and trends monitoring for watershed health and salmon recovery. Quality assurance monitoring plan. Washington State Department of Ecology. Olympia, WA. 62 p.	Annual reports available on-line ecology website www.ecy.wa.gov	Jim Ross 509.329.3425 JROS461@ECY.WA.G
Hancock Springs Channel and Riparian Restoration	Yakama Nation	USFS. 2006. Stream Inventory Handbook. Level I and II. Version 2.6. Pacific Northwest Region, Region 6. 117 p. (Habitat)	Hand and electronic data collection into Excel, reviewed and stored in-house.	John Jorgensen 509.996.3122 john@mid-columbia-co

Program	Entity	Protocols	Data Management	Contact
Includes: Hancock and Methow habitat, WQ, BMI, photo, and snorkel monitoring		Thurow, R.F. Underwater Methods for Study of Salmonids in the Intermountain West. 1994. USDA, Forest Service, Intermountain Research Station, General Technical Report INT-GTR-307. (Snorkel) Hall, Frederick C. 2001. Photo point monitoring handbook: part A—field procedures. Gen. Tech. Rep. PNW-GTR-526. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 48 p. 2 parts. (photo) Modified Hankin and Reeves. (BMI)		
Twisp River Nutrients	Yakama Nation	TBD, modeled after Kootenai Tribes program in MT	TBD	John Jorgensen 509.996.3122 john@mid-columbia-co
Bull Trout Redd Surveys	USFWS	Total Counts and WDFW (Larry Brown) Index Reaches	By hand into Access and stored in-house. Annual reports.	Judy De Lavergne 509.665.3508 x21 Judy_Delavergne@fws
Bull Trout Population Structure, Density and Habitat	USFWS	Peterson, J., Dunham, J., Howell, P., Thurow, R., and Bonar, S. 2002. Protocol for Determining Bull Trout Presence. Western Division of the American Fisheries Society. 54 p. Haskins, J. 200X. Okanogan – Wenatchee N.F. Aquatic Biota Survey Protocol. 5 p. (Snorkel Survey, modified). USFS. 2006. Stream Inventory Handbook. Level I and II. Version 2.6. Pacific Northwest Region,	By hand into Access and stored in-house. Annual reports.	Judy De Lavergne 509.665.3508 x21 Judy_Delavergne@fws

Program	Entity	Protocols	Data Management	Contact
		Region 6. 117 p. (Habitat)		
Bull Trout Genetic Monitoring	USFWS	USFWS Abernathy Lab Analysis Protocol.	Field collected tissue samples to USFWS Abernathy Lab.	Judy De Lavergne 509.665.3508 x21 Judy_Delavergne@fws
Hydrologic Benchmark Program	USGS	Protocols numerous and specific. Techniques of water resources investigations (TWRI) available at http://pubs.usgs.gov/twri Also: Alexander, R.B., Ludtke, A.S., Fitzgerald, K.K., Briel, L.I., and Schertz, T.L., 1996, Data from the U.S. Geological Survey National Stream Water-Quality Monitoring Networks (WQN) on CD-ROM: U.S. Geological Survey Open-File Report 96-337 and Digital Data Series DDS-37.	Discharge data collected electronically and downloaded into USGS system. Annual reports available at http://ny.cf.er.usgs.gov/hbn/siteinfo.cfm?ID=Andrews%20Creek. WQ data from grab samples analyzed by Denver USGS, reviewed then entered into USGS system. Data available at http://ny.cf.er.usgs.gov/hbn/siteinfo.cfm?ID=Andrews%20Creek.	Nick Elwell 509.353.2633 nelwell@usgs.gov
Reach Based Ecosystem Indicators	BOR	Various and TBD pending field trials, but relies heavily on *Monitoring Strategy*.	TBD	Jennifer Molesworth 509. 997.0640 jmolesworth@pn.usbr.g
Streamflow	USGS	Grantz et al. 1982. Measurement and computation of streamflow. Geological Water Supply Paper #2175. US Geologic Survey.	Electronic data collection stored in-house. Annual data reports available on-line at www.waterdata.usgs.gov/nwis	Bob Drzymkoski 509.353.2633 redrz@usgs.gov
Water Diversion Flow Measurements	USFS	Swafford Flow meter publication.	Electronic data collection (Swafford 3000) into specific database. Data sent to NMFS.	Gene Shull 509.996.4005 gshull@fs.fed.us

Attachment 2. Biological indicator variables currently monitored for Spring Chinook in the Methow River Basin (table modified from Hillman, 2006).

General characteristics	**Specific indicators** Entity program -Variables (project #, no # = all projects) * = not a core variable
Adults WDFW tracks all redds on a weekly basis from Aug-Sep. Methow (to Ballard CG), Chewuch (to 30 mile Ck.), Twisp (to Roads End CG), and Lost (to Eureka Ck) Rivers, and Wolf, Beaver, Early Winters, Gold Creeks. Carcass collection occurs to address several indicators. Status and trend. WDFW conducts broodstock activities at Wells Dam that includes escapement, age, sex, size, origin. Status and trend. WDFW also collects fecundity data from fish spawned at WDFW facilities (Methow Hatchery – spring Chinook, Wells Hatchery – steelhead). Status and trend. SRFB Effectiveness Monitoring conducts spawner and carcass surveys in four 500m reaches of the Chewuch River (above and below both Fulton and Chewuch diversion dams). Reach scale effectiveness monitoring (led by Tetra Tech Consulting).	**Escapement/Number** 1. WDFW Broodstock Program (basin) 2. WDFW Basinwide Redd Counts (tributaries) 3. SRFB Effectiveness Monitoring (reach) -Total spawners (1,3) -Spawners/tributary (2) -Spawn timing (2)
	Age structure 1. WDFW Basinwide Redd Counts (Carcass) 2. WDFW Broodstock Program -Scale analysis
	Size 1. WDFW Basinwide Redd Counts (Carcass) 2. WDFW Broodstock program -Morphometrics
	Sex ratio 1. WDFW Basinwide Redd Counts (Carcass) 2. WDFW Broodstock Program -Male:Female ratio
	Origin (hatchery or wild) 1. WDFW Basinwide Redd Counts (Carcass) 2. WDFW Broodstock Program -Tags/fin clips -Stray rates (1)
	Genetics 1. WDFW Basinwide Redd Counts (Carcass) 2. WDFW Broodstock Program -WDFW Olympia lab analysis
	Fecundity 1. WDFW Broodstock Program 2. WDFW Basinwide Redd Counts (Carcass) -Female fecundity (1) -Egg voidance/retention (2)

General characteristics	Specific indicators Entity program -Variables (project #, no # = all projects) * = not a core variable
Redds WDFW tracks all redds on a weekly basis from Aug-Sep. Methow (to Ballard CG), Chewuch (to Lake Ck.), Twisp (to Roads End CG) Rivers, also Lost, Wolf, Beaver, Early Winters, Gold Creeks. Status and trend. SRFB Effectiveness Monitoring conducts redd surveys in four 500m reaches (Above and below both Fulton and Chewuch dams). Reach scale effectiveness monitoring (led by Tetra Tech Consulting).	**Number** 1. WDFW Basinwide Redd Counts 2. SRFB Effectiveness Monitoring – fish passage -Total count (1) -Reach count (2)
	Distribution 1. WDFW Basinwide Redd Counts -Location of redds
Parr/Juveniles SRFB Effectiveness Monitoring has juvenile snorkel surveys in eight 500m reaches (above and below both Fulton and Chewuch dams, four in two locations in mainstem Methow). Reach scale effectiveness monitoring (led by Tetra Tech Consulting). USGS began Middle Methow Effectiveness Monitoring (middle Methow (Twisp-Winthrop), upper Methow, lower Twisp and lower Chewuch, Wolf and Eightmile Creeks) in 2008 that will likely to encounter Chinook juveniles. USGS also conducts juvenile work in Beaver, Gold and Libby Creeks that was completed 2007 but portions on-going and not Chinook specific. Reach/population scale effectiveness monitoring. USFS conducts snorkel surveys as a portion of its Stream Inventory. Ten year rotating panel in fish-bearing HUC 5 and 6 watersheds. Status and trend.	**Abundance** 1. SRFB Effectiveness Monitoring – fish passage, habitat 2. USGS Middle Methow Effectiveness Monitoring -juveniles/m2 (1) -fish/m/habitat (2)
	Distribution 1. USGS Middle Methow Effectiveness Monitoring 2. USFS Stream Inventory -Location via PIT tag interrogators, traps, etc. (1) -Presence/absence (2)
	Size 1. USGS Middle Methow Effectiveness Monitoring 2. USFS Stream Inventory 3. SRFB Effectiveness Monitoring – fish passage, habitat -Length, weight (1) -Length estimates (2,3)
Smolts WDFW smolt trapping occurs in the Methow R. at McFarland Creek and in the lower Twisp R. to determine how many, and when, smolt migrated per brood year. Monitoring generally occurs from mid-Feb-Nov. Transitional parr collected during Fall emigration and are combined with the Spring smolt count for total brood emigration rate.	**Number** 1. WDFW Smolt Trapping -Production estimates/CPUE -Smolts/redd
	Size 1. WDFW Smolt Trapping -Length, weight, FCF, age
	Genetics 1. WDFW Smolt Trapping -WDFW Olympia lab analysis
Macroinvertebrates	**Transport**

General characteristics	**Specific indicators** Entity program -Variables (project #, no # = all projects) * = not a core variable
SRFB Habitat Protection Effectiveness Monitoring program has one site on the Methow River near Fawn Creek. Reach scale effectiveness monitoring (led by Tetra Tech Consulting). PIBO Reach-based Effectiveness Monitoring has 14 reaches in a 5-year rotating panel including NF Boulder (2), Pebble, 30-mile (2), 20-mile (2) SF Beaver (2), Jack, Frazer, Benson (2) and Andrews (Sentinel) Creeks. Integrator, DMA and Sentinel sites. PACFISH/INFISH effectiveness monitoring. AREMP Reach-based Effectiveness Monitoring monitors three sites (Gold Ck, SF Lost R., lower Lost R.). Protocol changed in 2007. Multiple reaches within HUC6 watersheds. Forest Plan effectiveness and status and trend monitoring. Yakama Nation Nutrient Monitoring monitors six locations in the Twisp River. Ongoing statistics dictate sampling regime.	**Composition** 1. SRFB Effectiveness Monitoring - protection 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. Yakama Nation Nutrient Monitoring Program -BMI Community Metrics

Attachment 3. Biological indicator variables currently monitored for Steelhead in the Methow River Basin (table modified from Hillman, 2006).

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
Adults WDFW collects adult steelhead data through the broodstock collection program (includes rearing) at Wells Dam. Collection occurs Aug-Oct. Escapement also informed by redd counts. Status and trend.	**Escapement/Number** 1. WDFW Broodstock Program 2. WDFW Redd Surveys -Total spawners (1) -Spawners per tributary (2)
	Age structure 1. WDFW Broodstock Program -Scale analysis
	Size 1. WDFW Broodstock Program -Morphometrics
	Sex ratio 1. WDFW Broodstock Program -Male:Female ratio
	Origin (hatchery or wild) 1. WDFW Broodstock Program -% wild/%hatchery -Stray rate
	Genetics 1. WDFW Broodstock Program -Olympia lab analysis
	Fecundity 1. WDFW Broodstock Program -Female fecundity
Redds WDFW conducts steelhead redd counts using the Index Expansion Method in Methow, Chewuch,	**Number** 1. WDFW Redd Surveys -Index count

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
Twisp Rivers and Beaver and Little Bridge Creeks and rotating panel of smaller tributaries. Protocol uses ratio of visible/non-visible redds from index reach in each subbasin to extrapolate to entire basin during 1x/year sampling during mid Mar-May. Status and trend. Included is the adult spawning surveys WDFW conducts in the restoration site in Hancock Springs for Yakama Nation. Status, trend, and effectiveness monitoring.	**Distribution** 1. WDFW Redd Surveys -Location of redds
Parr/Juveniles USGS Lower Tributary Effectiveness Monitoring in Beaver, Gold and Libby Creeks (Completed 2007, but portions on-going). USGS Middle Methow Effectiveness Monitoring (middle Methow (Twisp-Winthrop), upper Methow, Chewuch River and Wolf and Eightmile Creeks) began in 2008. Reach and population scale effectiveness monitoring. SRFB has juvenile snorkel surveys in eight 500m reaches (Above and below both Fulton and Chewuch dams, four in two locations in mainstem Methow). Chinook specific, but may also encounter steelhead. Reach scale effectiveness monitoring (led by Tetra Tech Consulting). USFS conducts snorkel surveys as a portion of its Stream Inventory. Ten year rotating panel in fish-bearing HUC 5 and 6 watersheds. Status and trend. <u>Note</u>: WDFW implants PIT tags in all wild steelhead and spring Chinook juveniles captured during smolt trapping. Additionally, WDFW captures and PIT tags wild steelhead and spring Chinook juveniles via angling and may expand this effort to include other capture methods.	**Abundance** 1. USGS Lower Tributary Effectiveness Monitoring 2. USGS Middle Methow Effectiveness Monitoring 3. SRFB Effectiveness Monitoring – passage, habitat -juveniles/m/habitat type (1,2) -juveniles/m2 (3) **Distribution** 1. USGS Lower Tributary Effectiveness Monitoring 2. USGS Middle Methow Effectiveness Monitoring 3. USFS Stream Inventory -Location via PIT tag interrogators, traps, etc. (1,2) -fish/m/habitat type (1,2) -Presence/absence (3) **Size** 1. USGS Lower Tributary Effectiveness Monitoring 2. USGS Middle Methow Effectiveness Monitoring 3. USFS Stream Inventory 4. SRFB Effectiveness Monitoring – passage, habitat -Length, weight, FCF (1,2) -Length estimates (3,4)
Smolts WDFW steelhead smolt trapping occurs in the Methow R. at McFarland Creek and in the lower Twisp R to determine how many smolt migrated per brood year (smolt/redd). Monitoring generally	**Number** 1. WDFW smolt trapping -Production estimates/CPUE -Timing of emigration -Egg to smolt survival

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
occurs from mid-Feb-Nov. Each year, captured transitional parr are added into smolt production estimates for that year. Status and trend.	**Size** 1. WDFW smolt trapping -Length/weight at emigration **Genetics** 1. WDFW smolt trapping -WDFW Olympia lab analysis
Macroinvertebrates SRFB Habitat Protection Effectiveness Monitoring program has one site on the Methow River near Fawn Creek. Reach scale effectiveness monitoring (led by Tetra Tech). PIBO Reach-based Effectiveness Monitoring has 14 reaches in a 5-year rotating panel including NF Boulder (2), Pebble, 30-mile (2), 20-mile (2) SF Beaver (2), Jack, Frazer, Benson (2) and Andrews (Sentinel) Ck. Integrator, DMA and Sentinel sites. Effectiveness monitoring. AREMP Reach-based Effectiveness Monitoring monitors three sites (Gold Ck, SF Lost R., lower Lost R.). Protocol changed in 2007. Multiple reaches within HUC6 watersheds. Effectiveness and status and trend monitoring. Yakama Nation monitors BMI community in Hancock Springs and an adjacent site in Methow R. Two year (2006 and 2007) effectiveness monitoring, possibly on-going. Yakama Nation Nutrient Monitoring monitors six transects in the Twisp River. Ongoing statistics dictate sampling regime.	**Transport** **Composition** 1. SRFB Habitat Protection Monitoring - protection 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. Yakama Nation Hancock Springs Monitoring Program 5. Yakama Nation Nutrient Monitoring Program - BMI Community Metrics

Attachment 4. Biological indicator variables currently monitored for Bull Trout in the Methow River Basin (table modified from Hillman, 2006).

General characteristics	**Specific indicators** Entity program -Variables (project #, no # = all programs) * = not a core variable
Adults USFWS conducts population density surveys as needed for baseline information and with no long-term status and trend sites presently monitored. Occasional partnership with USFS, WDFW and USGS. Although not bull trout specific, USGS Lower Tributary Effectiveness Monitoring in Beaver, Gold and Libby Creeks (Completed 2007, but portions on-going). USGS Middle Methow Effectiveness Monitoring (began in 2008) encounter low numbers of bull trout. Reach scale effectiveness monitoring. SRFB has juvenile snorkel surveys in eight 500m reaches (above and below both Fulton and Chewuch dams, four in two locations in mainstem Methow) which may encounter bull trout. Reach scale effectiveness monitoring (led by Tetra Tech).	**Escapement/Number** 1. USFWS Population Density Project 2. USFWS Redd Surveys 3. USGS Lower Tributary Effectiveness Monitoring 4. USGS Middle Methow Effectiveness Monitoring 5. SRFB Effectiveness Monitoring – passage, habitat -fish/m (1) -Spawning class estimate (2) -fish/m/habitat type (3,4) -fish/m2 (5)
	Age structure
	Size 1. USFWS Population Density Project 2. USGS Lower Tributary Effectiveness Monitoring 3. USGS Middle Methow Effectiveness Monitoring 4. SRFB Effectiveness Monitoring – passage, habitat -Length estimates (1,4) -Length, weight, FCF (2,3)

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
USFWS is collecting bull trout genetic information to addresses population structure across the Upper Columbia Basin. USFS, WDFW and USGS partner in collection of samples.	**Sex ratio**
	Origin (hatchery or wild) Not applicable to Bull Trout
	Genetics 1. USFWS Bull Trout Population Structure Monitoring -USFWS Abernathy lab analysis
	Fecundity
Redds USFWS conducts redd surveys in partnership with USFS, WDFW, and USGS. Twisp, WF Methow, Chewuch, North, Lake, Crater, Foggy Dew Creeks. Wild Fish Conservancy began upper Lost R. in 2008. Status and trend.	**Number** 1. USFWS Redd Surveys -Total number -Index reach methodology (limited use)
	Distribution 1. USFWS Redd Surveys -Location of redds
Parr/Juveniles USGS Lower Tributary Effectiveness Monitoring in Beaver, Gold and Libby Creeks (Completed 2007 but portions on-going). USGS Middle Methow Effectiveness Monitoring (middle Methow (Twisp-Winthrop), upper Methow, Chewuch River and Wolf and Eightmile Creeks) began in 2008. Reach and population scale effectiveness monitoring. USFS conducts snorkel surveys as a portion of its Stream Inventory. Ten year rotating panel in fish-bearing HUC 5 and 6 watersheds. Status and trend. USFS conducts snorkel surveys as a portion of its Stream Inventory. 10 year rotating panel in fish-bearing HUC 5 and 6 watersheds. Status and trend monitoring. SRBF has juvenile snorkel surveys in eight 500m reaches (above and below both Fulton and Chewuch dams, four in two locations in mainstem Methow) which may encounter juvenile bull trout. Reach scale effectiveness monitoring (led by Tetra Tech Consulting). WDFW collects and PIT tags a limited number of bull trout through its smolt trapping program in the Methow R (at McFarland Creek) and	**Abundance** 1. USGS Lower Tributary Effectiveness Monitoring 2. USGS Middle Methow Effectiveness Monitoring 3. SRFB Effectiveness Monitoring – passage, habitat -fish/m/habitat (1,2) -juveniles/m2 (3)
	Distribution 1. USGS Lower Tributary Effectiveness Monitoring 2. USGS Middle Methow Effectiveness Monitoring 3. USFS Stream Inventory 4. WDFW Smolt Trapping -Location via PIT tag interrogators, traps, etc. (1,2,4) -Presence/absence (3)
	Size 1. USGS Lower Tributary Effectiveness Monitoring 2. USGS Middle Methow Effectiveness Monitoring 3. USFS Stream Inventory 4. SRFB Effectiveness Monitoring – passage, habitat -Length, weight (1,2) -Length estimates (3,4)

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
Twisp R (near Twisp).	
Smolts Not applicable to Bull trout.	**Number**
	Size
	Genetics
Macroinvertebrates	**Transport**
SRFB Habitat Protection Monitoring program has one site on the Methow River. Reach (project) scale effectiveness monitoring (conducted by Tetra Tech consulting). PIBO Reach-based Effectiveness Monitoring has reaches in a 5-year rotating panel including NF Boulder (2), Pebble, SF Beaver (2), Jack, Frazer, Benson (2) and Andrews Creeks. Effectiveness monitoring. AREMP Reach-based Effectiveness Monitoring monitors 3 sites (Gold Ck, SF Lost R., lower Lost R.). Protocol changed in 2007. Multiple reaches within HUC6 watersheds. Effectiveness and status and trend monitoring. Yakama Nation Nutrient Monitoring monitors six transects in the Twisp River. Ongoing statistics dictate sampling regime	**Composition** 1. SRFB Habitat Protection Monitoring Program 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. Yakama Nation Nutrient Monitoring Program -BMI Community Metrics

Attachment 5. A list of physical/environmental indicator variables currently monitored in the Methow Subbasin. Table is modified from Hillman (2006) and Action Agencies/NOAA Fisheries RME Plan (2003).

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
Water Quality DOE conducts WQ monitoring at four sites (Chewuch R., Twisp R., Methow R. at Winthrop and Pateros) through its Environmental Monitoring and Trends Program. Monthly (bi-monthly for metals) status and trend. USGS conducts WQ monitoring in Andrews Ck. through the Hydrologic Benchmark Program. Also monitors metals, chloride, silica, sulfate, hardness and carbon. Biannual status and trend monitoring. USGS also sporadically monitors temperature at five gauging stations and through the Methow Effectiveness Monitoring program (upper and lower locations in Gold, Libby, Beaver, Wolf, Eightmile Creeks). Status and trend.	**MWMT and MDMT** 1. DOE Environmental Monitoring and Trends 2. USGS Hydrologic Benchmark - Andrews Creek 3. USGS Streamflow (locations vary) 4. USGS Effectiveness Monitoring (Methow and Tributary) 5. Yakama Nation- Hancock Springs and Twisp River 6. USFS Temperature Monitoring 7. USBR Reach-based Ecosystem Indicators 8. PIBO Reach-based Effectiveness Monitoring 9. AREMP Reach-based Effectiveness Monitoring -Temperature, hourly -Max/M7AT (5) - M7DM (5,6,7,8)

<table>
<tr><th>General characteristics</th><th>Specific indicators
Entity program
-Variables (project #, no # = all programs)
* = not a core variable</th></tr>
<tr><td rowspan="6">USFS monitors hourly temperature from Jun-Sep at mouths of selected (20+/-) HUC 5 and 6 watersheds associated with stream inventories and in conjunction with USBR, and other, projects. Status and trend.

Yakama Nation monitors WQ in Hancock Springs every two weeks May-Sep. Also monitors alkalinity. In 2006 and 2007 had adjacent reference site in Methow R. Effectiveness monitoring. YN also monitors several WQ indicators in six locations in the Twisp River as a portion of its status and trend Nutrient Monitoring Program.

PIBO Reach-based Effectiveness Monitoring has 14 reaches in a 5-year rotating panel including NF Boulder (2), Pebble, 30-mile (2), 20-mile (2) SF Beaver (2), Jack, Frazer, Benson (2) and Andrews (Sentinel) Ck. Integrator, DMA and Sentinel sites. Effectiveness monitoring.

AREMP Reach-based Effectiveness Monitoring monitors WQ in three sites (Gold Ck, SF Lost R., lower Lost R.). Protocol changed in 2007. Multiple reaches within HUC6 watersheds. Effectiveness and status and trend monitoring.

USBR Reach-based Ecosystem Indicators will monitor WQ through reach-based assessments and in partnership with several entities. Effectiveness monitoring.</td>
<td>Turbidity
1. DOE Environmental Monitoring and Trends
2. USBR Reach-based Ecosystem Indicators
-NTU
-TSS (1)</td></tr>
<tr><td>Conductivity
1. DOE Environmental Monitoring and Trends
2. USGS Hydrologic Benchmark - Andrews Creek
3. Yakama Nation - Hancock Springs
4. PIBO Reach-based Effectiveness Monitoring
5. AREMP Reach-based Effectiveness Monitoring
6. USBR Reach-based Ecosystem Indicators
-Specific Conductance</td></tr>
<tr><td>pH
1. DOE Environmental Monitoring and Trends
2. USGS Hydrologic Benchmark - Andrews Creek
3. Yakama Nation- Hancock Springs
4. USBR Reach-based Ecosystem Indicators
5. PIBO Reach-based Effectiveness Monitoring
6. AREMP Reach-based Effectiveness Monitoring (2002-2006)
-pH (1,2,3,4,6)</td></tr>
<tr><td>Dissolved oxygen
1. DOE Environmental Monitoring and Trends
2. USGS Hydrologic Benchmark - Andrews Creek
3. Yakama Nation- Hancock Springs
4. USBR Reach-based Ecosystem Indicators
5. AREMP Reach-based Effectiveness Monitoring
-mg/L</td></tr>
<tr><td>Nitrogen
1. DOE Environmental Monitoring and Trends
2. USGS Hydrologic Benchmark - Andrews Creek
3. Yakama Nation- Hancock Springs and Twisp River
4. USBR Reach-based Ecosystem Indicators
-Total Nitrogen
-Nitrate/Nitrite
-Ammonia (1,3)</td></tr>
</table>

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
	Phosphorus 1. DOE Environmental Monitoring and Trends 2. Yakama Nation- Hancock Springs and Twisp River 3. USBR Reach-based Ecosystem Indicators -Total Phosphorous -Orthophosphorous (1) -Soluble and Reactive Phosphorous (2)
	Metals* 1. DOE Environmental Monitoring and Trends 2. USGS Hydrologic Benchmark - Andrews Creek -Ca, Mg, K, Na, C
	Other WQ Parameters* 1. DOE Environmental Monitoring and Trends 2. USGS Hydrologic Benchmark - Andrews Creek 3. Yakama Nation- Hancock Springs and Twisp River 4. USBR Reach-based Ecosystem Indicators 5. PIBO Reach-based Effectiveness Monitoring 6. AREMP Reach-based Effectiveness Monitoring (2002-2006) -Alkalinity -Total P (5) -Hardness/Chloride/Silica (2)
Habitat Access USBR is conducting habitat assessments in selected reaches through the Reach-based Ecosystem Indicators (REI) program. Effectiveness monitoring. Partnership with USFS. USFS Stream Inventory monitors habitat in selected fish-bearing HUC 5 and 6 watersheds on a 10-year rotating panel and as needed for specific projects. Status and trend and effectiveness monitoring.	**Road crossings** 1. USBR Reach-based Ecosystem Indicators 2. USFS Stream Inventory -Type -Number -Distribution -Description
	Diversion dams 1. USBR Reach-based Ecosystem Indicators 2. USFS Stream Inventory -Type -Number -Distribution -Description
	Fishways Not applicable to Methow.

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
	Culverts* 1. USBR Reach-based Ecosystem Indicators 2. USFS Stream Inventory -Type -Number -Distribution -Description
Habitat Quality USBR is conducting habitat assessments in selected reaches through the Reach-based Ecosystem Indicators (REI) program. Effectiveness monitoring. Partnership with USFS. PIBO Reach-based Effectiveness Monitoring has 14 reaches in a 5-year rotating panel including NF Boulder (2), Pebble, 30-mile (2), 20-mile (2) SF Beaver (2), Jack, Frazer, Benson (2) and Andrews (Sentinel) Creeks. Integrator, DMA and Sentinel sites. Effectiveness monitoring. AREMP Reach-based Effectiveness Monitoring monitors habitat in three sites (Gold Ck, SF Lost R., lower Lost R.). Protocol changed slightly in 2007. Multiple reaches within HUC6 watersheds. Effectiveness and status and trend monitoring. USFS Stream Inventory monitors habitat in selected fish-bearing HUC6 watersheds on a 10-year rotating panel and as needed for specific projects. Status and trend and effectiveness monitoring. USFS, in partnership with WCC, conducts McNeil core sampling in four sites (three samples per site) in both the Twisp and Chewuch rivers. Status and trend monitoring. SRFB has habitat surveys in four 500m reaches (four in two locations in mainstem Methow). Reach (project) scale effectiveness monitoring (led by Tetra Tech Consulting). SRFB also monitors habitat protection effectiveness at one site on the Methow River. Reach scale effectiveness monitoring (led by Tetra Tech Consulting).	**Dominant substrate** 1. USBR Reach-based Ecosystem Indicators 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. USFS Stream Inventory 5. USFS Sediment Surveys -Wolman pebble counts (1,2,3,4) -McNeil core samples (1,5) **Embeddedness** 1. USBR Reach-based Ecosystem Indicators 2. USFS Stream Inventory 3. SRFB Effectiveness Monitoring – protection -Embeddedness **Depth fines** 1. USBR Reach-based Ecosystem Indicators 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. USFS Sediment Surveys -Depth via McNeil core samples (1,4) -Pooltail % fine sediments (2,3) **LWD (pieces/km)** 1. USBR Reach-based Ecosystem Indicators 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. USFS Stream Inventory 5. SRFB Effectiveness Monitoring – passage, habitat -Size -Location --LWD/mile by reach (1,2,3,4,5) -Distribution (1) -Recruitment potential (1) -Complexes/mile (1)/reach (2,3,4) -Stability (1)

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
	Pools (pools/km) 1. USBR Reach-based Ecosystem Indicators 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. USFS Stream Inventory 5. SRFB Effectiveness Monitoring – passage, habitat -frequency -pool length (2,3) -riffle/pool ratio (1) -pools >5'/mile (1) --Pool crest depth (4) -Type/formation (1,2,4,5)
	Residual pool depth 1.USBR Reach-based Ecosystem Indicators 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. USFS Stream Inventory 5. SRFB Effectiveness Monitoring – passage, habitat -Average residual pool depth -Average max pool depth (1,4)
	Fish cover
	Side channels and backwaters 1. USBR Reach-based Ecosystem Indicators 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. USFS Stream Inventory 5. SRFB Effectiveness Monitoring – passage, habitat Side Channel: -Wetted length -Wetted area -Depth Floodplain: -Wetted area (1) -Potential wetted area (1) -Percent wetted area (1) Physical Barriers: -Type (1,4) -Location (1,4) -Distribution (1,4) -Discharges that access side channels (1) -Significant geomorphic/biologic discharges (1)

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
Channel condition USBR is conducting habitat assessments in selected reaches through the Reach-based Ecosystem Indicators (REI) program. Effectiveness monitoring. Partnership with USFS. PIBO Reach-based Effectiveness Monitoring has 14 reaches in a 5-year rotating panel including NF Boulder (2), Pebble, 30-mile (2), 20-mile (2) SF Beaver (2), Jack, Frazer, Benson (2) and Andrews (Sentinel) Creeks. Integrator, DMA and Sentinel sites. Effectiveness monitoring. AREMP Reach-based Effectiveness Monitoring monitors habitat in three sites (Gold Ck, SF Lost R, lower Lost R.). Protocol changed in 2007. Multiple reaches within HUC6 watersheds. Effectiveness and status and trend monitoring. USFS Stream Inventory monitors habitat in selected fish-bearing HUC6 watersheds on a 10-year rotating panel and as needed for specific projects. Status and trend and effectiveness monitoring. SRFB has habitat surveys in two 500m reaches (Fender Mill site in Methow R.). Reach scale effectiveness monitoring (led by Tetra Tech Consulting). SRFB also monitors channel condition at one site in the Methow R. as a portion of habitat protection monitoring. Reach scale effectiveness monitoring (led by Tetra Tech Consulting). Yakama Nation conducts thalweg surveys, via USBR, in the restored channel at Hancock Springs. Status and trend.	**Stream gradient** 1. USBR Reach-based Ecosystem Indicators 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. USFS Stream Inventory 5. SRFB Effectiveness Monitoring - passage, habitat -Percent
	Wetted width 1. USBR Reach-based Ecosystem Indicators 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. USFS Stream Inventory 5. SRFB Effectiveness Monitoring – passage,habitat -Meters
	Bankfull width 1. USBR Reach-based Ecosystem Indicators 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring 4. USFS Stream Inventory 5. SRFB Effectiveness Monitoring - passage, habitat -Meters
	Width/depth ratio 1. USBR Reach-based Ecosystem Indicators 2. PIBO Reach-based Effectiveness Monitoring 3. AREMP Reach-based Effectiveness Monitoring -Width:depth ratio
	Bank stability 1. USBR Reach-based Ecosystem Indicators 2. PIBO Reach-based Effectiveness Monitoring 3. USFS Stream Inventory 4. SRFB Effectiveness Monitoring - habitat protection -Erosion length/mile (1) -% eroding banks (1,4) -Length unstable (3) -Bank protection (1) -Bank angle (2) -Type (2) -Material (2) -Undercut (2) -Stability (2)

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
	Sinuosity* 1. PIBO Reach-based Effectiveness Monitoring 2. AREMP Reach-based Effectiveness Monitoring 3. USFS Stream Inventory -Sinuosity
	Entrenchment* 1. PIBO Reach-based Effectiveness Monitoring 2. AREMP Reach-based Effectiveness Monitoring 3. USFS Stream Inventory -Entrenchment
	Thalweg Profile* 1. SRFB Effectiveness Monitoring 2. Yakama Nation – Hancock Springs -Thalweg profile
Riparian Condition USBR is conducting habitat assessments in selected reaches through the Reach-based Ecosystem Indicators (REI) program. Effectiveness monitoring. Partnership with USFS. USFS Stream Inventory monitors habitat in selected fish-bearing HUC 5 and 6 watersheds on a 10-year rotating panel and as needed for specific projects. Status and trend and effectiveness monitoring. SRFB has habitat surveys in two 500m reaches (Fender Mill site in Methow R.). Reach (project) scale effectiveness monitoring (led via Tetra Tech Consulting). PIBO Reach-based Effectiveness Monitoring has 14 reaches in a 5-year rotating panel including NF Boulder (2), Pebble, 30-mile (2), 20-mile (2) SF Beaver (2), Jack, Frazer, Benson (2) and Andrews (Sentinel) Creeks. Integrator, DMA and Sentinel sites. Effectiveness monitoring.	**Riparian structure** 1. USBR Reach-based Ecosystem Indicators 2. USFS Stream Inventory 3. SRFB Effectiveness Monitoring – habitat, protection 4. PIBO Reach-based Effectiveness Monitoring -Type (1,2,4) -Abundance -% Cover (canopy, understory, ground) **Riparian disturbance** 1. USBR Reach-based Ecosystem Indicators -% disturbance -Road density -Human influences **Canopy cover** 1. USBR Reach-based Ecosystem Indicators 2. SRFB Effectiveness Monitoring – habitat, protection -% mature/large trees (1) -% shading

General characteristics	Specific indicators Entity program -Variables (project #, no # = all programs) * = not a core variable
Flows and Hydrology USGS monitors daily discharge and gauge height at seven stations (Andrews Ck., Twisp R., Chewuch R., Methow R. at Goat Ck., Winthrop, Twisp and Pateros). Status and trend. USFS Stream Inventory monitors habitat in selected fish-bearing HUC6 watersheds on a 10-year rotating panel and as needed for specific projects. Status and trend and effectiveness monitoring. USFS also measures flow above and below diversions on Early Winters, Wolf and Little Bridge Creeks (former USGS gauging stations).	**Streamflow** 1. USGS Streamflow 2. USGS Hydrologic Benchmark Program 3. USFS Stream Inventory 4. USFS Diversion Flow Measurements -Daily discharge (1,2) -Gauge height (1,2) -Instantaneous discharge (3,4)
Watershed Condition USBR is conducting habitat assessments in selected reaches through the Reach-based Ecosystem Indicators (REI) program. Effectiveness monitoring. Partnership with USFS. AREMP Reach-based Effectiveness Monitoring monitors habitat conditions in three sites (Gold Ck., SF Lost R., lower Lost R.). Protocol changed in 2007. Multiple reaches within HUC6 watersheds. Effectiveness and status and trend monitoring. Developed a Reach and Watershed (HUC6) condition model. PIBO Reach-based Effectiveness Monitoring has 14 reaches in a 5-year rotating panel including NF Boulder (2), Pebble, 30-mile (2), 20-mile (2) SF Beaver (2), Jack, Frazer, Benson (2) and Andrews (Sentinel) Creeks. Integrator, DMA and Sentinel sites. Effectiveness monitoring. Pacific Biodiversity Institute completed a basinwide watershed roads and land use study in 2004. Data is available from that project, but monitoring is not on-going. Okanogan County compiles data on land ownership, but this project is not specifically related to fish or habitat monitoring.	**Watershed road density** 1. USBR Reach-based Ecosystem Indicators 2. AREMP Reach-based Effectiveness Monitoring 3. PIBO Reach-based Effectiveness Monitoring 4. Pacific Biodiversity Institute -Location -Length -Density **Riparian-road index** 1. USBR Reach-based Ecosystem Indicators 2. AREMP Reach-based Effectiveness Monitoring 3. PIBO Reach-based Effectiveness Monitoring 4. Pacific Biodiversity Institute -Location -Length -Density **Land ownership** 1. Okanogan County **Land use** 1. Pacific Biodiversity Institute

APPENDIX C

Reach Documentation

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REACH DOCUMENTATION
MIDDLE METHOW RIVER, OKANOGAN COUNTY, WASHINGTON

During the initial side assessment bedrock, side channels, channel units, and anthropogenic features were documented. A summary of the locations where bedrock crops-out and its impact on channel processes can be found in Table 1. Side channels were observed in the field and mapped remotely using the geographic information system (GIS) and are summarized in Table 2.

Table 1: Location of lateral and vertical bedrock controls.

River Mile	Description
RM 49.8	Crops-out in floodplain along river right indicating shallow alluvium
RM 49.7	Crops-out along river left controlling lateral channel migration
RM 49.3	Crops-out along river right controlling lateral channel migration
RM 49.0	Crops-out along river left controlling both vertical and lateral channel migration
RM 48.7	Crops-out along river right controlling lateral channel migration
RM 48.0	Crops-out along river left controlling both vertical and lateral channel migration
RM 47.7	Crops-out along river right controlling lateral channel migration; scour pool forced by bedrock at lower end of side channel (3R side channel)
RM 47.2	Crops-out along river right controlling lateral channel migration
RM 45.5	Crops-out along river right controlling both vertical and lateral channel migration
RM 44.1	Crops-out along river right controlling lateral channel migration
RM 41.2	Crops-out along river left controlling lateral channel migration; opposes Twisp River alluvial fan to form geologic floodplain constriction

Table 2: Summary of side channels by subreach.

Subreach	Side Channel Identifier	Total Acres	Side Channel Type	Wetted
MM-IZ-1	SC_49.63_L	2.19	Artificial	Perennial
MM-IZ-2	SC_49.25_R	0.52	Gravel Bar	Perennial
	SC_48.50_R	0.55	Gravel Bar	Ephemeral
	SC_48.37_L	0.68	Gravel Bar	Perennial
MM-OZ-5	SC_49.0_R	3.91	Floodplain	Ephemeral
MM-OZ-8	SC_47.90_R	0.99	Floodplain	Perennial
MM-IZ-3	SC_47.70_L	0.46	Floodplain	Perennial
	SC_46.80_R	0.48	Gravel Bar	Perennial
	SC_46.70_L	0.75	Gravel Bar	Perennial
MM-IZ-4	SC_46.25_L	0.70	Artificial	Perennial
	SC_45.59_R	0.26	Gravel Bar	Ephemeral
MM-OZ-11	SC_46.04_R	3.52	Floodplain	Perennial
	SC_45.75_R	0.40	Gravel Bar	Ephemeral
	SC_45.60_R	1.15	Floodplain	Perennial
MM-IZ-5	SC_45.30_L	1.24	Floodplain	Ephemeral
	SC_44.90_L	0.55	Gravel Bar	Perennial
MM-OZ-14	SC_45.10_R	4.74	Floodplain	Ephemeral
	SC_44.35_R	0.53	Floodplain	Ephemeral
MM-DOZ-14	SC_45.30_R	8.38	Floodplain	Perennial
MM-DOZ-15	SC_44.30_L	0.86	Floodplain	Ephemeral
MM-IZ-6	SC_43.85_R	0.78	Gravel Bar	Perennial
MM-OZ-15	SC_42.90_L	0.86	Floodplain	Ephemeral
	SC_42.60_L	2.16	Floodplain	Ephemeral
	SC_42.50_L	0.18	Floodplain	Ephemeral
MM-IZ-7	SC_43.10_L	2.26	Gravel Bar	Perennial

Subreach	Side Channel Identifier	Total Acres	Side Channel Type	Wetted
	SC_42.85_R	1.42	Floodplain	Ephemeral
	SC_42.60_R	0.32	Gravel Bar	Perennial
	SC_42.30_R	5.02	Floodplain	Ephemeral
	SC_41.40_L	1.77	Floodplain	Ephemeral
	SC_41.35_L	0.34	Gravel Bar	Perennial
MM-OZ-7	SC_42.90_R	0.77	Floodplain	Ephemeral
	SC_42.65_R	3.98	Floodplain	Ephemeral
	SC_42.59_R	0.12	Floodplain	Ephemeral
	SC_42.00_R	4.54	Floodplain	Ephemeral
	SC_41.25_R	0.30	Gravel Bar	Ephemeral
MM-OZ-18	SC_41.70_L	0.60	Floodplain	Perennial

Channel unit mapping is a useful tool in determining how sediment is moving through a given reach or channel segment at channel forming flows. Channel units are interpreted in the field based on the fluvial processes that created them. They should not be confused with habitat units that are a measure of habitat quantity available at low flows. Channel unit mapping was conducted for the Middle Methow reach assessment and charted to graphically illustrate the general trends in sediment transport and deposition (Figure 1). Channel unit and anthropogenic feature maps for each inner zone subreach are illustrated in Figure 2 through Figure 9. Geomorphically, the moderately confined section of the reach (subreaches MM-IZ-1, MM-IZ-2, and MM-IZ-3) should have a balance of runs (transport channel unit) with riffles and bars (depositional channel units) unless there are other natural and/or artificial constraints. In subreaches MM-IZ-1and MM-IZ-2 there appears to be a relatively good balance. However, in subreach MM-IZ-3 runs significantly increase due to bedrock controls that restrict the river from moving laterally and vertically.

In the unconfined section of the reach (subreaches MM-IZ-4, MM-IZ-5, MM-IZ-6, and MM-IZ-7) depositional channel units should increase in the downstream direction and transport channel units should decrease. There are a high percentage of transport channel units in MM-IZ-4, MM-IZ-5, and MM-IZ-6, the opposite of what would be anticipated. This is primarily due to bank protection (i.e. riprap) that has reduced lateral channel migration resulting in vertical channel instability (localized incision) adjacent to long sections of riprap, a reduction in sediment supply and an increase in channel transport capacity.

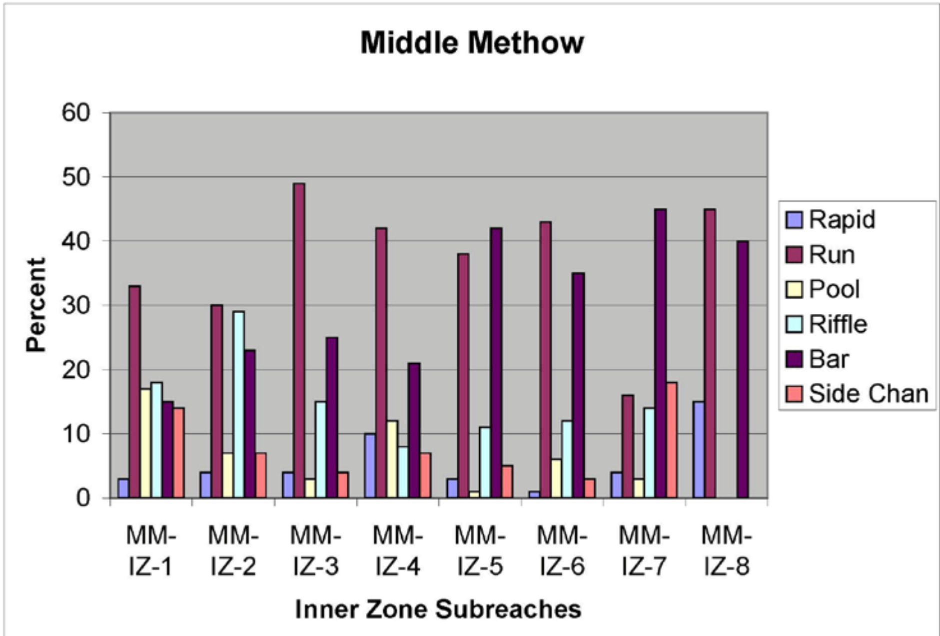


Figure 1. Bar graph of channel unit percentages by subreach.

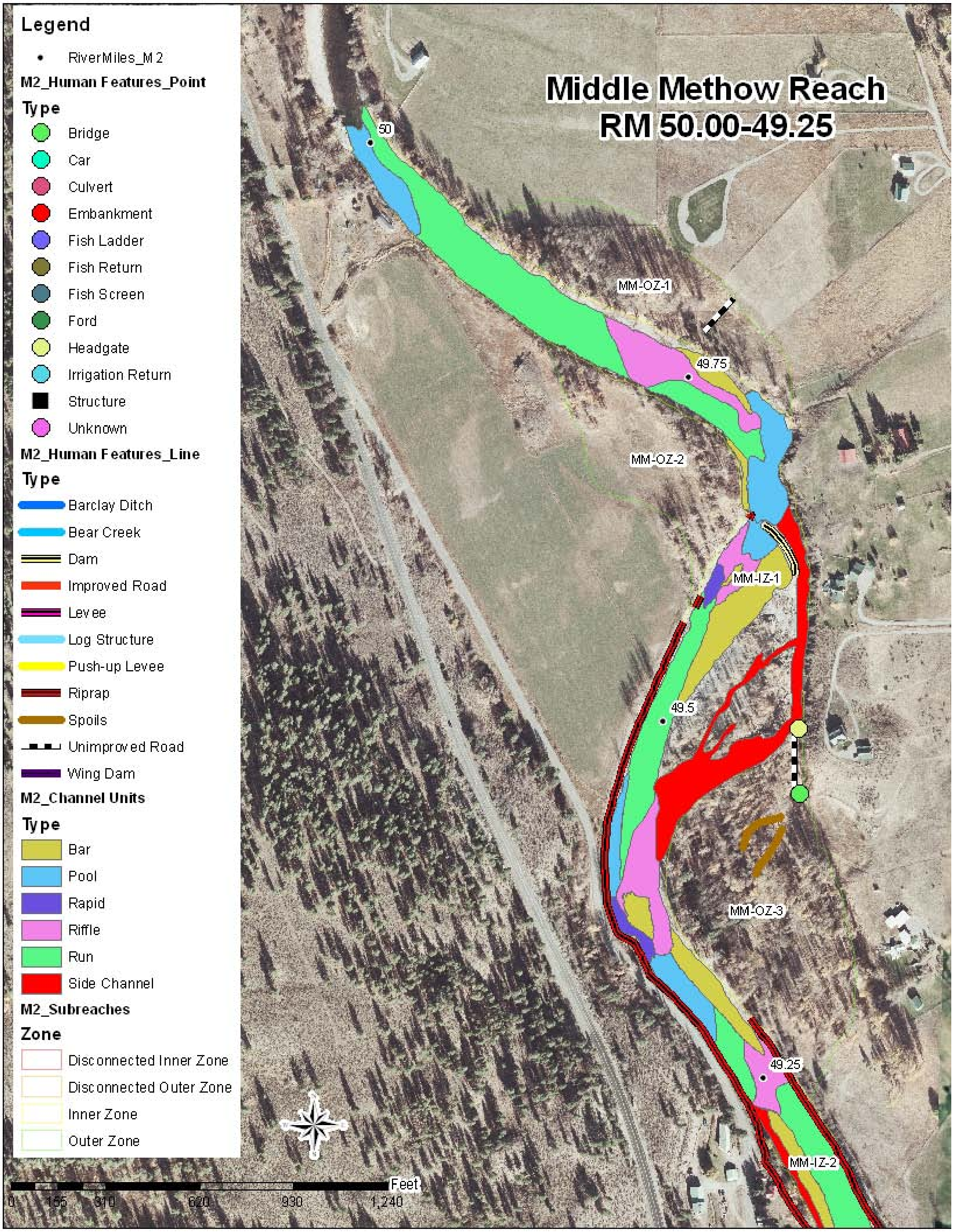


Figure 2. Channel unit mapping from RM 50.00 to RM 49.25.

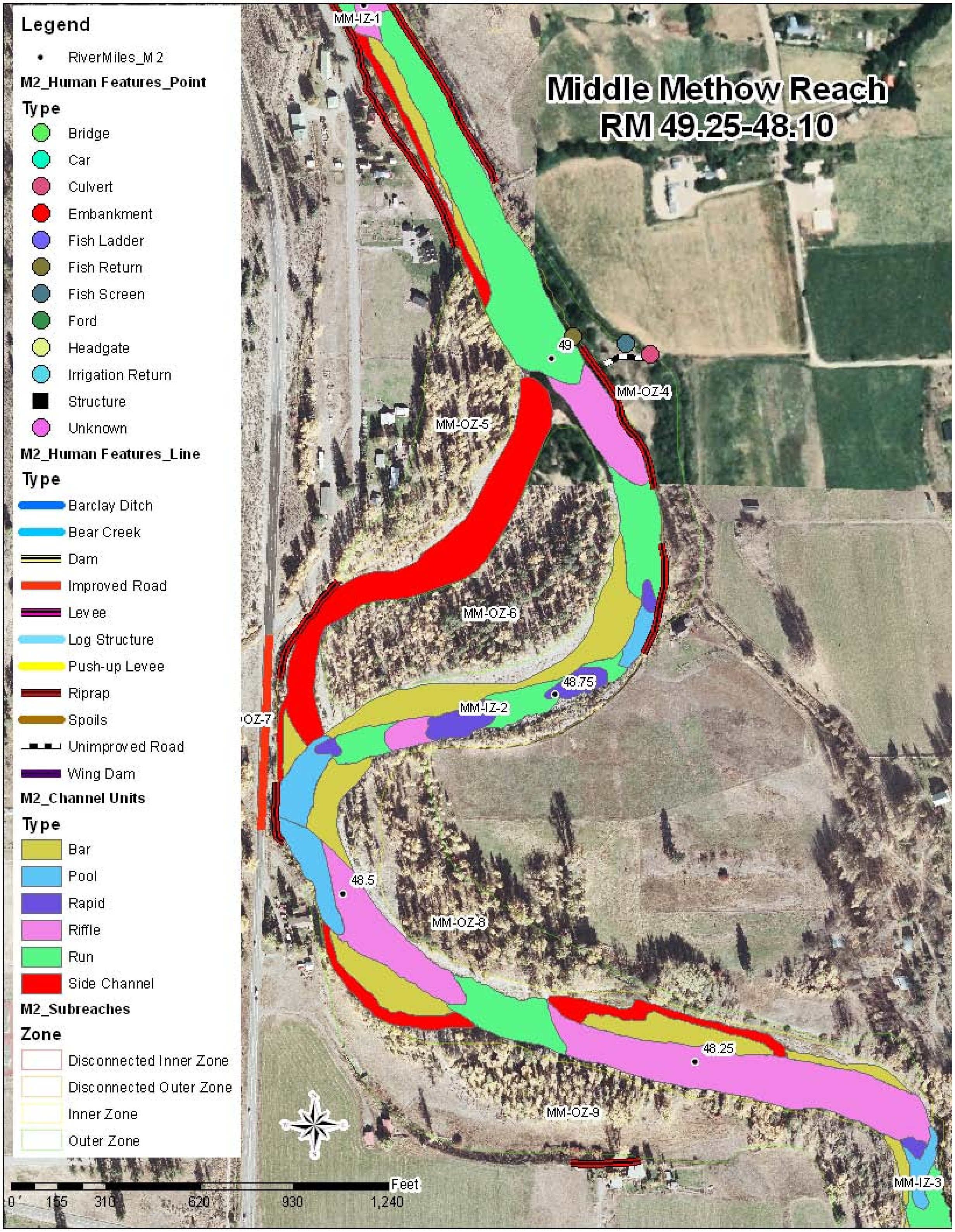


Figure 3. Channel unit mapping from RM 49.25 to RM 48.10.

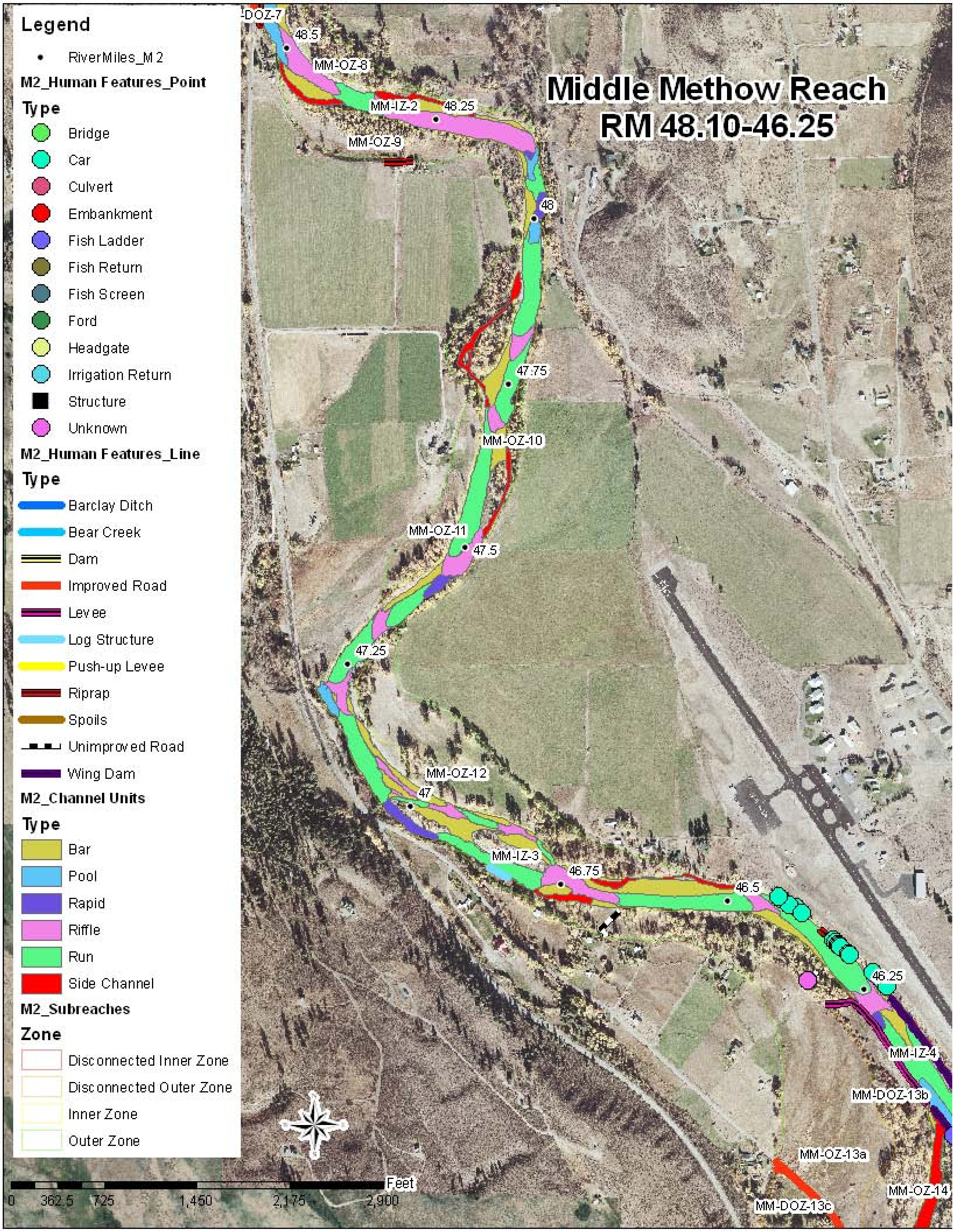


Figure 4. Channel unit mapping from RM 48.10 to RM 46.25.

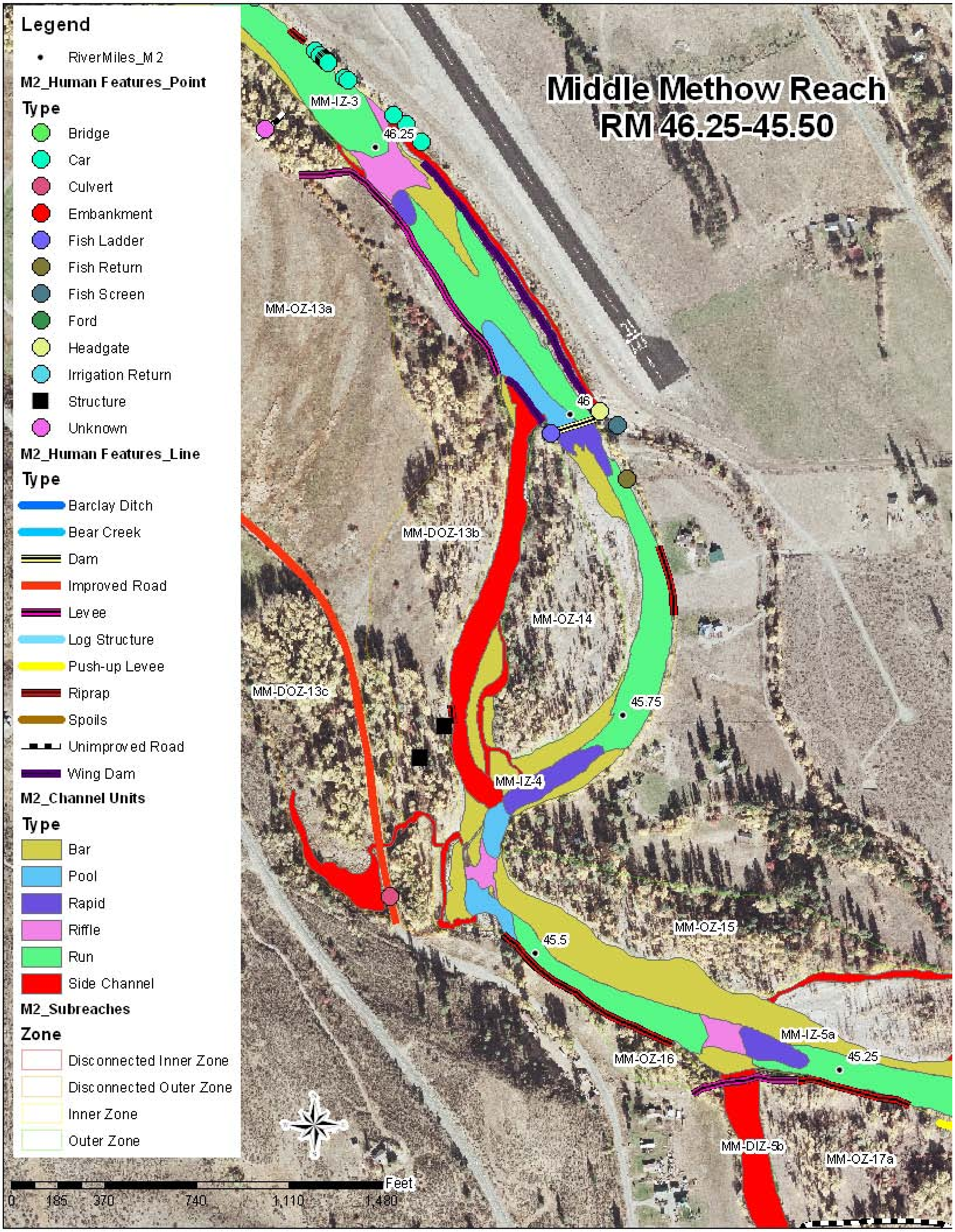


Figure 5. Channel unit mapping from RM 46.25 to RM 45.50.

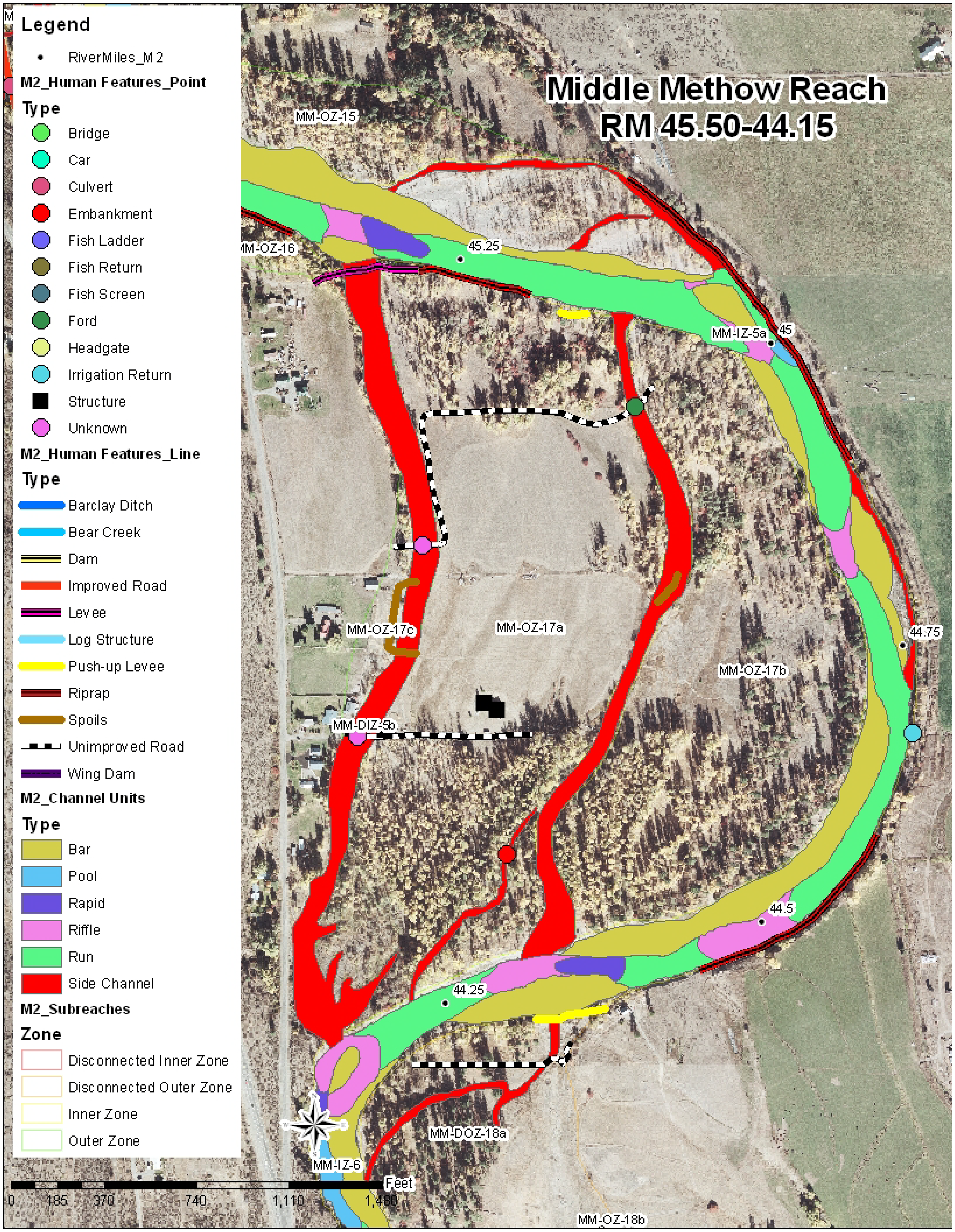


Figure 6. Channel unit mapping from RM 45.50 to RM 44.15.

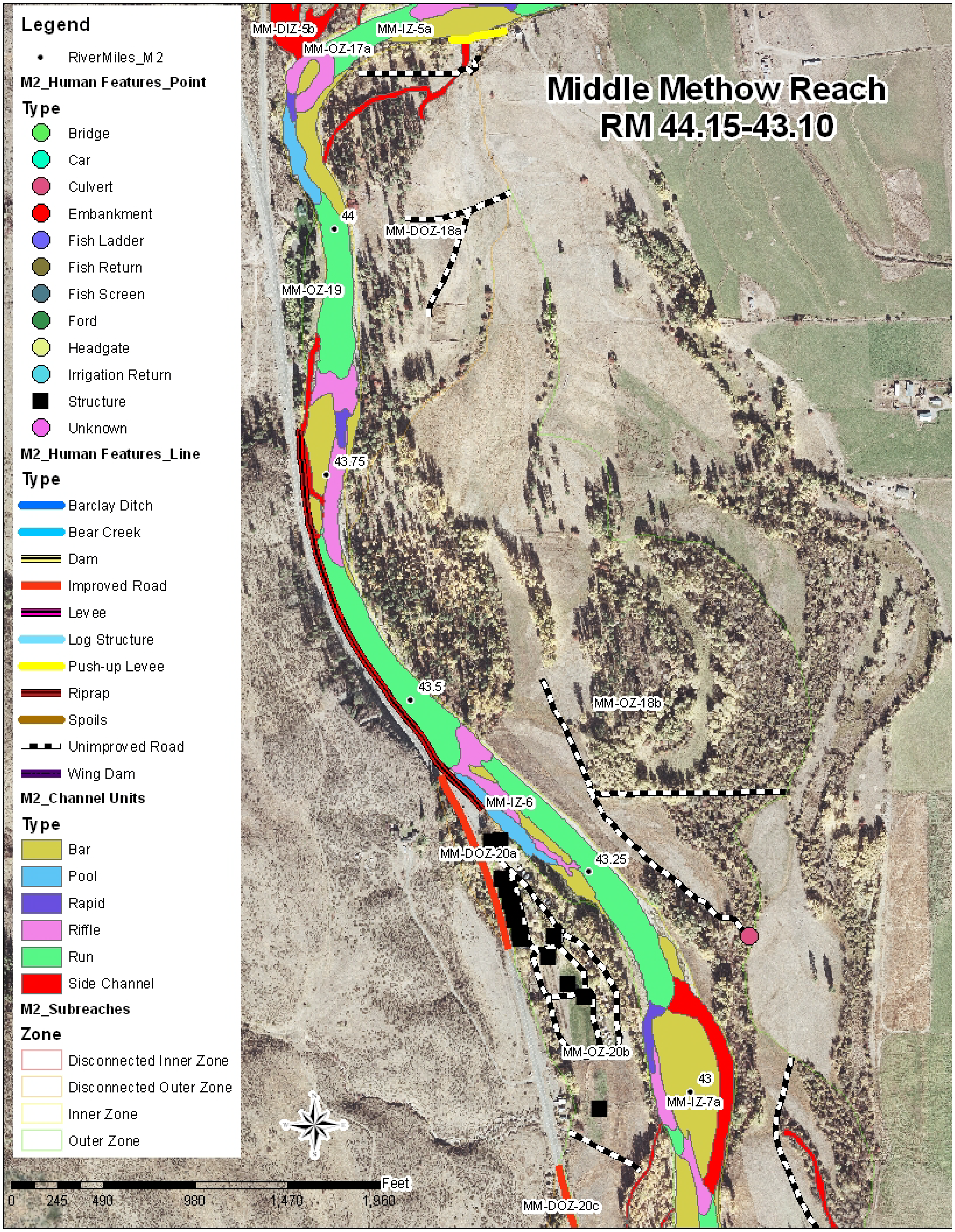


Figure 7. Channel unit mapping from RM 44.15 to RM 43.10.

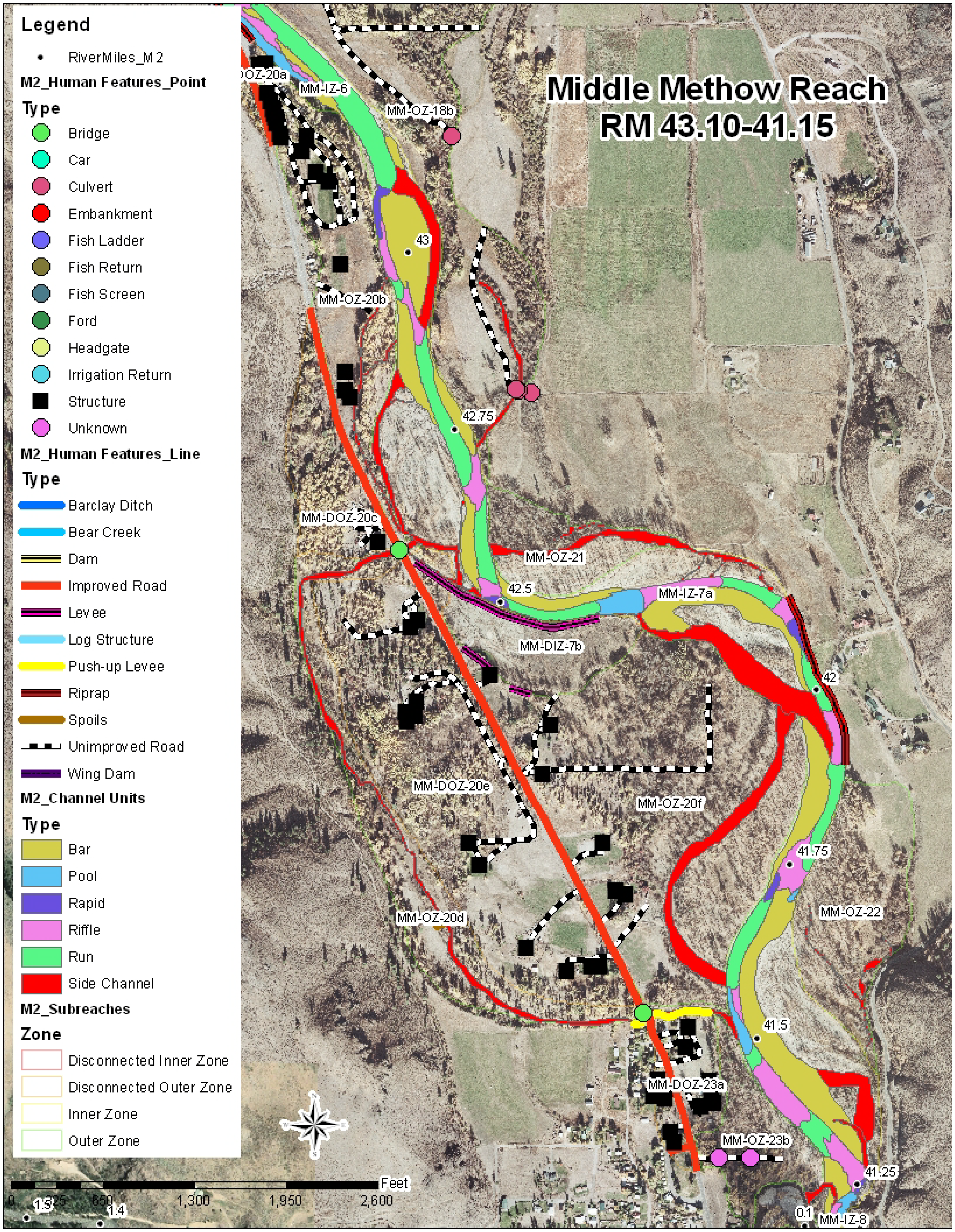


Figure 8. Channel unit mapping from RM 43.10 to RM 41.15.

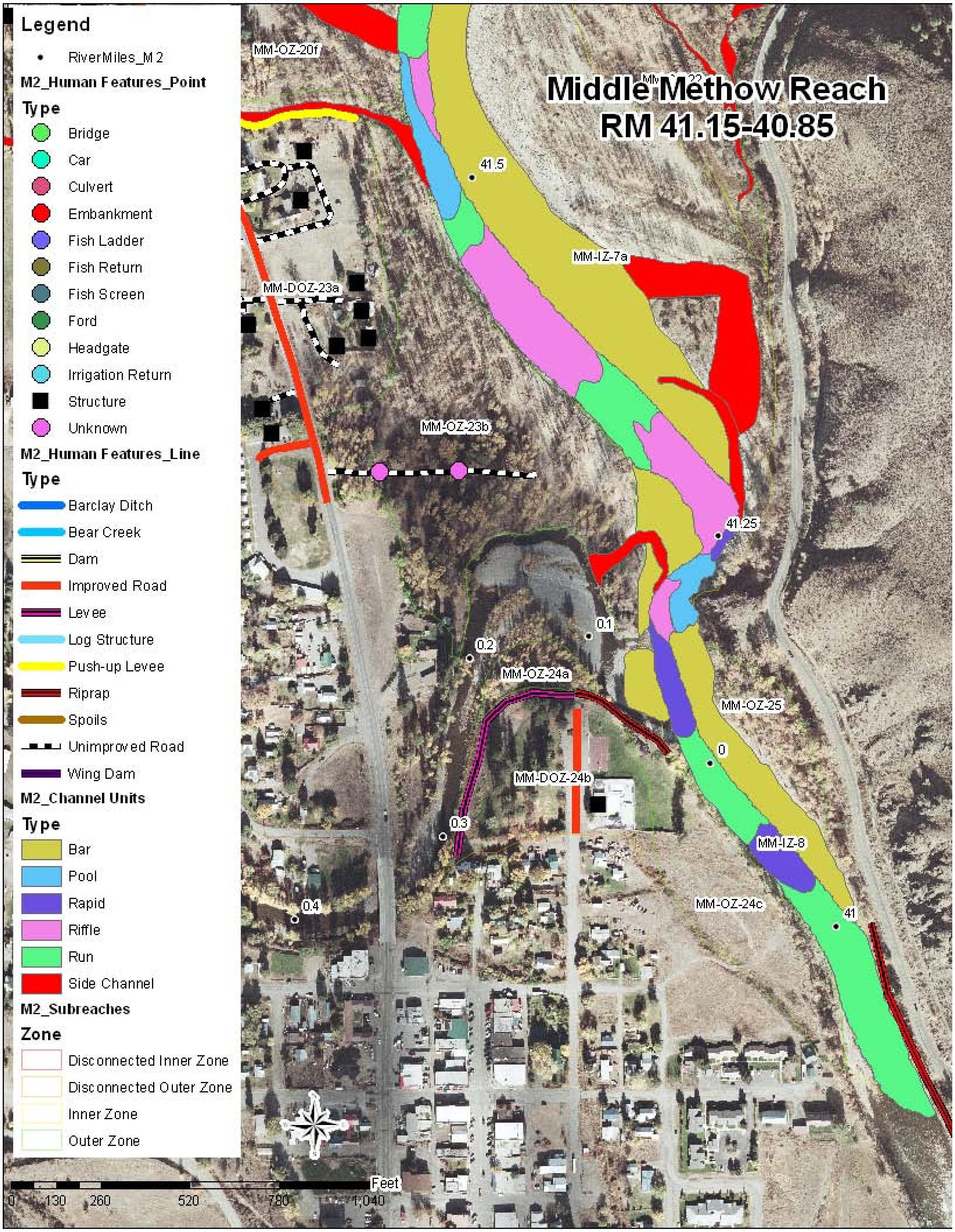


Figure 9. Channel unit mapping from RM 41.15 to RM 40.85.

Photographic documentation of the Middle Methow reach was completed during the initial site assessment. Photographs were taken in the field and the location and direction were noted on aerial photographs. The location or photopoints were then mapped using GIS (Figures 10 through Figure 17). Each photograph was then captioned including the direction of the photograph, subject matter and date. Captioned photographs are included in this assessment following the photopoint location maps in the Middle Methow Reach Photographic Documentation section.

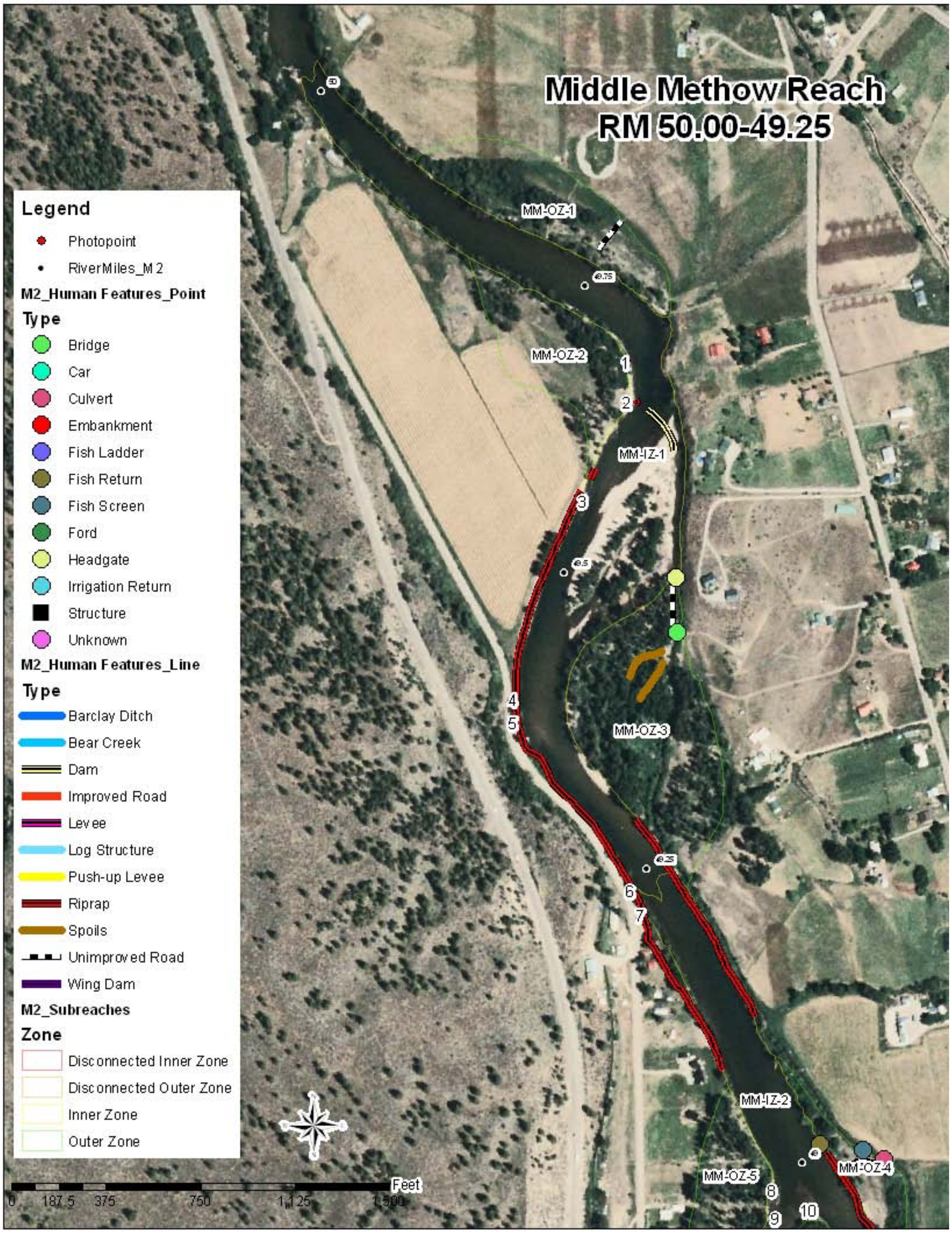


Figure 10. Photopoint locations from RM 50.00 to RM 49.25.

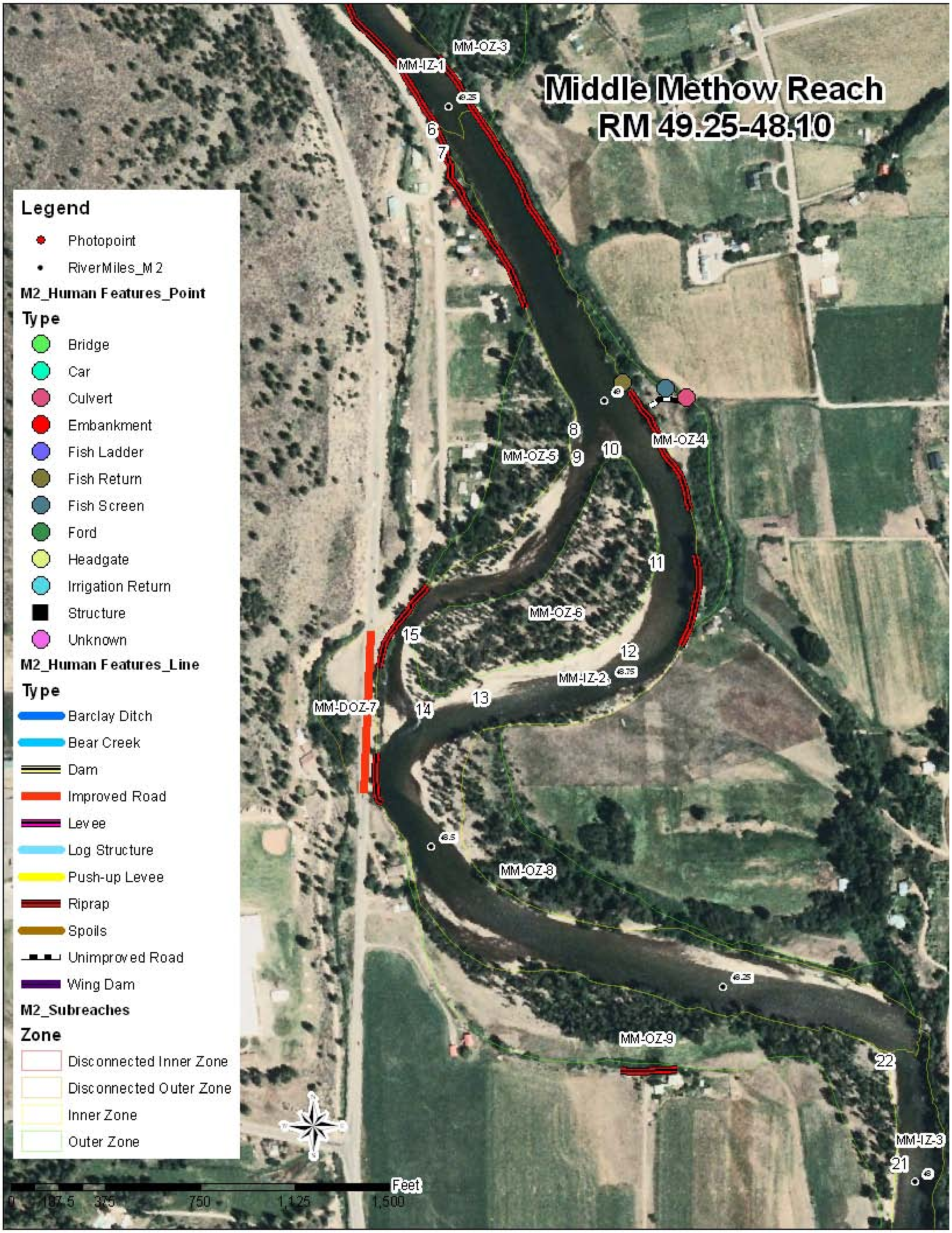


Figure 11. Photopoint locations from RM 49.25 to RM 48.10.

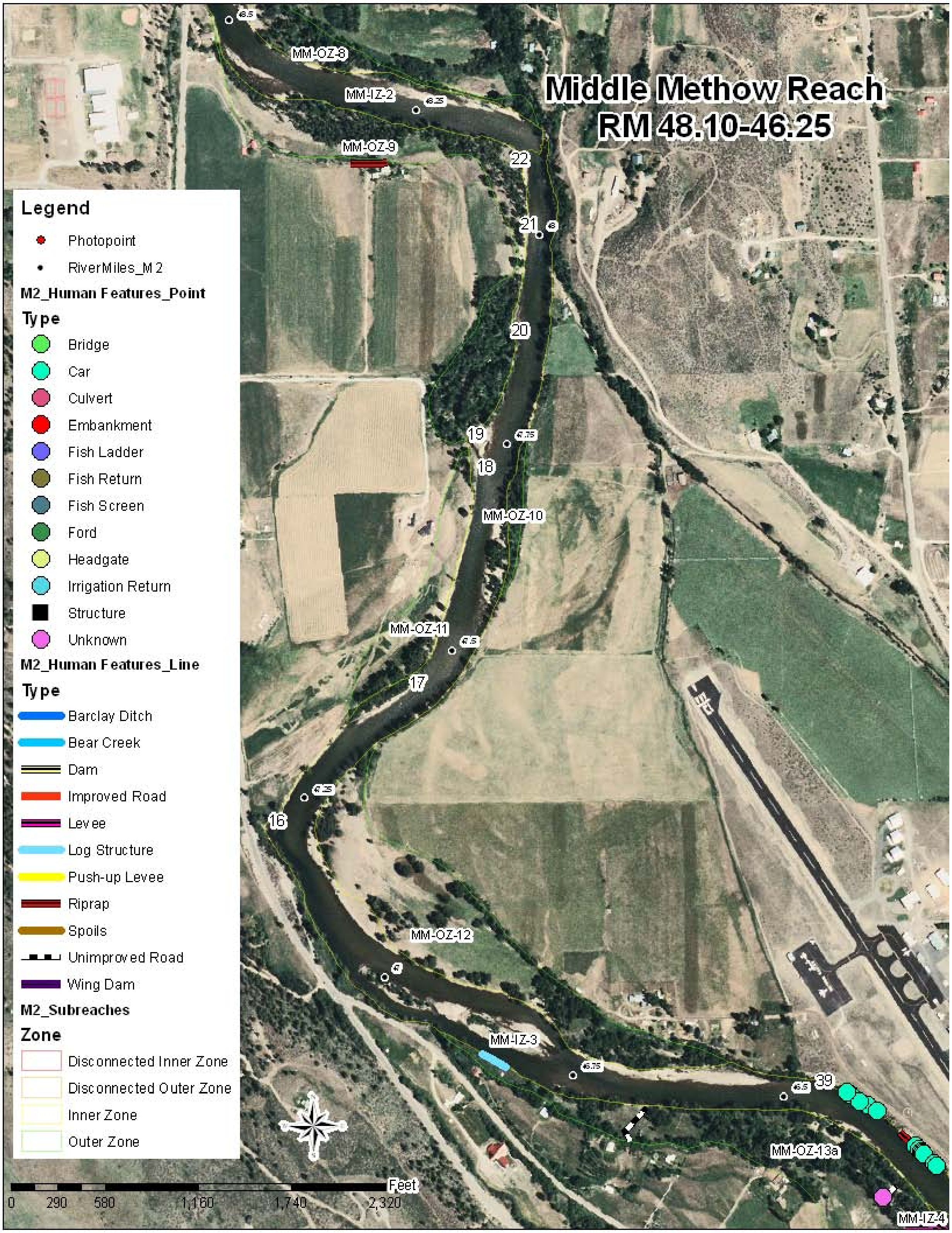


Figure 12. Photopoint locations from RM 48.10 to RM 46.25.

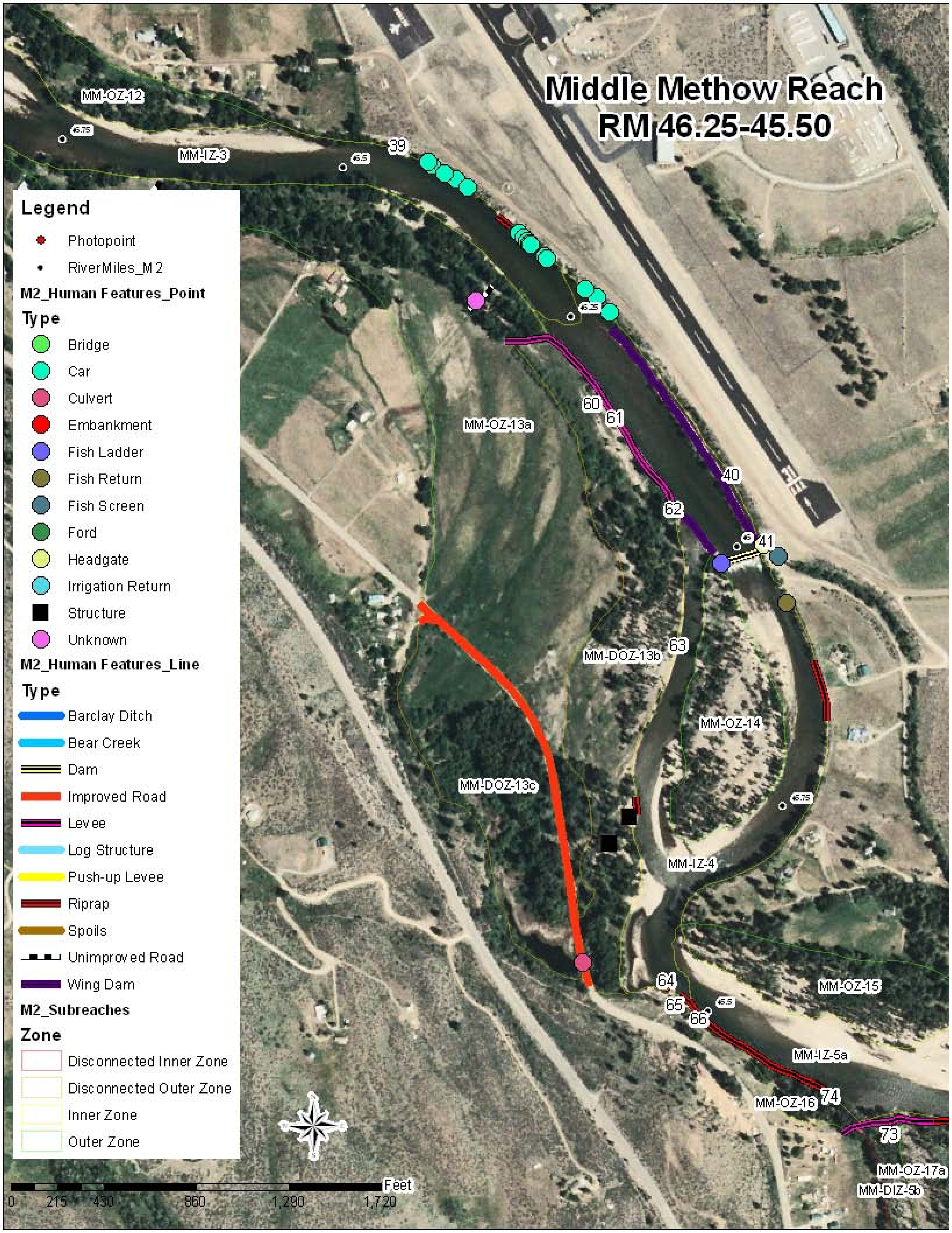


Figure 13. Photopoint locations from RM 46.25 to RM 45.50.

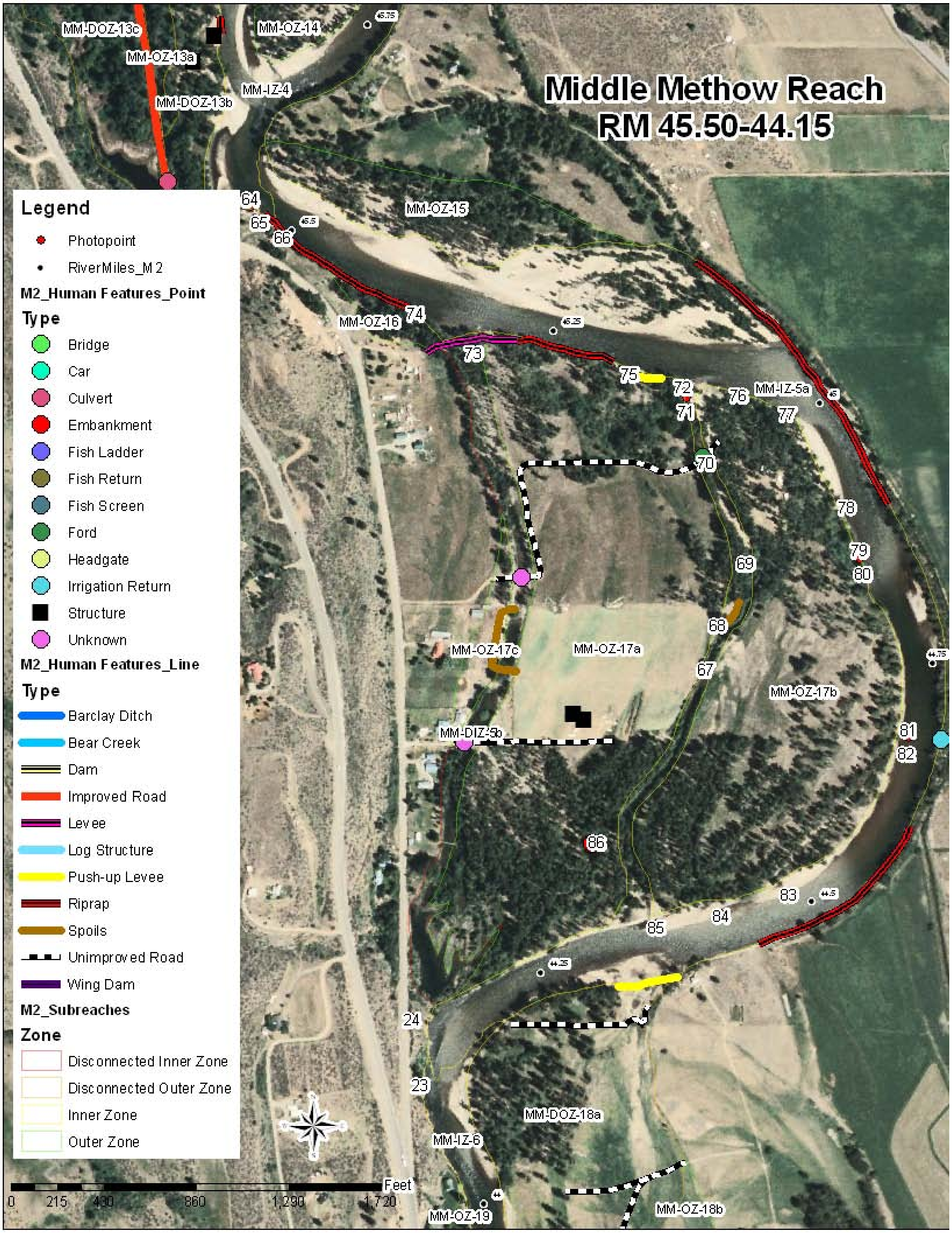


Figure 14. Photopoint locations from RM 45.50 to RM 44.15.

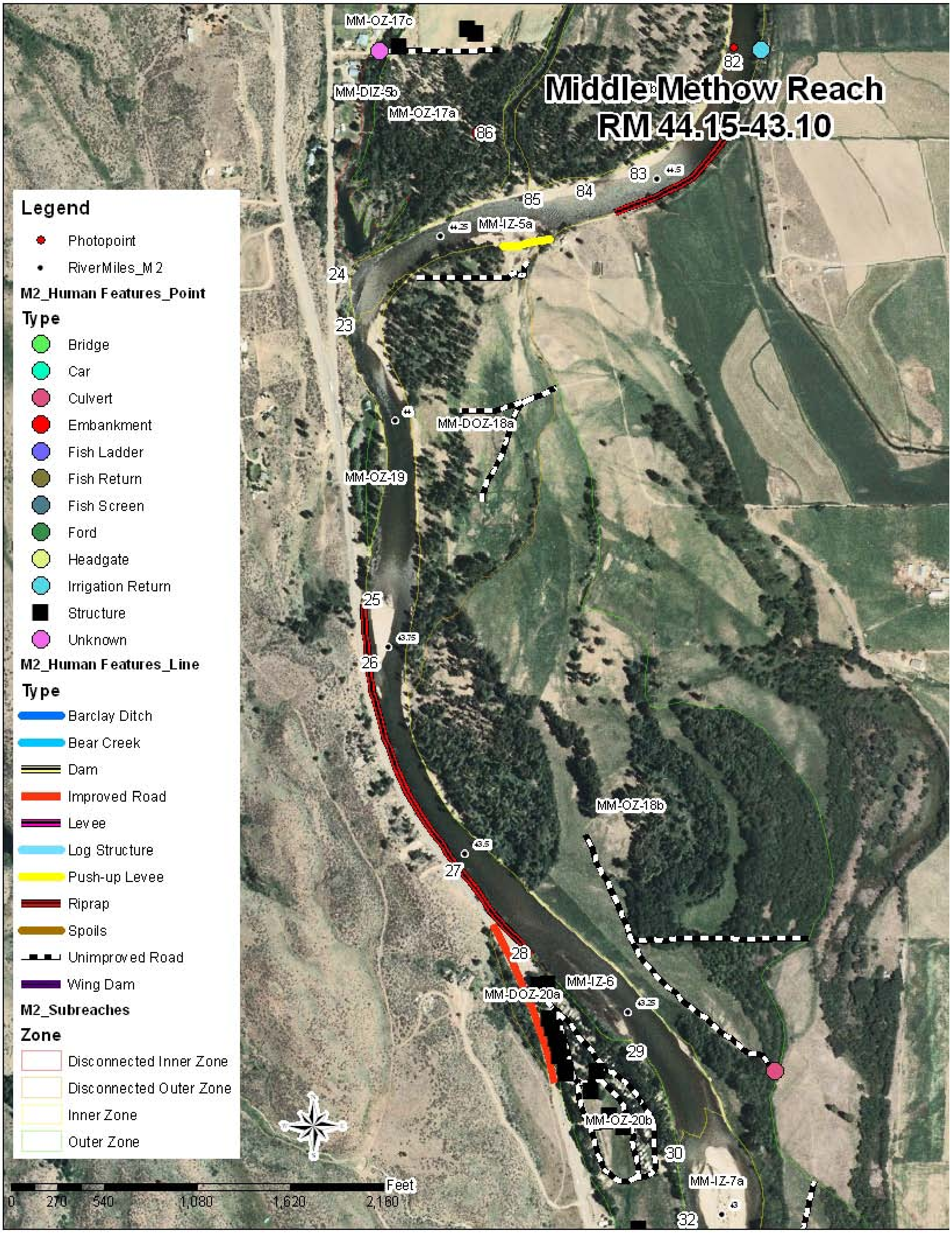


Figure 15. Photopoint locations from RM 44.15 to RM 43.10.

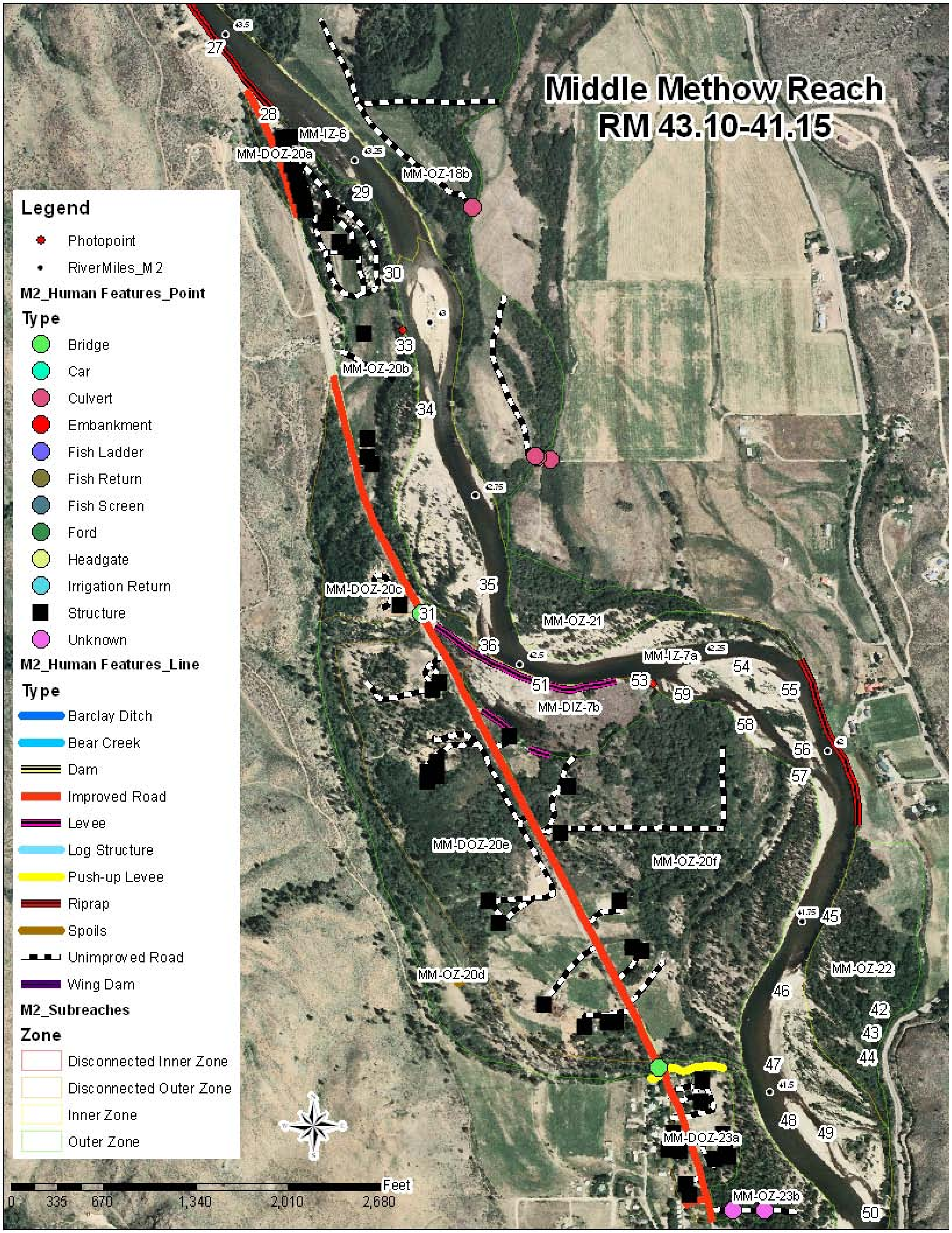


Figure 16. Photopoint locations from RM 43.10 to RM 41.15.

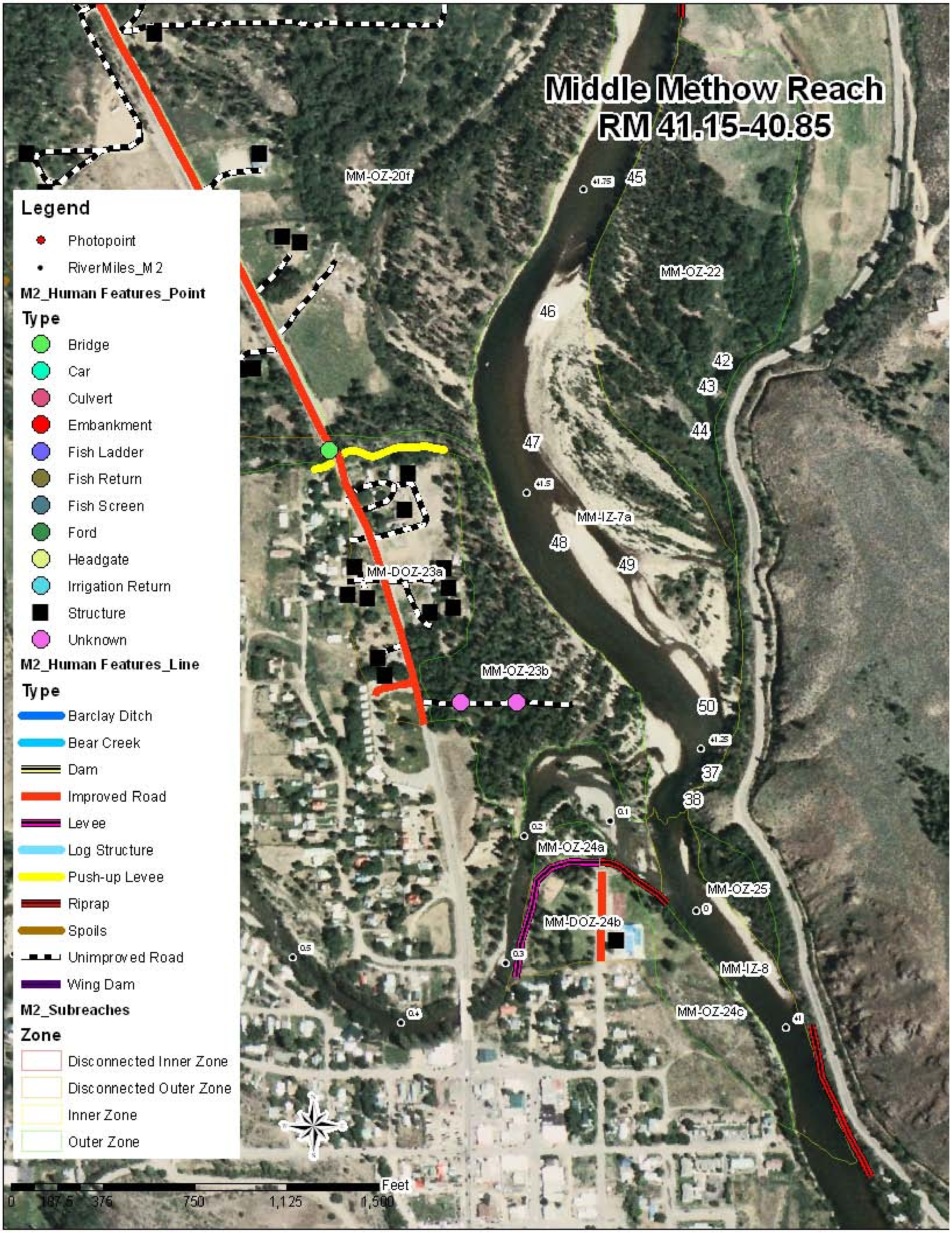


Figure 17. Photopoint locations from RM 41.15 to RM 40.85.

MIDDLE METHOW REACH PHOTOGRAPHIC DOCUMENTATION

Photograph No. 1. View is to the southeast looking downstream at a large pool ponded by the Barclay Diversion Dam near RM 49.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 2. View is to the south looking downstream at a pool-riffle-rapid-run channel unit sequence downstream of the Barkley Diversion Dam near RM 49.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 3. View is to the southwest looking downstream at a deep run developed by scour along riprap placed along river right near RM 49.4. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 4. View is to the northeast looking across the Methow River and upstream at the side channel from the Barkley diversion near RM 49.3. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 5. View is to the southeast looking downstream at a rapid running along a bedrock outcrop along river right near RM 49.3. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 6. View is to the southeast looking at spawning summer Chinook salmon and redds on a riffle comprised of predominantly of gravel near RM 49.2. Also note the riprap placed along river left to protect the Barkley irrigation ditch. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 7. View is to the northeast looking at the same spawning summer Chinook salmon and redds as in Photograph No. 6 near RM 49.2. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 8. View is to the northwest looking upstream along river right at a run that is over 0.1 mile long near RM 49.0. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 9. View is to the southwest looking downstream from the head of Bird side channel along river right near RM 49.0. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 10. View is to the southwest looking downstream at a riffle comprised predominantly of large gravel to small cobbles. Spawning summer Chinook salmon and redds were observed in the tail-out section of the riffle near RM 48.9. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 11. View is to the southeast looking downstream at a run-rapid sequence and riprap placed along river left near RM 48.9. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 12. View is to the southwest looking downstream at a rapid-run-rapid sequence near RM 48.8. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 13. View is to the southwest looking downstream at a rapid-pool sequence at the mouth of Birds side channel near RM 48.7. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 14. View is to the southwest looking downstream at a lateral scour pool formed by riprap and bedrock along river right from the mouth of Bird side channel near RM 48.7. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 15. View is to the southwest looking downstream at a lateral scour pool formed by riprap along the Bird side channel near RM 48.7. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 16. View is to the southwest looking downstream at a rapid and lateral scour pool formed by bedrock along river right near RM 47.2. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 17. View is to the south looking downstream at a riffle-rapid-run sequence near RM 47.4. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 18. View is to the south looking downstream at a riffle-run sequence where redds were observed in the tail-out section of the riffle near RM 47.6. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 19. View is to the south looking downstream at a lateral scour pool formed by bedrock along Pigott side channel along river right near RM 47.6. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 20. View is to the south looking downstream at a run with the dominant substrate being cobbles and boulders near RM 47.9. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 21. View is to the south looking downstream at a run-rapid-pool sequence where bedrock crops out in the channel near RM 48.0. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 22. View is to the southeast looking downstream at a rapid-pool sequence where bedrock crops out in the channel near RM 48.0. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 3, 2008.

Photograph No. 23. View is to the southeast looking downstream at a large lateral scour pool formed by bedrock near RM 44.1. Note cattle accessing the river along river left. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 24. View is to the northwest looking upstream at a run-riffle sequence near RM 44.1. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 25. View is to the south looking downstream along a perennial side channel along river right near RM 43.6. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 26. View is to the south looking downstream at the outlet of the perennial side channel in Photograph No. 25 near RM 43.6. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 27. View is to the southeast looking downstream at a split flow near RM 43.4. Note the bank erosion occurring along river left where the vegetation has been disturbed. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 28. View is to the southeast looking downstream along the right split-flow channel near RM 43.3. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 29. View is to the southeast looking downstream at a run-riffle sequence where summer Chinook salmon were observed spawning near RM 43.1. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 30. View is to the south looking downstream at a rapid where the stream gradient has increased and the river is trying to migrate laterally along river right near RM 43.0. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 31. View is to the southwest looking downstream at the highway bridge crossing an overflow channel near RM 42.6. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 32. View is to the east looking at turbulence caused by spawning summer Chinook salmon near RM 43.0. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 33. View is to the southeast looking downstream at a run-riffle-rapid sequence near RM 43.0. Numerous summer Chinook salmon were observed spawning in the run-riffle channel units as noted in Photograph No. 32. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

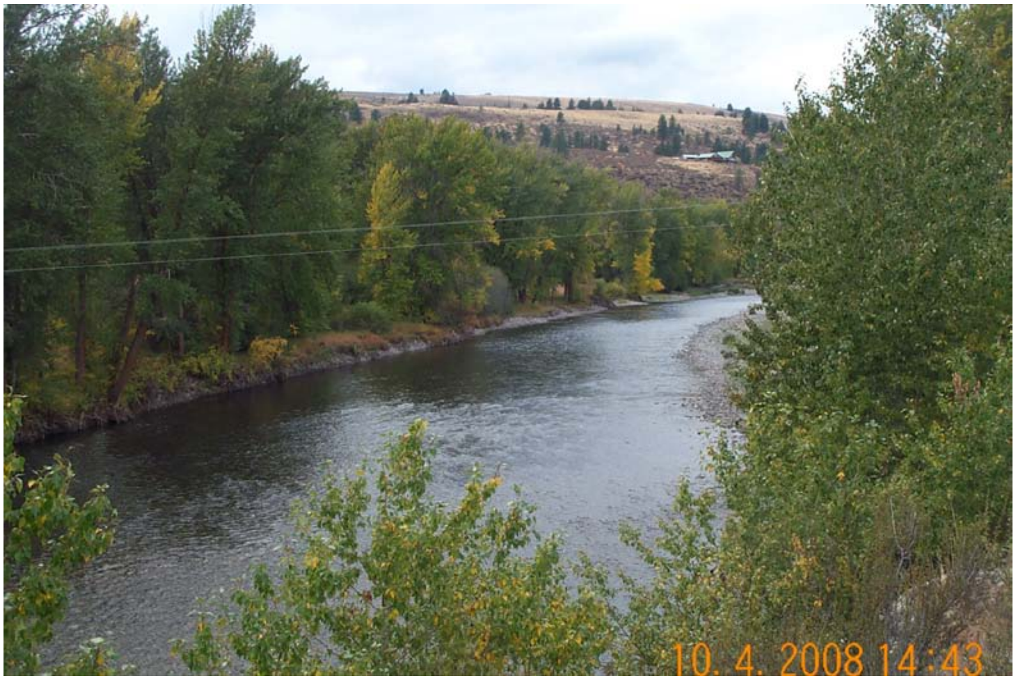
Photograph No. 34. View is to the south looking downstream at the head of a side channel forming along river right near RM 42.9. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 35. View is to the south looking downstream at a levee placed along river right near RM 42.6. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 36. View is to the southeast looking downstream at a riffle-rapid sequence where the river encounters the levee placed along the outside of a meander on river right near RM 42.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 37. View is to the north looking upstream at a riffle-rapid-pool sequence as the river flows against a bedrock outcrop along river left near RM 41.2. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 38. View is to the west looking at a large pool formed by lateral scour against a bedrock outcrop near RM 41.2 just upstream of the confluence with the Twisp River. Also note the large redd and spawning summer Chinook salmon in the "clean gravels" in the pool tailout. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.



Photograph No. 39. View is to the west looking upstream at a run-riffle-run-riffle sequence near RM 46.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 40. View is to the southwest looking across at the head of a perennial side channel along river right just upstream of Methow Valley Irrigation District east diversion near RM 46.0. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 41. View is to the west looking across at the Methow Valley Irrigation District's east canal diversion dam that was mechanically lowered in 2007 near RM 46.0. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 4, 2008.

Photograph No. 42. View is to the south looking downstream along Anderson side channel at a historic beaver dam or embankment near RM 41.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 43. View is to the south looking downstream along the Anderson side channel near RM 41.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 44. View is to the northwest looking upstream at an overflow channel along river left near RM 41.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 45. View is to the southwest looking downstream at a riffle-rapid-run sequence near RM 41.8. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 46. View is to the southwest looking downstream at a run near RM 41.6. Note the bank erosion along river right. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008**.**

Photograph No. 47. View is to the northwest looking across at the head of a side channel (left of center in photograph) that is elevated about 0.5 m above the channel; and the mouth of an unnamed side channel (right of center in photograph) that is elevated about 1 m above the channel along river right near RM 41.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 48. View is to the south looking downstream at a run-riffle sequence near RM 41.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 49. View is to the east looking downstream at a side channel developing along river left near RM 41.4. During high flows this side channel connects the outlet of the Anderson side channel to the mainstem. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 50. View is to the south looking downstream at a riffle and large lateral scour pool formed by bedrock near RM 41.3. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 51. View is to the east looking downstream at a run developed along levee placed on river right near RM 42.5. Note the downstream end of the riprap is failing. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 52. View is to the southeast looking downstream at the head of Pederson side channel on river right near RM 42.3. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 53. View is to the west looking downstream at a large mid-channel scour pool downstream of the riprap in Photograph No. 51 near RM 42.3. Note summer Chinook salmon were observed spawing at the head of the riffle downstream of the pool. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 54. View is to the southeast looking downstream at a run-riffle-rapid sequence near RM 42.2. Note riprap placed along river left where the rapid has developed. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 55. View is to the southeast looking downstream at a riffle-rapid sequence near RM 42.1. Note riprap placed along river left appears to have captured the thalweg where the rapid has developed. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 56. View is to the south looking across the Pederson side channel and downstream at the head of a developing unnamed side channel near RM 42.0. Note cattle accessing the river along river left. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 57. View is to the southwest looking downstream along the developing side channel in Photograph No. 56 near RM 42.0. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 58. View is to the southeast looking downstream along the Pederson side channel near RM 42.1. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 59. View is to the east looking downstream at a lateral scour pool formed by large wood along the Pederson side channel near RM 42.3. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 5, 2008.

Photograph No. 60. View is to the southeast looking downstream along the backside of a levee along river right near RM 46.1. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 61. View is to the southeast looking downstream along a levee placed along river right upstream of Methow Valley Irrigation District East Canal diversion dam near RM 46.1. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 62. View is to the east looking across the head of McNae side channel with riprap placed across the channel to keep more water in the main channel near RM 46.0. Note the Methow Valley Irrigation District East Canal diversion dam in background. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 63. View is to the south looking downstream along McNae side channel at a run-riffle-run sequence and the head of a side channel developing on river left near RM 45.9. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 64. View is to the northwest looking upstream from a bedrock outcrop at a riffle-rapid-pool sequence along river right near RM 45.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 65. View is to the southeast looking downstream from a bedrock outcrop at a lateral scour pool and riprap placed along river right near RM 45.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 66. View is to the southeast looking downstream at a pool-run sequence developed along riprap placed on river right near RM 45.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 67. View is to the south looking downstream along Habermahle side channel at where groundwater maintains the flow in the lower section near RM 44.7. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 68. View is to the southeast looking at spoil piles probably excavated from the Habermahle side channel and placed as a training levee near RM 44.7. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

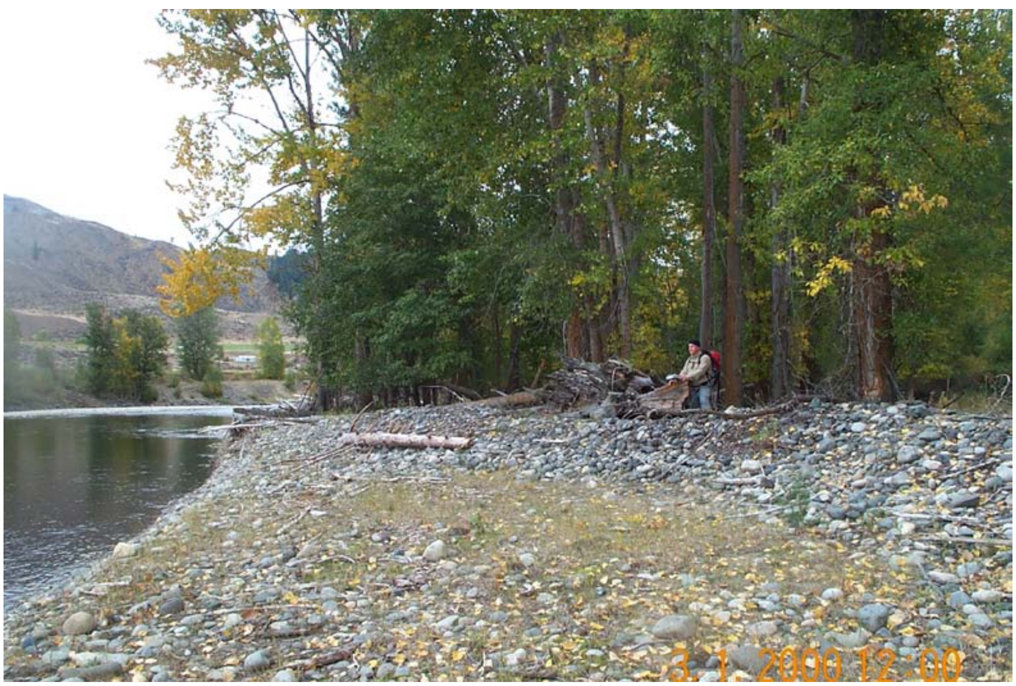
Photograph No. 69. View is to the south along the Habermahle side channel looking downstream at large wood complexes near RM 44.8. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 70. View is to the west looking at a ford crossing the Habermahle side channel near RM 44.9. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 71. View is to the southeast looking downstream at a large wood complex at the head of the Habermahle side channel near RM 45.1. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 72. View is to the east looking downstream from the head of the Habermahle side channel near RM 45.1. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 73. View is to the east looking at a levee placed across the head of the Lankhaar side channel near RM 41.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.



Photograph No. 74. View is to the southeast looking downstream along river right at a push-up levee upstream of Habermahle side channel near RM 45.2. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 75. View is to the southeast looking downstream along river right at bank erosion near RM 45.1. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 76. View is to the southeast looking downstream at a riffle-rapid-pool sequence near RM 45.0. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 77. View is to the south looking downstream at a run-riffle sequence near RM 44.9. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 78. View is to the northeast looking across a riffle where summer Chinook salmon were observed spawning near RM 44.8. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 79. View is to the west looking at a spawning summer Chinook salmon (center of photograph) near RM 44.8. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 80. View is to the south looking downstream at a run-riffle sequence near RM 44.7. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 81. View is to the east looking across at an irrigation return on river left near RM 44.7. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 82. View is to the southwest looking downstream at bank erosion downstream of riprap placed along river left and a house that may be threatened if bank erosion continues near RM 44.5. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 83. View is to the southwest looking downstream at a rapid near RM 44.4. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 84. View is to the north looking upstream at the mouth of Habermahle side channel near RM 44.4. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

Photograph No. 85. View is to the southwest looking downstream along an overflow channel adjacent to the Habermahle side channel that has a road embankment crossing the channel near RM 44.3. Middle Methow Reach Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, October 6, 2008.

APPENDIX D

Stream Inventory Survey

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Revised 03-10-09

MIDDLE METHOW RIVER HABITAT ASSESSMENT
RIVER MILE 40.3 TO 52.4

(From 0.9 miles below the confluence with Twisp River to the confluence with Wolf Creek)

Survey Dates: September 16-17, September 22-25, and September 31-October 1, 2008

TABLE OF CONTENTS

MIDDLE METHOW RIVER HABITAT ASSESSMENT
RM 40.3 to RM 54.2
September 2008

Methodology and Objectives: A modified Hankin-Reeves Level II habitat survey (USDA Forest Service *Stream Inventory Handbook, 2007, Version 2.7*, Pacific Northwest Region) was conducted on a 14 mile segment of the Methow River located from approximately 0.9 miles below the confluence with Twisp River to the confluence with Wolf Creek. The survey was conducted to help determine fish habitat quantity and quality in the surveyed area. The surveyed stream area was broken into five subreaches based on channel confinement, described below:

-Subreach 1: A 0.9 mile river segment which begins about a quarter mile below the bridge crossing of the Methow River in the town of Twisp and ends at the confluence with the Twisp River. The reach is naturally confined. Most of the banks in the reach are protected by rip rap to prevent erosion.

-Subreach 2: A 5.8 mile segment in an unconfined river segment located between the confluence with Twisp River to about river mile (RM) 47, at the top of a side channel. At RM 47 the stream changes from an unconfined to moderately confined channel.

-Subreach 3: A 3.0 mile moderately confined segment of the river located between RM 47 and RM 50, just below the limits of the town of Winthrop.

-Subreach 4: A 1.4 mile long naturally confined segment of the river located between RM 50 and the confluence with the Chewuch River.

-Subreach 5: A 2.8 mile segment of the river located between the confluence with the Chewuch River and the confluence with Wolf Creek. Although most of the reach historically was unconfined, rip rap and dikes installed after the 1948 flood have reduced the amount of floodplain available to the river. The channel starts to become naturally confined just below the confluence with Wolf Creek.

Habitat data was collected and compared in the five surveyed stream segment areas.

Data Attributes: The following data attributes were collected during the habitat survey conducted on September 16-17, September 22-25 and September 30-October 1, 2008.

●Stream Habitat Type: Habitat in the main channel and all the wetted side channels were broken into 4 main habitat unit types; riffles, pools, runs, and side channels. The % habitat type was compared in the five surveyed stream segments. Run habitat measured in the survey is non-turbulent riffle habitat. Runs are very low gradient, generally slow-moving habitat with little surface turbulence, but without the scour element associated with pools. The long tail-outs in the glide pools in the Methow River were included as pool habitat.

●Habitat Area: The length and wetted width of all habitat units were measured. The % area (square footage) of all 4 habitat unit types was calculated.

●Pools: Pools depths were measured with a stadia rod from a raft on September 17, 2008. The pools were spatially located with a hand-held gps unit. Pool-tail crests were measured with a depth rod during the habitat survey. Total pools were counted and pools per mile were calculated. The average maximum depth and average residual depth (max depth minus pool crest) were calculated.

●Riffles and Runs: Habitat dimensions, average thalweg depth, and maximum thalweg depth in riffles and runs were measured.

●Large woody debris: Pieces of large wood that intersected the bankfull channel width were counted in three size categories; small (> 20' long with a diameter of at least 6"), medium (> 35' long with a diameter between 12" and 20"), and large (> 35' long with a diameter greater than 20"). Large wood was counted in the main channel, in the wetted side channels, and in dry side channels. Standing trees within the bankfull width were counted but calculated separately from the in-channel wood.
●Bank Erosion: The linear distance of eroding banks above the bankfull width was measured.
●Substrate: Two Wolman pebble counts were conducted in each reach. Substrate was ocularly estimated in every habitat unit in 5 size categories (sand, gravel, cobble, boulder, bedrock) based on size categories from Wolman pebble counts.
●At least two bankfull width/depth measurements were taken in each surveyed stream segment except reach 1 (one bankfull measurement was taken in reach 1). A total of 7 bankfull depths were measured and averaged across each bankfull width transect to compute width/depth ratio. The floodprone area was defined based on survey protocol (floodprone area is the elevation calculated at two times the maximum bankfull depth in each bankfull channel cross-sectioin).

Deviations from Hankin-Reeves Protocol: Certain attributes were measured differently than described in the Forest Service *Stream Inventory Handbook, 2007*. These differences and reasons for changing the protocol are described below:

1. Habitat Dimensions of a channel unit (pool, riffle, run): The protocol states that in order to consider a channel unit type as a separate unit, the channel unit length must be equal to or greater than the wetted width. The wetted width in the Methow River was up to 250' wide. Large streams such as the Middle Methow River have a significant number of riffle habitat units that are wider than long. In order to get a more accurate picture of habitat, all habitat units were recorded as separate units, even if wider than long.
2. Bankfull depth measurements: The protocol states that three bankfull depth measurements be taken across the measured bankfull width to calculate a width/depth ratio. We felt that three measurements would be insufficient, due partly to the wide lateral bars in man of the riffles. Seven equally-spaced bankfull measurements were taken on each bankfull width measurement. Seven measurements are likely also insufficient, but are probably more accurate than three measurements.
3. Fish Distribution: Fish distribution surveys were not conducted during the habitat survey. However, the USGS did extensive snorkel surveys in the spring, summer and fall of 2008, and fish mark and recapture efforts are underway as a complement to this survey.

Water Temperature Monitoring: A total of 19 calibrated water temperature monitors were deployed in the Methow River and its associated tributaries and springs during the summer of 2008 (see pages 10 & 11 of the Habitat Assessment for data and analysis on water temperature).

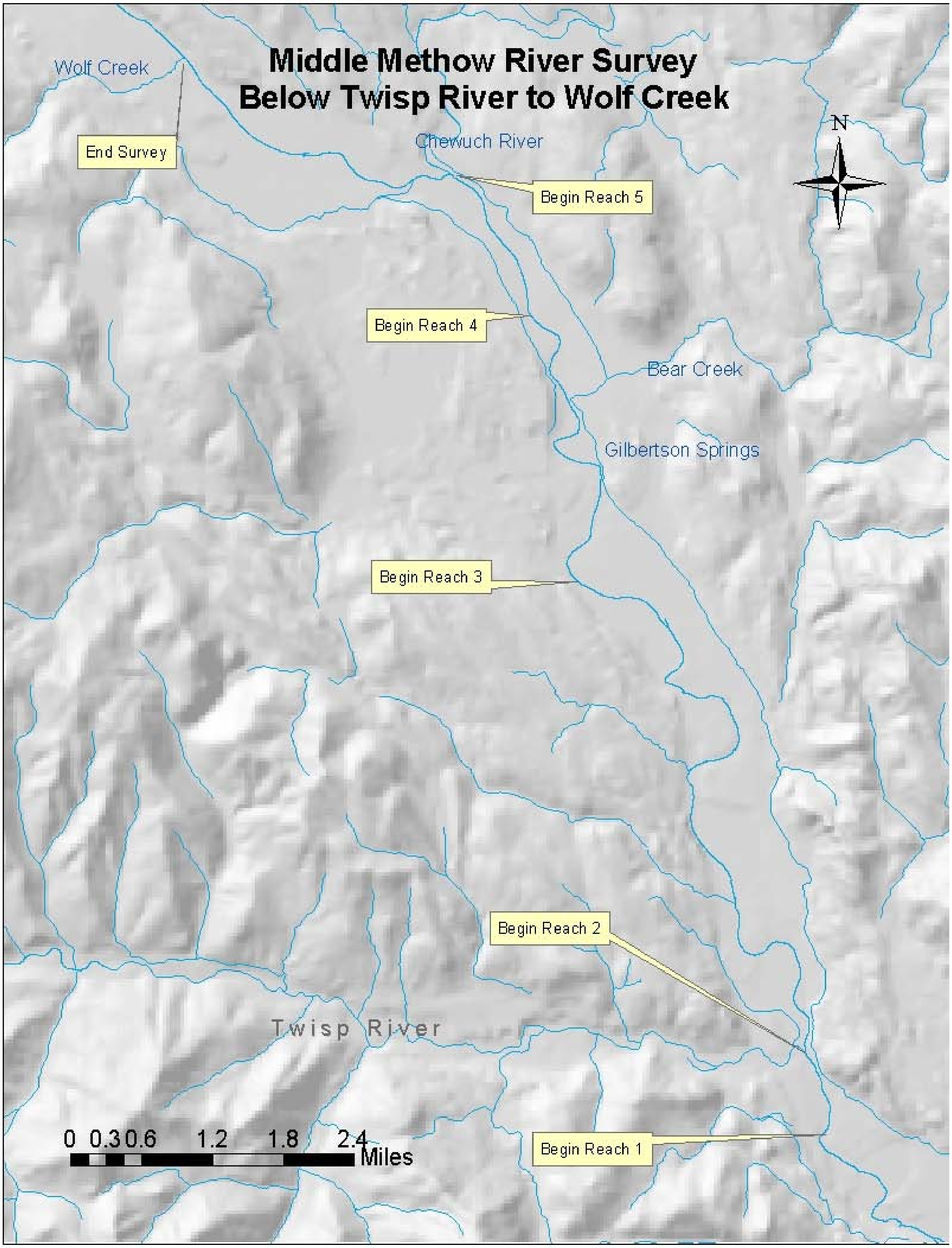
River Mileage: River mileage is determined from maps provided by the Jennifer Bountry of the Bureau of Reclamation. The actual measured survey mileage in reach 3 was slightly lower than the map distance (2.83 miles compared with 3.0 miles on the map). The measured miles were the same as the map miles in reaches 1, 2, 4 and 5. All statistical data was generated using the measured length in each reach.

Stream Flow: The stream survey was conducted at low flow. The flow in the Methow River at the USGS gage in Winthrop was 228 cfs on September 16, 2008, the first day of the survey. The USGS gage is located below the confluence with the Chewuch River. The table on the following page summarizes USGS flow data during the survey:

Table: Methow River Stream Flow: USGS Gage Data in Winthrop (Station 12448500)
Provisional Data Subject to Review

Date	Flow in cfs
09-16-08	228 cfs
09-17-08	225
09-18-08	221
09-19-08	217
09-20-08	214
09-21-08	215
09-22-08	217
09-23-08	214
09-24-08	223
09-25-08	225
09-26-08	223
09-27-08	225
09-28-08	221
09-29-08	219
09-30-08	217
10-01-08	227

Note: Rain in early October increased flow in the Methow River at the gage site to 314 cfs on 10-05-08. Heavy rain in early November increased flow in the river to 810 cfs on 11-13-08.


Middle Methow River Survey
Below Twisp River to Wolf Creek
Wolf Creek
End Survey
Chewuch River
Begin Reach 5
N
Begin Reach 4
Bear Creek
Gilbertson Springs
Begin Reach 3
Begin Reach 2
Twisp River
0 0.3 0.6 1.2 1.8 2.4
Miles
Begin Reach 1

MIDDLE METHOW RIVER (M2 Reach) HABITAT ASSESSMENT OVERVIEW
River Mile 40.3 to River Mile 52.4

Although some high quality fish habitat currently exists in the surveyed segment of the Methow River, a significant amount of the habitat in this stream segment has been simplified by human activities (e.g. bank hardening and removal of wood). Rip rap and dikes constructed to prevent bank erosion and flooding have disconnected the river from its floodplain in some areas of the reach (see Reach Assessments found later in this report for details on the locations and site impacts of rip rap and dikes).

Large Wood: In addition to providing rearing habitat for juveniles and holding habitat for adult salmonids, large wood sorts sediment and creates spawning gravels, channel complexity and dissipates stream energy. Amounts of large wood in the channel are at very low levels in the surveyed segment of the Methow River. Large wood may have been removed from the channel in the past for development or flood control. A total of 11.5 pieces of large wood per mile at least 35' long with a diameter of at least 12" was counted in the main channel in the surveyed segment of the Methow River during the survey. Most of the wood in the survey was found high on the bars and in jams at the confluence with side channels, which is to be expected in a large mainstem river with high spring flows and low base flows. The MPI standards for large wood calls for a minimum of 20 pieces per mile greater than 35' long with a diameter of at least 12" for properly functioning habitat, with adequate sources of woody debris recruitment in riparian areas. The future recruitment potential is poor to fair in the surveyed river segment due to the removal of vegetation in the floodplain for agriculture and development. The Methow River is not functioning properly for large wood. The wood count in the surveyed segment of the Methow River is summarized in the table below by reach:

Table 1: Summary of Large Wood per Mile: Methow River RM 40.3 to RM 52.4

	Reach 1: Below Twisp River	Reach 2: Twisp River to RM 47.0	Reach 3: RM 47.0 to RM 50.0	Reach 4: RM 50 to Chewuch	Reach 5: Chewuch to Wolf Creek	Total: Below Twisp River to Wolf Creek
River Mile: from/to	40.3 – 41.2	41.2 – 47.0	47.0-50.0	50.0 – 51.4	51.4- 54.2	40.3 – 41.2
# Miles:	0.9	5.8	3.0	1.4	2.8	13.9
Large wood per Mile[1]						
-Main channel[2]	2.4	16.0	9.9	5.7	9.7	11.5
-Standing Trees[3]	0	0.5	1.4	35.0	14.4	6.8
Total Main Channel	2.4	16.5	11.3	40.7	24.1	18.3
LWD in side channels						
-Wetted side channels	0	1.7	10.7	2.9	3.2	3.1
-Dry channels	0	4.0	0.7	1.4	0	1.9
Total in side channels	0	5.7	11.4	4.3	3.2	5.0
TOTAL Large Wood	2.4	22.2	22.7	45.0	27.3	23.3

[1]Pieces of large wood at least 35' long with a diameter of at least 12".
[2]Total downed large wood within the bankfull channel.
[3]Trees standing on the banks within the bankfull width of the channel.

See the Reach Assessments found later in the report for more details on large wood.

Pool Habitat: Pool depth provides cover from predators, buffers against wide fluctuations in water temperatures, and acts as a refuge during fire, drought and cold water temperatures. Although only 3.5 pools per mile were counted in the survey, habitat units are very large in a stream as big as the Methow River. Pools per mile is probably not a good method to determine the quantity of pool habitat. Although pool habitat is abundant as a percentage of total habitat area in much of the surveyed segment of the Methow River (almost 40% of the habitat area was pools), the lack of wood in the channel has reduced habitat complexity in the pools. Historically, there were likely more wood formed pools in the Methow River, before the wood clean outs. There is little cover in many of the pools in the reach not formed by bedrock (mainly lateral scour pools at river bends). Bedrock was the primary pool forming agent of the deep pool habitat in the surveyed segment of the Methow River. Fifteen of the 39 pools located in the Methow River between the beginning of the survey and the confluence with the Chewuch River were bedrock formed pools (reaches 1 to 4 in the survey). These pools were very deep, ranging in depth from 6' to 17'. These deep pools provide excellent resting and holding habitat for migratory fish. One of the 9 pools in reach 5 (Chewuch River to Wolf Creek) was formed by bedrock. Large numbers of Chinook salmon have been observed holding in the bedrock pool at the beginning of reach 5. Most of the pools in reach 5 were shallow (< 5' deep). An 8' deep pool in the reach was formed by the Foghorn Diversion (RM 52.9). Most of the spring Chinook salmon redds in the reach were observed just below or just above the diversion. The table below summarizes pool habitat data in the surveyed segment of the Methow River, by reach.

Table 2: Summary of Pool Habitat: Methow River RM 40.3 to RM 52.4

	Reach 1: Below Twisp River	Reach 2: Twisp River to RM 47.0	Reach 3: RM 47.0 to RM 50.0	Reach 4: RM 50 to Chewuch	Reach 5: Chewuch to Wolf Creek	Total: Below Twisp River to Wolf Creek
River Mile: from/to	40.3 – 41.2	41.2 – 47.0	47.0-50.0	50.0 – 51.4	51.4- 54.2	40.3 – 41.2
# Miles:	0.9	5.8	3.0	1.4	2.8	13.9
% Habitat Area Pools	39.9%	40.7%	50.5%	30.2%	24.3%	38.9%
Total # of Pools	2	19	12	6	9	48
Pools per Mile	2.3	3.3	4.3	4.3	3.2	3.5
Pools/Mile > 5' deep	2.3	1.7	3.6	1.4	1.1	2.0
Average Max Depth	5.40'	6.32'	7.81'	5.12'	4.60'	6.18'
Avg. Residual Depth[1]	3.40'	4.59'	6.03'	3.38'	3.19'	4.49'
Pool Form:						
# Bedrock Pools	0	4	8	3	1	16
# Lateral Scour Pools[2]	1	13	4	2	4	24
# Formed by LWD	0	0	0	0	1	1
# Other Pool Form[3]	1	2	0	1	3	7

[1]Pool maximum depth minus maximum depth at pool crest.
[2]Scour from rip rap increased the depth in several of these pools.
[3]Forming agents such as rip rap, bridge abutments, or at confluences.

The lack of large wood in the river channel likely puts this segment of the river at risk for both pool quantity and quality. See the Reach Assessments found later in the report for more details on pools.

Off-channel Habitat: At low flow, about 5% of the habitat area in the surveyed segment of the Methow River consists of side channel habitat. Many of the larger side channels in this stream segment dewater in mid to late summer. These dewatered side channels provide good rearing habitat for juvenile fish during higher stream flows. Although rip rap and diking have reduced the amount of side channel and off-channel habitat in the surveyed segment of the river, some man-made off-channel rearing habitat exists in this segment of the river that is used by large numbers of fish. These off-channel rearing areas include the Barkley Ditch, the Winthrop Fish Hatchery outfall and the State Salmon Hatchery outfall (note: the Barkley Ditch, which is shut off in the fall, was not surveyed and is not included in the % habitat computation). The table below summarizes side channel and off-channel habitat observed at low flow during the habitat survey. The Barkley Ditch is not included in the table. The screen on the Barkley Ditch is nearly ¾ of a mile downstream of the headgate. The ditch provides rearing habitat for a variety of fish species until it is turned off in the fall. The Washington State Department of Fish and Wildlife electrofishes the ditch every fall at the time the ditch is turned off to rescue fish stranded in the ditch. The WDFW report written by Jonathan Kohr is found on pages 20 and 21 of this report.

Table 3: Summary of Side channel and Off-channel Habitat in the Methow River (RM 40.3 to RM 54.2)

River Mile	Bank	Length	Width	Avg/Max Depths	Date Dewatered	% Pool Habitat	% Riffle Habitat	Max Water Temp.	Notes
41.2[1]	Left	1,500'[1]	Dry	-	?	-	-	n/m	Connects to wetlands
42.0	Right	1,350'	Dry	-	07-11-08	-	-	n/m	Located below dike
42.5	Right	>1,000'	Dry	-	06-09-08	-	-	n/m	Channel not walked
42.7	Left	n/m	Dry	-	07-07-08	-	-	n/m	Lehman side channel.
42.9	Left	1,100'	15'	0.6' / 3.0'	-	n/m	n/m	n/m	3.0' pool in channel
44.2	Right	1,250'	70-100'	n/m	-	100%	0	23.23◦C	Beaver ponds
44.5[2]	Right	2,600'	Dry	-	09-20-08	-	-	19.37◦C	State land above ponds
45.6	Right	1,585'	70'	1.0' / 4.0'	-	63%	37%	18.72◦C	McNae Side Channel
46.7	Left	1,255'	80'	1.2' / 5.0'	-	66%	34%	n/m	At end of reach
47.7	Right	1,150'[1]	Dry	-	06-09-08	-	-	n/m	Nancy Farr property.
48.1	Left	950'	15'	1.0' / 2.0'	-	n/m	n/m	11.60◦C	Gilbertson Springs
48.6	Right	1,700'	Dry	0	Midsummer	-	-	-	Large, up to 140' wide
49.3	Left	1,225'	39'	2' / 6'	-	70%	30%	n/m	Barkley side channel
51.3	Right	1,800'	30'	2' / 5'	-	59%	41%	n/m	Fed. Hatchery outfall
52.2	Right	1,085'	8'	1.8' / 3.5'	-	59%	41%	n/m	State Hatchery outfall

n/m = not measured.

[1]Two dry side channels, total length 1,500'. One of the side channels connects to a series of wetland ponds. On 10-02-08 (low flow), the six ponds had a total area of about 22,500 sq. ft., with depths ranging from 0.4' to 3.0'.

[2]There were a few disconnected, wetted pools in the lower part of the channel at the time of the habitat survey.

[3]The lower 100' of the side channel was flowing. The remaining length was dry, with 4 pools that are stranding fish

Because the river is disconnected from its floodplain in many areas of the surveyed segment of the Methow River, the reach is likely functioning at risk for amounts of off-channel habitat. See the Reach Assessments found later in the report for more details on side channel and off-channel habitat.

Substrate and Fine Sediment: Cobble and gravel are the dominant substrate types we documented in the surveyed reach, which in proper relation to other habitat elements, provides preferred spawning substrate for anadromous fish. Substrate embeddedness did not appear to be excessive in our ocular estimates, as very little of the substrate was judged by surveyors to be embedded. Fine sediments appeared to be a problem between RM 45.0 and RM 45.5. Cobble and coarse gravel substrate at the pool crests of the two pools in this area were embedded due to high amounts of fine sediments. The MPI has a properly functioning standard for fine sediments in spawning gravel (<12% fines < 0.85 mm), which is measured by using McNeil Core sampling. McNeil samples were not taken in this reach and fine sediment levels within spawning gravels is not known. Surface fine sediments were measured during the survey by conducting 10 Wolman pebble counts, spaced throughout the survey. The MPI standard for an appropriately functioning stream is < 12% surface fines < 6 mm. Surface fine sediments < 6 mm averaged about 7.5% in the ten Wolman pebble counts, with a range of 4% to 11% surface fine sediments < 6 mm. The surveyed segment of the Methow River appears to be properly functioning for substrate and fine sediments in most of the surveyed segment of the stream.

Steelhead, spring Chinook salmon and summer Chinook salmon all spawn in the surveyed segment of the Methow River. Most of the spring Chinook salmon spawning occurs above the bridge crossing of the Methow River at RM 51.1. About 14.4% of the total spring Chinook salmon spawning and about 16.9% of the total observed steelhead spawning in the Methow River Basin between the years 2003 and 2007 occurred in the 13.9 mile surveyed segment of the Methow River (including the hatchery outfalls). The tables below summarize spring Chinook salmon and steelhead spawning surveys conducted by the Washington State Department of Fish and Wildlife in the Methow River between the confluence with Twisp River and the confluence with Wolf Creek from 2003 to 2007:

Table 4: WDFW Spring Chinook Salmon Redd Count Data 2003-2007 (Twisp River to Wolf Cr) (Source: Tables from WDFW Spawning Ground Survey Reports 2003-2007)

Stream Segment	# of Miles	2003	2004	2005	2006	2007	Total
Middle Methow River							
-Twisp River to MVID Diversion	4.5		n/s	n/s	0	n/s	0
-MVID Dam to Winthrop Bridge	5.0	5[2]	0	5	0	n/s	10
-Winthrop Bridge to Foghorn Dam	1.7	19	17	18	46	12	112
-Foghorn Dam to Wolf Creek	1.1	20	16	19	59	10	124
-Winthrop National Fish Hatchery Outfall	0.4	11	8	5	21	3	48
-Methow State Fish Hatchery Outfall	0.4	13	9	8	75	7	112
Total Middle Methow River	**13.1**	**68**	**50**	**55**	**201**	**32**	**406**
Total of Methow River Basin Surveys	**109.7[1]**	**474**	**543**	**566**	**929**	**307**	**2,819**
% Middle Methow River to Total Methow River Basin	**11.9%**	**14.3%**	**9.2%**	**9.7%**	**21.6%**	**10.4%**	**14.4%**

[1]Total miles of Spring Chinook salmon habitat surveyed by WDFW in Methow River Basin (including Chewuch and Twisp Rivers).
[2]The Twisp River to MVID Diversion reach and MVID Diversion to Winthrop Bridge reach were combined in 2003.

Table 5 WDFW Summer Steelhead Redd Count Data 2003-2007 (Twisp River to Wolf Cr)
(Source: Tables from WDFW Spawning Ground Survey Reports 2003-2007)

Stream Segment	# of Miles	2003	2004	2005	2006	2007	Total
Middle Methow River							
-Twisp River to MVID Diversion	4.5	-	24	50	0	4	**78**
-MVID Dam to Winthrop Bridge	5.0	89[2]	14	44	15	0	**162**
-Winthrop Bridge to Foghorn Dam	1.7	325[3]	0	34	0	0	**359**
-Foghorn Dam to Wolf Creek	1.1	-	0	9	5	0	**14**
-Winthrop National Fish Hatchery Outfall	0.4	61	113	83	29	68	**354**
-Methow State Fish Hatchery Outfall	0.4	n/s	18	15	14	25	**72**
Total Middle Methow River Surveys	**13.1**	**475**	**169**	**235**	**63**	**97**	**1,039**
Total of Methow River Basin Surveys	**198.3[1]**	**2,019[4]**	**1,000[4]**	**1,576[4]**	**807[4]**	**740[4]**	**6,142[4]**
% Middle Methow River to Total Methow River Basin	**6.6%**	**23.5%**	**16.9%**	**14.9%**	**7.8%**	**13.1%**	**16.9%**

[1]Total miles of steelhead habitat surveyed by WDFW in Methow River Basin, including stream segments with expanded redd counts.
[2]The Twisp River to MVID Diversion reach and MVID Diversion to Winthrop Bridge reach were combined in 2003.
[3]The Winthrop Bridge to Foghorn Dam and Foghorn Dam to Wolf Creek reaches were combined in 2003.
[4]Expanded redd count (includes redds allocated to unsurveyed streams based on available spawning habitat and the estimated total number of steelhead in the Methow River basin).

Bank Erosion: About 12.5% of the stream-banks are actively eroding, above the 10% threshold in the MPI (streams with > 90% stable banks are considered properly functioning in the Matrix). Much of the bank erosion is from natural causes, at the bends as the river migrates across its floodplain. Much of the spawning gravels in the surveyed stream segment are being recruited from the eroding stream banks. At least a third of the erosion is caused by the removal of vegetation on the banks for agriculture and development. Diking and rip rap prevent bank erosion in many segments of the stream segment (see reach summaries for details). The amount of erosion caused by the removal of vegetation may be off-set by the amount of bank hardening. Although the stream banks are above the 10% threshold in the MPI, the total amount of bank erosion could be near natural levels. A 2006 habitat survey of a six mile segment of the Methow River located between Wolf Creek (RM 54.2) and Hancock Springs (RM 60.0) found that 14% of the banks were actively eroding. The Wolf to Hancock river segment is in near pristine condition, with a very small amount of bank hardening and a riparian area in excellent condition. The surveyed segment of the Methow River is likely functioning properly for bank erosion.

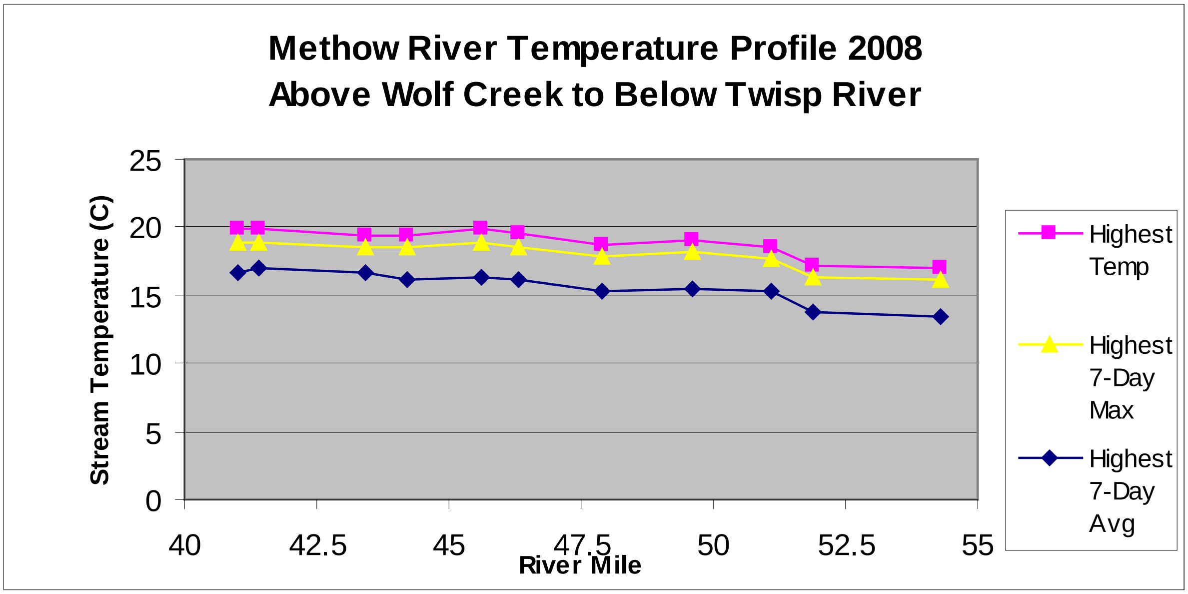
Fish Barriers: The Foghorn Dam at RM 52.9 could be a barrier to upstream juvenile fish migration. No other physical barriers to upstream or downstream fish migration were observed in the surveyed segment of the Methow River.

Water Temperatures: High water temperatures have been shown to reduce growth and survival, and influence behavior and metabolism (*Meehan*, 1991). Summer water temperatures in the Methow River above the confluence with the Chewuch River are likely close to temperatures that are naturally occurring. The Methow River dewaters in late summer above the Weeman Bridge. Bureau of Reclamation flow data from 2006 show that the river is continually gaining flow between the Weeman bridge and the town of Winthrop. Habitat and riparian conditions in this segment of the river are excellent due to the lack of development and agriculture above the banks. Water temperatures rise only slightly in the three mile reach located between the confluence with Wolf Creek. The maximum water temperature recorded above the Chewuch River was 17.1◦ C, about 0.2◦C warmer than above Wolf Creek. Much of the habitat in this three mile stream segment consists of slow, shallow riffles and runs. It's possible that increasing flows in the reach moderate water temperatures.

The Chewuch River is warming water temperatures in the Methow River during the summer. The maximum water temperature recorded about a third of a mile below the confluence with the Chewuch River was about 1.4◦C warmer than at the site located just above the Chewuch confluence (18.55◦C below the Chewuch compared with 17.12◦C above the Chewuch). The maximum temperature recorded at the mouth of the Chewuch River was 21.65◦C during the summer of 2008. Large fires in the Chewuch River watershed in 2001, 2003 and 2006 are partially responsible for elevated water temperatures in the Chewuch River.

The maximum water temperature in the Methow River during the summer of 2008 increased by only 1.3◦C in the 10 mile segment located between RM 51.1 (just below the Chewuch River) and RM 40.9 (just below the Twisp River). Water temperatures cooled by about 0.5◦C between RM 45.6 (about ½ mile below the MVID Diversion) and RM 44.2 (just above the beaver ponds on State land), possibly from upwellings or springs. Gilbertsen Springs (RM 48.1) contributes very cold water to the Methow River during the summer. The highest recorded temperature in Gilbertsen Springs was 11.6◦C during the summer of 2008. Water temperatures in the Methow are slightly cooler at RM 47.9 (below Gilbertsen Springs) than upstream at RM 49.6 (at the Barkley Diversion). A temperature profile of the surveyed segment of the Methow River showing the maximum water temperature and the 7-day average maximum temperature at each monitor site is shown in the chart below:

Chart 1: Methow River Temperature Profile



The habitat attributes measured in the survey and briefly discussed in this overview are presented in greater detail in the reach summaries on pages 12 to 30 of the report. A statistical summary by reach is found on page 31 of this report.

1. HABITAT ASSESSMENT: MIDDLE METHOW SUBREACH 1
From a quarter mile below the Methow River bridge crossing in the Town of Twisp to the confluence with the Twisp River (RM 40.3 to RM 41.2)

Summary of Habitat Data:

●**Reach Description:** This 0.9 mile reach is a relatively straight, naturally confined, low gradient (0.3%) channel segment comprised mainly of riffles and runs. Highway 153 crosses the river about a quarter mile above the beginning of the reach. The reach is within the town limits of Twisp, with development along both banks of the river. Rip rap has been installed on both banks throughout most of the reach to prevent erosion.

●**Habitat Area:** The habitat area in the reach is about 50,860 square yards (56,500 square yards per mile), consisting of about 60% riffle and run habitat and 40% pool habitat. There is no side channel habitat in the reach and no backwater pool habitat in the reach due to the straight, confined channel.

●**Large Wood:** Large wood is very scarce in the 0.9 mile segment of stream, possibly due in part to past wood removal for development and flood control. A total of 2 pieces of wood (2.4 pieces per mile) greater than 35' long with a diameter of at least 12" were counted in the reach. The future recruitment potential is poor due to the in-town location of the reach.

●**Pool Habitat:** Pools comprise about 40% of the habitat area in the reach. Only 2 pools are found in the reach (2.3 pools per mile). However, habitat units are very large in a stream as big as the Methow River. Pools per mile is probably not a good method to determine the quantity and quality of pool habitat. Both pools in the reach lack good cover and habitat complexity. Rip-rap on the banks of the lower pool in the reach creates some pool depth and provides cover along the channel margins. Although the maximum depth in both pools were greater than 5' deep, most of the pool habitat in both pools was relatively shallow for a stream as large as the Methow River.

●**Riffle/Run Habitat:** About 40% of the total habitat area consists off riffle habitat in the reach. Runs comprise about 20% of the total habitat area. The average thalweg depth of both the riffles and the runs were greater than 2.3', providing good depth for fish migration. Hiding cover for juveniles in the riffles and runs was fair, with large cobbles, small boulders, and rip rap providing fish cover.

●**Side Channel and Off-Channel Habitat:** No side channel or off-channel habitat is found in this reach.

●**Fish Spawning Habitat:** Although most of the substrate in the reach is too coarse for spawning fish, some spawning habitat for summer Chinook salmon exists in the reach (mainly at the pool crests and in the run located below the bridge crossing of the river).

Juvenile Salmonid Rearing Habitat: Fish rearing habitat is limited in the reach due to the lack of off-channel habitat, lack of side channels, and lack of fish hiding cover (lack of wood). Boulders in some areas of the reach and rip-rap that is protecting the banks are providing some hiding cover for rearing fish. Roots and undercut banks along the right bank of a 365' long run just below the confluence with Twisp River provided some excellent rearing habitat for juvenile fish.

●**Substrate and Fine Sediment:** Two pebble counts were conducted in the reach. About 8% of the substrate at the pebble counts sites consisted of fine sediments < 6 mm, which is considered functioning properly in the USFWS Matrix of Pathways and Indicators (< 12% surface fine sediments < 6 mm is considered functioning properly). Small sediments, including spawning gravel, is being transported downstream due to the confined banks in the high energy river. No large wood or bends in the river exist in the reach to capture spawning gravels. Substrate embeddedness did not appear to be a problem in the reach, as very little of the coarse gravel/small cobble substrate was judged to be embedded by surveyors. The pebble count D50 was 140 millimeters, which was the highest in the surveyed segment of the Middle Methow River.

●**Bank Erosion:** About 5% of the banks are actively eroding in the reach. About half the erosion appears to be naturally occurring. The remainder is caused by development and roads. Rip rap has been installed on the banks in most of the reach.

●**Stream Temperature:** One temperature monitor was installed in the reach, about a quarter mile below the confluence with the Twisp River. Water temperatures in the reach exceeded the 16°C State DOE standard for water temperature on 41 days during the summer of 2008. The highest recorded water temperature was 19.85°C on 08-17-08. The highest recorded 7 day average maximum temperature was 18.83°C on 08-18-08. The Twisp River had little, if any, effect on summer water temperatures in the Methow River. Water temperatures in the Methow River above the confluence with the Twisp River were nearly identical to downstream water temperatures.

Rearing habitat along right bank at top of reach

Bank confinement in Reach; large cobble substrate

Pool under bridge near beginning of Reach

Floodplain widens at confluence with Twisp River

1I. HABITAT ASSESSMENT: MIDDLE METHOW SUBREACH 2
From the confluence with the Twisp River to where the floodplain narrows at RM 47
(RM 41.2 to RM 47.0)

Summary of Habitat Data:

●**Reach Description:** This 5.8 mile reach is a naturally unconfined, low gradient (0.3%) channel segment comprised mainly of riffles and lateral scour pools. Reach 2 had the highest amount of off-channel habitat in the survey. The floodplain is very wide (> 1,000') throughout most of the reach. Rip rap and diking have reduced the amount of floodplain available to the river in the areas described below:

-About 585' of rip rap on the left bank at RM 42 prevents the river from migrating to the east at this location. This segment of the reach has evidence of high energy because the wetted channel is only 45' wide at low flow compared to over 100 feet wide in adjacent channel areas.

-An 880' long dike along the right bank at RM 42.5 was constructed after the 1948 flood to protect houses and highway 153.

-Rip rap and dikes have been constructed along the right bank between RM 44.5 and RM 45, reducing the amount of floodplain available to the river.

-Rip rap protects houses along the left bank just below the MVID Diversion at RM 46. Rip rap has been installed on the left bank and right bank both above and below the Diversion.

The floodplain begins to narrow naturally about a quarter mile above the Diversion.

●**Habitat Area:** The habitat area in the reach is about 443,000 square yards (75,000 square yards per mile), consisting of about 41% pool habitat, 33% riffle habitat, 18% run habitat and 8% side channel habitat. Backwater pool habitat is found at many of the bends in the river.

●**Large Wood:** Although reach 2 has the highest amount of large wood in the surveyed segment of the Methow River, the amount of large wood is considered very low for an unconfined, low gradient river channel. Only 16 pieces of large wood per mile greater than 35' long with a diameter of at least 12" were counted in the main channel during the survey. An additional 10 pieces per mile were counted in the 4 wetted side channels in the reach. Most of the wood was either found in log jams at the confluence with the side channels, or high up on the wide bars in the reach. Large wood may have been removed in the past for development and flood control. The future recruitment potential is reduced due to the removal of vegetation along the banks for agriculture and development in many segments of the reach. Good future recruitment potential was observed in several segments of the river, including along the right bank between RM 44 and RM 45.

●**Pool Habitat:** Pools comprise about 40% of the habitat area in the reach. Most of the pools were lateral scour pools formed by the bends in the river. About 3.3 pools per mile were counted in the reach. Although the numbers of pools per mile are low, habitat units are very large in a stream as big as the Methow River. Pools per mile is probably not a good method to determine the quantity and quality of pool habitat. About half of the pools in the reach were greater than 5' deep. Three pools greater than 10' deep are found in the reach, two formed by bedrock constrictions. A bedrock formed pool with a maximum depth of 17' at low flow is found at the beginning of the reach, just above the confluence with the Twisp River. A bedrock formed pool with maximum depth of 13.0' is found at the bend in the river just above RM 44. A 12.3' deep pool is found at RM 45.6, at the confluence of the Methow River and the McNae side channel. The deep pools provide excellent holding habitat for migratory fish, and provide winter refugia. Many of the pools in the reach lacked habitat complexity due to the lack of large wood. Mainstem pools in a system like the Methow River are generally not capable of holding wood because of the high stream power during spring run-off. The depth of the bedrock pools provides excellent cover. Some good pool habitat was found in the side channels. A 750' long pool with a maximum depth of 4' is found in the McNae side channel at RM 46. Large wood in the pool created the 4' scour and provides hiding cover for juvenile fish. A 5' deep pool in a side channel at the end of the reach was formed by a log jam at the confluence of the two channels.

●**Riffle/Run Habitat:** About 33% of the total habitat area consists off riffle habitat in the reach. Runs comprise about 18% of the total habitat area. The average thalweg depth of the riffles and runs were 1.8' and 2.2', respectively, providing good depth for fish migration. Hiding cover for juveniles in the riffles and runs was fair, with large cobbles, small boulders, and rip rap providing fish cover.

●**Side Channel and Off-Channel Habitat:** About 8.3% of the total habitat area in the reach consisted of side channel habitat, the highest amount in the surveyed segment of the Middle Methow River. In addition, five large side channels in the reach provide good fish habitat until they become dewatered in late summer. A dry side channel at RM 41.2 (just above Twisp River) leads to six wetland ponds (at low flow), ranging in size from 180 sq. ft. to 15,000 sq. ft. The table below summarizes side channel habitat in the reach:

Table 6: Reach 2 Side Channel Habitat Summary

River Mile	Bank	Length	Avg. Width	Avg/Max Depth	Date De-Watered	% Pool Habitat	% Riffle	Lwd/Mile > 35', 12"	Max Water Temp	Notes
41.2[1]	Left	1,500'[1]	Dry	-	?	-	-	0	n/m	Wetland[1]
42.0	Right	1,350'	Dry	-	07-11-08	-	-	47	16.92◦C	Below dike
42.5	Right	>1,000	Dry	-	06-09-08	-	-	n/m	n/m	Didn't walk
42.7	Left	n/m	Dry	-	07-07-08	-	-	n/m	n/m	Lehman S.C.
42.9	Left	1,100'	15'	0.6'/3.0'	-	n/m	n/m	0	n/m	3' pool
44.2	Right	1,250'	70'-100'	n/m	-	100%	-	n/m	23.23◦C	Beaver Ponds
44.5[1]	Right	2,600'	Dry	-	09-20-08	-	-	4[2]	19.37◦C	State land
45.6	Right	1,585'	70'	1.0'/4.0'	-	63%	37%	23[3]	18.72◦C	McNae S.C.
46.7	Left	1,255'	80'	1.2'/5.0'	-	66%	34%	8[3]	n/m	End of reach

n/m = not measured

[1]Two dry side channels, total length 1,500'. One of the side channels connects to a series of wetland ponds. On 10-02-08 (low flow), the six ponds had a total area of about 22,500 sq. ft., with depths ranging from 0.4' to 3.0'.

[2]There were a few disconnected, wetted pools in the lower part of the channel at the time of the habitat survey. Although there were few pieces of large wood > 35' and > 12", the side channel had numerous small pieces of wood.

[3]The wood in the large jams at the top of these side channels was counted in the main channel.

Juvenile salmonids were observed in all of the wetted side channels. Stranded fish in the pools that were becoming dewatered were observed in the side channel on State land at RM 44.5. Juvenile salmon were observed in early summer in the beaver ponds above the right bank at RM 44.2. Water temperatures are very warm in these ponds during the middle of summer (the maximum temperature recorded was 23.23◦C on 08-17-08). The water temperature exceeded 19◦C on 21 days in the ponds during the summer of 2008. A spring with cold water was found near the top of the McNae side channel on the left bank. The maximum water temperature recorded on the right bank of the McNae side channel during the summer of 2008 was 18.72◦C, about 0.8◦C cooler than in the Methow River just above the MVID Diversion.

Backwater pool habitat was observed at many of the bends in the river.

●**Fish Spawning Habitat:** Although substrate was too coarse for anadromous fish spawning in some areas of the reach, some excellent spawning habitat was observed, mainly in the riffles and at the pool crests in the following segments of the reach: RM 41.2 to 41.9, RM

42.6 to 43.1, RM 44.7 to 45.0 and at RM 45.5. Very few spring Chinook salmon spawn in the Methow River below the confluence with the Chewuch River. No spring Chinook salmon redds were observed in this reach during the survey. Summer Chinook salmon and steelhead are known to spawn in the reach. Summer Chinook salmon spawning in the Methow River was first observed by surveyors in 2008 on September 30^{th}, six days after this reach was surveyed.

Two pebble counts were conducted per reach. The pebble count data shows that reach 2 has the highest amount of gravel and small cobbles in the surveyed stream segment, as well as the lowest D50 (85.8 millimeters). Spawning gravels could be held if river energy was dispersed through it's natural floodplain and off-channel areas by piercing levees allowing for increased wood recruitment in side channels. A large amount of fine sediment was observed in the wetted channel between RM 45.0 and RM 45.5 (about ½ mile below the MVID Diversion). Cobble and coarse gravel substrate were embedded at the crests of the two large pools in this segment of the river. This was the only area of cobble embeddedness observed in the Methow River by surveyors during the habitat survey.

Juvenile Salmonid Rearing Habitat: Although the quantity of fish rearing habitat was fairly abundant in the reach, rearing habitat would be greatly enhanced by higher amounts of large wood, which would provide cover for rearing fish. Although the rip rap installed in the reach prevents stream migration, it does provide hiding cover for juvenile fish. Backwater pools at the river bends and slow water braids provide good rearing habitat in the main channel. Juvenile salmonids were observed in all of the wetted side channels in the reach. Fish stranding occurs in the 5 side channels that become dewatered at lower flows.

●**Substrate and Fine Sediment:** Two pebble counts were conducted in the reach. About 8% of the substrate at the pebble counts sites consisted of fine sediments < 6 mm, which is considered functioning properly in the USFWS Matrix of Pathways and Indicators (< 12% surface fine sediments < 6 mm is considered functioning properly). The pebble count D50 was 86 millimeters, which was the lowest in the surveyed segment of the Middle Methow River. The pebble count data shows that reach 2 has the highest amount of gravel and small cobble substrate in the surveyed segment of the river.

●**Bank Erosion:** About 16.6% of the banks are actively eroding in the reach. Although some erosion is caused by the removal of vegetation along the banks for agriculture and development, most of the erosion appears to be naturally occurring. The eroding banks are a good source of spawning gravel in the reach.

●**Stream Temperature:** Five temperature monitors were installed in the river in the reach during the summer of 2008, at RM 41.4, RM 43.4, RM 44.2, RM 45.6 and RM 46.3. In addition, temperature monitors were installed in the side channels at RM 42.0, RM 44.2, RM 44.5 and RM 45.6. Water temperatures warmed only slightly in the 5.8 mile reach. The highest recorded water temperature at RM 46.3 was of 19.53◦C during the summer of 2008. The highest recorded water temperature at RM 41.4 was 19.89◦C in 2008. Water temperatures cooled by about 0.5◦C between RM 45.6 (about ½ mile below the MVID Diversion) and RM 44.2 (just above the beaver ponds on State land), possibly from upwellings or springs. Water temperatures at the top of the reach exceeded the 16◦C State DOE standard for water temperature on 43 days during the summer of 2008. The highest recorded water temperature was 19.53◦C on 08-16-08. The highest recorded 7 day average maximum temperature was 18.58◦C on 08-18-08. The highest recorded water temperature in the side channel on State land across from the Visalli property was 19.37◦C, slightly cooler than the main stem. The highest water temperature recorded in the McNae side channel at the MVID Diversion was about 0.8◦C cooler than in the main stem. A cold spring was observed on the left bank near the top of the side channel. Water temperatures in the beaver ponds that enter the Methow River just below the side channel across from the Visalli property were almost 4◦C warmer than in the river.

REACH 2 PHOTOS

Rip Rap and Narrow Channel at RM 42

Dike on Right Bank at RM 42.3

Beaver Pond above Right Bank at RM 44.2

Backwater pool habitat in reach 2

Remains of MVID Diversion at RM 46

Pool Habitat in McNae Side Channel at RM 46

1II. HABITAT ASSESSMENT: MIDDLE METHOW SUBREACH 3
From RM 47.0 to where the channel becomes constricted at RM 50.0
(RM 47.0 to RM 50.0)

Summary of Habitat Data:

●**Reach Description:** This 3.0 mile reach is a moderately confined, low gradient (0.3%) channel segment comprised mainly of riffles and bedrock formed pools. Reach 3 had very little side channel and off-channel habitat, due largely to the moderately confined channel (the floodplain is about 400' wide in the reach). Much of the land above the floodplain in reach 3 is agricultural land. Rip rap has been installed in much of the upper half of the reach. The rip rap, installed to protect houses, agricultural land and Highway 20, generally does not reduce the amount of floodplain available to the river. The sites with rip-rap are described below:

-About 300' of rip rap was installed on the right bank at RM 48.6 to protect the highway.

-At RM 48.9, about 550' of rip rap was installed on the left bank at the bend of the river to protect a house.

About 600' of rip rap was installed on the left bank at RM 49.2, near the bottom end of the Barkley Diversion side channel.

-About 430' of rip rap was installed on the right bank at the bend in the river at RM 49.3 to protect the highway.

-About 800' of rip rap was installed on the right bank just below the Barkley Diversion.

●**Habitat Area:** The habitat area in the reach is about 225,000 square yards (75,000 square yards per mile), consisting of about 50% pool habitat, 27% riffle habitat, 19% run habitat and 3% side channel habitat. Backwater pool habitat is found at the bends in the river.

●**Large Wood:** With the exception of the large wood load in the Barkley side channel, large wood is scarce in the reach. Only about 10 pieces of wood per mile > 35' long with a diameter of at least 12" was counted in the main channel during the survey, a very low amount for a low gradient (0.3%) river segment. An additional 11 pieces per mile were counted in the 3 wetted side channels in the reach. About half the wood counted in the main channel was in log jams along the channel margin at RM 47.5, RM 48.2, and just below the Barkley Diversion at RM 49.6. The Barkley diversion area is on the outside of the first major bend below the confluences of the methow and Chewuch Rivers and is a place where wood naturally accumulates. Over 25 pieces of large wood > 35' long with a diameter of at least 12" was counted in the side channel created for the Barkley Diversion. The wood is piled up by excavators on the right bank every year after the spring run-off. Large wood has been removed from the channel in the past for development and flood control. The future recruitment potential is only fair due to the removal of vegetation along the banks for agriculture and development in many segments of the reach. Only small pockets of heavily forested banks exist in the reach, including the right bank between RM 47.75 and RM 48.5, the right bank between RM 48.5 and 49.0, and the left bank between RM 49.25 and 49.5.

●**Pool Habitat:** Pools comprise about half of the habitat area in the reach, highest in the surveyed segment of the Methow River. Reach 3 had the deepest pool habitat in the survey, with an average maximum depth of 7.8' deep and a residual depth of 6.0'. Eight of the twelve pools in the reach were formed by bedrock. The bedrock pools were very deep, with maximum depths ranging from 6' to almost 17'. The average maximum depth of the 8 bedrock pools was 9.4'. The deep pools provide excellent holding habitat for migratory fish and provide fish with winter refugia. The four lateral scour pools in the reach had depths ranging from 3.5' deep to 5.0' deep. A total of 4.3 pools per mile were counted. Although the numbers of pools per mile seems low, habitat units are very large in a stream as big as the Methow River. Pools per mile is probably not a good method to evaluate the quantity and quality of pool habitat.

●**Riffle/Run Habitat:** About 27% of the total habitat area consists off riffle habitat in the reach. Runs comprise about 19% of the total habitat area. The average thalweg depth of the riffles and runs were 1.7' and 2.1', respectively, providing good depth for fish migration. Hiding cover for juveniles in the riffles and runs was fair, with large cobbles, small boulders, and rip rap providing fish cover.

●**Side Channel and Off-Channel Habitat:** About 3% of the total habitat area in the reach consisted of side channel habitat (not including the Barkley Ditch, which provides attractive rearing habitat for high numbers of fish until shut off in the fall). The lack of floodplain available to the river reduces the amount of potential side channel habitat in the reach. The side channel created at the Barkley Diversion (which supplies water to the Barkley Ditch) had good fish spawning and rearing habitat. A salmon redd was observed in the side channel below the ditch headgate. Wood that has been piled along the right bank by excavators provides good cover in a 6' deep pool directly below the headgate. A 1/3 mile long side channel on the right bank between RM 48.5 and RM 49.0 provides good rearing habitat until it becomes dewatered in mid-summer. The side channel is well forested, with braids from the side channel flowing through the forest at high flows. A spring on the left bank at RM 48.1 (Gilbertson Springs) contributes very cold water to the Methow River. The highest recorded temperature in the springs during the summer of 2008 was 11.6◦C. Numerous juvenile salmonids were observed in the 950' long spring during the survey. The table below summarizes side channel habitat in the reach:

Table 7: Reach 2 Side Channel Habitat Summary

River Mile	Bank	Length	Avg. Width	Avg/Max Depth	Date De-Watered	% Pool Habitat	% Riffle	Lwd/Mile > 35', 12"	Max Water Temp	Notes
47.7[1]	Right	100'[1]	5'	0.2'/0.2'	06-09-08[2]	-	-	0	n/m	Nancy Farr Property[1]
48.1	Left	950'	15'	1.0'/2.0'	-	n/m	n/m	22	11.6◦C	Gilbertsen Springs
48.6	Right	1,700'	Dry	-	? Mid-summer	-	-	6	n/m	Wide channel (up to 140')
49.3	Left	1,225'	39'	2'/6'	-	70%	30%	112	n/m	Barkley Side Channel

n/m = not measured

[1]The lower 100' of the side channel was flowing. The remaining length of side channel (1,050') was dry, with 4 pools that are possibly stranding fish. The largest of the pools was about 75' long and 30' wide, with a depth of about 5.5'. No fish were observed in the pools at the time of the survey. Only one piece of wood > 35' long with a diameter of at least 12" was observed in the dry segment of the side channel.

[2]Approximate date that the top of the side channel was disconnected from the river.

The screen on the Barkley ditch is almost ¾ of a mile downstream of the headgate. The ditch provides fish attracting rearing habitat for a variety of fish species until it is turned off in the fall. The Washington State Dept. of Fish and Wildlife (WDFW) electrofishes the ditch every fall at the time the ditch is turned off to rescue fish stranded in the ditch. The WDFW report on the following 2 pages written by Jonathan Kohr summarizes the fish rescue efforts in 2008.

Barkley Ditch fish salvage effort and observation report for October 6, 2008

Personnel:
Eastern Washington Water Team – Jonathan Kohr
Washington Rivers Conservancy - Aaron Penvose
Yakima Construction Shop – David John and David Floyd

Project Overview
On October 6, 2008 the Water Team supported work on a salvage effort to recover fish stranded after draw drown of the Barkley Irrigation Ditch (Methow River).

- The crew conducted electrofish capturing within the forebay of the screen and a small pool near the operational spill ~ 20 meters upstream of the forebay.
- Electrofishing techniques were also used for middle and upper pools.

Start time of salvage: 1:30 PM
End time: 5:30 PM

Location
From screen site (on Mosley property), within the forebay and bypass channel working upstream to the headgate (approx. ½ mile) *see map – orange line

Fish salvage species and enumeration

- 323 Juvenile Coho
  - All from 70-110 mm length
  - An additional 2 coho were morts found in the dewatered forebay area
  - Most fish captured in LWD, or reed canary grass habitat
- 86 Juvenile Chinook
  - All from 70-110 mm length
  - An additional 52 chinook were morts found in the dewatered forebay area
  - Most fish captured in LWD, or reed canary grass habitat
- 74 Rainbow/Steelhead trout
  - Various size range from parr to 12 inches
  - Unidentified between resident rainbow and anadromous steelhead
  - An additional 6 trout morts in the dewatered forebay area
- 30 Eastern brook trout
  - Mostly juvenile size of 80-120 mm
  - Likely from mid to upper reaches of Bear Creek
  - An additional 3 brook trout morts in the dewatered forebay area
- 74 Lamprey
  - Most (67) lamprey captured were in dewatered area, but still alive
  - Identified as Pacific lamprey (approx. 20 ID'd) by John Crandall of the Wild Fish Conservancy (WFC) – Phone # 509.341.4341
  - No mort's, but many more lamprey were likely stranded in muddy areas and are difficult to capture using the day's electrofishing technique
  - Lamprey appeared to prefer muddy/sandy/silt areas downstream where sedimentation within the ditch occurred

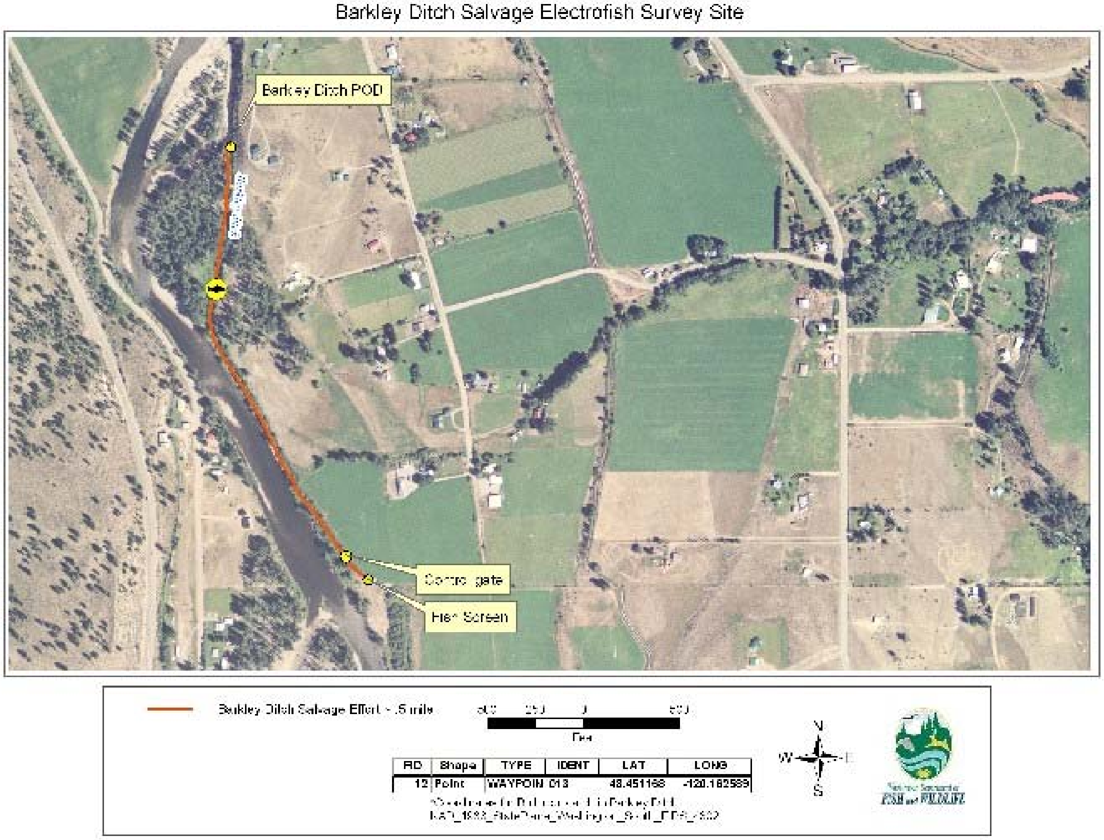
- 38 sculpin
    - Mix of fry, juvenile, and adult
    - Very hard to capture as they would “head-down” into the rocks and mud
    - Species were unidentified and enumerated as cottidae family.
- 9 suckers
    - All juvenile and fry
    - Appeared to be largescale sp.
- 30 whitefish
    - All were juvenile, approx. 100 mm (smaller than last year)
- 0 dace
    - Interesting note that no dace were captured this year

Notes

Total number of fish captured and salvaged = 664
Total number of mortalities = 76 (mostly chinook and coho parr from dewatered area)

Water Temps:
Barkley Ditch = 49° F
Methow River = 48° F

Barkley Ditch Salvage Electrofish Survey Site



●**Fish Spawning Habitat:** Although substrate was too coarse for anadromous fish spawning in many areas of the reach, some excellent spawning habitat was observed, mainly in some of the runs and at the pool crests in the upper half of the reach. Three spring Chinook salmon redds were observed in the reach, all above RM 48.5. Summer Chinook salmon and steelhead are known to spawn in the reach. Summer Chinook salmon spawning in the Methow River was first observed by surveyors in 2008 on September 30th, five days after this reach was surveyed. Two pebble counts were conducted per reach. The pebble count data shows that reach 3 has the second lowest amount of coarse gravel and small cobbles in the surveyed segment of the Methow River. The average D50 of the 2 pebble counts conducted in the reach was 132 millimeters. Spawning gravels could be held if river energy was dispersed through it's natural floodplain and off-channel areas by piercing levees allowing for increased wood recruitment in side channels. Only 11% of the substrate in the two pebble counts were gravel sized substrate. None of the pools in the reach was judged by surveyors to be embedded.

●**Juvenile Salmonid Rearing Habitat:** Good fish rearing habitat exists in the Barkley Ditch and in the side channels in the reach, especially at higher flows when the side channels at RM 47.7 and RM 48.6 are wetted. Rip rap in the upper half of the reach, large cobbles and small boulders provide most of the cover for juvenile fish in the main stem. Some backwater pool habitat and braids provide rearing habitat in the main channel. Increased amounts of large wood would greatly improve rearing habitat in the reach.

●**Substrate and Fine Sediment:** Two pebble counts were conducted in the reach. About 5% of the substrate at the pebble counts sites consisted of fine sediments < 6 mm, which is considered functioning properly in the USFWS Matrix of Pathways and Indicators (< 12% surface fine sediments < 6 mm is considered functioning properly). The pebble count D50 was 132 millimeters, which was the second highest in the surveyed segment of the Middle Methow River. The pebble count data shows that reach 3 has some of the lowest amounts of gravel and small cobble substrate in the surveyed segment of the river.

●**Bank Erosion:** About 8% of the banks are actively eroding in the reach. Most of the erosion in the reach is caused by the removal of vegetation along the banks for agriculture. Rip rap installed in the upper half of the reach is preventing a large amount of agricultural land from eroding.

●**Stream Temperature:** Two temperature monitors were installed in the river in reach 3 during the summer of 2008, at RM 47.9 (just below Gilbertsen Springs) and at RM 49.6 (at the Barkley Diversion). In addition, temperature monitors were installed in Gilbertson Springs (RM 48.1) and at the mouth of Bear Creek. The highest water temperature recorded in the main stem in the reach was 19.03◦C (at RM 49.6) on 08-16-08. Water temperatures exceeded the 16◦C State DOE standard for water temperature on 35 days at RM 49.6 and on 28 days at RM 48.9 during the summer of 2008. Gilbertson Springs contributes very cold water to the Methow River during the summer. The highest recorded temperature in Gilbertson Springs was 11.6◦C during the summer of 2008. Methow River water temperatures were slightly cooler below Gilbertsen Springs than at RM 49.6, at the Barkley Diversion.

REACH 3 PHOTOS

Deep Pool in side channel at RM 47.7 (no flow in the side channel on the day of the survey)

Bedrock on banks and in channel at RM 48

Rearing Habitat in Backwater Pool in Reach 3

Eroding Bank in Dry Side Channel at RM 48.6

Rearing habitat in the Barkley Ditch

The Barkley Irrigation Diversion – note push up dam used to direct river flow towards head gate

1V. HABITAT ASSESSMENT: MIDDLE METHOW REACH 4
From RM 50.0 to the Confluence with the Chewuch River at RM 51.4
(RM 50.0 to RM 51.4)

Summary of Habitat Data:

●**Reach Description:** This 1.4 mile reach is a straight, naturally confined, low gradient (0.5%) channel segment has equal amounts of riffles, runs and pools. Lateral scour pools are found in the lower half of the reach, while pools in the upper half of the reach are formed mainly by bedrock. Although no natural side channels are found in the reach due to the constricted channel, the outfall of the USFWS hatchery at the top of the reach provides excellent off-channel fish habitat.

●**Habitat Area:** The habitat area in the reach is about 109,000 square yards (78,000 square yards per mile), consisting of about 30% pool habitat, 32% riffle habitat, 33% run habitat and 5% side channel habitat. Some backwater pool habitat is found in the reach.

●**Large Wood:** The amount of in-channel large wood is scarce in the reach, with only 6 pieces of wood per mile > 35' long with a diameter of at least 12" counted in the main channel during the survey. However, there are many trees along the banks that are within the bankfull width of the channel during high flows. Thirty-five standing trees per mile within the bankfull width of the channel were counted in the reach (trees > 35' high with a diameter of at least 12"). The standing trees create some scour along the channel margins. The scour and tree roots provide habitat to rearing fish. Large wood may have been removed from the channel in the past for development and flood control. The future recruitment potential is poor due to the removal of vegetation along the banks for agriculture and development in many segments of the reach. Only a very thin strip of vegetation exists along the river in this reach.

●**Pool Habitat:** Pools comprise about 30% of the habitat area in the reach, the second lowest amount in the surveyed segment of the Methow River. Half of the 6 pools in the reach were formed by bedrock. The average maximum depth of the six pools was about 5', the lowest of the four reaches below the confluence with the Chewuch. Pools lacked complexity, with little, if any wood found in the pools. A total of 4.3 pools per mile were counted. Although the numbers of pools per mile seems low, habitat units are very large in a stream as big as the Methow River. Pools per mile is probably not a good way to judge the quantity and quality of pool habitat.

●**Riffle/Run Habitat:** About 32% of the total habitat area consists off riffle habitat in the reach. Runs comprise about 33% of the total habitat area. The average thalweg depth of the riffles and runs were 1.7' and 2.0', respectively, providing good depth for fish migration. Hiding cover for juveniles in the riffles and runs was fair, with large cobbles, small boulders, and rip rap providing fish cover.

●**Side Channel and Off-Channel Habitat:** Although no natural side channels exist in the reach due to the constricted channel, the outfall of the Winthop National Hatchery functions as a side channel and provides excellent spawning and rearing habitat to anadromous fish. The channel from the outfall has three sources of flow. Three wells at the hatchery provide most of the stream flow to the channel, up to 10 cfs (C. Pasley). A spring (Spring Creek) was re-routed from its natural channel into the out-fall channel when the hatchery was built. A third source of the out-fall is overflow from the Foghorn Ditch, which supplies water to the State salmon hatchery further upstream. Nutrients from the fish waste at the hatchery stimulates the growth of both aquatic plants and insects in the outfall, contributing to its excellent fish habitat (C. Pasley). The outfall is about 1,800' long with an average width of about 30'. Most of the channel is pool habitat up to 5' deep. Wood and aquatic vegetation provide excellent habitat for juvenile salmonids. Spawning gravels are abundant in the channel. A total of 16 spring Chinook salmon redds were counted in the out-fall during the survey.

●**Fish Spawning Habitat:** Although substrate was too coarse for anadromous fish spawning in some areas of the reach, some excellent spawning habitat was observed, mainly in some of the runs and at the pool crests in the lower half of the reach, and in the hatchery out-fall. Summer Chinook were observed spawning on the date of the survey (Sept. 30). Three summer Chinook redds and two summer Chinook salmon were observed on the survey date. A spring Chinook salmon redd was observed at the crest of the pool at RM 50.7. Sixteen spring Chinook salmon redds were counted in the Winthrop hatchery outfall, including 5 in the channel within the river's bankfull width. Two pebble counts were conducted in the reach. The pebble count data shows that reach 4 has the second highest amount of coarse gravel and small cobbles in the surveyed segment of the Methow River below the confluence with the Chewuch River. The average D50 of the 2 pebble counts conducted in the reach was 108 millimeters. Only reach 2 had a lower D50 value than reach 4. About 22% of the substrate in the two pebble counts were gravel sized substrate. An increase in the amount of large wood in the reach would likely greatly increase the amount of spawning habitat in the reach. None of the pools in the reach was judged by surveyors to be embedded.

●**Juvenile Salmonid Rearing Habitat:** Good fish rearing habitat exists in the Winthrop Fish Hatchery Outfall. Some good rearing habitat was observed in the main channel in the reach, mostly on the channel margins in the scour created by standing trees and in the braids of the channel. Some backwater pool habitat was observed in the reach. Increased amounts of large wood would greatly improve rearing habitat in the reach.

●**Substrate and Fine Sediment:** Two pebble counts were conducted in the reach. About 10% of the substrate at the pebble counts sites consisted of fine sediments < 6 mm, which is considered functioning properly in the USFWS Matrix of Pathways and Indicators (< 12% surface fine sediments < 6 mm is considered functioning properly). The pebble count D50 was 108 millimeters, which was the second lowest in the surveyed segment of the Middle Methow River. The pebble count data shows that reach 4 has some of the highest amounts of gravel and small cobble substrate in the surveyed segment of the river.

●**Bank Erosion:** About 2% of the banks are actively eroding in the reach, the lowest amount of bank erosion in the surveyed segment of the river. The straight channel and confined banks provide a high amount of bank stability in the reach.

●**Stream Temperature:** One temperature monitor was installed in the river in reach 4 during the summer of 2008, at RM 51.1, about a third of a mile below the confluence with the Chewuch River. A maximum temperature of 18.55◦C was recorded at the temperature monitor site during the summer, about 1.4◦C warmer than at the temperature monitor site located just above the Chewuch confluence. The Chewuch River is warm water source to the Methow River. The maximum temperature recorded at the mouth of the Chewuch River was 21.65◦C during the summer of 2008. Large fires in the Chewuch River watershed in 2001, 2003 and 2006 are partially responsible for warm water temperatures in the Chewuch River.

REACH 4 PHOTOS

Summer Chinook redds in Reach 4

Standing trees within bankfull in Run Habitat

Spring Creek (fish hatchery outfall) at top of reach

Riffle Habitat below Confluence with Chewuch

Confluence of Methow River andChewuch River

V. HABITAT ASSESSMENT: MIDDLE METHOW REACH 5
From the Confluence with the Chewuch River to the Wolf Creek Confluence
(RM 51.4 to RM 54.2)

Summary of Habitat Data:

●**Reach Description:** Most of the 2.8 mile reach is a naturally unconfined, low gradient (0.3%) channel segment that consists primarily of riffle and run habitat. The channel becomes naturally confined in the upper ½ mile of the reach, in the alluvial fan of Wolf Creek Most of the pools in the reach are lateral scour pools that have been deepened by rip rap, which is abundant in the middle of the reach. Rip rap and dikes have reduced the amount of floodplain available for river migration between the Winthrop National Fish Hatchery at RM 51.8 and the Foghorn Diversion at RM 52.9. Rip-rap has also likely diminished the amount of side channel habitat in this area of the reach. More rip rap is likely to be installed in this area in the future to protect houses that are being built in the floodplain. The areas that have been constricted by rip rap are described below:

-A dike was installed on the right side of the river at the Winthrop National Fish Hatchery after the 1948 flood to protect against future flooding. About 750' of the river bank at this site (RM 51.8) is affected by the dike.

-About 100' of rip rap was installed on the right bank at RM 52.2 to protect agricultural land.

-About 250' of rip rap was installed on the left bank at RM 52.3 to protect the banks at the River Run Inn.

-Log structures and about 550' of rip rap protect houses constructed on the banks of the river at RM 52.5.

-Rip rap has been installed on the banks above and below the Foghorn Diversion (RM 52.9). The Foghorn Diversion is a boulder push-up dam that channels most of the flow to the right side of the channel (side of the ditch). A huge cobble bar has formed above the Foghorn Diversion. The river has been pushed to the right side of its channel above the dam. At low flow, the river is only 20' wide and very high energy at the top end of the cobble bar.

●**Habitat Area:** The habitat area in the reach is about 171,000 square yards (61,000 square yards per mile), consisting of about 24% pool habitat, 41% riffle habitat, 34% run habitat and less than 1% side channel habitat. Some backwater pool habitat is found in the reach.

●**Large Wood:** The amount of in-channel large wood is scarce in the reach, with only 10 pieces of wood per mile > 35' long with a diameter of at least 12" counted in the main channel during the survey. However, there are many trees along the banks that are within the bankfull width of the channel during high flows. Fourteen standing trees per mile within the bankfull width of the channel were counted in the reach (trees > 35' high with a diameter of at least 12"). The standing trees create some scour along the channel margins. The scour and tree roots provide habitat to rearing fish. Large wood may have been removed from the channel in the past for development and flood control. The future recruitment potential is poor to fair due to the removal of vegetation along the banks for agriculture and development in many segments of the reach. Only a very thin strip of vegetation exists along the river in some segments of the reach.

●**Pool Habitat:** Pools comprise about 24% of the habitat area in the reach, the lowest amount in the surveyed segment of the Methow River. Pools were shallow, with an average maximum depth of 4.6' (lowest of the survey). Most of the pools lacked habitat complexity due to the lack of large wood. Only three of the 9 pools in the reach were greater than 5' deep. The pool below the diversion dam is the deepest pool in the reach, with an estimated depth of about 8'. Chinook salmon have been known to hold in a 5'+ deep bedrock formed pool at the beginning of the reach. A total of 3.2 pools per mile were counted. Although the numbers of pools per mile seems low, habitat units are very large in a stream as big as the Methow River. Pools per mile is probably not a good way to judge the quantity and quality of pool habitat.

●**Riffle/Run Habitat:** About 41% of the total habitat area consists off riffle habitat in the reach. Runs comprise about 34% of the total habitat area. The average thalweg depth of the riffles and runs were 1.4' and 1.7', respectively, providing good depth for fish migration. Hiding cover for juveniles in the riffles and runs was fair, with large cobbles, small boulders, and rip rap providing fish cover.

●**Side Channel and Off-Channel Habitat:** Only one wetted side channel was observed during the habitat survey. The outfall of the State Salmon Hatchery connects at the lower end with a natural side channel in the river. The hatchery outfall provides excellent spawning and rearing habitat to anadromous fish. Eleven spring Chinook salmon redds were counted in the side channel and hatchery outfall. The outfall is about ¼ mile long with an average width of about 8' to 9' at low flow. Two beaver dams in the outfall create pools greater than 20' wide depths greater than 2'. Hiding cover is good in the outfall, with wood and aquatic vegetation providing cover for rearing fish. Reach 5 likely had abundant side channel habitat historically, before the rip rapping and development occurred.

●**Fish Spawning Habitat:** Although substrate was too coarse for anadromous fish spawning in some areas of the reach, such as in the upper ½ mile, areas of excellent spawning habitat was observed. Some excellent spawning areas were observed in many in the runs, at the pool crests, and in the hatchery out-fall. A total of about 27 spring Chinook salmon redds were counted in the river channel in the reach during the survey, with another 11 redds counted in the hatchery outfall. Most of the Chinook redds were found just below the diversion and in a ½ mile long segment of the river located between RM 53.1 and RM 53.6. This area of the river was very wide (up to 150' wide), with shallow, slow-moving runs and riffles, and abundant coarse gravel and small cobble. The average D50 of the 2 pebble counts conducted in the reach was 127 millimeters, about average in the surveyed segment of the river. None of the pools in the reach was judged by surveyors to be embedded.

●**Juvenile Salmonid Rearing Habitat:** Good fish rearing habitat exists in the State Fish Hatchery Outfall. Some good rearing habitat was observed in the main channel in the reach, mostly on the channel margins in the scour created by standing trees. Some backwater pool habitat was observed in the reach. Increased amounts of large wood would greatly improve rearing habitat in the reach.

●**Substrate and Fine Sediment:** Two pebble counts were conducted in the reach. About 7% of the substrate at the pebble counts sites consisted of fine sediments < 6 mm, which is considered functioning properly in the USFWS Matrix of Pathways and Indicators (< 12% surface fine sediments < 6 mm is considered functioning properly). The pebble count D50 was 127 millimeters, which was about average in the surveyed segment of the Middle Methow River. The pebble count data shows that reach 5 has some of the highest amounts of gravel and small cobble substrate in the surveyed segment of the river.

●**Bank Erosion:** About 16% of the banks are actively eroding in the reach, the second highest amount of bank erosion in the surveyed segment of the river. Erosion is both from natural causes and from the removal of vegetation along the banks for agriculture.

●**Stream Temperature:** Three temperature monitors were installed in the river in reach 5 during the summer of 2008, just above the confluence with Wolf Creek, in Wolf Creek at the mouth, and about ¼ mile above the confluence with the Chewuch River. The water temperature in the Methow River increased by only 0.2◦C in the reach, from a 2008 maximum temperature of 16.93◦C above Wolf Creek to a 2008 maximum temperature of 17.12◦C above the Chewuch River. Water temperatures are warmer in Wolf Creek. The maximum recorded temperature at the mouth of Wolf Creek in the summer of 2008 was 19.69◦C. However, at low flows (August) Wolf Creek contributes less than 10 cfs to the Methow River. The reach of the Methow River between the Weeman Bridge (RM 66.8) and the confluence with the Chewuch River (RM 51.4) is a gaining flow reach. It's possible that increasing flows in the reach moderate water temperatures.

REACH 5 PHOTOS

Bedrock formed pool just above the Confluence With the Chewuch River

Dike at RM 51.8 at National Fish Hatchery

House in floodplain and eroding bank at RM 52.4

Channel downcutting on river right side just Below the Foghorn Diversion

Huge cobble bar and narrow river above Diversion

Wide and very shallow run at RM 53.1

MIDDLE METHOW RIVER STATISTICAL SUMMARY BY REACH: 2008 SURVEY

	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Total
River Mile From:	40.3	41.2	47.0	50.0	51.4	40.3
River Mile To:	41.2	47.0	50.0	51.4	54.2	54.2
River Miles – BOR maps	0.9	5.8	3.0	1.4	2.8	13.9
Measured Miles in Reach	0.87	5.74	2.83	1.38	2.78	13.60
Beginning Elevation (estimate)	1,555’	1,570’	1,675’	1,720’	1,755’	1,555’
Ending Elevation (estimate)	1,570’	1,675’	1,720’	1,755’	1,790’	1,790’
POOLS						
-Total # of Survey Pools in Reach	2	19	12	6	9	48
-Survey Pools per Mile	2.3	3.3	4.3	4.3	3.2	3.5
-Survey Pools > 5’ Deep/Mile	2.3	1.7	3.6	1.4	1.1	2.0
-Average Maximum Pool Depth	5.40’	6.32’	7.81’	5.12’	4.60’	6.18’
-Average Pool Residual Depth	3.40’	4.59’	6.03’	3.38’	3.19’	4.49’
LWD per mile (in-channel only)*						
-Small (>20’L, >6” D)	13.8	30.0	15.6	22.3	22.7	23.7
-Medium (>35’L, >12” D)	1.2	12.7	7.8	5.0	8.6	9.3
-Large (>35’ L, > 20” D)	1.2	3.3	2.1	0.7	1.1	2.2
-Total > 35’ L (Medium & Large)	2.4	16.0	9.9	5.7	9.7	11.5
% HABITAT AREA						
-% Pool	39.9%	40.7%	50.5%	30.2%	24.3%	38.9%
-% Riffle	39.0%	33.0%	27.2%	31.7%	40.8%	33.2%
-% Run	21.1%	18.0%	19.2%	32.6%	34.3%	22.9%
-% Side Channel/Off-channel Habitat	0%	8.3%	3.1%	5.5%	0.6%	5.0%
SEDIMENT/EROSION						
-Linear Ft. Erosion per Mile	558’	1,748’	827’	223’	1,720’	1,319’
-% Eroding Banks (total both banks)	5.3%	16.6%	7.8%	2.1%	16.3%	12.5%
CHANNEL MORPHOLOGY						
-Average Wetted Width in Feet	102’	120’	132’	127’	105’	120’
-Bankfull Width in Feet	197’	207’	190’	176’	157’	Varies
-Width/Depth Ratio	71.1	68.0	72.2	60.3	52.3	Varies
-Floodplain Width in Feet	232	> 1,000’	400’	216’	625’	Varies
-Entrenchment Ratio	1.18	> 5.0	2.10	1.23	4.0	Varies
-Sinuosity	1.10	1.35	1.15	1.10	1.15	1.23
-Gradient	0.3%	0.3%	0.3%	0.5%	0.25%	0.3%
-Rosgen Channel Types	F3	C3	C3	F3	C3	C3, F3
SUBSTRATE (Pebble Counts)						
% Surface Fines (< 6 mm)	8%	8%	5%	10%	7%	
-D50 (millimeters)	140.4	85.8	132.0	108.0	127.0	
-D84 (millimeters)	317.5	156.9	230.4	237.6	246.9	
-% Sand (< 2 mm)	8%	6%	5%	9%	6%	
-% Gravel	17%	28%	11%	22%	22%	
-% Cobble	55%	61%	72%	57%	59%	
-% Boulder	20%	5%	12%	12%	13%	
-% Bedrock	-	-	-	-		

*In-channel only. Does not include standing trees or LWD in side channels. See table on page for complete LWD

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APPENDIX E

Riparian Vegetation Assessment

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Middle Methow
Riparian Vegetation Assessment Report

Executive Summary

This report provides information on the status of riparian vegetation in the Middle Methow Reach Assessment area. Riparian vegetation was surveyed in 2009 along the Middle Methow (M2) assessment area between river miles 51.50 and 41.30. The main goals of the vegetation survey were to establish a baseline for future monitoring and to identify potential riparian habitat protection and enhancement projects. This report provides background information on riparian vegetation, the status of riparian vegetation between River Miles 51.50 and 41.30, and recommendations for potential restoration or protection of riparian features.

The Background Section provides a brief introduction on riparian forest ecology and the main factors and processes that influence the spatial patterns, structural conditions and species composition of riparian forest vegetation in watersheds of the western United States.

Status of riparian vegetation:

Riparian forests in the Middle Methow Reach Assessment area are dominated by black cottonwood with locally abundant quaking aspen, thin-leaf alder (*Alnus incana*), water birch (*Betula occidentalis*), and ponderosa pine. The upper segment (RM 51.5 to 47) is moderately confined with relatively thin bands of riparian vegetation along the main channel. Adjacent areas are predominantly nonforested agricultural and residential lands.

The lower segment (RM 47 to 41.5) is generally unconfined, and broad sections of floodplain forest are supported by river meander and channel migration in several areas. Most trees in this segment are small-diameter trees, and many stands likely date back to the 1948 flood event. Cottonwood recruitment on several gravel bars is not detectable in the 2006 orthophotographs and is probably associated with the 2006 and 2008 high water events. Large tracts of the active floodplain have been converted to agricultural fields or residential property. Black cottonwood trees are common near the river edge in agricultural fields, but their sprouts are heavily browsed by deer.

Recommendations for protection and rehabilitation include:

Many portions of the Middle Methow Reach Assessment area contain intact riparian forest and hydrological processes, and opportunities to protect and enhance riparian habitat are promising along unconfined segments of the river in particular. Key recommendations for protection and rehabilitation include:

1) Limit future development in the active floodplain through protection of existing riparian forest.
2) Increase LWD in the main and side channels of the Middle Methow reach through strategic placement, education and outreach to dissuade cutting instream logs, and promoting recruitment of large-diameter trees along river channels.
3) Enhance riparian tree cover along the river bank on agricultural lands. Projects could include planting, fencing and caging projects.

4) Allow for the recovery of beaver through ongoing landowner education and cooperation with the Methow Beaver Restoration Project.

Introduction

Riparian vegetation was surveyed along the Middle Methow (M2) reach assessment area in 2009. The main goals of the vegetation survey were to establish a baseline for future monitoring and to identify potential riparian habitat protection and enhancement projects. The specific tasks of the vegetation survey were to:

1) Update an existing vegetation map of active flood plain areas (Baesecke 2005) to current 2009 conditions between river miles 51.50 and 41.30.

2) Survey riparian forests and identify major stand types, successional class, and index of vigor.

3) Recommend areas for potential protection and/or rehabilitation.

Vegetation mapping was conducted using high-resolution orthophotographs taken during Light Distancing and Ranging (LIDAR) overflights of the M2 assessment area and a LIDAR 1-m vegetation model image. Mapping was confined to the active floodplain, broadly defined as the 1948 floodplain boundary which fully encompasses the geomorphic unit Qa3. The active floodplain includes the most dynamic surfaces in the floodplain. Many side channels within the active floodplain have the ability to be reconnected to the main channel (Qa4) in 2- to 5-year high water events. Forests in the Qa3 surfaces are dominated by black cottonwood (*Populus balsimifera* ssp. *trichocarpa*) and quaking aspen (*P. tremuloides*) with codominant ponderosa pine (*Pinus ponderosa*).

Mapped polygons (Appendix A) were visited to assess vegetation type, successional class and forest health and recorded in a geospatial database (available for download at http://cuatro.cfr.washington.edu/repos/stuff/M2/). Vegetation types were taken from the original vegetation classification (Basaeke 2005) with a few additions specific to this assessment (Table 2). Successional classes from the Stream Inventory Handbook (USDA Forest Service 2008) were assigned to each vegetation type (Table 3)(http://www.fs.fed.us/r6/water/fhr/sida/handbook/Stream-Inv-2009.pdf). Forest health was subjectively delineated for polygons with forest vegetation (Table 4).

This report provides background information on riparian vegetation, the status of riparian vegetation between River Miles 51.50 and 41.30 and recommendations for potential restoration or protection of riparian features.

Table 1: Vegetation attributes in the geospatial database, M2RiparianVegetation.mxd.

Attribute	Definition
OBJECTID	Unique polygon id
VegCode	Vegetation code (table 2)
Vegetation	Vegetation description (table 2)
OverSpp	Overstory species (table 3)
SuccCode	Successional class (table 4)
Health	Health code (1 = poor, 2 = fair, 3 = poor)

Attribute	Definition
Notes	Field notes

Table 2: Vegetation codes

VegCode	Definition
1	Quaking aspen
1a	Quaking aspen with deciduous shrubs
2	Black cottonwood
2a	Black cottonwood with mixed conifers and deciduous trees
2b	Black cottonwood with mixed deciduous shrubs
3	Other broadleaf deciduous trees
4	Wetlands, water other than river
5	Bars with deciduous shrubs
5a	Bars with regenerating cottonwood
6	Bars with forbs or no vegetation
6a	Bars with young cottonwood
7	Mixed deciduous shrubs (not on bars)
7a	Shrub steppe
8	Ponderosa pine
8a	Upland forest
9	Mixed coniferous/deciduous
10	Agricultural areas (current and fallow)
11	Residential areas
12	Other use areas (runway, golf course, etc.)
13	Cut bank
14	Road
15	River channel

Table 3: Successional class codes (Stream Inventory Handbook (USDA Forest Service 2008), Appendix E)

SuccCode	Definition
NV	No vegetation
GF	Grass/forb condition. This grass/forb stand conditions lasts 2-5 years and occasionally as long as 10 years. Shrubs and some trees that sprout are not yet dominant
SS	Shrub/seedling condition. The shrub stand condition often lasts 3-10 years but may remain for 20-30 years if tree regeneration is delayed. Tree regeneration may be common, but trees are generally less than 10-ft tall and provide less than 30 % of crown cover.
SP	Sapling/pole condition. The open sapling/pole condition occurs when trees exceed 10 ft in height and are between 5 and 8.9 in dbh.
ST	Small tree condition. The small tree condition has very little ground vegetation because of closed crown canopy. Average stand diameter is 9-20.9 in.
LT	Large tree condition. The large tree condition is characterized by trees with an average dbh of 21-32 in. dbh. An understory of shrubs and young shade-tolerant trees is present.
MT	Mature tree condition. The mature tree stand conditions are characterized by old live trees, snags, down woody material, and the replacement of some of the long-lived pioneer species such as Douglas-fir by shade-tolerant species such as western hemlock. Size is generally greater than 32 in. dbh.

Table 4: Overstory species

Code	Common name	Scientific name
Hardwood		
HA	Alder	*Alnus spp. (A. incana)*
HASP	Quaking aspen	*Populus tremuloides*
HC	Black cottonwood	*Populus balsamifera ssp. trichocarpa*
HW	Willow	*Salix spp.*
HX	Other/unknown hardwood	
Conifer		
CD	Douglas-fir	*Pseudotsuga menziesii*
CPP	Ponderosa pine	*Pinus ponderosa*
CX	Other/unknown	

Table 5: Forest health codes (applicable to forest vegetation only)

Health codes	
0	Majority of trees are dead or dying
1	Poor (broken or dead tops and dying trees)
2	Fair (some broken tops, dying trees, sparse forest coverage)
3	Good (majority of trees are thriving with few broken or dead tops)

Background

Riparian vegetation plays a critical role in maintaining and creating a diversity of fish habitat (Bolton and Shelberg 2001, Naiman and Latterel 2005). Forest cover along streams and rivers moderates temperatures in pools and side channels, stabilizes streambanks, and provides a diet of terrestrial macroinvertebrates for juvenile and adult fish. Riparian zones serve as a reservoir of nutrients, complex habitats for aquatic and terrestrial organisms, and a source of filtered ground water (Naiman et al. 2002). Large woody debris generated from riparian forests has a number of functions that influence fish habitat and maintenance of riparian forests (Table 1).

Table 1: River functions of LWD and riparian forests (adapted from Bolton and Shelberg 2001).

Functions of LWD	**Reference**
Interrupt the stream flow to trap coarse sediment upstream of the LWD to create bars or islands	Abbe and Montgomery 1996
Promote gravel bar development and anchor points for riparian forest development	Fetherston et al. 1995
Modify stream flow to create pool structure/downstream habitat	Cherry and Beschta 1989
Trap and retain small organic materials	Culp et al. 1996
Provide hydraulic roughness during high flow conditions	Abbe and Montgomery 1996
Provide habitat for aquatic and terrestrial invertebrates and vertebrates	Borchardt 1993
Provide structure and nutrients for microbiological organisms	Bilby and Ward 1989
Provide habitat for aquatic and semi-aquatic plant communities (substrate and silt traps)	Bilby and Ward 1989
Provide cover and shade for juvenile and adult salmonid species	Bisson et al. 1987

Floodplain forests are dynamic ecosystems, influenced by a wide variety of disturbance agents, including fire, debris flows, forest insects and pathogens, and of course, flood events (Bolton and Shelberg 2001, Dwire and Kauffman 2003, Pettit and Naiman 2007). The patchwork of riparian vegetation types and forest age classes resulting from frequent disturbances provides diverse habitat for aquatic and terrestrial plants and animals. In turn, riparian forests play an active role in flood events and can influence side channel creation and channel migration (Featherston et al. 1995, Naiman and Latterel 2005). During flood events, riparian vegetation can absorb flow velocities and capture sediment and debris, retaining both water and nutrients in a particular reach and widening hyporheic zones (Culp et al. 1996, Bolton and Shelberg 2001, Naiman et al. 2000). Log jams, formed in flood and high water events, can serve as anchor points for gravel bar development and colonization of riparian trees and shrubs (Featherstone et al. 1995). Once established, islands of riparian forests can continue to grow and coalesce into a contiguous floodplain forest with other islands.

Complex linkages between riparian vegetation and the hyporheic zone are critical to nutrient cycling and salmonid rearing habitat (Naiman et al. 2000). Hyporheic zones are saturated sediments beneath and adjacent to stream and river channels and are zones where surface and ground water can mix and exchange nutrients. The high interstitial surface area and volume of hyporheic zones provides habitat for a wide variety of organisms and an interchange of nutrients and water between riparian zones and streamwater (Naiman et al. 2000). Biogeochemical cycling is dynamically linked between riparian forests and hyporheic zones (Boulton et al. 1998). Decomposing organic matter in riparian forests is a source of carbon and nutrients for micro- and macrooganisms in the hyporheic zone, and these nutrients and microorganisms are important in the early life stages of salmonids and other fish, which use the interstitial spaces below the stream channel for cover and forage. Conversely, anadromous fish can contribute marine-derived nutrients to rivers and have been shown to be a significant source or nitrogen in some riparian forests (Bilby et al. 1996).

Ecology of Riparian Forests

Riparian forests in the Middle Methow reach are dominated by black cottonwood with locally abundant quaking aspen, thin-leaf alder (*Alnus incana*), water birch (*Betula occidentalis*), and ponderosa pine. Black cottonwood thrives in riparian environments and is a dominant tree species in riparian zones throughout semiarid landscapes of the western United States (Braatne et al. 1996, Rood et al. 2003a). On moist, productive growing sites, black cottonwood growth rates can rival that of any other tree species.

Black cottonwoods are dependent on water in every stage of their life cycle (Braatne et al. 1996). Cottonwoods rely on an alluvial groundwater connection to active water channels for their survival (Rood et al. 2003a). Although the immense stems of mature cottonwoods act as large reservoirs of water, cottonwoods are very sensitive to drought and can exhibit branch loss and crown dieback under sustained drought. Periodic flooding of riparian forests help maintain the vitality of mature cottonwood by saturating riparian soils and recharging groundwater tables.

In the springtime, generally timed with high water in streams and rivers, cottonwoods produce prolific, tiny seeds that are covered in long cottony hairs and widely dispersed by wind and water. Cottonwood seeds collect in eddies and moist depressions along the high-water mark of water channels, conveniently placed in moist mineral soil where seed germination and survival is most likely. Each tiny seed has few resources, but if light and soil conditions are favorable, black cottonwood can regenerate abundantly from seed. Ideal growing conditions include ample light, moist mineral soil, and available nutrients including nitrogen and phosphorus. On suitable sites, cottonwoods grow quickly and extend deep roots to access ground water. Cottonwoods are tolerant to periodic inundation of their stems by high water. With its rapid height growth and adaptations to periodic flooding, cottonwood has a distinct competitive advantage in riparian floodplain forests.

Black cottonwood is relatively short-lived species compared to conifer species such as ponderosa pine or Douglas-fir with lifespans 500 years or more. Cottonwood generally reaches maturity at 60 to 80 years old and can live up to 150 to 200 years on productive sites. Because of its relatively short life compared to most conifers, cottonwood depends on frequent disturbances to maintain its dominance in riparian zones. The most favorable times for cottonwood recruitment are flood events. Floods remove overstory vegetation, scour organic matter from mineral soils, deposit new sediment, and fully saturate floodplain soils. They also can transport uprooted black cottonwood boles and branches which can anchor downstream, root and grow (Nilsson et al. 1991). Although black cottonwood can regenerate locally in nonflood years, many floodplain forests can be dated back to the last large flood that created widespread conditions for cottonwood recruitment (Rood et al. 2003a).

In many reaches where water levels have been regulated by dams, cottonwood regeneration has sharply declined due to lack of suitable sites for seedling germination and survival (Rood et al. 2003b, Elliot 2008). Cottonwood trees are dioecious (i.e., either male or female), and some studies have shown that as suitable sites for regeneration have declined, male cottonwood trees have been favored over female trees, which require more nutrients and available water to survive (Hultine et al. 2007). Unequal sex ratios can further reduce the reproduction potential of cottonwood in affected reaches.

Most tree species regenerate best after large disturbances. Flood events can also encourage regeneration of quaking aspen, thin-leaf alder and water birch, all species that require open light and saturated soils to reproduce by seed. Quaking aspen also reproduces clonally through sprouting, which can be triggered by disturbances to overstory trees (Frey et al. 2003). Conifer species also regenerate well after disturbance but are poorly adapted to periodic inundation by high water events.

Beaver

As with many watersheds throughout North America, beaver (*Castor canadensis*) and other fur-bearing animals were trapped extensively throughout the Methow Valley and the surrounding Okanogan County. Near extirpation of beaver likely altered the structures of streams and rivers. Because trapping predated any historic records, we have no clear reference on how numerous beavers were along the Middle Methow or how they influenced riparian forests and hydrology. Beaver are slowly recovering along the Methow River but may be at only a small fraction of their original population (Kent Woodruff, Methow Valley Ranger District, personal communication).

Through their felling of cottonwood, aspen, and other trees, beaver actively recruit large woody debris into water channels (Naiman et al. 1988). Beaver require ample numbers of trees and can locally alter stand conditions, reducing canopy cover and even altering species composition. Beaver prefer black cottonwood and quaking aspen over conifer species, and although riparian stand structure and composition can be strongly influenced by beaver activity, both cottonwood and aspen sprout vigorously when felled. Felled trees increase the structural complexity of river channels, and during flood events, large woody debris tends to accumulate in log jams and can initiate gravel bar recruitment. Once anchored, black cottonwoods can sprout and regenerate in their new location.

Beaver dams provide protected habitat for numerous fish species (Pollock et al. 2003) and have been linked with reproductive success of salmonid species (Pollock et al. 2004). Beaver dams are associated with slower water flow and support abundant aquatic invertebrates, both of which benefit foraging salmonids. Juvenile salmonid species in reaches with beaver dams have been found to be more abundant, larger in size, and with greater overwinter survival rates than reaches without beaver dams.

Fire and Riparian Forests

Fires were historically frequent in lower elevations of the Methow Valley with an estimated 2- to 18-yr fire return interval between 1700 and 1900 based on fire scar records (Ohlson 1996). The historic fire regime was characterized by low severity surface fires that burned in the grass-dominated understories of ponderosa pine savannah or forest (Agee 1993).

Although riparian zones contain substantial accumulations of woody fuels, they are generally less flammable than adjacent, upland forests. Riparian forests tend to be shadier with higher relative humidity and fuel moistures than upland forests (Pettit and Naiman 2007). In addition, riparian forests in the Methow Valley are dominated by broadleaf deciduous trees and shrubs, which intrinsically are not as flammable as coniferous trees. For these reasons, fire was probably an episodic visitor to riparian forests, occasionally creeping into riparian zones from adjacent forests and grasslands.

Episodic fires in riparian forests likely contributed to the structural heterogeneity of these forests and like flood events, encouraged regeneration of short-lived riparian tree species. Black cottonwood, quaking aspen and alder have thin bark and are susceptible to even low intensity surface fires (Agee 1993). However, if root systems are not killed by surface fires, both species can sprout vigorously after they are top-killed, particularly in areas where surface and ground fuels such as woody debris, litter, and soil organic matter are removed by fire (Dwire and Kauffman 2003). Depending on the timing of high water events in the subsequent years following fire, black cottonwood and other species may regenerate by seed under favorable moisture conditions (Pettit and Niaman 2007). Ponderosa pine is a classic fire resister with its thick bark and ability to shed lower branches (Agee 1993). Due to these characteristics, mortality of ponderosa pine was probably fairly low in fire events and was likely associated with long-duration smoldering of woody fuels and litter and duff. Open light conditions and mineral soil following fire events could also favor regeneration of conifer species such as ponderosa pine and Douglas-fir.

Fire plays a role in nutrient cycling of aquatic systems. Depending on the scale of upland and riparian fire events, they may cause an increase in runoff and also a short-term influx of nutrients released by the fire event (Pettit and Naiman 2007).

Over the past 100 years, fire intervals have lengthened due to fire exclusion (Hessberg et al. 2000). Fires are actively suppressed at low elevations in the Methow Valley, and as fire intervals have lengthened, forests have become denser with greater accumulations of surface fuels. Upland forests dominated by ponderosa pine are now susceptible to higher-intensity surface fires and contain ladder fuels that may carry surface fires into crown fires. In some areas of the Methow Valley, riparian forests are now more at risk for large, stand-replacing fire events based on the increased vulnerability of adjacent forests. However, agricultural fields along Middle Methow fragment forest cover and limit the possibility of fire spread from upland to riparian forests.

Survey Findings

The following sections describe the main riparian vegetation conditions for the reach assessment area and detailed descriptions by river mile. Vegetation maps by river mile are included in Appendix A.

River Mile 51.50 – 50.00

The RM 51.50 to 50.00 segment runs through the town of Winthrop and is confined with a thin strip of riparian vegetation on banks above the main channel. Small- to large-diameter black cottonwood, quaking aspen, and ponderosa pine line the river banks. Two gravel bars (RM 51.50 to 51.30) have recently recruited to willow species and black cottonwood; regeneration is not detectable on the 2006 orthophotographs. Mature black cottonwoods along this reach are in fair condition, with some branch loss and crown dieback.

River Mile 50.00 to 49.25

The RM 50.00 to 47.00 segment is moderately confined and has one broader section of riparian forest, between RM 49.7 and 49.25. Adjacent lands are non-forested, agricultural or residential properties.

- **RM 49.70 to 49.40**. A push-up dam associated with the Barclay ditch diverts river flow around a gravel bar island downstream. The upstream portion of the gravel bar is manipulated annually for dam maintenance. The island is partially vegetated with a young forest of sapling-sized black cottonwood, willow and aspen in the center of the island.

- **RM 49.40 to 49.25**. On river left, an older forest of large-diameter black cottonwood and ponderosa pine is adjacent to where the active side channel (SC 49.63 L) meets the main channel.

River Mile 49.25 to 48.10

The river meanders between RM 49.25 and 48.10 and divides around Bird Island. Riparian forests are more extensive in this segment and support mixed stands of black cottonwood and ponderosa pine.

- **RM 49.25 to 48.50**. Bird Island is at the next bend in the river and supports an older forest of black cottonwood and ponderosa pine in fair condition. Many of the cottonwoods have broken or dead tops. Ponderosa pine is regenerating amongst open cottonwood stand and becoming codominant.

- **RM 48.50 to 48.10**. The riparian forest is wider through this span of the river and supports mixed stands of open-grown black cottonwood and ponderosa pine. Small to large diameter black cottonwoods are common through this section and generally are in fair condition; crown dieback is common. Adjacent upland is mostly agricultural with few residences.

River Mile 48.10 to 46.25

- **RM 48.10 to 47.75**. Riparian vegetation continues as in the previous segment with two noteworthy features (48.50 to 48.10).
    - **RM 48.15**. Gilbertson Springs (SC 48.37 L) enters the main channel on river left. The small drainage is surrounded by reed canary grass and small willow trees near the main channel and black cottonwood further inland.
    - **RM 47.85 to 47.75**. The Pigott side channel (SC 47.90 R) runs through a wide band of riparian forest dominated by black cottonwood with some other deciduous trees and ponderosa pine. The black cottonwood that line the channel are small- to large-diameter trees with some broken and dead tops.
- **RM 47.75 and 47.00**. The river is moderately confined with thin strips of riparian vegetation, primarily composed of black cottonwood, ponderosa pine, and willow shrubs.
- **RM 47.25 and 46.90**. On the river left, widely spaced cottonwood, aspen and ponderosa pine trees stand amongst fallow agricultural fields in the active floodplain (Qa3 surface). This particular section has the potential to support a floodplain forest. Any restoration project would probably require tree planting and deer and cattle fencing.
- **RM 47.00 to 46.80**. A large gravel bar island is partially forested with black cottonwood. Cottonwood sprouts are heavily browsed by deer, and severed stumps indicate that beaver have felled many of the large cottonwoods on the island (Fig 1). Ponderosa pine is recruiting and in the absence of a flood disturbance, will likely succeed cottonwood on this island. The gravel bar extends down river and is regenerating with willow shrubs.
- **RM 46.80 to 46.50**. Open-grown stands of cottonwood, ponderosa pine and willow are on either side of the main channel. On river right, the riparian forest is interspersed between agricultural fields and a residence.
- **RM 46.50 to 46.25**. On river left, cottonwood, serviceberry and ponderosa pine line the edges of the North Cascades Smoke Jumper Base airstrip. On river right, wider swaths of riparian forest exist, intermixed with agricultural forests. The forests are sparsely populated with cottonwood with willow and serviceberry understory vegetation.

Figure 1: Evidence of beaver activity on a gravel bar island at RM 47.00. Cottonwood regeneration in foreground has been browsed by deer.

River Mile 46.25 to 45.50

The RM 46.25 to 45.50 segment contains a large gravel bar island downstream of the Methow Valley Irrigation Ditch. The island supports small-diameter black cottonwood and ponderosa pine. Downstream of the ditch, on river right, a beaver pond supports a wetland area and is surrounded by gallery cottonwood forest.

- **RM 46.25 to 45.70**. The Methow Valley Irrigation Ditch east dam was removed between 2007 and 2008. A thin line of cottonwood saplings and small-diameter trees follows the irrigation ditch through residential and agricultural properties. Downstream of the old dam site, a large gravel bar island (McNae Island) is mostly vegetated with small-diameter black cottonwood, ponderosa pine and willow species. Recent scouring of soil surfaces indicate that this area was inundated during recent high water events. The gravel bars surrounding the island are being colonized by willow shrubs. Deer browse on regeneration is evident here.

- **RM 45.70 to 45.50**. On river right, a beaver pond (Plumber wetlands, SC 45.60 R) extends from the bend in the river (Fig 2). Gallery forests of mature black cottonwood line either side of the Old Twisp Highway, which bisects the beaver pond and riparian forest. The forest here is dense, shady and has a mixture small and large diameter black cottonwood trees with full, live crowns. Riparian vegetation surrounding the beaver pond is dominated by willow and other deciduous shrub species.

Figure 2: Beaver pond at RM 45.55 (Plumber wetlands, SC 45.60 R).

River Mile 45.50 to 45.30

On river left, between RM 45.50 and 45.30, there is a mixed stand of black cottonwood, quaking aspen, and ponderosa pine with a gradation of stand ages. Closest to the main channel, a wide gravel bar has shrub-sized cottonwood and willow that colonized the bar after the 2006 orthophotographs were taken. A band of sapling-sized cottonwoods extends upslope and merges with a more extensive forest of large-diameter pine, cottonwood and a few quaking aspen.

River Mile 45.30 to 44.10

As the river bends to the east, the floodplain widens and supports several side channels created in the 1948 flood. Forests on this broad floodplain mostly likely established following the 1948 flood event and are dominated by black cottonwood with codominant ponderosa pine. The center of the floodplain is an elevated, older geomorphic surface (Qa2) and is covered in agricultural fields. There are two side channels that bisect the floodplain. The west side channel, commonly known as the Lankhaar side channel (SC 45.30 R), and east side channel, commonly known as the Habermehl side channel (SC 44.35 R), both have a groundwater connection, and portions are perennially inundated. Several smaller side channels toward the main river channel have scouring and debris, likely deposited from more recent high-water events. These channels do not contain water and support flows during high water events.

- The Lahkhaar side channel is lined with black cottonwood, aspen and other deciduous species. The north end of the side channel has been blocked by a levee. The mid portion has been excavated and is void of much vegetation cover. The south portion of the channel merges into a beaver pond that is vegetated with rush, grass and willow species.

- The Habermehl side channel (Fig 3) begins upriver within a forest of small-diameter cottonwoods with codominant ponderosa pine. The entrance contains a large log jam but is presumably permeable to high water. Where the channel runs through an agricultural field, vegetation grades to narrow band of thin-leafed alder. This vegetation type extends into the mixed deciduous forest at the southern end of the channel.

Figure 3: Habermehl side channel, lined by reed canary grass and thin-leaf alder.

  - The land to the east of the Habermehl side channel was recently purchased by Washington Department of Fish and Wildlife. The old agricultural field supports some black cottonwood and ponderosa pine. Black cottonwood suckers are heavily browsed at this site, and ponderosa pine is regenerating under the existing black cottonwoods (Fig 4). Many black cottonwood crowns exhibit crown dieback, probably associated with lowered groundwater during dry summer months.

Figure 4: Ponderosa pine regeneration under black cottonwood in an old agricultural field, WDFW land. Note crown dieback on a few cottonwood trees.

- Small side channels to the east are surrounded by a mixed forest dominated by black cottonwood with codominant ponderosa pine (Fig 5). Fire scars were observed on some of the mature ponderosa pine. Although tree cores were not taken, large-diameter ponderosa pine at this site most definitely predated the 1948 flood. Active deer browse was observed on all black cottonwood suckers. Dense ponderosa pine seedlings and sapling in the forest understory suggest that in the absence of another flood event, this forest would succeed to ponderosa pine.

Figure 5: One of the small side channels, located along the eastern margin of subreach MM-0Z-16b. Note the dense ponderosa pine regeneration in the understory.

- **RM 44.5 to 43.75**. On river left, the active floodplain extends broadly to the east and contains a mosaic of broadleaf deciduous forests and cleared land currently grazed by livestock (Fig 6). Bands of small-diameter aspen, water birch, willow, and cottonwood likely regenerated from the 1972 flood. A small levee, located at RM 44.3 in subreach MM-DOZ-17, diverts high water from entering the wide floodplain.

Figure 6: Broad floodplain south of small levee at RM 44.3. The levee, marked by the white arrow at the top center of the image, prevents floodwaters from entering the active floodplain surface.

- **RM 44.30 to 44.10**. On river left, a stand of large-diameter pine and widely spaced cottonwood follows the river bend. A portion of the site appears to be an old field, with a grass-dominated understory and old dirt road. A wide gravel bar extends towards the main channel and is mostly unvegetated with a few patches of willow and cottonwood regeneration.

River Mile 44.10 to 43.10

Riparian forest through the RM 44.10 to 43.10 segment is confined on river right and bordered by State Route 20. Riparian vegetation is more extensive on river left and supports mixed stands of black cottonwood, ponderosa pine, quaking aspen, and water birch. Riparian vegetation is generally continuous along the main channel but is interspersed with agricultural fields on the broad floodplain east of the main channel.

- **RM 44.10 to 43.80**. On river right, a residential property lines the river channel with large-diameter ponderosa pine, some hardwood species, and an irrigated lawn down to the river's edge.
- **RM 44.00 to 43.50**. On river left, the riparian forest is somewhat discontinuous and bordered by agricultural fields. The dry-site forest is dominated by ponderosa pine with codominant black cottonwood and small patches of quaking aspen. Ponderosa pine exceeds black cottonwood in height and is regenerating in the understory. On river right, the steep bank supports sparse cottonwood, ponderosa pine and shrub-steppe vegetation between State Route 20 and the main channel. Two gravel bar islands are partially vegetated with shrub-stage willow between RM 43.8 and 43.7.
- **RM 43.50 to 43.10**. On river left the riparian forest yields to a large stretch of agricultural field, interspersed with lobes of mixed deciduous forest, dominated by small-diameter water birch, willow, quaking aspen, and black cottonwood. On river right, a large gravel bar island at RM 43.3 has shrub-stage willow and cottonwood regeneration in front of the River Bend RV Park. The RV Park is partially forested and has a narrow band of black cottonwood near the main channel.

River Mile 43.10 to 41.15

The river in this segment is generally unconfined, and broad sections of floodplain forest are supported by river meander and channel migration in several areas. Although stands were not dated, it is likely that most riparian forests in this reach were initiated following the 1948 and 1972 flood events. Most trees in this segment were classified as small-diameter trees. However, many stands likely date back to the 1948 flood and are around 60 years old. Cottonwood recruitment on several gravel bars is not detectable in the 2006 orthophotographs and is probably associated with the 2006 and 2008 high water events.

Although there are areas of intact floodplain forests, large tracts of the active floodplain have been converted to agricultural fields or residential property. Black cottonwood trees are common near the river edge in agricultural fields, but their sprouts are heavily browsed by deer at many sites. Closer to the town of Twisp, around RM 42.50, State Route 20 bisects the floodplain with residences on either side of the highway.

- **RM 43.1 to 42.6**. On river left, vegetation continues as a mosaic of agricultural fields and dense mixed deciduous forest. A large gravel bar island at RM 43 has been colonized by shrub-stage black cottonwood and willow. Continuing down river, the floodplain widens on river right and spans State Route 20, an agricultural field, a residential property, and an auto junk yard. Between RM 42.80 and 42.60, a young forest dominated by small-diameter black cottonwood saplings and trees is interspersed with several side channels with evidence of scouring and wood deposition from recent high water events.

- **RM 42.6 to 42.3**. On the river right, a bridge on State Route 20 marks the head of a historic river channel path, now commonly known as the Doran side channel (SC 46.25 R). This was likely the main channel of the river in the late 1800s and supported river flow during the 1897 and 1947 floods. A wide riparian forest spans this section, bisected by State Route 20 and containing increasingly dense residential properties as State Route 20 approaches Twisp. The forest is dominated by black cottonwood, quaking aspen, and ponderosa pine and is in fair condition with high fragmentation from residential properties.
  - A large levee, constructed sometime in the 1960s, disconnects the river channel from its historic channel path (Subreach MMI-DIZ-7). The site behind the levee was recently filled and bulldozed; a few cottonwood trees and saplings grow among weedy herbaceous species. A small human-made pond borders a residential property.
  - On river left, a wide band of small-diameter cottonwood saplings and trees is nearest to the main channel and merges upslope with an older forest dominated by black cottonwood. Numerous cottonwood trees have been felled by beavers along the river bank (Fig 7).

Figure 7: Recently felled black cottonwood trees from beaver activity at RM 42.25.

- **RM 42.30 to 42.00**. The floodplain is at its broadest in this section, spanning nearly three quarters of a mile wide. State Route 20 runs through the middle of the floodplain and is surrounded by agricultural fields and residential properties. A floodplain forest dominated by black cottonwood forest with clumps of quaking aspen extends from State Route 20 to the river channel. The forest is in fair condition with evidence with a network of unimproved roads, disturbed understory, patchy forest cover, and crown dieback.

- On river left, a small wetland (SC 42.59 L) lies near the main channel as it turns south. Wetland vegetation is dominated by shrubs and grasses and a few standing black cottonwood. Numerous cottonwoods have been felled by beavers in this area.

- On river right, a side channel (commonly known as the Pederson side channel , SC 42.30 R) runs between a riparian forest and a large gravel bar with dense cottonwood saplings and seedlings (Fig 8). The side channel between the gravel bar and mature forest had flow in June 2009 and runs in small side channels through the gravel bar island.

Figure 8: Dense black cottonwood recruitment on a gravel bar island along the Pederson side channel about RM 42.1 on river right.

- **RM 42 to 41.3**.

  - On river right, another side channel runs through a forest dominated by small-diameter cottonwood, meeting the main channel around RM 41.5 (commonly known as the Kedrowski side channel SC 42.00 R). A large gravel bar extends to the river channel and is mostly unvegetated. Forest composition changes somewhat with increased ponderosa pine from RM 41.5 to 41.4, and the floodplain constricts toward the main channel. Near the confluence of the Twisp and Methow Rivers about RM 41.3, young stands of cottonwood saplings and small trees line the main channel. Farther from the channel an older forest is dominated by small-diameter black cottonwood with codominant large-diameter ponderosa pine.

  - On river left, a steep bank with sections of riprap follows the main channel from RM 42.2 to 41.9 and is bordered by agricultural fields. A mature forest dominated by black cottonwood extends from RM 41.9 to 41.7. As the main channel winds to the west from RM 41.7 to 41.3, a large gravel bar extends to the west and is being colonized by black cottonwood and willow seedlings.

Opportunities for Riparian Habitat Protection and Rehabilitation

Riparian forests in the Middle Methow are dominated by relatively short-lived species that depend on episodic flood events and channel migration to regenerate. The most important factor in maintaining and enhancing riparian vegetation along the Middle Methow is to allow for channel migration and flooding of floodplain surfaces. Without regeneration opportunities and periodic inundation of floodplain surfaces, wide floodplain forests will decline and be replaced by drier site species, including ponderosa pine and Douglas-fir. Black cottonwood is a keystone riparian species (Braatne et al. 2006) and plays a critical role in large woody debris dynamics, provides habitat for a host of terrestrial and aquatic organisms, and contributes to nutrient cycling in hyporheic zones. With regulated flow, channel restriction, and floodplain development in many watersheds throughout the inland West, cottonwood and other riparian species have dramatically declined over the past century (Kauffman et al. 1997, Rood et al. 2003b). Riparian vegetation has been altered along the Middle Methow reach with an estimated 27% of the forest cover cleared between RM 51.00 to 47.00 and 37% between RM 47.00 and 41.30 (Maguire et al. 2008). However, large portions of the assessment area contain intact riparian forest and hydrological processes, and opportunities to protect and enhance riparian habitat are promising along unconfined segments of the river in particular.

Floodplain development

Floodplain development presents a major challenge to maintaining the dynamic river processes that are vital for riparian forests and fish habitat. Once permanent residences are in place, flood control measures including riprap and levees are often constructed to protect residences during high water events. Limiting future development in the active floodplain is probably the most important action that could be taken to protect current riparian habitat.

In at least two cases, existing residences could be acquired or protected to allow for flow during high water and channel migration: (1) A small levee, located at RM 44.30, diverts high water at a bottleneck location from entering the wide floodplain surface to the south. A residence is in close proximity to the main channel and levee and may require some bank protection to allow for removal of the levee. (2) Some residences along the east side of State Route 20 between RM 42.6 to 41.5 could be acquired or moved so that the existing levee could be removed, modified or relocated, allowing for channel migration over a portion of the existing floodplain.

Large Woody Debris

Large woody debris (LWD) is conspicuously uncommon in the Middle Methow reach. Log jams were identified at the apex of many gravel bar islands, but instream LWD is almost absent. Historically, LWD was removed from the main channel to facilitate log transport to mills. More recently, boaters have contributed to LWD removal to reduce instream hazards. LWD is important for fish habitat, and log jams can act as anchors for sediment and debris and promote gravel bar island development (Naiman et al. 2000). Several types of rehabilitation projects could serve to increase LWD in the main and side channels of the Middle Methow reach:

- Strategic placement of mature trees including root wads into the channel to enhance instream habitat and structural diversity.
- Support education and outreach to dissuade boater and landowners from cutting logs to reduce perceived hazards. Actual signage on critical structures may be necessary.
- Enhance riparian tree cover along the river bank on agricultural lands. Projects could include planting, fencing and caging projects.
- Allow for the recovery of beaver along the reach through ongoing landowner education and cooperation with the Methow Beaver Restoration Project. Although beaver activity along some sections of the Middle Methow reach has locally reduced forest cover and removed large trees along the riverbank, beaver promote continued recruitment of LWD into the main channel, potential regeneration down river where black cottonwood anchors and grows, and sprouting of existing cottonwood and aspens (Naiman et al. 1988). In addition, beaver dams offer important habitat for juvenile salmonid species.

Riparian Forest Cover

Agricultural fields border the river along many portions of the Middle Methow reach and often support only a thin line of riparian trees along the river bank. Deer browse is particularly heavy on cottonwood spouts in agricultural fields as compared to recruitment on gravel bars (Fig 9). Repeated browse appears to be limiting tree recruitment and forest cover development in these areas. Stark differences in browse damage between cottonwood regeneration on gravel bars and agricultural fields may be due to a combination of factors. Regeneration is generally so dense on gravel bars that it may overwhelm the effects of deer browse. Agricultural fields also probably support larger concentrations of deer, and browsing on sprouts is likely more common than in gravel bars.

Figure 9. Browsed cottonwood sprouts. Deer browsing appears to be most common on cottonwood sprouts in old agricultural fields and is less of a factor in gravel bar islands with dense cottonwood regeneration.

Several properties with agricultural fields along the river are under private or public conservation easements and may be candidates for tree planting and caging projects. These include properties at RM 48.25 to 47.25 (river right), RM 47.8 to 47.2 (river left), RM 48.5 to 48.1 (river left), RM 50.2 to 49.25 (river right), and RM 46.8 to 46.6 (river left). The Methow Conservancy already is working with some conservators to cage cottonwood sprouts and encourage recruitment of cottonwood trees.

In addition to promoting more forest along the river bank, several areas have the capacity to support actual floodplain forests. These include:

- RM 47.5 to 47.2: the floodplain widens on river right but is mostly covered by old agricultural fields with a small stand of black cottonwood.
- Old fields, partially covered by cottonwood and ponderosa pine, on river left between RM 48.25 and 47.25 are in the active floodplain and have the potential to support a floodplain forest. In the absence of a flood event, this area will require a combination of tree planting, caging and fencing to increase forest cover.
- On river left, between RM 44.5 and 42.75, fields are interspersed with floodplain forests. Cattle are actively grazed in this area. Cattle fencing and reconnecting the floodplain surface would encourage forest development and expansion.
- On river right, between RM 42.5 and 42.25, moving back the levee could expand gravel bar and riparian forest development.

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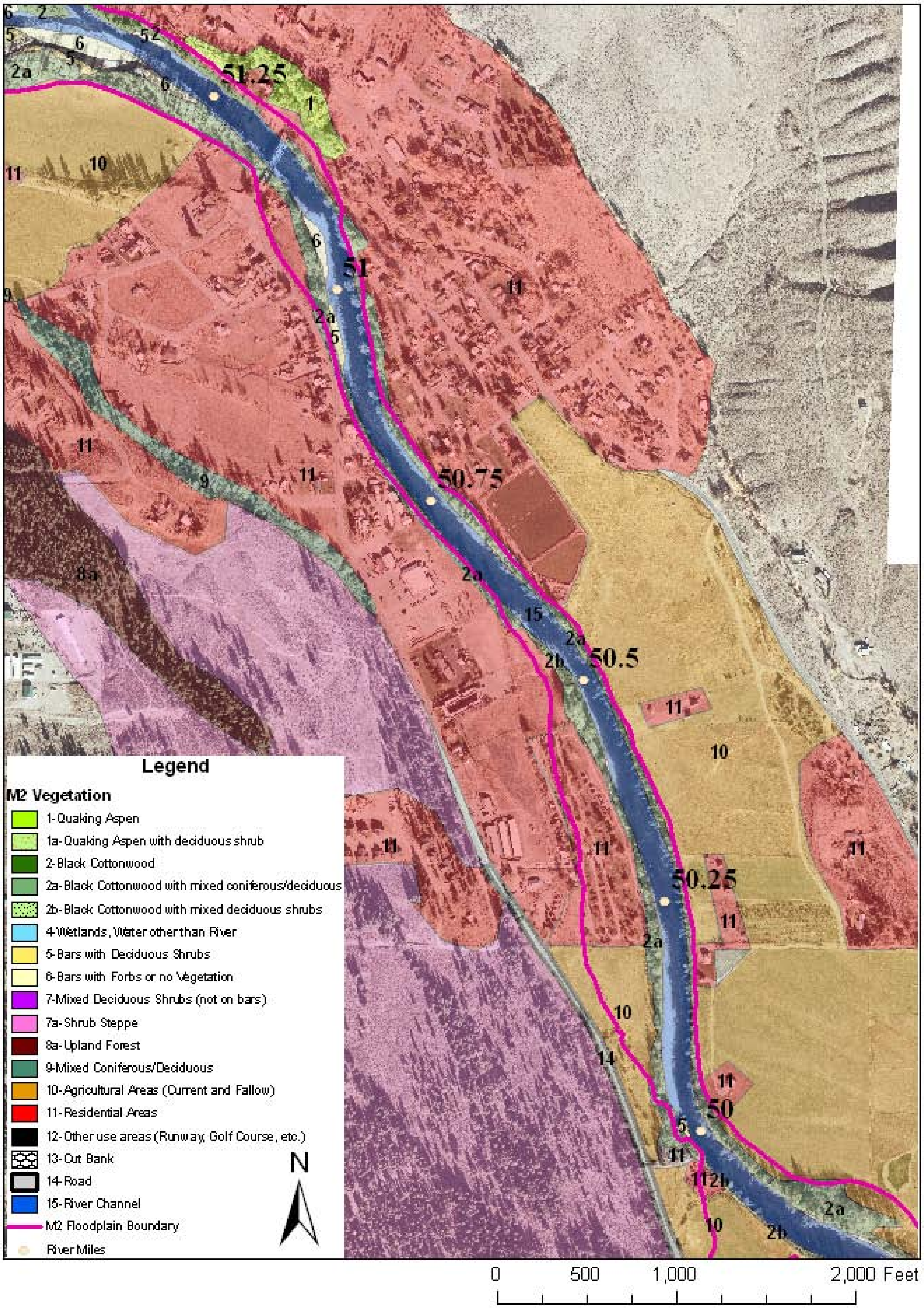
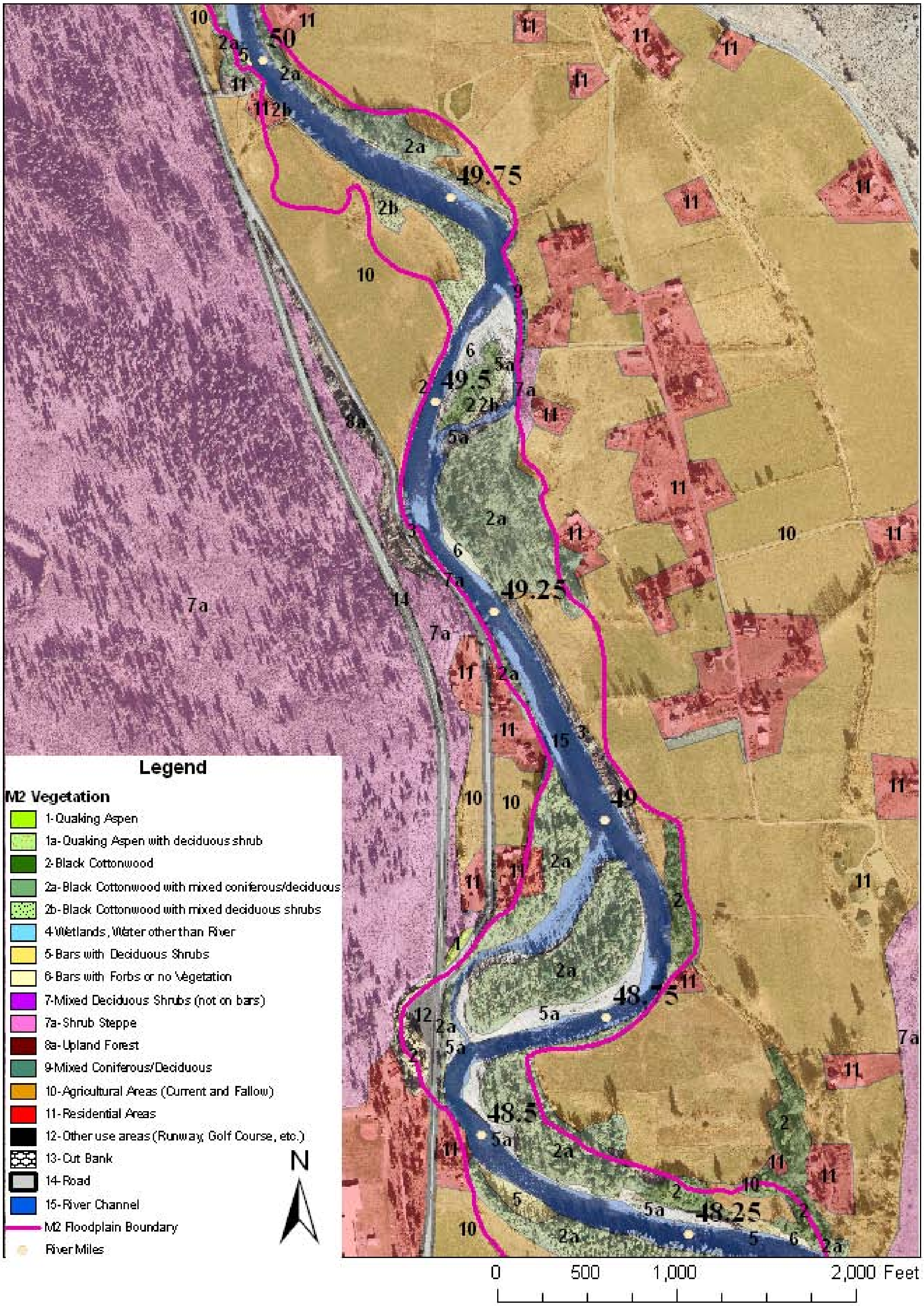
Appendix A: Vegetation Mapping overlays on 2006 orthophotos.

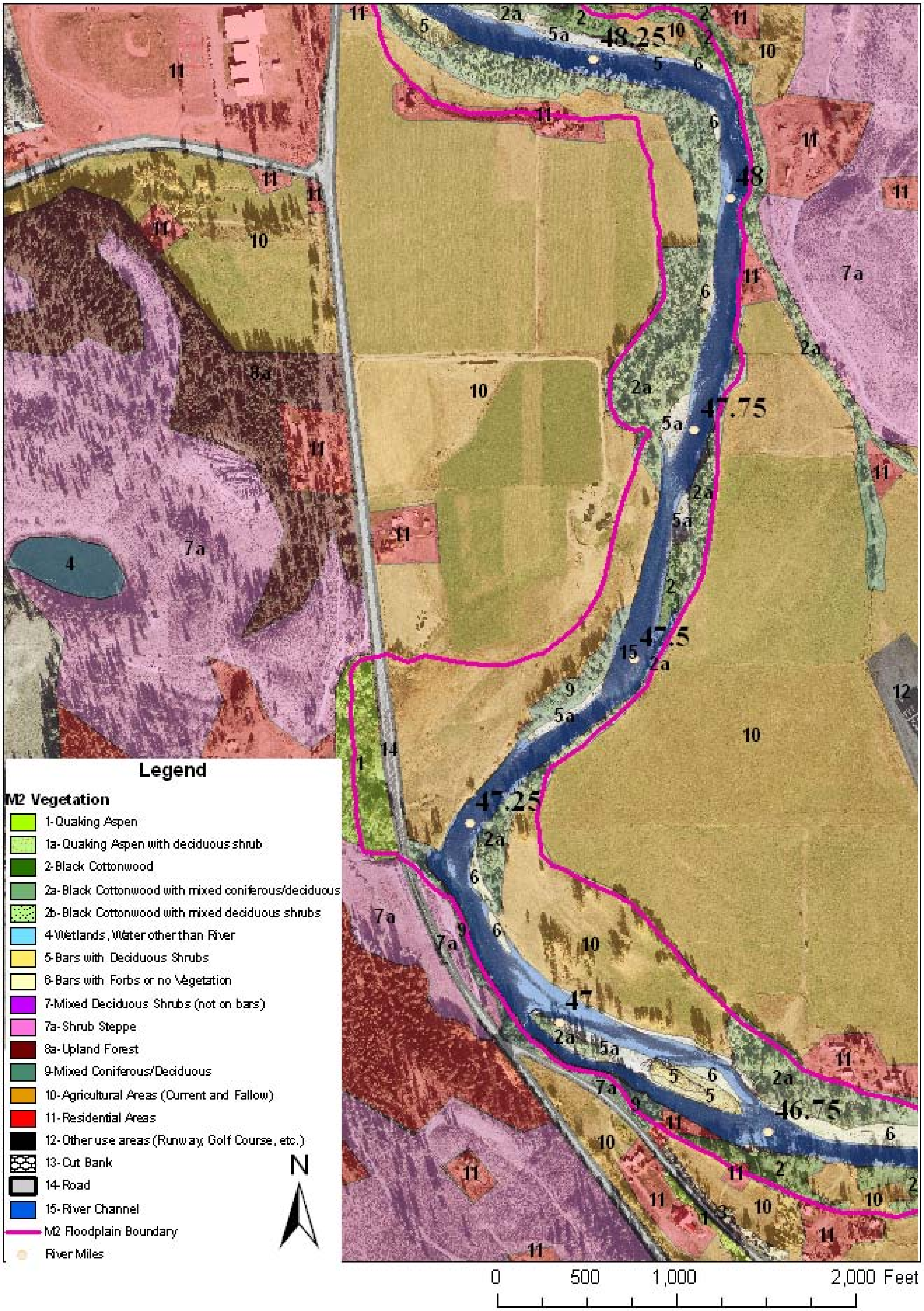
M2 River Miles 51 to 50



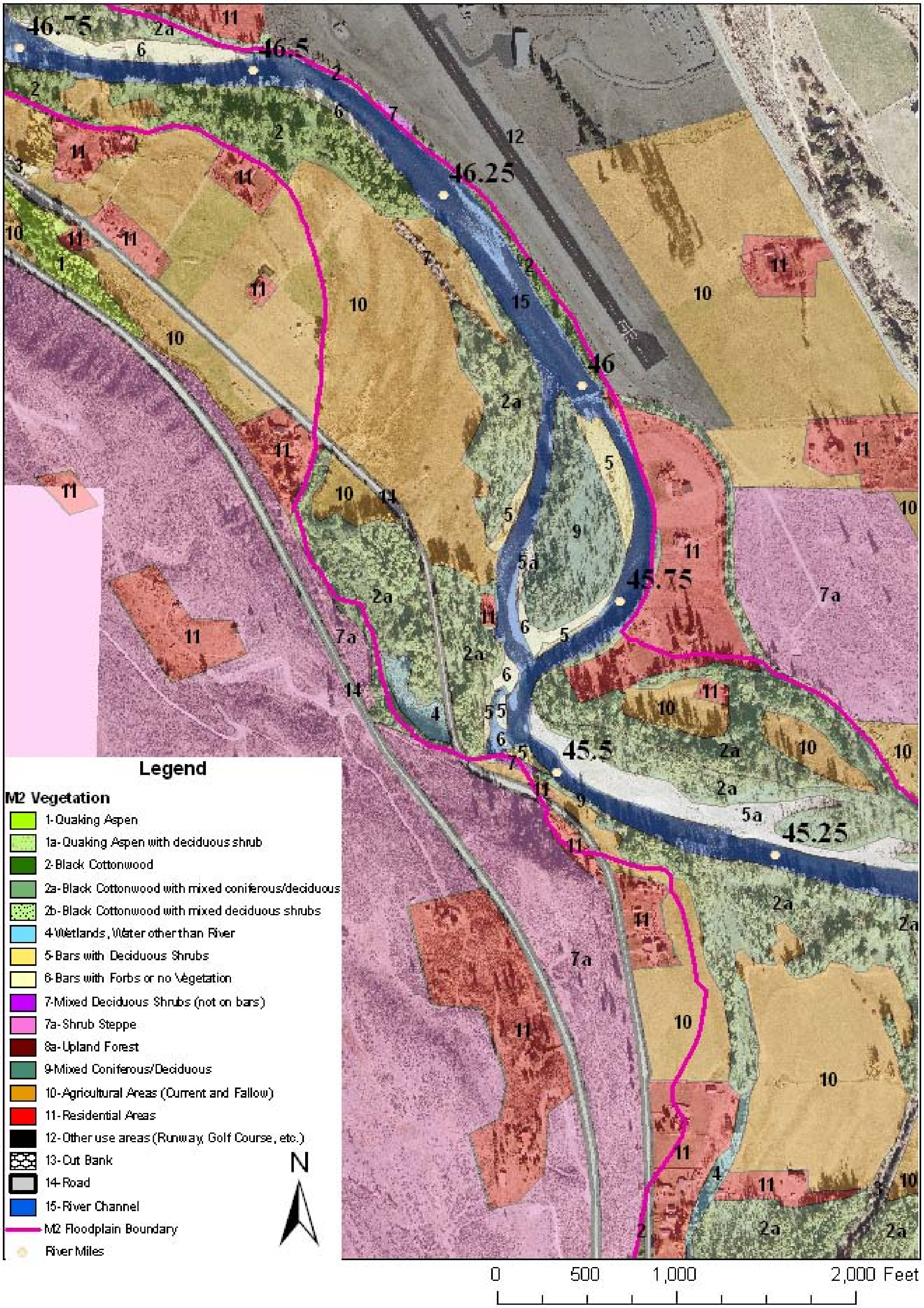
M2 River Miles 50 to 48.25



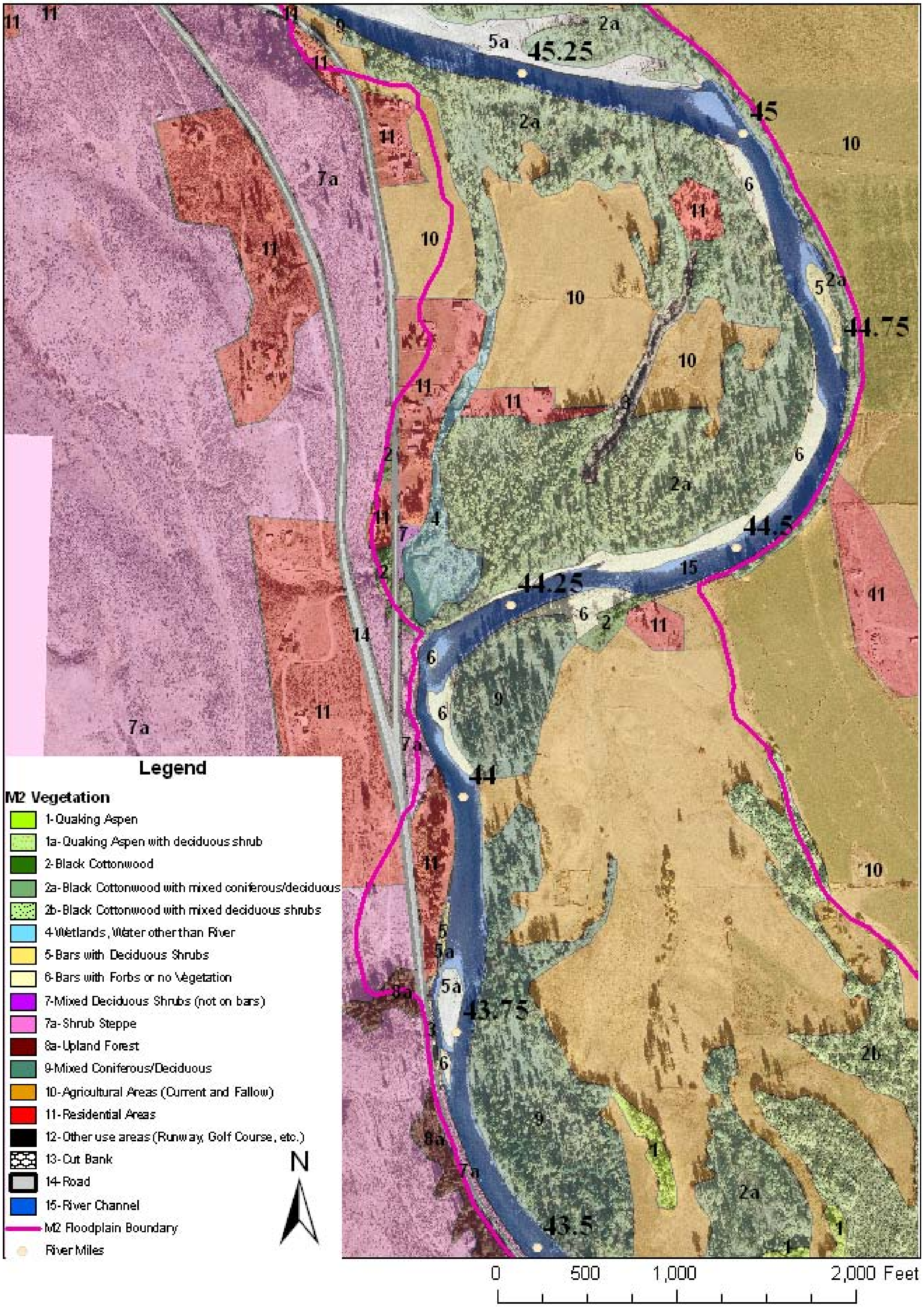
M2 River Miles 48.25 to 46.75



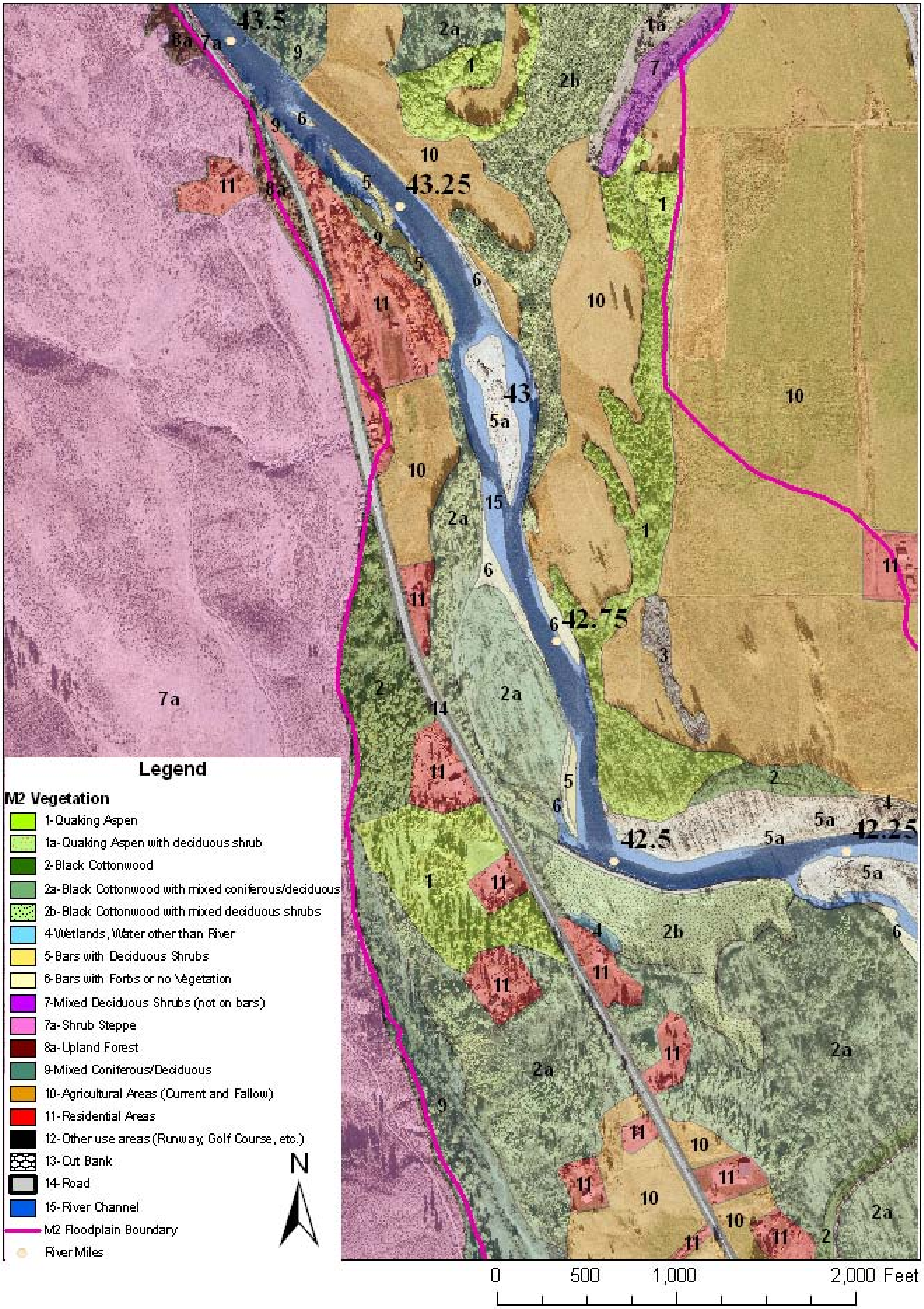
M2 River Miles 46.75 to 45.25



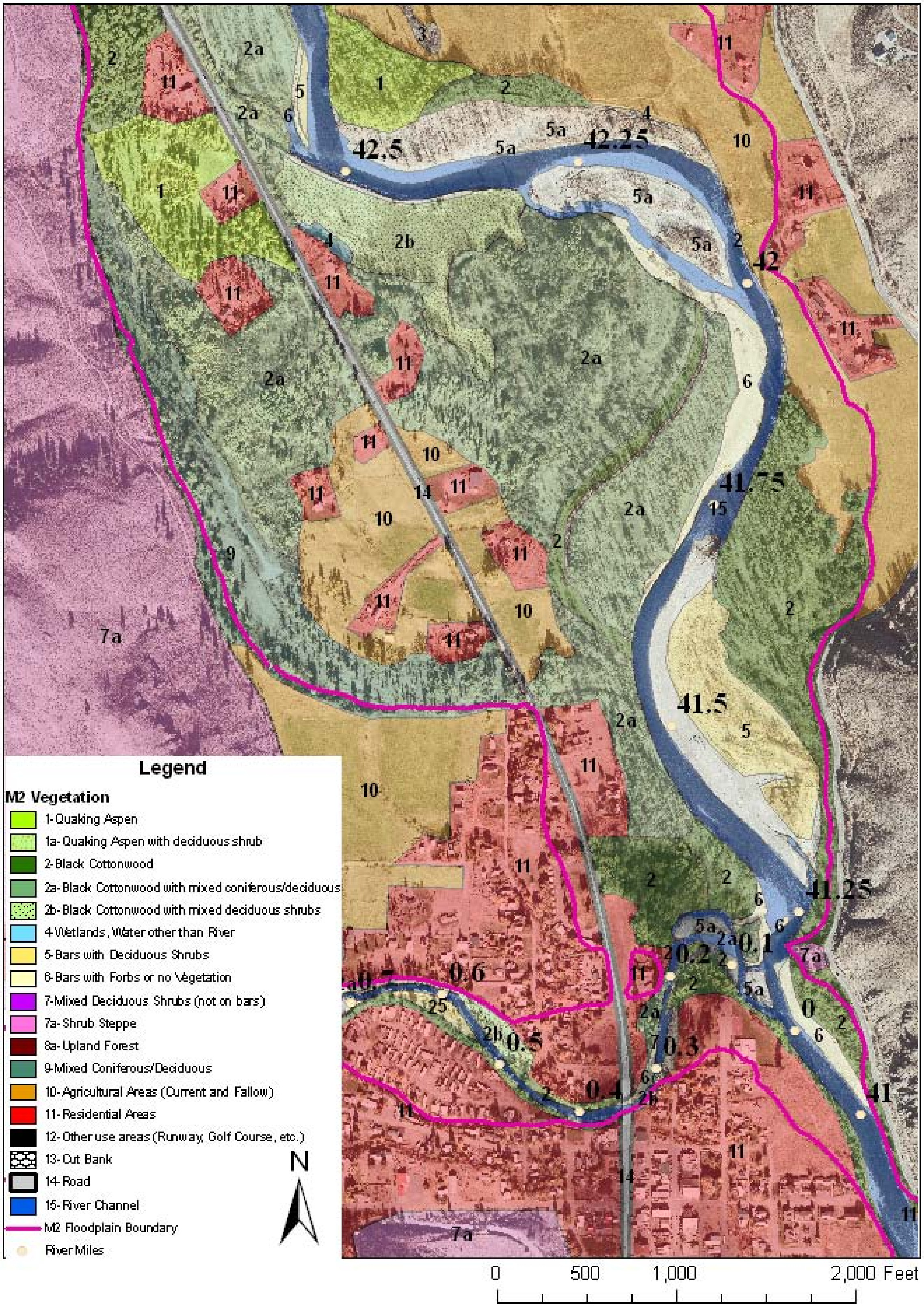
M2 River Miles 45.25 to 43.5



M2 River Miles 43.5 to 42.25



M2 River Miles 42.5 to 41



APPENDIX F

GIS Database

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Appendix F

GIS Databases

The Middle Methow Reach GIS (Geographic Information System) File Geodatabase was produced in support of the document, *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*. More file geodatabases at the valley segment spatial scale are contained in the *Geomorphology and Hydraulic Modeling for the Middle Methow River from Winthrop to Twisp* (Reclamation 2010), *Methow Subbasin Geomorphic Report, Okanogan County, Washington* (Reclamation 2008), and *Middle Methow Riparian Vegetation Assessment Report* (Appendix E).

The ***M2Reach*** File Geodatabase includes multiple feature classes:

Feature Classes	Description
M2_Channel Units	Physical attributes of the channel (polygon)
M2_Human Features_Point	Human created features (point)
M2_Human Features_Line	Human created features (polyline)
M2_Subreaches	Inner/outer zone divisions (polygon)
M2_Photopoint	Photograph locations (point)
M2_Habitat Features_Point	Biological features (point)
M2_Habitat Features_Line	Biological features (line)
M2_IZ Perimeter	Perimeter of inner zone (polygon)
M2_OZ Perimeter	Perimeter of outer zone (polygon)
M2_Perimeter	Perimeter of reach (polygon)
M2_Roughness Element	Potential element placements (point)

For more information or to request a copy of the Middle Methow Reach GIS File Geodatabase on DVD, contact Kristin Swoboda at the Reclamation's Pacific Northwest Regional Office, kswoboda@usbr.gov.

Middle Methow Reach File Geodatabase

Project Feature Classes

Feature Class – M2_Subreaches
Title – M2_Subreaches: This feature class was created for the *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Inner zone, Outer zone, Subreaches
Abstract – This feature class contains polygons that show the location and extent of the inner and outer zones, and subreaches of the Middle Methow reach area.

Feature Class – M2_IZ Perimeter
Title – M2_IZ Perimeter: This feature class was created for the *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Inner zone perimeter
Abstract – This feature class contains polygons that show the location and extent of the inner zone used in the vegetation analysis.

Feature Class – M2_OZ Perimeter
Title – M2_OZ Perimeter: This feature class was created for the *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Outer zone perimeter
Abstract – This feature class contains polygons that show the location and extent of the outer zone used in the vegetation analysis.

Feature Class – M2_Perimeter
Title – M2_Perimeter: This feature class was created for the *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Perimeter
Abstract – This feature class contains polygons that show the location and extent of the Middle Methow reach assessment area.

Feature Class – M2_Channel Units
Title – M2_Channel Units: This feature class was created for the *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Channel units
Abstract – This feature class contains polygons that show the location and extent of channel units within the Middle Methow reach area.

Feature Class – M2_Human Features_Point
Title – M2_Human Features_Line: This feature class was created for the *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Human features, Anthropogenic features

Abstract – This feature class contains points that show the location of anthropogenic features that impact channel processes and floodplain connectivity.

Feature Class – M2_Human Features_Line
Title – M2_Human Features_Line: This feature class was created for the *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Human features, Anthropogenic features
Abstract – This feature class contains polylines that show the location and extent of anthropogenic features that impact channel processes and floodplain connectivity.

Feature Class – M2_Habitat Features_Point
Title – M2_Human Features_Point: This feature class was created for the *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Habitat features, Large wood, Redds
Abstract – This feature class contains points that show the location of biological features.

Feature Class – M2_Habitat Features_Line
Title – M2_Habitat Features_Line: This feature class was created for the *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Habitat features, Erosion
Abstract – This feature class contains polylines that show the location and extent of streambank erosion.

Feature Class – M2_Photopoint
Title – M2_Photopoint: This feature class was created for the *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Photopoint, Photograph locations
Abstract – This feature class contains points that display location and photograph number that correlate to the initial site assessment Appendix C.

Feature Class – M2_Roughness Element
Title – M2_Roughness Element: This feature class was created for the *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Roughness elements, Large wood placement, Rock spur placement
Abstract – This feature class contains points that display potential roughness element placement locations. Further field evaluations are needed prior to placement.

Feature Class – M2_Geology
Title – M2_Geology: This feature class was created for the *Middle Methow Reach Assessment, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Composite geologic map
Abstract – This feature class contains polygons that display prominent geologic features within the Middle Methow reach assessment area.

Feature Class – M2_Habitat Action
Title – M2_Habitat Action: This feature class was created for the *Middle Methow Reach Assessment, Okanogan County, Washington*
Keywords – Middle Methow Reach Assessment, Potential habitat action classes
Abstract – This feature class contains polygons that display areas where potential habitat action classes could be implemented in the Middle Methow reach.

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