Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: **1. Confluence to Brown Road (RM 0.0 to 0.7)**
PRIORITY RANK: **High**

SUB-REACH DESCRIPTION

Sub-reach 1 begins at the Yakima River and extends upstream 0.7 miles to Brown Road (Figure 2). Between RM 0.0 and 0.3 the stream flows down a large alluvial delta that it has created on the south floodplain of the Yakima River. At RM 0.3 the stream enters a deeply incised narrow valley carved into a Yakima River/glacial outwash terrace.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. Flood hazards are high on the floor of the valley and on the active portion of the delta.
2. The valley wall beneath the home on parcel 955517 is eroding.
3. The residence on parcel 178233 is on the floor of the valley and is susceptible to repeated flooding.

Habitat Limitations:

1. Juvenile fish rearing and refuge habitat.
2. A flood protection berm surrounds the structure on Parcel 178233 which cuts off a portion of the historical floodplain.
3. Fill left from an abandoned road crossing constricts the channel.
4. Reduced base flow and increased temperature, turbidity, and nutrients during low flow due to irrigation withdrawals and return flows.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Site or Item	Potential Actions
Flood	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas.
	Active Delta	Propose conservation easement to prevent development (Note this would also be a significant habitat benefit.)
	Parcel 178233	Purchase property and remove structures.
Erosion	Parcel 955517	Construct ELJ (or other) to protect eroding bank.
	General -- Bank Protection	Where appropriate, construct ELJs or re-vegetate to increase bank stability, especially adjacent to floodplain structures.
Habitat	Delta	Restore portions of the delta to improve juvenile salmonid

		rearing and refuge
	Parcel 178233	Purchase property, remove structures and restore active floodplain.
	Abandoned Road Crossing	Modify or Remove Fill
	General – Stable LWD	Install anchored LWD or ELJs in appropriate locations to provide improved refuge habitat for Yakima River salmonids

DISCUSSION OF RECOMMENDED ACTIONS

Flood

1. ***Floodplain Regulations*** – FEMA maps should be updated or produced to establish a defensible floodplain and floodway for Manastash Creek (RM 0 to 12.5). These maps then should be used to prevent or limit development in high flood hazard areas.
2. ***Active Delta*** – The active delta is highly prone to flooding and erosion; therefore, building in this area should be discouraged or prevented. Recommend pursuing a conservation easement.
3. ***Repetitive Loss Property*** – The home on parcel 178233 is the only home on the floor of the valley within this sub-reach. It is in a high hazard flood area as demonstrated by the May 2011 flood which inundated the home. Repeated flooding is to be expected, therefore, property purchase is recommended.

Erosion

4. ***Parcel 955517*** —The valley wall below the home and deck on this property is eroding. Protection is recommended. Use LWD as component of structure design to double as habitat.

Habitat

5. ***Active Delta*** – The delta presents a significant opportunity to design and construct features that will provide high quality rearing and refuge for juvenile salmonids. Revegetate streambanks where appropriate.
6. ***Parcel 178233*** – Removal of the existing home and flood protection berm would present an opportunity to restore natural floodplain connection and function.
7. ***Abandoned Road Crossing*** – At the location where the stream leaves the incised reach and begins to flow across the delta there appears to be road fill from an old crossing. This fill should be inspected to determine if should be modified or removed to improve habitat.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.

5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. For purposes of evaluation and prioritization, the actions were grouped into 3 distinct projects. The table below summarizes these projects. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
1-1	Procure/establish a conservation easement to ensure the protection of mature floodplain forest bottomlands at the dynamic confluence of Manastash Creek and the Yakima River. Enstate development restrictions in high-hazard areas. Modify or remove abandoned road crossing fill Install multi log habitat structures where appropriate in the downstream portion of this reach (0.0 - 0.5). Improve habitat, accumulate naturally recruited pieces of LWD, and potentially aggrade the stream bed to improve overall floodplain connectivity in the reach.	14/20	Kittitas County PW/ KCCD	SRFB
1-2	Site specific revegetation at Parcel 228233. Work will require collaboration with and approval from the landowner.	7/20	KCCD	SRFB
1-3	Seek property buyout for Parcel 955517. Perform minor excavation creating small floodplain benches and/or removing existing push up levees to enhance floodplain inundation and reduce hydraulic severity. Revegetate site.	11/20	KCFZD/KCCD	FEMA/ SRFB

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: 2. Barnes to Brown Road (RM 0.8 to 1.6)
PRIORITY RANK: Low

SUB-REACH DESCRIPTION

Sub-reach 2 begins at Brown Road and extends 0.8 miles upstream to Barnes Road (Figure 3). The reach includes both bridges. The stream is confined to the floor of a deeply incised narrow valley carved into a Yakima River/glacial outwash terrace. There are no homes or other inhabitable structures located on the floor of the valley within the reach.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. Flood hazards are high on the floor of the valley.
2. Lateral erosion is attacking the wall of the valley in several places. Most sites affect farm or riparian areas; however, there is at least one location where the erosion may pose a threat to a home or structures. This is near RM 1.0 and the structures are located on Parcel 628233.

Habitat Limitations:

1. Lack of habitat structure including stable in-stream wood.
2. Generally stream bank and floodplain vegetation is adequate, with the exception of a few isolated areas.
3. Both the Brown and Barnes Road crossings constrict the natural floodplain and impact stream morphology. The impact caused by Brown Road is minor while the impact of Barnes Road is greater because the bridge is quite narrow.
4. Immediately downstream from Barnes Road, the stream flows along the face of a concrete wall that is part of the Barnes Road irrigation diversion structure. Velocities along the base of the wall are swift.
5. Reduced base flow and increased temperature, turbidity, and nutrients during low flow due to irrigation withdrawals and return flows.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Site or Item	Potential Actions
Flood	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas. In this reach this would amount to keeping homes from being built on the floor of the valley.

Erosion	Parcel 628233	Examine erosion to determine if it poses a threat to the structures that are located near the edge of the valley wall.
	General -- Bank Protection	Where appropriate, construct ELJs or re-vegetate to increase bank stability, especially adjacent to floodplain structures.
Habitat	General - Habitat Structure	Install anchored LWD or boulder vanes in appropriate locations.
	General – Vegetation	Plant vegetation along banks and floodplain where it is lacking.
	Reduced Base Flow	Acquire instream flow via voluntary acquisition and water conservation projects
	Brown Road Crossing	When the existing bridge reaches the end of its useful life, consider replacing with a wider crossing.
	Barnes Road Crossing	When the existing bridge reaches the end of its useful life, consider replacing with a wider crossing.
	Berms	Examine existing berms to determine if they can be removed to improve floodplain and side channel connectivity.
	Wall of Irrigation Diversion	Examine to determine if features could be installed to roughen channel along base of wall to reduce swift velocities.

DISCUSSION OF RECOMMENDED ACTIONS

Flood

1. ***Floodplain Regulations*** – FEMA maps should be updated or produced to establish an accurate floodplain and floodway for Manastash Creek (RM 0 to 12.5). These maps then should be used to prevent or limit development in high flood hazard areas. The valley floor within this reach is a high hazard area where homes should not be built, except if analyses can demonstrate that the home will be built in an area that is safe.

Erosion

2. ***Parcel 628233*** –The stream is eroding the toe of the valley wall below the home (and/or associated structures) on this parcel. A site inspection should be completed to determine if the erosion poses a threat to the home (or structures) and if it does, take appropriate action to protect the bank or deflect the stream away from the eroded area. Use LWD to the extent possible as a component of the structure to improve habitat.

Habitat

3. ***Bridges*** – At both bridges, the west approach fill cutoffs the historical floodplain. The Brown Road bridge is wider than the Barnes Road bridge and therefore, has less of an impact on channel processes. The Barnes road bridge is quite narrow and therefore has a greater impact.
4. ***Wall of the Irrigation Diversion Structure*** – The stream flows along the toe of a relatively long vertical concrete wall that is part of the irrigation diversion facility. Consider adding rocks or wood to increase roughness which will reduce velocities along the base of the wall.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. For purposes of evaluation and prioritization, the actions were grouped into 5 distinct projects in addition to a general flow restoration effort that applies to much of the lower project area. The table below summarizes these projects. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General-1	Instream flow restoration	17/20	KCCD	
2-1	The Brown Road Crossing is structurally sound and is not scheduled for replacement. When it is, conduct detailed hydraulic and geomorphic evaluation to determine the best replacement design to balance costs and habitat.	7/20	Kittitas County PW	
2-2	Remove existing berms along the left bank to improve floodplain connectivity and access to remnant side channels.	11/20	KCCD	SRFB
2-3	Install instream habitat / erosion protection structures where appropriate. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk.	11/20	KCFZD/KCCD	FEMA/ SRFB
2-4	Replace the Barnes Road crossing with hydraulically and geomorphically appropriate crossing.	7/20	KCCD	SRFB
2-5	Consider adding rock or wood roughness elements along concrete wall to reduce velocities	7/20	KCCD	SRFB

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: 3 – Westside Irrigation Crossing Reach (RM 1.6 to 1.9)
PRIORITY RANK: High

SUB-REACH DESCRIPTION

Sub-reach 3 begins just above Barnes Road and extends upstream 0.3 miles beyond the Westside Irrigation District siphon crossing (Figure 4). Between Barnes Road and the siphon the channel is straight and the right (north) bank is lined with a single row of large diameter cottonwood trees. This reach of the channel was straightened in the 1940s or 1950s. Due to the straight planform, the channel is generally a continuous riffle or glide with few pools or resting areas for fish. The irrigation siphon and its protective scour apron create a rise in the longitudinal bed profile. Upstream, the channel is attempting to reestablish meanders and the outside banks of the bends are actively eroding.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. The primary hazard within this reach is the risk scour and erosion pose to the Westside Irrigation District siphon. The top of the siphon has been exposed by past floods. Temporary countermeasures were recently installed to protect the siphon.
2. Upstream from the siphon the banks are actively eroding in several locations; however, the erosion does not pose a threat to structures.

Habitat Limitations:

1. There are virtually no pools or woody debris within the straight reach between Barnes Road and the siphon.
2. Stream channel is confined and disconnected from floodplain
3. A significant portion of the right (south) bank between Barnes Road and the siphon is covered with broken concrete rubble.
4. There is little shade vegetation along the right (south) bank of the stream and there is a single row of mature cottonwoods on the left (north) bank.
5. Reduced base flow and increased temperature, turbidity, and nutrients during low flow due to irrigation withdrawals and return flows.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Site or Item	Potential Actions
Flood	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas.

Erosion	Westside Siphon	The Westside Irrigation District is in the process of designing a replacement crossing for the siphon. They hope to replace it with an elevated bridge structure. Construction is tentatively planned for the summer 2014. As part of the replacement, the stream channel and return flow ditch will need to be reconfigured to accommodate the new crossing which will provide an opportunity to improve channel geomorphic characteristics while reducing scour and erosion potential.
	General -- Bank Erosion	Where appropriate, construct ELJs or re-vegetate to increase bank stability. However, do not prevent natural channel migration if it does not pose a threat to structures or other facilities.
Habitat	Straight Channel	Conduct investigation to determine how to restore or, at a minimum, improve geomorphic characteristics and habitat complexity within the straight reach (i.e. increase pools).
	Concrete Rubble	Remove concrete rubble from right (south) bank and replace with vegetation.
	Vegetation	Increase bank and floodplain vegetation to create adequate shade and a reasonable riparian buffer.
	Reduced Base Flow	Acquire instream flow via voluntary acquisition and water conservation projects
	Irrigation Return Flows	Investigate methods to reduce water temperature impacts caused by irrigation return flows (e.g. infiltration).
	General – Habitat Structure	Install anchored LWD or ELJs in appropriate locations.

DISCUSSION OF RECOMMENDED ACTIONS

Flood

1. ***Floodplain Regulations*** – FEMA maps should be updated or produced to establish an accurate floodplain and floodway for Manastash Creek (RM 0 to 12.5). These maps then should be used to prevent or limit development in high flood hazard areas.

Erosion

2. ***Bank Erosion*** – If the bank erosion is not threatening structures or is unlikely to progress into and take a significant portion of a parcel, let it progress. In these areas we recommend planting the floodplain landward of the erosion to slow the progression naturally. In areas where the erosion is a significant concern or threat, install appropriate countermeasures.

Habitat

3. ***Straight Reach*** – As stated previously, the channel reach between Barnes Road and the siphon was straightened 60 to 70 years ago, leaving it with little in the way of geomorphic complexity and therefore, little fish habitat. A design investigation which engages the

landowners should be conducted to identify and examine alternatives to increase complexity without causing an unacceptable increase to flood and erosion risk.

4. ***Concrete Rubble*** – The erosion potential is low along the majority of the right (south) bank that is covered with concrete rubble. Examine the bank and if appropriate, remove the rubble and replace it with vegetation.
5. ***Vegetation*** – Vegetation buffers on the stream bank and floodplain do not exist or are extremely narrow. Increase vegetation on the stream banks and floodplain.
6. ***Irrigation Return Flows*** – Investigate methods to reduce water temperature impacts caused by irrigation return flows (e.g. infiltration).

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. For purposes of evaluation and prioritization, the actions were grouped into 4 distinct projects in addition to a general flow restoration effort that applies to much of the lower project area. The table below summarizes these projects. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General-1	Instream flow restoration	17/20	KCCD	
3-1	Large scale revegetation of banks and cleared areas. Work with landowners throughout the reach to develop a revegetation strategy that benefits habitat in Manastash Creek and is acceptable to property owners aesthetically. Develop and implement plans to add roughness and complexity to existing bank armoring treatments to improve habitat.	12/20	KCCD	SRFB
3-2	Reconnect floodplain habitat on both banks	10/20	KCCD	SRFB
3-3	Restore channel and floodplain habitat at Westside Siphon crossing location when replaced/repaired	11/20	Westside Irrigation/ KCCD	SRFB

3-4	Conduct study to determine the feasibility/effectiveness of an infiltration or other facility to treat warm, silt laden return flows before they reenter Manastash Creek	8/20	KCCD	SRFB

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: 4. Serenity Lane Reach (RM 1.9 to 2.6)
PRIORITY RANK: High

SUB-REACH DESCRIPTION

Sub-Reach 4 includes approximately 0.8 miles of Manastash Creek, beginning upstream from the Westside siphon and extending to just beyond the private Serenity Lane bridge (see Figure 5). This reach is dry during portions of the irrigation season due to irrigation withdrawals upstream at the Reed diversion.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. Scour has partially undermined the footings of the Serenity Lane bridge.
2. Stream banks eroded both upstream and downstream from bridge during the May 2011 flood. The erosion exposed a residential power line upstream. Erosion upstream from bridge was influenced by significant sediment deposition.
3. Sediment and woody debris deposited on the left floodplain near RM 2.3 downstream from Serenity Lane during May 2011 flood.
4. Flooding during the May 2011 event on the left floodplain (RM 1.9 to 2.4) was partially due to overland flow that was redirected toward the creek by Hanson Road.
5. A driveway bridge near RM 2.1 constricts the floodplain. It sustained scour and erosion damage during the May 2011 flood.

Habitat Limitations:

1. Reduced base flow leads to dry channel conditions during summer months
2. Straightening of the channel downstream from the Serenity Lane bridge has altered the natural movement and deposition of sediment, which has in-turn altered in-channel gravel habitat features.
3. Berms limit flooding and therefore floodplain connectivity and fish refuge. They also impact sediment transport because they increase or concentrate flow energy.
4. In general this reach is incised which has reduced floodplain connectivity.
5. Lack of buffer vegetation along the stream in specific locations.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood	Serenity Lane Bridge	• Install temporary scour countermeasures to protect the foundations until a replacement bridge can be designed and

		installed. • Replace bridge with a longer, secure structure.
	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas.
Erosion	Bank Erosion at or near Serenity Lane Bridge	• Install temporary measures to prevent erosion from outflanking of existing bridge. • Modify right (south) bank upstream from bridge to remove in-channel spoil pile berm and protect power line. • When new bridge is installed, modify and protect banks as needed.
	Driveway Bridge	Seek to increase size of waterway to reduce velocities and install erosion protection as needed.
	General	Construct ELJs or re-vegetate to increase bank stability where appropriate.
Habitat	Stream Flow	Restore year-round stream flows.
	Straightened Channel Downstream from Serenity Lane	Restore channel complexity.
	Berms	Evaluate impact, modify or setback if appropriate.
	Bank Vegetation	Re-vegetate banks and floodplain where adequate buffers do not exist or are narrow.
	Habitat Structure	Install anchored LWD or boulder vanes in key locations to provide bank stability and habitat enhancement

DISCUSSION OF RECOMMENDED ACTIONS

Note – Landowner engagement and input will be critical for success.

Flood/Erosion

1. ***Serenity Lane Bridge –*** The Serenity Lane bridge has a major impact on channel form and function because it is too narrow. This causes sediment to deposit upstream which aggravates lateral bank erosion; flow is "throttled" through the bridge, which scours the streambed and causes the downstream banks to erode. The abutment foundations have been partially undermined and therefore the bridge is scour critical and interim countermeasures should be installed to protect the structure until a replacement crossing can be installed. Action should be taken immediately to develop a plan to secure funds to replace the bridge.
2. ***Floodplain Regulations*** – FEMA maps should be updated or produced to establish a defensible floodplain and floodway for Manastash Creek (RM 0 to 12.5). These maps then should be used to prevent or limit development in high flood hazard areas.
3. ***Bank Erosion*** – The exposed power line should be protected or moved. The existing protection on right (south) bank immediately upstream should be extended upstream to

reduce the potential for the stream to erode the bank and outflank the bridge. When a replacement bridge is installed, the banks of the channel upstream and downstream will need to be modified to accommodate a new bridge.

4. ***Driveway Bridge*** – The driveway bridge at RM 2.1 constricts the channel and was damaged during the May 2011 flood. This, along with numerous other driveway bridges along Manastash Creek, should eventually be modified or replaced to minimize their impact on channel processes and to reduce the likelihood that they will be damaged during floods. We are not suggesting that every landowner replace their driveway bridge, only that individually and collectively these bridges have a significant impact on the channel. Over the long term, it would be best if there was a plan to help landowners replace their bridges with longer and higher structures as the existing bridges reach the end of their useful lives.

Habitat

5. ***Stream Flow*** – Restore year-round flows to Manastash Creek in the "Dry Reach" which begins at the Reed Diversion (RM 4.9) and extends downstream to the Westside Irrigation Diversion (RM 1.7).
6. ***Straightened Channel*** – Consider restoring the straightened channel immediately downstream from Serenity Lane. This may include removing or setting the existing earthen berms back from the channel and restoring floodplain connectivity through benching. The potential benefits or impacts to hydraulics and sediment transport will need to be carefully considered before any significant channel modifications are made.
7. ***Berms*** - There are numerous independent spoil pile berms that border the channel along this reach. Each should be examined to determine its function, whether it adversely impacts stream morphology, and if it should be modified or set back from the channel.
8. ***Bank and Floodplain Vegetation*** – Vegetation buffers are important for both bank stability and habitat. Vegetation should be planted where there is no vegetation or where the buffers are too narrow.
9. ***Habitat Structure*** – Anchored LWD or boulder vanes should be installed where appropriate.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Update FEMA maps.
5. Complete design and permitting.
6. Purchase land or easements.
7. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. For purposes of evaluation and prioritization, the actions were grouped into 4 distinct projects in addition to a general flow restoration effort that applies to much of the lower project area. The table below summarizes these projects. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General-1	Instream flow restoration	17/20	KCCD	
4-1	Install bank habitat structures where appropriate to reduce property loss where Manastash Creek is eroding into confined valley walls/high banks and simultaneously improve habitat conditions. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk.	12/20	KCCD	SRFB
4-2	Remove or set back berms along reach where risk of erosion and flooding is not increased	7/20	KCCD	SRFB
4-3	Channel and floodplain restoration/ revegetation downstream of Serenity Lane crossing	13/20	KCCD	SRFB
4-4	Replace the Serenity Lane Bridge crossing with a hydraulically and geomorphically appropriate structure. Reconstruct channel to reduce flood/erosion problems and improve habitat. Install bank habitat structures where appropriate to reduce property loss where Manastash Creek is eroding banks and simultaneously improve habitat conditions. Bank protection measures should strive for short term stability until appropriate bank and floodplain vegetation can be reestablished. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk. Large scale revegetation of banks and cleared areas. Work with landowners throughout the reach to develop a revegetation strategy that benefits habitat in Manastash Creek and is acceptable to property owners aesthetically.	15/20	KRD/KCCD	SRFB

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: 5. Abandoned Dam Reach (RM 2.6 to 3.3)
PRIORITY RANK: Medium

SUB-REACH DESCRIPTION

Sub-reach 5 begins at the first driveway bridge upstream from Serenity Lane and continues 0.6 miles upstream (Figure 6). The reach contains and old, now abandoned, concrete irrigation diversion dam. The center portion of the dam was removed during the May 2011 flood. The reach downstream from the dam is deeply incised, likely due in-part to the retention of sediment upstream of the dam.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. Due in-part to the channel incision downstream from the abandon dam, flooding is not a major problem along the reach. There are several swales or channels on both the floodplain to the north and south that transport water during major floods. Homes located within the Serenity Lane development on the south floodplain were impacted by these flows during the May 2011 flood.
2. There are several areas where the banks are eroding, but none appear to threaten homes or structures.

Habitat Limitations:

1. Reduced base flow leads to dry channel conditions during summer months
2. The reach downstream from the abandoned dam is deeply incised which has reduced floodplain and side channel connectivity.
3. The incised reach also appears to have been straightened at some time in the past. This may have contributed to the incision.
4. There is a relatively long spoil pile berm along the left (north) bank downstream from the abandoned dam. This berm may also have contributed to channel incision by increasing flow intensity within the channel.
5. The first driveway bridge upstream from Serenity Lane appears to be large and high and therefore likely has little impact on the channel. The second driveway bridge upstream is to be narrower and likely constricts the channel.
6. Lack of healthy vegetation in areas along stream banks and floodplain buffer.
7. Lack of stable in-stream wood and spawning-sized substrate.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Site or Item	Potential Actions
Flood	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas.
	Incised Reach Downstream from Abandoned Dam	Conduct investigation to determine how the longitudinal stream profile will adjust in the future. If it will aggrade, the frequency and severity of flooding will increase on the adjacent floodplain.
	Entire Reach – Response to Cove Road Changes	If improvements are eventually made at the Cove Road Crossing upstream, and if these increase flows downstream, determine how the increased flows will influence flooding within the abandoned dam reach.
Erosion	General - Bank Erosion	Where appropriate, construct ELJs or re-vegetate to increase bank stability. However, do not prevent natural channel migration if it does not pose a threat to structures or other facilities.
Habitat	Side Channel Connectivity	Seek methods to reconnect and restore side channels. Do this in conjunction with the investigation recommended above that seeks to predict long term adjustments of the longitudinal stream bed profile.
	Stream Flow	Restore year-round stream flows.
	Spoil Pile Berms	Examine existing spoil pile berms to determine their impact on channel processes and therefore habitat. Determine if improvements or modifications can be made to reduce their impact (e.g. can they be set back from the edge of the channel?).
	Straighten Reach downstream from Abandon Dam	As part of the investigation recommended above, determine the impact that channel straightening has had on natural geomorphic processes. Determine if actions can be taken to restore channel complexity.
	Driveway Bridge	Typical of most existing driveway bridges along Manastash Creek, examine bridges to determine if improvements can be made to reduce impacts to the channel.
	Vegetation	Increase bank and floodplain vegetation in areas where buffers are thin or do not exist.
	General – Habitat Structure	Install anchored LWD or boulder vanes in appropriate locations.

DISCUSSION OF RECOMMENDED ACTIONS

Flood

1. ***Floodplain Regulations*** – FEMA maps should be updated or produced to establish an accurate floodplain and floodway for Manastash Creek (RM 0 to 12.5). These maps then should be used to prevent or limit development in high flood hazard areas.
2. ***Incised Reach Downstream of Abandon Dam –*** Now that the center portion of the Abandon Dam has been removed, it is likely that the longitudinal profile of the channel

downstream will begin to rise because coarse sediment transport will increase. Eventually the profile may return to pre-dam levels. If this occurs, the frequency and severity of flooding on the adjacent floodplain will increase. This will benefit fish, for it will naturally increase side channel connectivity.

3. ***Cove Road Improvements –*** see table above.

Habitat

1. ***Stream Flow*** – Restore year-round flows to Manastash Creek in the "Dry Reach" which begins at the Reed Diversion (RM 4.9) and extends downstream to the Westside Irrigation Diversion (RM 1.7).
2. ***Side Channel Connectivity*** – see comments in No. 2 above.
3. ***Spoil Pile Berms*** – Spoil pile berms located at the edge of a stream can impact natural geomorphic processes by increasing the discharge intensity within the channel. This can lead to scour and channel incision. Each berm along the reach should be examined to determine if it is impacting stream processes and if it does the landowner should be engaged to determine if the berm can be modified, removed or setback from the channel.
4. ***Straightened Channel*** – The reach downstream from the abandoned dam was likely straightened 60 to 70 years ago. As mentioned above, this straightening has altered the channel morphology and complexity. Methods should be identified to improve natural fluvial processes to allow the stream to create and sustain geomorphic features that improve habitat.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. For purposes of evaluation and prioritization, the actions were grouped into 2 distinct projects in addition to a general flow restoration effort that applies to much of the lower project area. The table below summarizes these projects. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)

General-1	Instream flow restoration	17/20	KCCD	
5-1	Assessment of driveway bridge improvements and possible berm modifications. Determine if actions can be taken to improve crossing security and flood protection while enhancing stream function. Remove or breach left bank berm to open access to forested floodplain areas. May need to build setback berm -- further study required. Large scale revegetation of banks and cleared areas. Work with landowners throughout the reach to develop a revegetation strategy that benefits habitat in Manastash Creek and is acceptable to property owners aesthetically.	13/20	KCCD	SRFB
5-2	Assess future channel profile adjustments downstream of removed diversion dam. Determine how will this affect flooding, erosion, and habitat. Determine need for removing abandoned diversion dam structure to restore stream function and improve fish passage. Reconnect historic side channels in the vegetated right bank floodplain.	10/20	KCCD	SRFB

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: 6. Anderson Diversion Reach (RM 3.3 to 3.85)
PRIORITY RANK: Medium

SUB-REACH DESCRIPTION

Sub-Reach 6 centers on the Anderson Diversion and KRD 13-8 bridge crossing, and extends from approximately River Mile (RM) 3.3 to RM 3.85 (see Figure 7). This reach is dry during portions of the irrigation season due to irrigation withdrawals upstream.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. Flooding within floodplain swales.
2. Erosion of channel banks at multiple locations due in-part to lack of healthy vegetation.
3. Erosion at the Anderson diversion and bridge.

Habitat Limitations:

1. Reduced base flow leads to dry channel conditions during summer months
2. Lack of healthy vegetation along stream banks and floodplain buffer.
3. Channel incision has reduced frequency of floodplain connectivity.
4. Lack of stable in-stream wood and spawning-sized substrate.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood	Floodplain	• Monitor and take action if needed to protect buildings or infrastructure. Treat on a case-by-case approach. • Consider the impact possible future changes to the Cove Road crossing may have on flooding along reach.
	Channel Profile	Inspect channel and conduct evaluation to determine how the longitudinal profile will adjust in the future in response to the recent demolition of the abandoned dam and possible future changes to the Cove Road crossing. Profile adjustments could affect flooding, bank erosion, and habitat.
Erosion	Anderson Diversion & KRD 13-8 Bridge	Inspect to determine if improvements should be made to reduce scour/erosion problems and improve habitat. Determine if reasonable to consider replacing existing crossing with longer structure. Decommission diversion structure.
	Channel Banks	Once year-round flows are returned to the stream, re-establish healthy vegetation buffer along all banks. Where needed to

		protect facilities or structures, construct engineered log jams (ELJs) or other appropriate countermeasures.
Habitat	Bank Vegetation	Once year-round flows are re-established, re-vegetate banks and floodplain as needed to create appropriate buffer.
	Stream Flow	Restore year-round stream flows.
	Existing Berms	Inspect to determine their function and whether they should be set back from the stream or modified.
	Habitat Structure	Install anchored LWD or boulder vanes in secure and appropriate locations.

DISCUSSION OF RECOMMENDED ACTIONS

Flood/Erosion

1. ***Flooding*** – Flooding has not been a major problem in this reach; however, increased flooding could eventually occur if actions are taken at Cove Road (upstream) that increase the amount of water passing under the bridge. This issue must be addressed when improvements for Cove Road are considered.
2. ***Channel Profile*** – The elevation of the channel profile may change in the future now that the abandoned dam has been partially demolished and actions may eventually be taken at the Cove Road crossing. If the elevation of the profile increases, flooding may become more frequent.
3. ***Anderson Diversion and Bridge*** — Examine the site to determine if actions should be taken to minimize future flood and erosion damage to the existing bridge/diversion and to improve natural stream function. It is our understanding that the irrigation district may be considering replacing the crossing and decommissioning the diversion. If true, replace it with a crossing that minimizes impacts to the channel, and restore channel at site of diversion.
4. ***Channel Bank Erosion*** – Due to upstream withdrawals, this reach does not contain water during the summer irrigation season. As a result, the existing vegetation is generally in poor health, the root network has been weakened, and therefore the banks are susceptible to erosion. Healthy bank vegetation is critical to long term bank stability and reduced sediment transport/deposition downstream.

Habitat

1. ***Stream Flow*** – Restore year-round flows to Manastash Creek in the "Dry Reach" which begins at the Reed Diversion (RM 4.9) and extends downstream to the Westside Irrigation Diversion (RM 1.7).
2. ***Bank Vegetation*** – In addition to No. 4 above, healthy buffer vegetation will improve habitat by increasing shade and the quantity/quality of wood that interacts with the stream.

3. ***Existing Berms –*** Two spoil pile berms are located along either side of the stream near the downstream end of the reach (RM 3.25). We recommend examining these to determine if they are having an adverse impact on stream function. If they are, work with the landowners to determine if they can be modified or set back to reduce the impact.

4. ***Habitat Structure –*** Installing secure LWD or boulder vanes at key locations along the creek margins to provide habitat and bank stabilization while vegetation is given a chance to establish.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. For purposes of evaluation and prioritization, the actions were grouped into 4 distinct projects in addition to a general flow restoration effort that applies to much of the lower project area. The table below summarizes these projects. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General-1	Instream flow restoration	17/20	KCCD	
6-4	Install stable streambank habitat structures	9/20	KCCD	SRFB
6-5	Revegetation of streambanks and riparian zone where needed	17/20	KCCD	SRFB
6-6	Decommission diversion structure; adjust and control channel grade; restore streambanks and revegetate project area	10/20	KCCD	SRFB
6-7	Widen channel crossing and restore bank/floodplain	11/20	KRD/KCCD	SRFB

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: 7. Cove Road Reach (RM 3.8 to 4.2)
PRIORITY RANK: High

SUB-REACH DESCRIPTION

Manastash Creek sub-reach 7 includes the area directly affected by facilities and maintenance activities in the vicinity of Cove Road (see Figure 8). During the May 2011 flood, a large portion of the flow escaped the channel at Cove Road and flowed down the floodplain via numerous historical swales. Most of this overland flow was eventually intercepted by Hanson Road and returned to Manastash Creek downstream of Serenity Lane.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. Channel capacity is reduced during floods because large quantities of sediment deposit within the reach.
2. Cove, Cedar Cove and Hanson roads along with numerous gravel driveways are overtopped by the overland flows. This damages the roads and driveways.
3. The water that overtops the roads and driveways poses a threat to public safety.
4. The home immediately upstream and north of Cove Road (parcel 435133) sits in a low lying area of the floodplain and is highly susceptible to flooding. It was severely damaged during the May 2011 flood. The three other properties that border the bridge (parcel 11052, 408433, and 955748) also flood, but few structures are affected.
5. Numerous fields and several structures located in or near floodplain historical swales flood.
6. The reach is bordered by spoil pile berms, several of which are very old and of unknown integrity.
7. Bank and floodplain erosion along the parcels that border the north channels edge both upstream and downstream north of the bridge.

Habitat Limitations:

1. Reduced base flow leads to dry channel conditions during summer months
2. Natural channel characteristics have been disturbed within the reach due to repeated channel excavation and the construction of spoil pile berms.
3. Existing spoil pile berms reduce floodplain connectivity and opportunities for fish refuge.
4. Lack of sufficient buffer vegetation along significant portions of the reach.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood	Cove Road Bridge	Conduct detailed hydraulic and sediment transport investigation to determine if the bridge should be replaced with a wider/higher crossing.
	Channel Sediment	Use the investigation above to determine if sediment management activities should be conducted, and develop a maintenance plan that will maximize flood protection and improve habitat.
	Properties Downstream from the Sub-Reach Located near the Stream	Use the investigation above to determine if proposed changes in the vicinity of Cove Road will increase flow rates downstream from the reach. If they will, determine if this is likely to cause flood/erosion/and sediment problems and recommend actions to minimize impacts. (Note -- this issue will need to be considered in the design of the Serenity Lane replacement bridge.)
	Properties Downstream from Cove Road Located on the Floodplain near Swales that Carry Overland Flow	Use the investigation above to estimate reduction in overland flow and the reduction in flood damages to roads and property.
	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas.
	Home on Parcel 435133	Seek grant to elevate home.
	Parcels 11052, 408433, and 955748 (parcels that border Cove Rd Bridge)	Use the investigation above to make sure proposed improvements will not adversely impact, or better reduce, flooding on these properties
	Berms	1. Examine berms along right (south) bank upstream from Cove Road. These are quite old and the level of protection they provide is unknown. Determine the potential consequences should they fail. 2. Determine if berms downstream from Cove Road can be removed or setback without increasing sediment deposition within the stream channel.
Erosion	Bank Erosion along parcels 435133 and 408433	Examine existing conditions and recommend countermeasures.
	Banks Leading to and from Bridge	If bridge is replaced, make sure stream banks leading to and from the bridge are appropriately configured and protected.
Habitat	Channel Sediment	Develop a long term plan to manage sediment. Seek to minimize impacts to channel.

	Stream Flow	Restore year-round stream flows.
	Berms	Evaluate impact, modify or setback if appropriate.
	Bank Vegetation	Re-vegetate banks and floodplain where adequate buffers do not exist or are too narrow. This may have to wait until year-round flows are returned to the stream.
	Habitat structures	Install anchored LWD or boulder vanes in key locations where appropriate.

DISCUSSION OF RECOMMENDED ACTIONS

Note – Landowner engagement and input will be critical for success.

Flood/Erosion

1. ***Cove Road Bridge, Sediment, Overland Flow, Berm, etc. –*** This reach of the channel fills with sediment during floods which greatly reduces the capacity of the channel and bridge waterway. In response, flood water leaves the channel, crosses Cove and Cedar Cove Roads and finds its way downstream via numerous historical floodplain swales. This flow can cause significant damage as it inundates and erodes properties, roads, and driveways. A comprehensive investigation is needed to find a long term solution which reduces flooding in the vicinity of Cove Road and improves habitat.
2. ***Floodplain Regulations*** – FEMA maps should be updated or produced to establish a defensible floodplain and floodway for Manastash Creek (RM 0 to 12.5). These maps should be used to prevent or limit development in high flood hazard areas.
3. ***Bank Erosion Protection*** – Sections of bank along Parcels 435133 and 408433 have eroded. These sites need to be examined to determine if countermeasures are required.

   If the bridge is eventually replaced, the banks leading to and from the new bridge will need to be protected to ensure that scour and erosion cannot impact the bridge abutments.

Habitat

1. ***Stream Flow*** – Restore year-round flows to Manastash Creek in the "Dry Reach" which begins at the Reed Diversion (RM 4.9) and extends downstream to the Westside Irrigation Diversion (RM 1.7).
2. ***Sediment –*** Managing sediment is the key to reducing flooding in the vicinity of Cove Road and in the downstream floodplain swales. A plan is needed to allow sediment management activities to be performed in a manner that minimizes impacts to the channel and therefore habitat.
3. ***Berms -*** Each berm should be examined to determine if it provides significant flood protection, is structurally sound, and whether it impacts stream function. Ultimately, recommendations should be made to modify the berm if flood protection and/or habitat conditions can be improved.
4. ***Bank and Floodplain Vegetation*** – Vegetation buffers are important for both bank stability and habitat. Vegetation should be planted where there is no vegetation or where the

buffers are too narrow. This may need to wait until year-round flows are returned to the stream.

5. ***Habitat Structure*** – Anchored LWD or boulder vanes should be installed where appropriate.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete hydraulic / sediment investigation
5. Agree to a plan.
6. Complete design and permitting.
7. Purchase land or easements if needed.
8. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. The table below summarizes these actions. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General-1	Instream flow restoration	17/20	KCCD	
7-1	Develop comprehensive solution to manage sediment, minimize flooding, and restore channel and floodplain health. Flood Protection for Cove Road Residents -- berms, structure elevation, buyouts, etc. Replace or Modify Cove Road Bridge with hydraulically and geomorphically appropriate crossing. Install bank habitat structures where appropriate to reduce property loss where Manastash Creek is eroding banks and simultaneously improve habitat conditions. Bank protection measures should strive for short term stability until appropriate bank and floodplain vegetation can be reestablished. Perform hydraulic modeling and geomorphic	16/20	Kittitas County PW/ KCCD	KCFZD/ SRFB

	analysis to ensure that structures do not increase flood risk. Large scale revegetation of banks and cleared areas. Work with landowners throughout the reach to develop a revegetation strategy that benefits habitat in Manastash Creek and is acceptable to property owners aesthetically.			

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: **8. Upstream Cove Road to Downstream Reed Diversion Reach (RM 4.2 to 4.9)**
PRIORITY RANK: **Medium**

SUB-REACH DESCRIPTION

Sub-Reach 8 is the 0.7 mile long section of Manastash Creek that lies between the Cove Road and Reed Diversion reaches (see Figure 9). The reach is characterized by a relatively straight channel that flows through coarse porous stream and glacial alluvium. In its natural state, it appears that trees thrived on the banks of the stream but did not cover the floodplain. Floodplain vegetation was and continues to be mostly drought tolerant sagebrush type species. For more than 40 years, the reach typically has not carried flow during the late summer irrigation season due to withdrawals upstream at several diversions. In response, many of the trees on the stream banks have either died or are in poor health. This has left the banks vulnerable to erosion for the tree roots help to bind the bank material together and the trees themselves create roughness which reduces velocities along the bank. During the May 2011 flood, significant lateral erosion occurred within the reach and the eroded material was the primary source of sediment that deposited within the Cove Road reach downstream.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. The channel is quite large and has significant capacity and therefore flooding is not a major concern on the adjacent floodplain.
2. Erosion of channel banks is a significant issue; fortunately, most (but not all) homes and structures are setback from the edge of the channel.

Habitat Limitations:

1. Reduced base flow leads to dry channel conditions during summer months
2. Lack of healthy vegetation along the banks of the stream.
3. Lack of stable in-stream wood and spawning-sized substrate.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood	Floodplain	Determine if flooding will increase on the floodplain if future channel improvements are made upstream (e.g. removal of Reed Dam). If they will, take action to mitigate impacts.
	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas.
Erosion	Channel Banks (general)	Once year-round flows are returned to the stream, re-establish

		healthy vegetation buffer along all banks. Where needed to protect facilities or structures, construct engineered log jams (ELJs) or other appropriate countermeasures.
	Parcel 485133 and 355133	Bank erosion has progressed to the point that it is beginning to become a concern for the home on these parcels. Use engineered log jams (ELJs) or other appropriate countermeasures to prevent additional lateral migration of the channel toward homes.
	Sediment (general)	Consider methods to manage sediment within the reach so that less is transported downstream to Cove Road.
Habitat	Stream Flow	Restore year-round stream flows.
	Bank and Floodplain Vegetation	Vegetate channel banks, and to the extent possible the floodplain next to the stream once year-round flows are reestablished.
	Habitat Structure	Install anchored LWD or boulder vanes in secure and appropriate locations

DISCUSSION OF RECOMMENDED ACTIONS

Flood/Erosion

1. ***Flooding*** – The channel through this reach is quite large and therefore, flooding on the adjacent floodplain is not a significant concern. If actions are taken upstream that would direct more flow into this reach during floods, the potential flood and erosion impacts will need to be evaluated and actions may be necessary to protect homes and property that border the channel. Specifically, this issue will need to be considered when the Reed Diversion dam is removed. The dam has caused the channel upstream from it to fill with sediment which has reduced the channel's ability to convey flow downstream to this subreach. If capacity is restored to the reach upstream from the dam, more flow will be conveyed downstream to this sub-reach.
2. ***Channel Bank Erosion and Sediment*** – It is very important reestablish a healthy vegetation buffer on the banks of the channel within this reach. This will not only help to limit lateral channel movement, but more important will reduce the amount of sediment that is conveyed to and deposited at Cove Road. As part of the Cove Road sediment management plan, actions should be considered in this sub-reach that would further reduce the amount of sediment delivered to Cove Road during a major flood. For example, it may be possible to force sediment to deposit in this reach by flattening the profile by meandering the channel.

Habitat

1. ***Stream Flow*** – Restore year-round flows to Manastash Creek in the "Dry Reach" which begins at the Reed Diversion (RM 4.9) and extends downstream to the Westside Irrigation Diversion (RM 1.7).

2. ***Bank Vegetation*** – Healthy buffer vegetation will improve habitat by increasing shade and the quantity/quality of wood that interacts with the stream. It is unlikely that a vegetation buffer can be established on the floodplain because the ground is so porous and therefore ground water levels are likely well below the surface. Historical aerial photographs of the reach indicate that there was not a significant natural floodplain vegetation buffer.
3. ***Habitat Structures –*** Installing secure LWD or ELJ structures at key locations along the creek margins to provide habitat and bank stabilization while vegetation is given a chance to establish. Boulder structures could be used as an alternative, but may create less complex habitat in stream.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. For purposes of evaluation and prioritization, the actions were grouped into 2 distinct projects. The table below summarizes these projects. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General-1	Instream flow restoration	17/20	KCCD	
8-1	Evaluate benefit / impact of existing berm along right bank and modify to improve flood protection and habitat if needed. Install bank habitat structures where appropriate to reduce property loss where Manastash Creek is eroding banks and simultaneously improve habitat conditions. Bank protection measures should strive for short term stability until appropriate bank and floodplain vegetation can be reestablished. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not	17/20	KCCD	SRFB

	increase flood risk. Large scale revegetation of banks and cleared areas. Work with landowners throughout the reach to develop a revegetation strategy that benefits habitat in Manastash Creek and is acceptable to proprty owners aesthetically.			
8-2	Install instream habitat structures where appropriate. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk.	11/20	KCCD	SRFB

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: 9. Reed Diversion Reach (RM 4.9 to 5.2)
PRIORITY RANK: Medium

SUB-REACH DESCRIPTION

Sub-Reach 9 centers on the Reed Diversion Dam and includes a 0.1-mile long incised reach downstream and a 0.2-mile aggraded reach upstream (see Figure 10). The reach downstream is deeply incised because the dam cutoff the natural supply of coarse sediment. The reach upstream has aggraded or filled with sediment because coarse sediment has been retained by the dam.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. Flooding is a significant concern on both the left (north) and right (south) floodplains upstream from the Reed Diversion Dam.
2. Lateral erosion of the channel banks is not a significant issue along this reach.
3. Channel incision downstream from the dam has been significant and changes will occur once the dam is removed.

Habitat Limitations:

1. Reduced base flow leads to dry channel conditions during summer months
2. Bank vegetation is generally healthy along this reach.
3. Channel incision downstream from the Reed Diversion Dam has reduced connectivity to the floodplain.
4. Spoil pile berms line the channel upstream from the Reed Diversion Dam. These reduce floodplain connectivity.
5. Lack of stable in-stream wood and spawning-sized substrate.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood and Erosion	General	As part of the Reed Diversion removal plan, conduct an evaluation to determine how the longitudinal profile will adjust in response to the removal of the dam. Profile adjustments will affect flooding, bank erosion, and habitat. Engineer a solution to control profile adjustments so that habitat will be maximized and flood/erosion will be minimized.
	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas.

Habitat	Bank Vegetation	Once year-round flows are re-established, re-vegetate channel banks.
	Stream Flow	Restore year-round stream flows.
	Floodplain Connectivity	As part of the Reed Diversion Dam removal plan, carefully consider how the profile will adjust once the dam is removed to determine how floodplain function and connectivity may benefit or be impacted.
	Existing Spoil Pile Berms	Inspect to determine their function and whether they can be removed or setback from the stream or modified.
	Habitat Structures	Install anchored LWD or boulder vanes in secure and appropriate locations

DISCUSSION OF RECOMMENDED ACTIONS

Flood/Erosion

1. ***Flooding*** – Because sediment has filled the 0.2 mile reach upstream from the Reed Dam, the channel has very little capacity to contain flood flows. During large floods water overtops both banks, with the most significant flooding along the right (south) bank. The water that leaves the channel floods a large area of the floodplain, then finds its way into a historical swale that transports the flow downstream. This flow does not rejoin the mainstem until it reaches the abandoned dam and Serenity Lane areas. Flows in this swale damaged a number of structures and driveways during the May 2011 flood. Flows that leave the channel along the left (north) bank, generally flood areas adjacent to the Reed Diversion ditch. It is our understanding that these flows did not cause significant damage to homes or structures during the May 2011 flood, but did damage driveways. Ultimately this water is intercepted by Hanson Road where in May 2011 it joined other overflows and together they caused significant erosion damage to the road.
2. ***Channel Profile and Flooding*** – Changes to the channel profile will have to be carefully evaluated and considered as part of the Reed Dam removal project. Once the dam is removed, the channel profile will adjust. It may not be in the best interest from either a flood or habitat perspective to allow uncontrolled adjustments, for deep incision would progress upstream which would severely damage existing high quality habitat, floodplain connectivity, and channel stability. However, a controlled profile adjustment may improve both habitat and reduce flooding. Allowing the upstream channel to degrade one or two feet to reestablish pre-dam natural bed levels should be considered.

Habitat

1. ***Stream Flow*** – Restore year-round flows to Manastash Creek in the "Dry Reach" which begins at the Reed Diversion (RM 4.9) and extends downstream to the Westside Irrigation Diversion (RM 1.7).
2. ***Bank Vegetation*** – Plant additional vegetation in areas where the vegetated buffer is thin or has been removed.

3. ***Floodplain Connectivity*** – As part of the Reed Diversion Dam removal project, consider how the incised reach downstream from the dam will adjust. Seek to restore the natural profile so that the stream will reconnect with its floodplain
4. ***Existing Berms –*** A spoil pile berm is located along the left (north) side of the stream just upstream from the dam. The sediments were likely dredged from the channel to improve flow conveyance to the Reed Diversion. We recommend examining the berm to determine if it can be removed, modified, or setback from the stream to improve floodplain connectivity.
5. ***Habitat Structure –*** Installing secure LWD or boulder vanes at key locations along the creek margins to provide habitat and bank stabilization while vegetation is given a chance to establish

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. The table below summarizes these actions. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General-1	Instream flow restoration	17/20	KCCD	
9-1	Restore upstream fish passage for all life history stages at the Reed Diversion by removing structure. Predict channel response to dam removal - take action needed to prevent adverse impacts to flooding and habitat Install series of grade control weirs to prevent significant upstream channel incision once dam is removed and restore streambanks	14/20	KCCD	SRFB

	Enhance habitat within the Reed Ditch and ensure that fish stranding does not occur following the irrigation season Revegetate banks and cleared areas upstream of the Reed Diversion. Work with landowners throughout the reach to develop a revegetation strategy that benefits habitat in Manastash Creek and is acceptable to property owners aesthetically.			

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: 10. Natural Reach (RM 5.2 to 5.5)
PRIORITY RANK: High

SUB-REACH DESCRIPTION

Sub-Reach 10 is a 0.3 mile reach that appears to be in very good condition. It has excellent habitat and few significant flooding problems (see Figure 11).

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. No significant flood or erosion problems.

Habitat Limitations:

1. No significant limitations.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood, Erosion and Habitat	Entire Reach	Preserve in current condition. If necessary consider purchasing a conservation easement from the existing landowners.
	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas.
	Hatfield Diversion	Remove

DISCUSSION OF RECOMMENDED ACTIONS

Flood and Habitat

1. This is the only reach within the lower six miles of the stream that appears to be in a relatively natural state. Habitat appears to be in excellent condition, and there are no significant flooding problems. This reach should be preserved.
2. The Hatfield Diversion structure should be removed once diversion consolidation activities are complete.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.

5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. The table below summarizes these actions. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
10-1	Protect quality habitat from future impact. Pursue conservation easements to preserve existing high quality habitat. Remove remainder of Hatfield Diversion. Install necessary fish barrier to prevent fish loss down the abandoned Hatfield Ditch.	15/20	KCCD	SRFB

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: 11. KRD South Branch Road Reach (RM 5.5 to 5.7)
PRIORITY RANK: High

SUB-REACH DESCRIPTION

Sub-Reach 11 is a 0.2 mile long reach that includes the KRD South Branch Road crossing, a KRD canal flow return, a significant levee and a short reach that appears to contain excellent habitat (see Figure 11).

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. The KRD South Branch Road bridge is narrow and should be enlarged.
2. The levee upstream from the KRD South Branch Road overtops during large floods.
3. The KRD South Branch road is damaged when water flows over the road after the levee is overtopped upstream.
4. There are no active erosion problems.

Habitat Limitations:

1. The KRD South Branch Road bridge is narrow and includes a concrete apron on the channel floor.
2. The leveed reach upstream of the bridge was scoured clean during the May 2011 flood. The channel floor degraded 12 to 18 inches during the flood. As a result it has no significant channel complexity (i.e. pools, riffles, woody debris, etc.) and therefore, habitat conditions are poor.
3. The vegetation buffer along the right (south) bank upstream from the bridge is thin due to the presence of the levee and the adjacent pasture.
4. Irrigation water discharged into the stream at MWDA spill elevates stream water temperature in the hot summer months.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood and Erosion	KRD Bridge and Road	Replace KRD South Branch Road bridge with longer structure to improve conveyance. Modify road to accommodate new bridge.
	Levee	Consider setting the existing levee back from the stream to increase channel conveyance. Do this in conjunction with replacement of the KRD bridge.
	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate

		development in the high flood hazard areas.
Habitat	KRD South Branch Road Bridge	Remove concrete apron when a new crossing is installed.
	Levee	Setback the levee to reduce channel velocities so that the stream bed will not scour during floods.
	Habitat Structure	If the levee is setback restore channel complexity by installing anchored LWD or boulder vanes in secure and appropriate locations
	Vegetation	Increase vegetation on the right (south) bank. If the levee is setback, plant the floodplain bench between the stream and levee.
	Irrigation Return Flows	Investigate methods to reduce water temperature impacts caused by irrigation return flows (e.g. infiltration).

DISCUSSION OF RECOMMENDED ACTIONS

Flood/Erosion

1. ***KRD Bridge and Levee***– The KRD South Branch Road bridge is too narrow and the levee immediately upstream is too close to the stream. Combined these cause velocities to increase significantly during floods, causing the bed to scour.

   The levee overtops during major floods which allows water to flow across the floodplain and over the KRD gravel road.

   We recommend working with the KRD and the landowners to seek a comprehensive solution that would reduce flooding and improve habitat. Key components would include a new bridge and setting the existing levee back from the stream.

Habitat

1. ***KRD Bridge*** -- The concrete lining on the channel floor under the bridge adversely impacts natural fluvial processes.
2. ***Levee***– As noted previously, habitat conditions within the channel along the levee reach are poor. Consider setting the levee back from the edge of the channel to reduce and to restore natural fluvial processes.
3. ***Habitat Structure***-- If the levee is setback, restore channel complexity and fluvial processes within the existing channel by installing LWD or boulder vanes in secure and appropriate locations.
4. ***Bank Vegetation*** – If the levee is setback, restore a cottonwood gallery forest on the floodplain bench that would exist between the toe of the levee and the channel bank.
5. ***Irrigation Return Flows*** – see table above.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.

3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. The table below summarizes these actions. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
11-1	Replace or Modify KRD South Branch Road Crossing with a longer bridge (larger waterway) and armor road shoulder Assess impact of MDWA spill Remove or set back levee/access road on right bank to improve flood storage and enhance FP connectivity. Revegetate streambank and pasture areas on right bank if levees are set back. Install bank habitat structures where appropriate to replace current bank armoring and simultaneously improve habitat conditions. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk.	9/20	KRD, KCCD	

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Hazard Reduction

SUB-REACH: 12. Keach-Jensen to Manastash Road Bridge (RM 5.7 to 6.2)
PRIORITY RANK: High

SUB-REACH DESCRIPTION

Sub-Reach 12 begins at the Keach-Jenson Diversion and extends upstream 0.5 miles to the Manastash Road bridge (Figure 13). This reach is highly prone to flooding, sediment deposition, and lateral channel movement.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. As shown in Figure 1, the majority of the valley floor was inundated during the May 2011 flood and several homes were flooded.
2. Lateral channel movement and local bank erosion are concerns for all parcels. All experienced some form of erosion during the May 2011 flood.
3. Sediment deposition is and will continue to be a significant issue particularly on the three or four most upstream parcels. Sediment deposition initiated most of the lateral erosion that occurred during the May 2011 flood. Sediment deposits in this reach because: 1) the channel slope flattens approximately 20% and the valley expands as the stream leaves the narrow confines of the upstream reach; 2) the reach upstream from the bridge is narrow and therefore sediment tends to be transported through it rather than deposit.

Habitat Limitations:

1. Due to the natural sediment deposition characteristics within this reach, there are numerous historic channel scars and wetlands, several of which have been impacted by human activities such as grading, site development, or pond excavation.
2. A healthy stream bank vegetation buffer is absent in places.
3. Channel is confined at Manastash Road crossing and by revetments in reach.
4. Lack of LWD and spawning-sized substrate.

SUMMARY OF RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood	Floodplain Development Regulations	Refine FEMA floodplain and floodway boundaries to establish new defensible maps. Use these maps to regulate future development and structure improvements.
	Existing Homes within Floodway	Elevate homes if allowed under County Code; move homes out of floodway if possible; purchase existing homes when owners are ready to move then remove structures and convert to

		conservation land.
	Keach Jensen and MWDA Diversions	Examine flooding risk and consider measures to protect facilities.
Erosion	All Properties	Stabilize banks as needed to protect existing structures and high value land. Use methods that minimize impacts to habitat. Long term, seek to purchase properties and allow the stream to migrate freely. Highest priority parcels are those that are likely to see significant sediment deposition (three or four upstream most parcels).
	Private Bridge and Revetment on Parcel 175133	Monitor condition of existing revetment and bridge
Habitat	Wetlands on Parcels 235133, 055133, and 17936	Long term seek to purchase properties then restore wetlands and floodplains in a manner that allows natural hydraulic and fluvial process to maintain function
	MWD Diversion	Solve existing sediment deposition problem in the diversion intake.
	Bank Vegetation	Re-vegetate banks where buffers do not exist or are narrow
	Habitat Structure	Install anchored LWD or boulder vanes in key locations

DISCUSSION OF RECOMMENDED ACTIONS

Flood/Erosion

1. **Floodplain Development Regulations** – Kittitas County is a member of the National Flood Insurance Program (NFIP) and as such its citizens are allowed to purchase federally backed flood insurance. As a member of the NFIP, the County must uphold specific floodplain development regulations mandated by the Federal Emergency Management Agency. One rule is that structures cannot be built within a designated FEMA Floodway unless it can be demonstrated that the structure will have no impact on base flood elevations (BFE), which is the level of the 100-year flood. Existing structures that were present before the FEMA floodway was mapped can remain, but they cannot be modified unless it is shown that the proposed changes will not cause BFEs to rise. If a structure is substantially damaged (by flood, fire, landslide, etc.), it cannot be rebuilt within the designated floodway. Since nearly all of the homes within this reach are located within the mapped floodway, and because new LiDAR topographic data are available, we recommend updating the floodplain and floodway boundaries to ensure that they are correct and defensible. Refining the FEMA map would require a hydraulic investigation which would include the development of a simple hydraulic computer model of the reach.
2. **Existing Homes within Floodway –** For resident safety, preventing potential catastrophic monetary loss, and long term habitat health, it is our recommendation that a long term strategy be developed to remove structures from the floodway. The highest priority properties are those where significant sediment tends to deposit (Parcels 035133, 235133,

055133 and 17936). It is our understanding that steps have been taken by the County to determine if grant funds can be obtained to purchase parcel 035133, which is currently for sale. We are NOT suggesting that residents be forced to move, rather alternatives should be presented and discussed with the property owners which may include property purchase at such a time as they are ready to move.

3. **MWDA and Keach Jensen Diversion –** Both the MWDA and Keach Jensen diversion facilities flooded in May 2011. Determine if flood protection countermeasures should be installed.
4. **MWDA Diversion –** Coarse sediment deposits within the inlet to the diversion. Develop solution to prevent this deposition.

Habitat

1. **Wetlands –** A large wetland complex exists on the north side of Parcels 235133, 055133, and 17936 properties. This is a valuable habitat feature which should be preserved and enhanced.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee
2. Conduct detailed site inspection and meet with landowners
3. Update the FEMA floodplain and floodway maps for this reach.
4. Develop long term strategy and vision for reach in cooperation with the landowners.
5. Seek grants to for easement or land purchases, flood protection, structure relocation, stream and wetland restoration design, implementation/construction and post project monitoring.
6. Implement actions/strategy.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. For purposes of evaluation and prioritization, the actions were grouped into 2 distinct projects. The table below summarizes these projects. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
12-1	Consider measures to reduce flooding at Keach Jenson and MWDA diversion facilities; improvement of crossings and riprap embankments; install measures to discourage sedimentation at diversion inlets	10/20	KCCD	
12-2	Flood-Proof, Elevate or Protect Homes. Property owners in this area report regular and	10/20	Kittitas County	KCFZD/ SRFB

	significant problems with flooding, sedimentation, and ice jams. Consider purchasing the property at a fair price and restoring the area. Associated building/structure removal and floodplain restoration should be included. Revegetation of banks, floodplain areas, and cleared areas throughout the reach, especially on right bank along residential properties. Work with landowners throughout the reach to develop a re-vegetation strategy that benefits habitat in Manastash Creek and is acceptable to property owners aesthetically.		PW/ KCCD	

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: 13. Manastash Bridge Confined Reach (RM 6.2 to 6.6)
PRIORITY RANK: Low

SUB-REACH DESCRIPTION

Sub-Reach 13 begins at the Manastash Road bridge near the mouth of the canyon and extends 0.4 miles upstream. Within the downstream 0.2 miles the channel is confined to a narrow corridor by the County Road (see Figure 14). Within the upstream 0.2 miles the canyon widens and neither the County Road nor Canyon walls constrict the channel.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. Flooding is generally not a major problem within this reach, with the exception of Parcel 028136 which is located just downstream from the bridge on the left (north) bank.
2. Erosion is a significant concern. The channel is eroding the bank along the County Road in three locations. The existing riprap revetments at these sites are too steep and likely will be damaged or fail during future floods.
3. Logs with root wads project from the rock revetment that protects the County Road at the downstream erosion site. The logs project too far into the channel and are likely to catch debris and create log jams. This could have serious unintended consequences on flooding and erosion.

Habitat Limitations:

1. The lower 0.2 miles of the channel is artificially confined to a narrow "chute" by the County Road. There is little to no habitat complexity within this reach.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas.
	Home on Parcel 028136	Determine if the May 2011 flood inundated the home. If yes, determine best method to flood proof structure.
Erosion	Three Erosion Sites along County Road	• At the two upstream sites reconstruct the rock revetments on a flatter slope and add a buried toe key. • At the downstream site there is no obvious cost effective solution due to limited room. The greatest benefit would be to set the road back from the stream channel, but this is not a reasonable alternative at this time.

	LWD along County Road Revetment downstream site	Cut off the logs. If mitigation is required, replace with LWD at or near the two erosion sites upstream.
Habitat	0.2 mile Confined Reach	The only meaningful solution to improve habitat within this reach would be to move the County Road away from the stream. This is not a practical solution at this time.

DISCUSSION OF RECOMMENDED ACTIONS

Flood/Erosion

1. ***Homes*** – Within the downstream 0.2 miles there are four homes located on parcels north of the road. These parcels would flood if it were not for the County Road. The road is elevated on fill which prevents water from flooding the properties (with the exception of the home immediately downstream from the bridge). Near the upstream end of this confined reach the road is only elevated about one foot above the floodplain, so it is possible that water could overtop the road at this location and flow through all four of these properties during a major flood. It is unknown if this occurred during the May 2011 flood. Within the upstream 0.2 miles there is one developed parcel that may experience flooding during major events.
2. ***Three Erosion Sites*** – At all three sites the rock revetments are too steep and do not appear to contain an adequate rock toe. It is likely that all three revetments will be damaged during future large floods. The County should work with WDFW to reconstruct the revetments at the two upstream sites because these sites have adequate room to place the revetments on a flatter slope and to construct an adequate toe key. There isn't much that can be done at the downstream site with the road being so close to the stream. The best solution would be to move the road away from the stream, but this is an unrealistic alternative at this time for it would require purchase of the parcels to the north and major capital investment to physically move the road.
3. ***LWD Embedded in Rock Revetment*** – Several logs with root wads extend into the channel from the riprap revetment that protects the County Road within the confined reach at RM 6.3. These logs were installed as part of the recent revetment project. The logs present a serious hazard for they extend too far into the channel and will catch debris. This could aggravate flooding and poses a serious threat to the stability of the revetment. The logs should be cut off and if mitigation is necessary, securely anchored logs should be installed at a different and more appropriate location. The reach needs complexity; however, until the road can be moved away from the channel, wood should not be installed within this reach unless it can be done a manner that does not pose a hazard or risk.

Habitat

1. ***0.2 Mile Confined Reach*** – The only meaningful solution is to move the County Road away from the channel. This would be prohibitively expensive and not at all well received by landowners for at least three of the four parcels north of the road would have to be

purchased. It is our opinion that time and money would be far better spent pursuing other meaningful actions within other reaches of Manastash Creek.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. The table below summarizes these actions. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General -2	Address localized bank erosion that is threatening infastructure on an as-needed basis. Install bank habitat structures where appropriate to replace current bank armoring and simultaneously improve habitat conditions. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk. Flood-Proof, Elevate or Protect Homes.	8/20		
13-1	Modify existing bank protection LWD to prevent debris collection to ensure road protection.	9/20	Kittitas County PW	

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: **15. North Fork Manastash Creek (RM 8.9 to 9.5)**
PRIORITY RANK: **Medium**

SUB-REACH DESCRIPTION

Sub-Reach 15 includes the North Fork of Manatash Creek from its confluence with the mainstream to approximately 350 feet upstream from the Manastash Road crossing (see Figure 16). This reach of the stream flows down an alluvial fan that the North Fork has created on the floodplain of the main stem.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. The County Road and the parcel upstream/north of the road were severely damaged during the May 2011.
2. Earthen flood reduction berms parallel both banks of the channel downstream from the road and the left (east) bank upstream (see Figure 16).

Habitat Limitations:

3. The reach bordered by the berms is essentially a swift chute that has no significant channel complexity (i.e. pools, riffles, woody debris, etc.) and therefore, habitat conditions are poor.
4. The berms are located at the edge of the channel and cutoff the natural connection to the historical floodplain.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood	Crossing	Replace existing culvert crossing with a larger culvert or bridge.
	Berms	Construct floodplain bench to reduce confinement (see cautionary notes below).
Erosion	Berm Upstream	The upstream berm is critical to protecting the parcel to the east and the County Road.
Habitat	Berms	• Determine if the downstream berms are needed and remove or setback if possible (see cautionary notes below). • Setback the upstream berm to the extent possible without having to remove the cottonwood trees that cover the adjacent floodplain.

DISCUSSION OF RECOMMENDED ACTIONS

Flood/Erosion

1. ***Replace Crossing*** – The County has initiated a design study to develop plans to replace the existing seven-foot wide CMP culvert with a bridge. Construction will likely occur in 2014 or 2015 depending upon the availability of capital funds and permit requirements.
2. ***Upstream Berm Modifications*** – As part of the crossing replacement, the County plans to modify the upstream berm to reduce its impact on the stream.

Habitat

1. ***Berms -*** The upstream berm will be modified as part of the crossing replacement, but the downstream berms will not, other than to refine how they tie in to the new bridge waterway. If there is sufficient concern over the berms and their impact on channel processes, a detailed hydraulic and sediment investigation will need to be conducted. Due the confinement provided by the berms, the reach is a very efficient conveyor or sediment. Removing or setting the berms back from the channel may cause sediment to deposit in the vicinity of the bridge, which could create the need to conduct sediment management activities in the vicinity of the road to keep the bridge waterway open. This should be avoided.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. The table below summarizes these actions. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General -2	Address localized bank erosion that is threatening infastructure on an as-needed basis. Install bank habitat structures where appropriate to replace current bank armoring	8/20		

	and simultaneously improve habitat conditions. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk. Flood-Proof, Elevate or Protect Homes.			
15-1	Replace Manastash Road crossing over N.F. Manastash Creek; armor ditch and embankment; remove existing berms; develop sediment management plan	14/20	Kittitas County PW	

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: **16. County Road Reach (RM 9.8 to 10.3)**
PRIORITY RANK: **High**

SUB-REACH DESCRIPTION

Sub-reach 16 includes approximately 0.4 miles of Manastash Creek near River Mile 10 (see Figure 17). The reach passes through two private parcels and land owned by the Washington State Department of Fish and Wildlife (WDFW). Approximately one-half of the reach was straightened many years ago to maximize productive crop/range land and to accommodate the county road.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. Flooding of home/ranch buildings and lateral erosion that threatens a historic working barn.
2. Flooding of the County road and recurring damage to the revetment that protects the road.
3. Possible partial obstruction to the down-valley movement of water on the floodplain by an old, slightly elevated, driveway fill that crosses the floodplain on WDFW property.
4. Constriction of the channel and possible erosion risk at two driveway bridges.

Habitat Limitations:

1. The channel is confined to a straight reach along the County road, and is bounded by riprap protection along the road on the left (north) bank and a berm on the right bank that limits flooding of range land to the south.
2. The straightening of the channel has impacted sediment movement and therefore impacted natural in-channel geomorphic features such as riffles, pools, etc.
3. Lack of buffer vegetation along the stream in specific locations.
4. Small bridges cross Manastash Creek at many locations within Manastash Canyon, confining the channel and disconnecting the creek from the floodplain.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas.
	Parcel 950623	Investigate and implement appropriate methods to limit flood inundation damage to home and ranch buildings.
	County Road	Eliminate confinement by removing berm along right (south) bank and relocate channel to forested area.
	Old Driveway Road Fill	Determine if it impacts flooding. If it does, consider alternatives

		to minimize impact.
Erosion	County Road	Relocate stream away from road and reconstruct rock revetment on a flatter slope so that it is more secure.
	Parcel 950623	Install bank protection features to prevent additional migration toward buildings. Use methods that include LWD.
	Driveway Bridges	Inspect bridges to determine their impact on the stream and the condition of the abutments. If bridge abutments have been damaged, work with landowners to repair/protect. Long term seek to improve or replace crossings to minimize their impact to stream processes.
Habitat	Straightened Reach	Move channel away from county road into forested floodplain to the south. Restore natural geomorphic characteristics.
	Bridges	Evaluate potential to modify or remove driveway and private road bridges throughout the reach to improve flood/erosion protection and fluvial stream processes.
	Bank Vegetation	Re-vegetate banks where buffers do not exist or are narrow

DISCUSSION OF RECOMMENDED ACTIONS

Flood/Erosion

1. ***Home and Building*** –– Work with landowner (and WDFW) to determine best course of action.
2. ***County Road Protection and Habitat Restoration*** – Work with landowners to determine if it would be possible to purchase easements to relocated the stream to the forested floodplain. In doing so, restore the natural planform and fluvial characteristics of the channel.

   Improve the durability of the revetment along the road by placing it on a flatter slope and constructing a rock toe that is keyed into the ground. If necessary, build setback berm along south bank to provide security and protection for adjacent range land.
3. ***Old Driveway*** – Inspect driveway to determine if it aggravates flooding and/or inhibits natural fluvial processes. If it is an obstruction, and if WDFW is supportive, consider removing portions of the old road fill.
4. ***Driveway Bridges*** -- Inspect to determine if actions are required. During the inspection meet with landowners to discuss their needs, concerns, and desires.

Habitat

5. ***County Road*** – See No. 2 above.
6. ***Bank Vegetation*** – Conduct detailed site inspection and engage with landowners to determine where vegetation can and should be planted to create a healthy forested buffer along the stream.

7. ***Bridges*** – Evaluate bridge crossings to determine feasibility of removal or modification to reduce confinement and improve floodplain connectivity.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Meet with the landowners and if they are agreeable, conduct detailed site inspection.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. For purposes of evaluation and prioritization, the actions were grouped into 2 distinct projects. The table below summarizes these projects. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General -2	Evaluate potential to modify or remove driveway and private road bridges throughout the reach to improve flood/erosion protection and fluvial stream processes. Address localized bank erosion that is threatening infastructure on an as-needed basis. Install bank habitat structures where appropriate to replace current bank armoring and simultaneously improve habitat conditions. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk. Flood-Proof, Elevate or Protect Homes.	8/20		
16-1	Currently, the Manastash Creek channel runs parallel and immediately adjacent to Manastash Creek Road. Erosion and flooding issues are common here. Relocate the creek channel into the vegetated floodplain, away from county road Remove old access road fill in floodplain to	12/20	KCCD	SRFB

	improve FP function. Revegetation of floodplain areas, and cleared areas throughout the reach. Once mature vegetation becomes reestablished, the stream channel may be relocated into the vegetated area, away from Manastash Creek Road. Reconstruct existing rock armor along County Road to improve reliability as a short term resolution to erosion and flooding issues. Once stream is moved, place rock on flatter slope.			
16-2	Flood-Proof, Elevate or Protect Home Purchasing the property in the floodplain and removing associated buildings and structures would allow for a full restoration and re-vegetation of the floodplain in this area and eliminate flood issues for the landowner. If property purchase is not feasible, address localized bank erosion that is threatening infrastructure on an as-needed basis. Install bank habitat structures where appropriate to replace current bank armoring and simultaneously improve habitat conditions. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk.	11/20	Kittitas County PW	KCFZD

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: **18. Lazy F Reach (RM 11.1 to 11.4)**
PRIORITY RANK: **Medium**

SUB-REACH DESCRIPTION

Sub-Reach 18 includes 0.3 miles of Manastash Creek where it passes through the Lazy F Camp and Retreat Center (see Figure 19).

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. Flood water flows through a large pond located upstream of the main camp area. This water inundates one of the main camp buildings.
2. Local bank erosion has occurred in several places but it currently does not threaten center facilities.

Habitat Limitations:

3. Habitat is generally in good condition. There are numerous side channels upstream from the main camp. Examine connections to the main channel and improve if necessary.
4. The Retreat Center's main bridge over Manastash Creek is narrow and both it and the stream would benefit if it was longer. This is a common condition seen at nearly every driveway bridge that crosses the creek within the canyon.
5. Small bridges cross Manastash Creek at many locations within Manastash Canyon, confining the channel and disconnecting the creek from the floodplain.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood	Main Camp Building	Construct berm along the upstream side of building to divert flow around structure.
	Upstream Pond	Examine ponds and side channel that flow into them to determine if there is anything that should be done to minimize the amount of water that passes through the pond during large floods.
	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas.
Erosion	Various Locations	Monitor and take appropriate action if erosion begins to threaten center facilities.
Habitat	Side Channel	Inspect to determine if connections to the main channel can be

		improved without aggravating flooding.
	Bridges	Evaluate potential to modify or remove driveway and private road bridges throughout the reach to improve flood/erosion protection and fluvial stream processes
	Main Bridge	Replace with a longer and higher structure once it reaches the end of its useful life.

DISCUSSION OF RECOMMENDED ACTIONS

Flood/Erosion

1. ***Camp Buildings and Pond*** – According to the property managers, during large floods water from the stream flows through the large pond that is located just upstream from the main camp area. This water spills out of the pond and inundates one of the main camp buildings. We recommend a detailed site inspection to examine the situation and to determine the best course of action to reduce or prevent damage to the building. One logical solution would be to construct a low landscaped berm along the upstream side of the structure to divert the flow around the building and return it to the stream.

Habitat

1. ***Side Channel –*** Numerous old side channels cover the floodplain upstream from the main camp area. We recommend examining the area to determine how best to improve side channel connectivity and habitat, without increasing flood risk to the camp downstream.
2. ***Bridges*** – Evaluate bridge crossings to determine feasibility of removal or modification to reduce confinement and improve floodplain connectivity.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. The table below summarizes these actions. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General -2	Evaluate potential to modify or remove driveway and private road bridges throughout the reach to improve flood/erosion protection and fluvial stream processes. Address localized bank erosion that is threatening infastructure on an as-needed basis. Install bank habitat structures where appropriate to replace current bank armoring and simultaneously improve habitat conditions. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk. Flood-Proof, Elevate or Protect Homes.	8/20		
18-1	Replace or modify undersized private bridge crossings throughout the area to improve fluvial processes. Evaluate and determine solution to flooding problem through pond. Investigate potential to reconnect right bank floodplain/side channels without increasing flood risk to adjacent structures.	11/20		

Manastash Creek

DRAFT Recommended Actions for Habitat Enhancement & Flood Reduction

SUB-REACH: 20. Mitchell Road Reach (RM 12.3 to 12.5)
PRIORITY RANK: Medium

SUB-REACH DESCRIPTION

Sub-Reach 20 includes 0.2 miles of Manastash Creek where it passes through a developed area just upstream from Mitchell Road (see Figure 21). Several cabins have been built on the floodplain and two driveway bridges cross the stream. The canyon is narrow and several cabins are built close to the stream.

EXISTING HAZARDS AND LIMITATIONS

Flood and Erosion Hazards:

1. Flood, erosion, and sediment problems will continue to be a challenge for the property owners along this highly dynamic narrow reach.

Habitat Limitations:

2. The stream has been highly impacted by the development that has occurred within this reach.
3. Small bridges cross Manastash Creek at many locations within Manastash Canyon, confining the channel and disconnecting the creek from the floodplain.

RECOMMENDED ACTIONS

Recommended actions to address flood and erosion hazards, and habitat limitations are:

	Specific Features or Sites	Potential Actions
Flood , Erosion and Habitat	General	It will be very difficult to achieve both flood /erosion protection and maintain healthy stream processes and habitat within this reach. We recommend a detailed site inspection to examine conditions to determine what if anything can be done to reduce flooding and erosion without harming habitat.
	Floodplain Regulations	Update FEMA floodplain and floodway maps to regulate development in the high flood hazard areas. This is particularly important in this very narrow and high hazard portion of the canyon.
Habitat	Bridges	Evaluate potential to modify or remove driveway and private road bridges throughout the reach to improve flood/erosion protection and fluvial stream processes.

DISCUSSION OF RECOMMENDED ACTIONS

Flood/Erosion/Habitat

This is a highly dynamic reach of Manastash Creek that is confined to a narrow portion of the canyon. Due to the location of the cabins and driveway bridges, the stream generally must stay fixed in its current location or it will threaten the structures. Because of the high energy, it will be a perpetual challenge to prevent lateral erosion. There is no obvious solution that would protect the developed parcels from lateral erosion and allow the stream the freedom to create and sustain healthy habitat. The floor of the canyon is just too confined and narrow. A detailed investigation should be conducted to examine the site and its issues. Based upon the outcome, the landowners, agency representatives, and technical experts should try to agree to a long term strategy for the reach that strives to achieve maximize flood/erosion protection and habitat health.

Habitat

Evaluate bridge crossings to determine feasibility of removal or modification to reduce confinement and improve floodplain connectivity.

RECOMMENDED NEXT STEPS

1. Confirm/refine recommendations with technical advisory committee.
2. Conduct detailed site inspection and meet with landowners.
3. Seek grants to complete engineering evaluation and design, permitting, easement or land purchases, construction, and if needed post project monitoring.
4. Complete design and permitting.
5. Purchase land or easements.
6. Construct project elements.

IMPLEMENTATION

The actions recommended above should be considered together on the sub-reach scale, and implemented on that scale if possible. The table below summarizes these actions. Details regarding project score can be found in Appendices # and # of this plan.

Project #	Description	Project Score	Potential Lead Entity	Potential Funding Source(s)
General -2	Evaluate potential to modify or remove driveway and private road bridges throughout the reach to improve flood/erosion protection and fluvial stream processes. Address localized bank erosion that is threatening infastructure on an as-needed basis. Install bank habitat structures where appropriate to replace current bank armoring and simultaneously improve habitat conditions.	8/20		

	Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk. Flood-Proof, Elevate or Protect Home.			
20-1	Flood-Proof, Elevate or Protect Homes Assess Sediment deposition problems Purchase property to eliminate flooding issues and allow for restoration of floodplain processes. If infeasible, address localized bank erosion that is threatening infrastructure on an as-needed basis. Install bank habitat structures where appropriate to replace current bank armoring and simultaneously improve habitat conditions. Perform hydraulic modeling and geomorphic analysis to ensure that structures do not increase flood risk.	6/20		