Oregon
Theodore R. Kulongoski, Governor

Department of Land Conservation and Development
635 Capitol Street, Suite 150
Salem, OR 97301-2540
(503) 373-0050
Fax (503) 378-5518
www.lcd.state.or.us

NOTICE OF ADOPTED AMENDMENT

02/10/2011

TO: Subscribers to Notice of Adopted Plan or Land Use Regulation Amendments

FROM: Plan Amendment Program Specialist

SUBJECT: City of Sisters Plan Amendment
DLCD File Number 002-10

The Department of Land Conservation and Development (DLCD) received the attached notice of adoption. Due to the size of amended material submitted, a complete copy has not been attached. A Copy of the adopted plan amendment is available for review at the DLCD office in Salem and the local government office.

Appeal Procedures*

DLCD ACKNOWLEDGMENT or DEADLINE TO APPEAL: Tuesday, February 22, 2011

This amendment was submitted to DLCD for review prior to adoption pursuant to ORS 197.830(2)(b) only persons who participated in the local government proceedings leading to adoption of the amendment are eligible to appeal this decision to the Land Use Board of Appeals (LUBA).

If you wish to appeal, you must file a notice of intent to appeal with the Land Use Board of Appeals (LUBA) no later than 21 days from the date the decision was mailed to you by the local government. If you have questions, check with the local government to determine the appeal deadline. Copies of the notice of intent to appeal must be served upon the local government and others who received written notice of the final decision from the local government. The notice of intent to appeal must be served and filed in the form and manner prescribed by LUBA, (OAR Chapter 661, Division 10). Please call LUBA at 503-373-1265, if you have questions about appeal procedures.

*NOTE: The Acknowledgment or Appeal Deadline is based upon the date the decision was mailed by local government. A decision may have been mailed to you on a different date than it was mailed to DLCD. As a result, your appeal deadline may be earlier than the above date specified. NO LUBA Notification to the jurisdiction of an appeal by the deadline, this Plan Amendment is acknowledged.

Cc: Pauline Hardie, City of Sisters
Gloria Gardiner, DLCD Urban Planning Specialist
Karen Swirsky, DLCD Regional Representative
Amanda Punton, DLCD Regional Representative
Gary Fish, DLCD Transportation Planner

<paa> YA

FORM 2 DLCD Notice of Adoption

This Form 2 must be mailed to DLCD within **5-Working Days after the Final Ordinance is signed** by the public Official Designated by the jurisdiction and all other requirements of ORS 197.615 and OAR 660-018-000

☐ In person ☐ electronic ☐ mailed

DATE STAMP

DEPT OF

FEB 03 2011

LAND CONSERVATION AND DEVELOPMENT

For Office Use Only

Jurisdiction: **City of Sisters**

Local file number: **CP 10-03**

Date of Adoption: **January 27, 2011**

Date Mailed: **February 1, 2011**

Was a Notice of Proposed Amendment (Form 1) mailed to DLCD? ☒ Yes ☐ No Date: 10/04/10

☒ Comprehensive Plan Text Amendment

☐ Comprehensive Plan Map Amendment

☐ Land Use Regulation Amendment

☐ Zoning Map Amendment

☐ New Land Use Regulation

☐ Other:

Summarize the adopted amendment. Do not use technical terms. Do not write "See Attached".

The City of Sisters adopted the Whychus Creek Restoration and Management Plan and amended the Comprehensive Plan to reduce impacts on water quality and aquatic habitat, more heavily emphasize the presence of listed species in the creek and the City's commitment to stormwater management and the protection of the creek, and to incorporate the proposed Whychus Creek Restoration and Management Plan. The overall objective of the Whychus Creek Restoration and Management Plan was to develop restoration, management, and policy-level actions that will protect properties while restoring the proper functioning of the creek system.

Does the Adoption differ from proposal? Please select one

The Ordinance adopted revised language to Goal 2 and 5 per DLCD's recommendation

Plan Map Changed from: **N/A** to:

Zone Map Changed from: **N/A** to:

Location: **Citywide** Acres Involved: Citywide

Specify Density: Previous: **N/A** New: **N/A**

Applicable statewide planning goals:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
☐	☒	☐	☐	☒	☒	☒	☐	☐	☐	☒	☒	☐	☐	☐	☐	☐	☐	☐

Was an Exception Adopted? ☐ YES ☒ NO

Did DLCD receive a Notice of Proposed Amendment...

45-days prior to first evidentiary hearing? ☒ **Yes** ☐ **No**

DCLD File No. 002-10 (18560) [16504]

If no, do the statewide planning goals apply? ☐ Yes ☐ No

If no, did Emergency Circumstances require immediate adoption? ☐ Yes ☐ No

DLCD file No. _____

Please list all affected State or Federal Agencies, Local Governments or Special Districts: **Sisters**

Ranger District Forest Service, Oregon Department of Fish and Wildlife, U.S. Forest Service, US Fish and Wildlife Service, Oregon Department of Transportation, National Marine Fisheries Service, Oregon Department of Environmental Quality and Oregon Department of Water Resources

Local Contact: **Pauline Hardie** Phone: **(541) 323-5208** Extension:

Address: **520 E Cascade Avenue, PO Box 39** Fax Number: **541-549-0561**

City: **City of Sisters** Zip: 97759 E-mail Address: **phardie@ci.sisters.or.us**

ADOPTION SUBMITTAL REQUIREMENTS

This Form 2 must be received by DLCD no later than 5 days after the ordinance has been signed by the public official designated by the jurisdiction to sign the approved ordinance(s)
per ORS 197.615 and OAR Chapter 660, Division 18

1. This Form 2 must be submitted by local jurisdictions only (not by applicant).
2. When submitting the adopted amendment, please print a completed copy of Form 2 on light **green paper if available.**
3. Send this Form 2 and **one complete paper copy** (documents and maps) of the adopted amendment to the address below.
4. Submittal of this Notice of Adoption must include the final signed ordinance(s), all supporting finding(s), exhibit(s) and any other supplementary information (ORS 197.615).
5. Deadline to appeals to LUBA is calculated **twenty-one (21) days** from the receipt (postmark date) of adoption (ORS 197.830 to 197.845).
6. In addition to sending the Form 2 - Notice of Adoption to DLCD, please also remember to notify persons who participated in the local hearing and requested notice of the final decision. (ORS 197.615).
7. Submit **one complete paper copy** via United States Postal Service, Common Carrier or Hand Carried to the DLCD Salem Office and stamped with the incoming date stamp.
8. Please mail the adopted amendment packet to:

ATTENTION: PLAN AMENDMENT SPECIALIST
DEPARTMENT OF LAND CONSERVATION AND DEVELOPMENT
635 CAPITOL STREET NE, SUITE 150
SALEM, OREGON 97301-2540

CITY OF SISTERS
ORDINANCE NO. 401

AN ORDINANCE OF THE CITY OF SISTERS ADOPTING THE WHYCHUS CREEK RESTORATION AND MANAGEMENT PLAN AND COMPREHENSIVE PLAN AMENDMENTS TO GOAL 2, 5, 6, 7, 11 AND 12.

WHEREAS, in 2005 the City of Sisters conducted a Post Acknowledgement Plan Amendment to update a specific portion of the adopted and acknowledged Sisters Urban Area Comprehensive Plan of 1979 under the guidance of the Sisters City Council and Department of Land Conservation and Development; and,

WHEREAS, in 2008, the City of Sisters partnered with the Upper Deschutes Watershed Council to fund a Whychus Creek Restoration and Management Plan (the Plan), which was completed in June 2009; and,

WHEREAS, the overall objective of the Whychus Creek Restoration and Management Plan was to develop restoration, management, and policy-level actions that will protect properties while restoring the proper functioning of the creek system; and,

WHEREAS, the amendments to the City of Sisters Comprehensive Plan Goals 2, 5, 6, 7, 11 and 12 help provide enhanced erosion and property protection while assisting in long-term restoration of Whychus Creek; and,

WHEREAS, the City of Sisters recognizes that substantial public and private funds will be necessary to complete the long-term restoration of Whychus Creek, and it is the intent of City of Sisters public funds used toward the restoration of Whychus Creek will be expended in a manner consistent with Oregon Public Contracting Laws, including a public bidding process by qualified contractors, and that the City of Sisters would be a participant in any process to establish contractor qualifications or criteria; and,

WHEREAS, in accordance to the provisions found in the Sisters Development Code Table 4.1.200 and Section 4.1.600, the proposed adoption of the Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments are processed as a Type IV application; and,

WHEREAS, the Upper Deschutes Watershed Council and the City of Sisters held community meetings about the development of the Whychus Creek Restoration and Management Plan; and,

WHEREAS, the Department of Land Conservation and Development (DLCD) received the Notice of Proposed Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments to goals 2, 5, 6, 7, 11 and 12 at least 45-days prior to the first evidentiary hearing; and,

WHEREAS, after due notice, a public hearing on the proposed project was held before the Sisters Planning Commission at the City of Sisters Council Chambers (520 E Cascade

Avenue, Sisters, 97759) on December 16, 2010 and at which time findings were reviewed, witnesses were heard and evidence was received and at which time the Planning Commission recommended that the City Council adopt the Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments 2010-03 as amended by the Planning Commission; and,

WHEREAS, after due notice, a public hearing on the proposed project was held before the Sisters City Council on January 13, 2011, at which time the City Council found that the Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments 2010-03 as amended meet all applicable approval criteria, including all notice requirements, and that the ordinance will benefit the City of Sisters.

NOW, THEREFORE, the City Council of the City of Sisters ordains as follows:

SECTION 1. The Comprehensive Plan is amended as provided in the following exhibits, which is incorporated into this Ordinance by reference.

Exhibit A - Comprehensive Plan amendments to Goals 2, 5, 6, 7, 11 and 12
Exhibit B - Planning Commission recommended amended change to Goal 5

SECTION 2. In support of improving water quality and aquatic habitat, emphasizing the presence of listed species in the creek and committing to stormwater management and the protection of the creek and property, the City Council hereby adopts the Whychus Creek Restoration and Management Plan, 2009, attached hereto as Exhibit C to this Ordinance.

SECTION 3. In support of the adoption of the Whychus Creek Restoration and Management Plan in Section One and Comprehensive Plan amendments in Section Two, the City Council hereby adopts the findings attached hereto as Exhibit D to this Ordinance, which demonstrate compliance with the Sisters Development Code, the City's Comprehensive Plan, and the applicable statewide planning goals.

PASSED by the Common Council of the City of Sisters this 27th day of January 2011, and APPROVED by the Mayor of the City of Sisters.

Mayor Lon Kellstrom

ATTEST:

Kathy Nelson, City Recorder

Exhibit A
Comprehensive Plan Amendments to Goals 2, 5, 6, 7, 11 and 12

applications are Type I, II, III, or IV. These types have different levels of public participation associated with them, with more public involvement applying to applications with greater community impact. The process includes ministerial and administrative reviews by City staff with appeals heard by the City's Planning Commission (Type I), quasi-judicial public hearings held by the City Planning Commission (Type II and III), legislative public hearings held before the Planning Commission with appeals to the City Council (Type IV), and other land use processes as part of the City's Development Code. Each of these processes for notification, review, and appeal are in compliance with Oregon State law.

Planning Staff

The City has a Planning Department staffed by a Planning Director, Associate Planner and Administrative Assistant. Long-range and current planning projects are completed by planning staff and consultants with oversight by the City Manager, Planning Commission, and City Council. These persons work together to create, implement, review, and modify the Plan with guidance from the City's citizens.

2.3 FINDINGS

1. Upon acknowledgement of this Comprehensive Plan by the Land Conservation and Development Commission, this Plan will meet the State's requirements regulating the factual content, policy direction, scope of local Comprehensive Plans.
2. Planning studies have been completed since the last Comprehensive Plan update in 1994 to facilitate acknowledgement. These activities will help the City accommodate anticipated growth and development and form the backbone of the City's land use and planning framework. These include completing the Parks/Recreation and Open Space, A 20-Year Master Plan (2000); the City of Sisters Wastewater Treatment Plant Plan (2000); adopting the City of Sisters Development Code (2001) and the City of Sisters Transportation System Plan (2001). The City completed a Residential Land Supply and Demand Analysis, 3-17-05 Update that determines land needs in the City for until year 2025. The City also completed a Technical Report, City of Sisters Commercial and Industrial Future Land Needs Analysis in 2003 that determines needs for commercial and industrial land in the City until year 2025. In January, 2010 the City adopted an updated Transportation System Plan (TSP) that identifies specific transportation projects and programs needed to support the City's goals and policies and to serve planned growth through the TSP horizon year (2030). Also in January 2011 the City adopted the Whychus Creek Restoration Management Plan in order to reduce impacts to water quality and aquatic habitat, emphasize the presence of listed species in the creek and identify the City's commitment to stormwater management and the protection of the creek. These studies are incorporated into the Comprehensive Plan by reference.

2.4 POLICIES

1. The City of Sisters shall develop land use codes and ordinances that are based on an adequate factual basis as well as applicable local, state, and federal regulations.

Goal 5: Open Space, Scenic and Historic Areas, Natural Resources

5.1 GOAL

"To protect natural resources and conserve scenic and historic areas and open spaces."

5.2 BACKGROUND

The City of Sisters is virtually surrounded by National Forest Service and agricultural land. The surrounding open spaces separate Sisters from neighboring communities and provide much of the unique character and identity found in the City. In addition, the rural and forest setting of the Sisters area is important to the quality of life and economic development of the community.

Goal 5 requires local government to adopt programs that will protect natural resources and conserve scenic, historic, and open space resources for present and future generations. These resources promote a healthy environment and natural landscape that contributes to Oregon's and Sister's livability. The City has completed ~~this~~ an inventory of existing natural resources and the data is contained within this Chapter. OAR 660-023 requires specific Goal 5 resources to be reviewed and amended at each periodic review. However, cities with a population less than 10,000 are exempt from periodic review. Further direction on protecting these resources is provided in Oregon Administrative rule (OAR) 660-023.

~~State Goal #5 describes open space as lands used for agricultural or forest uses, and any land area that would, if preserved and continued in its present use:~~

~~a) Conserve and enhance natural or scenic resources~~
~~b) Protect air, streams, or water supply~~
~~c) Promote conservation of soils and wetlands~~
~~d) Conserve landscaped areas, such as public or private golf courses, that reduce air pollution and enhance the value of abutting or neighboring property~~
~~e) Enhance the value to the public of abutting or neighboring parks, forests, wildlife preserves, nature reservations, sanctuaries, or other open space~~
~~f) Enhance recreation opportunities~~
~~g) Preserve historic sites~~
~~h) Promote orderly urban development.~~

In compliance with State Goal #5, Deschutes County has worked towards providing programs that serve to inventory, protect, and manage historic and cultural resources. In 1980, the Deschutes County Board of Commissioners established the Historical Landmarks Commission. This Commission serves as a review body and Planning Commission for issues concerning historic and cultural resources inside Deschutes

County (including the City), reviews development applications for alterations to designated historic sites, and reviews the exterior treatments of buildings applying the Western Frontier Architectural Design Theme.

Also, in compliance with Goal #5, the City of Sisters and the Upper Deschutes Watershed Council (UDWC) partnered to develop the Whychus Creek Restoration and Management Plan, June 2009, in order to address concerns including the creek's natural dynamic system, development patterns that have put properties at risk and decades of "fixes" that have made the problems worse. The City has a long-term interest in the management of Whychus Creek to protect property from excessive stream bank erosion, provide recreational and aesthetic community benefits, enhance the natural resource values, and comply with the federal Endangered Species Act and other natural resource regulations. Therefore, the City is adopting the Whychus Creek Restoration and Management Plan as a Resource Element to the Comprehensive Plan

The overall goal of the Whychus Creek Restoration and Management Plan, June 2009, is to identify opportunities for the enhancement and restoration of the developed reaches of Whychus Creek throughout the project area. The objects for the project are to develop restoration, management, and policy-level actions that protect properties while restoring the proper function of the creek system.

~~State Goal #5 requires the City to inventory existing natural resources. The City has completed this and the data is contained within this Chapter.~~

5.3 FINDINGS

1. Open space within the Urban Growth Boundary (UGB) consists of forested land, land used for low-intensity agricultural uses (irrigation, growing feed grasses, and grazing), flood plain and parks.
2. Land that is undeveloped and is expected to remain so within the UGB includes:
    A. Parks
        1. The Village Green - 1.15 acres
        2. Creekside Park - 2.00 acres
        3. Sisters Overnight Park - 11.42 acres
        4. Forest Service Triangle - 19.12 acres
        5. Cliff Clemons Park - 2.32 acres
        6. Whychus Creek Trail – 2.32 acres
        7. Buck Run Mini-Park - .083 acres (3,600 square feet)
        8. Harold and Dorothy Barclay Park - .44 acres
    B. Whychus Creek Flood Plain - 26 acres within the City limits.
    C. Landscape Management (LM) zoned property, 69 acres within City limits.
3. National Forest lands within the City Limits are currently zoned Public Facility (PF) and Urban Area Reserve (UAR). The approximately 77 gross acres of National

12. Whychus Creek and its associated riparian vegetation community contribute to the health, safety, and general welfare in the City of Sisters UGB area. The stability of the natural systems and the vitality of the community depend on the excellent water quality and habitat provided by Whychus Creek.
13. Natural drainage ways such as Whychus are significant natural resources that provide protection from flooding, treatment of stormwater, and help maintain stream morphology important for resident fish and macroinvertebrates.
14. Local fish and wildlife, some of which are endangered or threatened, depend on the excellent water quality and habitat function that is provided by Whychus Creek.
15. The ability for native soils to absorb and filter stormwater is essential to maintaining high quality ground and surface water resources. These functions must be preserved or their loss mitigated by future development.

5.4 POLICIES

1. The City shall promote a harmonious relationship between residential, commercial, and industrial development.

   Tasks –

   a. The City shall balance quantities of land to ensure land is available for a variety of uses, classified in a manner consistent with the carrying capacity of the land.

   b. The City's Development Code shall contain provisions to include open space as a part of a Master Planned Development.

2. The City shall identify and protect historical sites within the UGB.

   Tasks –

   a. The Sisters City Council has entered into an agreement with the Deschutes County Landmarks Commission to periodically investigate and identify historic sites within the City Limits and study various means of interpreting local history.

   b. The Sisters City Council should review the policy relating to historical signs and plaques per City Council action of October 9, 1980 (ORD. 138)

   c. The City should encourage the placement of heritage markers on historical buildings for identification through the Development Code.

   d. Residential renovations and/or historic building designations (National Register of Historic Places) should be promoted and encouraged by the City to help upgrade and preserve older housing stock

3. The City shall identify and protect natural, riparian, and scenic resources within the UGB.

Tasks –

a. The City shall develop a riparian protection program for Whychus Creek consistent with State Planning Goal 5.

b. The approximate 23 gross acres of Deschutes National Forest lands within the City Limits zoned UAR shall be held as urban reserve areas until such time as needed for urban expansion.

c. The Whychus Creek Flood Plain shall be managed according to Federal Emergency Management Agency (FEMA) regulations, as incorporated into the City of Sisters Development Code.

d. Open space and forested lands along the highways outside the UGB should be protected as scenic corridors with landscape management programs implemented by the County, State, and United States Forest Service.

e. All City Parks shall continue to serve as public parks under the jurisdiction of the City of Sisters. When the City Limits expand, adequate park resources to serve the expansion shall be included.

f. Site-specific buffering, setback requirements, and best management practices (BMPs) may be required, as necessary, to enhance and protect stream-side properties as well as Whychus Creek riparian areas and channel migration zone.

g. Pursue development of a riparian protection overlay zone, a riparian setback ordinance, a stream protection overlay zone, or a habitat protection ordinance for the Whychus Creek riparian corridor (see *Whychus Creek Restoration and Management Plan* – June 2009 analysis of riparian/stream protection options in Section 4.5.1).

Goal 6: Air, Water, Land Resource Quality

6.1 GOAL

"To maintain and improve the quality of the air, water and land resources of the City."

6.2 BACKGROUND

Statewide Planning Goal #6 requires that air, water and noise be monitored and protected from pollution from existing and future land uses. Pollution cannot exceed state or federal standards, nor can it exceed the carrying capacity of local land, air and water resources. Goal #6 encompasses all aspects of pollution, including sewage, noise and process discharge and wastewater disposal. Further, the local economy and quality of life within the City depends on the balanced management and protection of our natural resources.

6.3 FINDINGS

1. Natural Resources within the Urban Growth Boundary (UGB) consist of air, water and land resources.

2. In the City of Sisters, air quality is generally good; however, air pollution sources in the Sisters area include wood stoves, auto emissions, tree pollen, irrigation ditch line burning and logging/slash burning. Reference source, "1993 Oregon Wood Heating Survey."

3. City-supplied water quality is excellent. Sources for City water are Pole Creek and two ground water wells.

4. Whychus Creek flows can be erratic and the 100-year flood plain identified by the FP District is necessary to prevent possible losses to life and property. The portion of Whychus Creek within the UGB has reduced flow, 1.86 cubic feet per second, during the time water is withdrawn for irrigation purposes. There are local efforts to increase creek flows.

5. Pinus Ponderosa (Ponderosa Pine) trees in forested areas add to the character and livability of the community and are abundant inside the City Limits and Urban Growth Boundary.

6. The City is concerned about air quality and unnecessary particulate emissions resulting from older (non-certified) wood-burning stoves.

7. According to DEQ/s 2004/2006 Water Quality Assessment, Whychus Creek is water quality limited for temperature. A Total Maximum Daily Load (TMDL) has been recommended for temperature in Whychus Creek which DEQ is beginning to develop.

8. Summer steelhead and bull trout have been listed as threatened species under the Endangered Species Act (ESA) by the National Marine Fisheries Service and U.S. Fish and Wildlife Service. Spawning, rearing and/or migration habitat for these species occurs in Whychus Creek within the City's boundaries.

9. Development activities permitted by the City of Sisters that result in harm to a threatened or endangered species, and fall outside the provisions for "incidental take" allowed by Section 4(d), a Section 7 consultation, or a Section 10 permit of the Endangered Species Act, could result in the City being held liable for a "take" under that Act.

10. Reduction of open space, removal of vegetation cover, and development that increases the amount of impervious surfaces in the City can contribute significantly to increased stormwater peak flows and decreased water quality.

11. Offsetting measures can reduce the negative effects of urban development on water quality and quantity. Example offsetting measures include reduction of stormwater runoff or maximization of infiltration, inclusion of landscaped buffer strips adjacent to new development, protection of the Whychus Creek floodplain and channel migration zone, preservation and improvement of streamside vegetation along Whychus Creek, and other development best management practices (BMPs).

6.4 POLICIES

1. The City of shall ensure the protection and wise use of our natural resources.

   Tasks –

   a. The City shall ensure vegetation is and remains an integral part of Sisters.

      Subtasks –

      1. The City shall encourage the protection of mature trees throughout the community. Native landscaping should be encouraged in all new developments. Mature trees, particularly Pinus Ponderosa, (Ponderosa Pine) should be protected in new developments and mitigation measures for cut trees shall be established. A standard shall be developed and added to the City's Development Code in Chapter 3.2, Landscaping, Street Trees, Fences and Walls to reflect protection requirements.
      2. Efforts should be made to establish a tree-planting plan for the City.
      3. The City should encourage water conservation through the use of native drought-tolerant plants in landscaping.

   b. The City shall establish a noxious weed control program in coordination with Deschutes County.

2. The City shall review, update, or develop new ordinances, as required to ensure that our air, water and land resources are protected.

   Tasks –

      a. New developments shall be regulated to ensure all uses meet State Department of Environmental Quality standards for air, noise, and water quality protection.
      b. That City owned and operated sewage systems shall be monitored to maintain good ground water quality.
      c. Whychus Creek shall be protected through the Development Code.
      d. The City shall cooperate with the restoration of in-stream water flow rights to Whychus Creek.

3. The City should review and appropriately update ordinances regarding replacing existing non-certified wood stoves and encourage non-polluting and efficient heat sources for homes.

4. All development within the City of Sisters city limits and Urban Growth Boundary (UGB) shall comply with applicable state and federal water quality requirements.
5. To protect and enhance water quality as required by state and federal requirements, the City will implement provisions in the *Central Oregon Stormwater Manual* (2007), possibly through an update of the City of Sisters Public Works Construction Standards.

   Tasks –

   a. Regulate site planning for new development and construction to better control drainage, and to reduce, retain and treat stormwater runoff prior to discharge to Whychus Creek.
   b. Require new construction to develop an erosion control plan that is consistent with "Chapter 9 – Erosion and Sediment Control Design" in the *Central Oregon Stormwater Manual* (2007) and/or the Oregon Department of Environmental Quality's *Erosion and Sediment Control Manual* (DEQ, 2005).
   c. Protect existing riparian vegetation along stream banks for bank stabilization and stream shading benefits.
   d. Increase riparian area buffer widths to address Total Maximum Daily Load (TMDL) requirements and other state and federal requirements, and to protect private property.
   e. Regulate the location of permitted uses that generate, store or use hazardous wastes or materials, and that may have higher than ordinary impacts on water quality.
   f. Reduce and treat stormwater runoff generated by City streets that may discharge to Whychus Creek.
   g. Increase public awareness of techniques and practices private individuals can employ to help correct water quality and quantity problems.
   h. Increase public awareness of polluting substances that affect surface and groundwater resources, minimizing their use, and encouraging the appropriate disposal of these substances.

Goal 7: Natural Disasters and Hazards

7.1 GOAL

"To protect people and property from natural hazards."

7.2 BACKGROUND

Natural disasters and hazards that threaten the City include forest fires, floods in Whychus Creek, earthquakes, and volcanic activities. Other hazards include the spread of diseases from insects and animals and threats from other hazards shared by all cities.

4. The City shall continue to participate in the National Flood Insurance Program so residents of the City may benefit from having flood insurance in the event of a flood.
5. Portions of the City are contiguous with National Forest lands and are at risk from forest fires.
6. Sisters/Camp Sherman Rural Fire Protection District provides fire-protection and emergency services to the City.
7. A branch office of the Deschutes County Sheriff's Office provides law enforcement services to the City.
8. Emergency evacuation service is provided to the area by Airlife located in Bend. There is currently a heliport pad available at the Sisters Eagle Air Airport.
9. Mutual aid arrangements are currently in force with all fire fighting agencies in Central Oregon.
10. There is no emergency power source available to City wells in the event of power loss. The City has two reservoirs that gravity feed the system with capacity for 10 days normal usage.
11. The City water lines are adequate for domestic water and fire protection with an upgrade completed in November 1994. All services are metered, encouraging conservation.
12. Of volcanic hazards, lahars pose the biggest sudden threat to people living in valleys that drain the Three Sisters, such as the City of Sisters. The best strategy for avoiding a lahar is to move to the highest possible ground. A safe height above river channels depends on many factors including size of the lahar, distance from the volcano, and shape of the valley. For areas beyond the proximal hazard zone, all but the largest lahars will probably rise less than 30 meters (100 feet) above river level.
13. Increased amounts of stream sedimentation lead to a loss of instream storage of flood water, leading to widening of stream banks and more flooding.
14. Stormwater runoff mitigation techniques can significantly reduce Whychus Creek flooding frequency and peak flows associated with urban development in Sisters.
15. To maintain species habitat and to protect stream-side properties in Sisters, the natural hydrology of Whychus Creek should be maintained so that annual flow patterns remain the same after development as before development.
16. The natural meandering stream channel of Whychus Creek and its associated riparian areas provide essential flood storage capacity.
17. Riparian areas associated with Whychus Creek contain natural assets such as significant vegetation and wildlife habitat, and are valuable for water quality, open space and recreation purposes.

7.4 POLICIES

1. The City shall regulate development in the 100-year floodplain and flood prone areas to protect life and property; to allow for transport of flood waters; to protect and enhance water quality; and to protect the economic, environmental, and open space

qualities of the land and Whychus Creek. ~~in a manner consistent with the hydrologic characteristics of Whychus Creek and flood risks unique to the City.~~

Tasks –

a. The City's Development Codes shall meet the minimum standards of the National Flood Insurance Program and incorporate the most recently Federal Emergency Management Agency -adopted Flood Insurance Rate Maps and Flood Insurance Rate Study.

b. A Flood Plain District shall be established to include areas designated as "Flood Hazard Areas" by the most recent Flood Insurance Study for the incorporated area of the City of Sisters.

c. No new structures shall be allowed in the 100-year flood plain identified by the most recently adopted Federal Emergency Management Agency Flood Insurance Study, FIRM map, amendments to the FIRM map, or more accurate site specific information. The Development Code shall establish standards requiring accurate documentation of the location of the 100-year flood plain prior to development and clearing. Absent more accurate information, the most recently adopted Flood Insurance Rate Maps shall be used to determine the location of the 100-year flood plain. The Development Code shall also provide for some economic use for existing parcels nearly entirely within the 100-year flood plain in a manner otherwise consistent with the Plan's policies.

d. The Development Code shall include development standards including but not limited to increased setbacks from Whychus Creek to reduce risks of erosion to structures.

e. Fill in the 100-year flood plain reduces the carrying capacity of the flood plain and shall be limited whenever possible. The Development Code shall include standards for filling in the 100-year flood plain.

f. All uses which could have any effect upon hazards set forth in this document shall be conditional uses and subject to rigorous review to ensure that use of the flood plain is only a last resort to allow necessary facilities and some beneficial use of the pre-existing lots of record.

g. No new parcels shall be created which would allow the construction of new dwelling units in the flood plain.

2. An emergency response program shall be developed to respond to natural or man caused disasters.

Tasks -

a. The City shall work with appropriate agencies, including the Sisters– Camp Sherman Rural Fire Protection District to develop emergency management plans.

b. The City shall develop a strategy to educate the public about volcanic hazards, and develop an evacuation plan that includes responding to volcanic hazards.

c. The City shall explore the provision of a redundant emergency power source for the operation of City wells in the event a power outage occurs.

3. The city shall promote development of an ordinance requiring fire resistant building materials and landscaping for all new construction.
4. The City should cooperate with any countywide efforts to reduce the spread of West Nile Virus by mosquitoes.
5. During preliminary subdivision review, the planning staff, in coordination with the Sisters – Camp Sherman Rural Fire Protection District, shall indicate whether the developers' plan has adequately provided for fire protection.
6. The City shall require certain land-disturbing activities associated with site clearing, grading, construction and other improvement to employ erosion control practices to prevent increased stream sedimentation.
7. To the extent possible, the Whychus Creek floodplain shall be kept in a natural state to reduce flooding, protect and enhance water quality, and to protect and enhance native plant species.
8. Standards for new development shall require stormwater runoff to be infiltrated or detained onsite to the maximum extent practicable, or stored and treated in a regional facility to preserve the natural hydrograph and water quality of Whychus Creek.

Chapter 8 Recreation Needs

8.1 GOALS

"To satisfy the recreational needs of the citizens of the City and visitors, and, where appropriate, to provide for the siting of necessary recreational facilities."

"Maintain adequate park facilities providing a variety of recreational and cultural opportunities for residents and visitors of Sisters."

8.2 BACKGROUND

The continued availability of parks and recreational facilities within and in the surrounding areas of the City of Sisters enhances the quality of life for residents. Within a 20 mile radius, the Deschutes National Forest provides numerous recreational options ranging from recreational sites and points of interest, to major tourist attractions such as Mt. Bachelor and HooDoo winter ski areas and Suttle Lake operated in conjunction with private enterprises.

8.3 FINDINGS

In October 2000, the City completed and adopted a Parks Master Plan for a 20-year planning period. The "Parks Recreation and Open Space: A 20-Year Master Plan, City

2. In 2001, the City constructed a public sewer system capable of serving all existing properties with expansion capabilities.
3. In 1994, the City completed a $2.1 million water improvement project on the current system which included upgrading most of the 4" size lines in the core area, looping some of the dead end lines and building a 1.6 million gallon storage reservoir in the approximate same location of the existing open reservoir. The system is metered for all water accounts.
4. The City Maintenance Center and Recycling Station located at the corner of Ash Street and Washington Avenue is inadequate for servicing and storing equipment and materials to be recycled. In addition, the center and station are currently non-conforming uses and should be relocated.
5. The Deschutes County Sheriff's Department currently provides police protection services to the City.
6. Sisters School District provides education for kindergarten through twelfth grade. School buildings and field areas provide for diverse community activities.
7. The City maintains a water right on Pole Creek of .2 cubic feet per second. Water from this source is not currently used for municipal purposes. A 2.3 million gallon storage pond is kept empty and available for emergency water storage.
8. The City will need additional wells for municipal and emergency purposes.
9. There is some home delivery mail service provided in Sisters. There is frequently traffic congestion at the Post Office Building.
10. Residential subdivisions on surrounding County lands place demands on City taxpayer-supported facilities and services.
11. The City now has a public restroom facilities for pedestrians and tourists in the downtown district located in the Harold and Dorothy Barclay Park at the intersection of Ash Street and Cascade Avenue, and at the Village Green Park.
12. The Sisters School District constructed a new high school designed for 700 students in 2001-2002. The former 600-student High School is now the Middle School. The two parcels abut, totaling 138.3 acres. There is adequate space for future expansion of both facilities and an elementary school.
13. The Sisters – Camp Sherman Fire District shall have four acres located near the City's sewage treatment plant for purposes of constructing and operating a fire training facility for the greater Sisters region.
14. Untreated stormwater discharge, and the loss of natural storage capacity due to increases in impervious surfaces and channelization of Whychus Creek, contribute to impaired water quality in the creek.
15. Improperly treated and/or stored stormwater can compromise the recovery of Endangered Species Act (ESA) listed bull trout and summer steelhead in Whychus Creek, and can lead to an illegal "take" of these protected species.

16. Effective stormwater treatment requires implementation of a range of programs including appropriate alterations to development patterns, on-site stormwater retention and treatment, and efforts to decrease impervious surfaces associated with new growth in Sisters.

11.4 POLICIES

1. The City shall be proactive in planning, financing, obtaining lands, facilities, equipment, and other system elements to ensure the safe and efficient operation of public services.

   Tasks-

   a. The City shall continue to update its water supply system to meet new State and Federal health requirements, and domestic and emergency needs.

   b. The City shall continue its policy of assessing fair and equitable charges in System Development Charges to finance the impacts of growth on public facilities.

   c. The City shall develop policies to adequately fund or require public facilities improvement and budget plans as well as ongoing maintenance for all public infrastructures (water, sewer, roads, etc.).

   d. The City of Sister Public Works Standards shall be periodically updated and improved for specificity, accuracy, consistency, and code compliance.

   e. Public Works Standards shall include standards for maintaining and paying for landscaping in the public right-of-way and multi-use paths.

   f. The City should maintain City garbage service and develop alternative disposal options to best serve the City residents in the future.

   g. The City shall develop adequate City Office facilities.

   h. Water Management and Conservation Plans shall be required by significant new developments impacting the City's water supply system.

   i. Police protection services should be maintained at levels consistent with the needs of the community.

   j. The City shall assist the Sisters – Camp Sherman Fire District in the annexation and ultimately the provision of city utilities to the 4 acre property known as the Sisters – Camp Sherman Fire District's fire training facility.

2. The City shall ensure that all properties within the Urban Growth Boundary are able to be provided with water, sewer, electrical and phone utilities.

   Tasks-

   a. Applications for annexations shall demonstrate that the full development of the annexed property will not reduce levels of service or adversely

impact the long-term operation of public infrastructure (water, sewer, roadways).

b. Public facilities and all utilities (phone, cable, and power) shall be located underground and required "to and through" when a property is developed or redeveloped, in order to ensure that neighboring properties can be served in the future.

3. The City shall provide adequate public restrooms in the downtown commercial core.
4. The City should help civic groups establish a Community Center.
5. The City shall work with agencies and interest groups including the Sisters School District, County, COCC, CATS, and SOAR to meet the educational and recreational needs for the community.
6. The City shall increase its efforts to protect and enhance water quality, including preserving natural drainage and hydrology features, and increase opportunities for on-site infiltration, detention, and treatment of stormwater through implementation of the *Central Oregon Stormwater Manual* (2007) in the development process.
7. The City shall take steps to minimize impacts to Whychus Creek water quality through the use of appropriate strategies as identified in the *Central Oregon Stormwater Manual* (2007).

Goal 12: Transportation

12.1 Transportation Goal

"To provide and encourage a safe, convenient and economic transportation system."

12.2 BACKGROUND

Historically, the City has relied heavily upon agriculture and its proximity to transportation routes for its economic livelihood. The City now has a more diversified economy that relies less upon agriculture and more upon commercial, light industrial and tourism sectors of the economy. The highways running through Sisters still supply pass through traffic vital to the local tourist economy, but also are the backbone of the local transportation network. This Comprehensive Plan chapter examines how the transportation system will function to accommodate a wide range of uses in the future.

The City of Sisters completed and Sisters City Council adopted the original Transportation System Plan (TSP) in June, 2001, then updated the Plan in January, 2010. The TSP is a long-range transportation planning tool that analyzes existing conditions, anticipates future needs, and suggests specific improvements to address system deficiencies. The TSP constitutes the transportation element of the City's Comprehensive Plan and is incorporated herein by reference. This part of the Plan

10. Section 660-12-045 (1) of the Transportation Planning Rule (TPR) requires that cities and counties amend their land use regulations to conform with the jurisdiction's adopted TSP. This section of the TPR is indented to clarify the approval process for transportation-related projects. The approval process for different types of projects should be clear.

11. Section 660-12-045 (2) (d) of the TPR requires that jurisdictions develop a process for the coordinated review of land use decisions affecting transportation facilities.

12. Section 660-12-045(2) of the TPR requires that jurisdictions protect future operation of transportation corridors. In addition, the proposed function of a future roadway and other transportation facilities such as airports must be protected from incompatible land uses.

13. Highways, roads, streets in Sisters can have negative impacts on water quality by increasing both the quantity and velocity of runoff, and by collecting oil and other pollutants that are flushed into Whychus Creek when it rains.

14. Narrower local streets, standards that limit the amount of parking, and pervious paving surfaces (where practical) can reduce the amount of impervious surfaces in the City.

12.4 POLICIES

1. The City shall implement the adopted City of Sisters Transportation System Plan, January 2010.
2. The City will be proactive in obtaining all elements of a well functioning multi-modal transportation system through all legal means.

   Tasks -

   a. The City shall plan for the development and maintenance of additional parking spaces and/or facilities.

   b. Right-of-way for planned transportation facilities, access ways, paths, or trails shall be preserved through all practical means, including exaction, voluntary dedication, conditions of approval, setbacks, or other appropriate means.

   c. The City of Sisters shall include a clear and objective process for the approval of transportation projects in the City's Development Code.

   d. New development shall integrate with the existing street and grid system to facilitate local traffic flows, access to developments, and safe access to state highways.

   e. All public streets shall be constructed to City Public Works Construction standards.

3. The City shall cooperate with neighboring Cities and with Deschutes County in the development of an inter-city transportation plan.

4. The City shall participate in the Central Oregon Commute Options Program by assisting in implementing measures outlined in their programming.
5. The City should develop and utilize telecommuting strategies to facilitate the movement of information and data rather than people.
6. The City of Sisters Tax Increment Financing District (Urban Renewal District) provides funding for the development of improvements along and adjacent to the commercial core.
7. Residential street lighting shall be designed consistent with the 1880s Western Design Theme, Dark Skies ordinance, and Development Code.
8. Street signs of a type approved by the City shall be provided by the developer for each new residential development.
9. The City shall work with ODOT to lower speed limits along highways within the entire Urban Growth Boundary.
10. The City shall work with ODOT to obtain design exceptions to the sidewalk and shoulder widths for Highway 20 in the downtown core.
11. The City should obtain a Special Transportation Area (STA) for Highway 20 through downtown Sisters Cascade Avenue from Larch Street to the intersection past Pine Street (the right-in/right-out at Old Highway 242).

    Tasks –
    a. Complete an STA Management Plan for Highway 20.
    b. Obtain Oregon Transportation Commission (OTC) approval of the STA designation.

12. Sisters Transportation System Plan shall be consistent with other City goals and policies, including the goal of protecting and enhancing water quality.
13. The Transportation System Plan shall promote walking and bicycling within the City to reduce the impacts of transportation on water quality.

Exhibit B
Planning Commission recommended change to Goal 5

5.2 BACKGROUND

The City of Sisters is virtually surrounded by National Forest Service and agricultural land. The surrounding open spaces separate Sisters from neighboring communities and provide much of the unique character and identity found in the City. In addition, the rural and forest setting of the Sisters area is important to the quality of life and economic development of the community.

DELETE

~~Goal 5 requires local government to adopt programs that will protect natural resources and conserve scenic, historic, and open space resources for present and future generations. These resources promote a healthy environment and natural landscape that contributes to Oregon's and Sister's livability. The City has completed this an inventory of existing natural resources and the data is contained within this Chapter. OAR 660-023 requires specific Goal 5 resources to be reviewed and amended at each periodic review. However, cities with a population less than 10,000 are exempt from periodic review. Further direction on protecting these resources is provided in Oregon Administrative rule (OAR) 660-023.~~

REPLACE WITH THE FOLLOWING LANGUAGE

Goal 5 requires local government to adopt programs that will protect natural resources and conserve scenic, historic, and open space resources for present and future generations. These resources promote a healthy environment and natural landscape that contributes to Oregon's and Sister's livability. The City's inventory of existing natural resources and the data is contained within this Chapter. The inventories could be updated in accordance with OAR 660-023 if the city finds that updated inventory information would be valuable. However, the City is not required to amend its inventories since cities with a population less than 10,000 are exempt from periodic review. Further direction on protecting these resources is provided in Oregon Administrative rule (OAR) 660-023.

Exhibit C
Whychus Creek Restoration and Management Plan, 2009

Watershed Professionals Network, LLC
Technical Report

Whychus Creek Restoration and Management Plan – June 2009

Prepared by: Watershed Professionals Network,
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June 2009

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City of Sisters

Table of Contents

List of Figures

List of Tables

EXECUTIVE SUMMARY

INTRODUCTION

Over the years, the City of Sisters has grown and expanded along and around Whychus Creek. The proximity of this dynamic creek to homes and property has lead to bank erosion that threatens property, public safety and the health of the creek. The issues the City of Sisters and its inhabitants are facing have three main root causes:

- Whychus Creek is a naturally dynamic system;
- Development patterns have put properties at risk; and
- Decades of "fixes" have made the problems worse.

The City of Sisters and the Upper Deschutes Watershed Council (UDWC) have partnered to develop this Whychus Creek Restoration and Management Plan in order to address many of the issues outlined above. The City has a long-term interest in the management of Whychus Creek to protect property from excessive stream bank erosion, provide recreational and aesthetic community benefits, enhance the natural resource values, and comply with the federal Endangered Species Act and other natural resource regulations.

The overall goal for the Whychus Creek Restoration and Management Plan is to identify opportunities for the enhancement and restoration of the developed reaches of Whychus Creek throughout the project area. The objectives for the project are to develop restoration, management, and policy-level actions that protect properties while restoring the proper functioning of the creek system.

DOCUMENT ORGANIZATION

The Whychus Creek Restoration and Management Plan is organized into six sections.

1. Section 1 provides project background along with goals and objectives
2. Section 2 provides a summary of existing conditions within the project area, and describes the relevance of these conditions to proposed restoration actions. Much more detailed descriptions of existing conditions are located in the report Appendix.
3. Section 3 outlines the proposed restoration and management actions for the entire project reach, and includes descriptions of restoration goals and objectives, key factors to project success, and other project considerations.
4. Section 4 provides an analysis of the City's policies and development codes with respect to property and habitat protection and water quality, and discusses changes that could be implemented to further protect Whychus Creek and adjoining properties.

5. Section 5 discusses tools that are available to landowners who may chose to initiate restoration actions on their own properties.
6. Section 6 provides a list of references utilized in compiling the report materials

RESTORATION GOALS, OBJECTIVES AND KEY FACTORS TO PROJECT SUCCESS

The overall goals for the Whychus Creek Restoration and Management Plan are to protect property along Whychus Creek while protecting and enhancing habitat for aquatic and riparian species. These objectives have been divided into two broad categories:

- *Property protection through both in-channel and off-channel restoration actions; and*
- Enhancement of channel and riparian function to benefit water quality, aquatic habitat and aquatic species.

In many instances improvements in one area like the riparian zone can have multiple benefits including property protection, water quality and aquatic habitat improvement. Any given action will have its own specific key factors that will allow the action to succeed in achieving intended objectives and goals. Listed below are the most significant factors influencing successful project implementation. These have been grouped by three primary categories:

- Willing and participative landowners;
- Funding availability; and
- Physical site considerations.

PROPOSED STREAM RESTORATION ACTIONS

The Whychus Creek Restoration and Management Plan provides a summary of the recommended restoration and enhancement actions within the Whychus Creek project area. These actions are based on the cross-disciplinary summary of geomorphology, hydrology, aquatic habitat and riparian conditions in the creek. Table 1 in the Plan provides a description for each proposed action, and project area maps available at www.whychus.com show the locations of specific recommended actions. Conceptual drawings of some typical stream restoration practices are included in the Plan to provide examples of what some of the actions recommended in Table 1 might look like. These drawings are provided for reference only as implementation of many of the action items recommended in this Plan would entail more detailed engineering and analysis beyond what is contained in the Plan.

EVALUATION OF CITY OF SISTERS POLICIES AND CODES

When developing restoration and management actions for an urban stream such as Whychus Creek, it is very important to not rely solely on scientific analyses to develop proposed actions. Instead it is critical to link this scientific framework with the social, political and policy frameworks that interplay in each community, in order to ensure that the proposed scientific recommendations will ultimately be understood and supported by the community as a whole.

City of Sisters policies and codes were evaluated in the Whychus Creek Restoration and Management Plan, and various policy-level actions are proposed that would help provide enhanced erosion and property protection, while assisting with the long-term restoration of Whychus Creek. Specific actions evaluated include:

- Changes to the Sisters Comprehensive Plan that would provide more protection for properties and Whychus Creek. Potential Plan adoptions could include protecting riparian zones and adopting measures to improve water quality.
- Changes and additions to the City Development Code that could help protect private property adjacent to the stream and riparian areas, and improve water quality.
- Possible adoption of a Stream Protection District (described in Plan Section 4.5.3) that would provide guidance for activities that would be permissible within different zones proximate to Whychus Creek.
- Implementation of best management practices (BMPs) and incentive programs for private property protection, water quality improvement and stream habitat protection.

LANDOWNER TOOLS

A variety of land conservation incentive programs are described in the Whychus Creek Restoration and Management Plan that can be developed by the City of Sisters to enable landowners to implement low cost, high value solutions for improving riparian habitat, minimizing stream bank erosion, protecting stream water quality and habitat, and protecting streamside properties. For those landowners interested in implementing proposed actions laid out in this Plan, there are significant financial and technical resources available through local non-profit organizations as well as state and federal agencies. Contact information is provided in the Plan for these potential partners who could help manage, fund and implement these projects.

1.0 Introduction

1.1 Background

The Whychus Creek drainage covers a total of 230 square miles beginning in the Three Sisters Wilderness, and extending north-eastward through the Deschutes National Forest, the City of Sisters (City), private agricultural land, and sagebrush steppe upland before discharging to the Deschutes River (Figure 1).

As the City of Sisters has grown and expanded along and around Whychus Creek through the years, the proximity of the dynamic creek to homes and property has lead to bank erosion that threatens property, public safety and the health of the creek. The issues the City of Sisters and its inhabitants are facing have three main root causes:

- Whychus Creek is a naturally dynamic system
- Development patterns have put properties at risk
- Decades of "fixes" have made the problems worse

The dynamic nature of the creek through the City of Sisters is linked to a number of factors. The City is located on Whychus Creek's alluvial fan made up of glacial outwash as it exits the Three Sisters Wilderness. Over time Whychus Creek has naturally migrated back and forth across the outwash plain through easily erodable glacial materials made up of cobbles, gravels, sands and fine sediments. While Whychus Creek is located in a fixed position as it flows through the City of Sisters, left to natural processes, Whychus Creek would continue to migrate laterally across its outwash plain. In addition, the creek being mainly snow melt driven, displays great variations in flows both on a daily and seasonal basis. Flooding events are not uncommon, especially in the fall and early winter when rain on snow events occur.

Development patterns in and around the City of Sisters have put properties at risk given the creek's dynamic nature. In many instances tax lots on either side of the creek extend to the center line of the creek, and homes have been constructed within the Federal Emergency Management Agency (FEMA) 100 year floodplain. In other instances, while homes are outside the FEMA 100 year floodplain boundary, they are still within what is call the channel migration zone (CMZ); the areas occupied by the creek in the past or that have a high likelihood of being either occupied by the creek in the near future or are susceptible to channel erosion.

Given these issues, a network of "fixes" have been implemented throughout the years on properties in an attempt to limit erosion issues. Unfortunately, these patchwork fixes have in

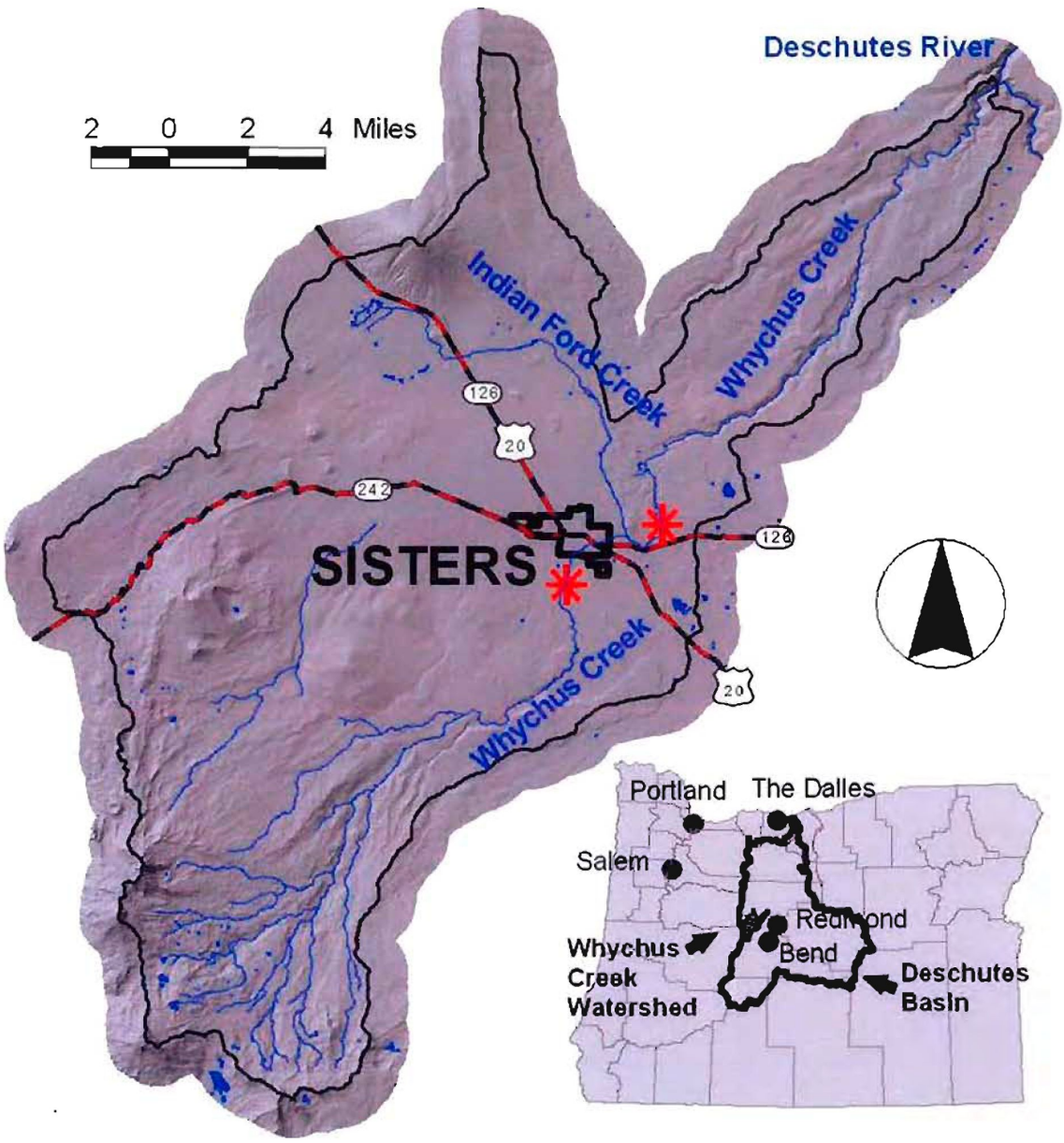


Figure 1. Location map. Red stars denote project area endpoints.

many instances transferred issues and problems to downstream property owners. For example, the rip-rapping of many of the banks and straightening the Whychus Creek channel between the Elm Street and Highway 20 bridges have caused water velocities to increase and sediment to be transported through this section. Below the Highway 20 Bridge, the sediment deposits or settles out, which then increases channel migration and erosion.

The City of Sisters and the Upper Deschutes Watershed Council (UDWC) have partnered to develop this Whychus Creek Restoration and Management Plan in order to address many of

the issues outlined above. The City has a long-term interest in the management of Whychus Creek to protect property from excessive stream bank erosion, provide recreational and aesthetic community benefits, enhance the natural resource values, and comply with the federal Endangered Species Act and other natural resource regulations.

The UDWC, in pursuit of its mission, is interested in working with the City and other partners to promote community-based management of local rivers and streams, including Whychus Creek, to promote clean water, healthy fish and wildlife populations, and improved natural resources management.

The plan described in this report is one component to meeting the restoration goals outlined in the Deschutes Subbasin Plan (Palmer et al., 2004). The Deschutes Subbasin Plan identifies Whychus Creek as the second highest priority for stream habitat restoration in the entire Deschutes Subbasin, largely because of the historical importance of the creek system for Chinook salmon and summer steelhead spawning and rearing, and the high likelihood of restoration project success (Palmer et al., 2004). This important habitat potential is recognized by a broad-based network in the Deschutes Basin community who are providing support for a number of ongoing and planned collaborative projects in the Whychus Creek system involving the Upper Deschutes Watershed Council (UDWC), the Deschutes River Conservancy (DRC), the Deschutes Land Trust (DLT), and the U. S. Forest Service (USFS) Sisters Ranger District.

The project reach defined for this plan begins at Forest Service Road 4606 (approximately RM 23), located ¾ of a mile upstream of the City's Urban Growth Boundary (UGB), extends downstream about 1.0 mile through the City's UGB, past the confluence with Indian Ford Creek and around the southern end of McKinney Butte, to about 2.0 miles downstream of the UGB boundary (approximately RM 19), for a total of approximately 4 miles.

1.2 Goals and Objectives

The overall goal for the Whychus Creek Restoration and Management Plan is to identify opportunities for the enhancement and restoration of the developed reaches of Whychus Creek throughout the project area. The objectives for the project are to develop restoration, management, and policy-level actions that protect properties while restoring the proper functioning of the creek system.

The Whychus Creek Restoration and Management Plan is intended to provide a restoration and management strategy that:

- Plans holistically throughout the entire project area, not piecemeal with spot treatments;
- Applies latest technology and approaches that have successfully been implemented by other communities;
- Promotes "fixes" that protect property and stream health simultaneously; and

- Looks ahead to the City's future growth to avoid many of the problems that have arisen by past development patterns.

There are a number of reasons to act now to develop this plan. Numerous homeowners have asked for assistance from the City, Watershed Council, Oregon Department of Fish and Wildlife (ODFW), and others. There is an improved understanding of how past 'fixes' have actually created more problems. Finally, the ongoing reintroduction of salmon and steelhead into Whychus Creek is bringing increased collaboration and new regulatory requirements, while providing a unique opportunity to access new funding and expand on existing efforts to manage the creek.

1.3 Document Organization

This document is organized into four main sections. Section 2 provides a summary of existing conditions within the project area, and describes the relevance of these conditions to proposed restoration actions. Much more detailed descriptions of existing conditions are located in the Appendix to this report. Section 3 outlines the proposed restoration and management actions for the entire project reach, and includes descriptions of restoration goals and objectives, key factors to project success, and other project considerations. Section 4 provides an analysis of the City's policies and development codes with respect to property and habitat protection and water quality, and discusses changes that could be implemented to further protect Whychus Creek and adjoining properties. Section 5 discusses tools that are available to landowners who may chose to initiate restoration actions on their own properties.

2.0 Summary of Existing Conditions and Relevance to Proposed Actions

Our initial action in completing the Whychus Restoration Plan was to review existing conditions within the project area, and the Whychus Creek watershed as a whole. A detailed description of existing conditions is provided in companion appendices to this document. The following is a summary of existing conditions and a brief discussion of how existing conditions pertain to protection and enhancement opportunities in the project area.

2.1 Geologic Setting

The majority of the project area is located on an alluvial fan consisting of glacial outwash. High-resolution topographical data available for the area clearly show many abandoned stream channels to the south and east of the current Whychus Creek channel. Whychus Creek's channel has migrated across the outwash plain in a northwesterly direction. As the creek migrated across the outwash plain its course was likely influenced by buried paleo-channels that it intersected within the glacial outwash deposit. East of McKinney Butte (downstream of the confluence with Indian Ford Creek; Figure 2), the creek channel is confined between the andesite lava flows of McKinney Butte and a Quaternary basalt flow that caps the bluff to the east. The channel upstream of Indian Ford Creek exhibits a "distributory" pattern,

and many of the relic channels are still present on the landscape. Channel location has been highly mobile in past, and would be expected to change in the future absent efforts to contain channel location in its current position.

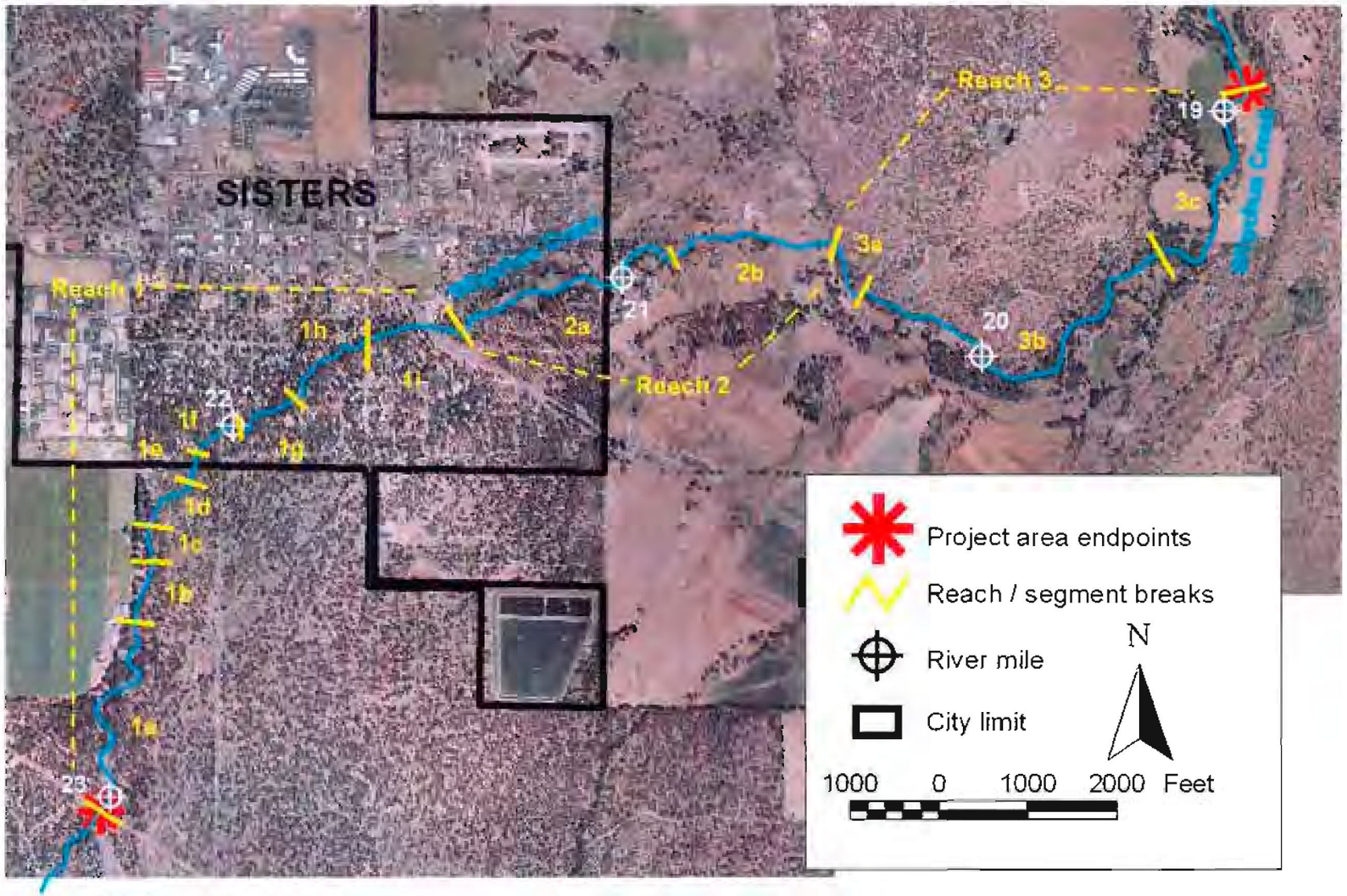


Figure 2. Project area map.

2.2 Geomorphic framework

Three broad reach types (transport–deposition–transport) have been defined for the project area (Figure 2). Additional segments have been broken out within these reaches based primarily on differences in natural and artificial confinement.

Approximately three miles upstream of the project area the stream exits a relatively steep, wide canyon. Although reaches of sediment deposition exist in the upstream portions of the watershed, the area primarily functions as a sediment source. The stream displays alluvial fan characteristics as it leaves the confining canyon walls, lessening its gradient and creating split channels across the fan. These transitional reaches are often the site of significant sediment deposition as stream energy is reduced by the decreasing slope and increasing channel width. The City of Sisters is located within such a transitional reach.

In a natural situation this area would contain many distributory channels that route flood flows away from the main channel. This is in contrast to typical valley floodplain functioning (for example, the area downstream of Indian Ford Creek, where high flow channels discharge back to the main channel. This distinction is central to understanding the functioning of Whychus Creek through the project area. The disconnection of high flow distributory channels results in concentration of flood flows within the confined main channel, leading to increased channel capacity and correspondingly decreased channel complexity.

The upper portions of the project area above the City exhibit the most complex combination of geomorphic processes. Extensive cobble /gravel bars and islands indicate that deposition of routed sediment is occurring. At the same time, these deposits are helping to force the stream laterally, as evidenced by active bank erosion on the outside of every major bend in the channel. The stream is trying to achieve a stable, slightly meandering pattern.

Through the City of Sisters above the Highway 20 Bridge, the stream has been channelized and narrowed, resulting in a sediment transport reach lacking in habitat diversity. Channelization, removal of instream and bank elements such as trees and riparian vegetation that provide roughness, and the reduction in spring peak flows associated with water withdrawals upstream have created a stream not likely to assume a broad multi-thread presence across the fan. Incision and modifications have effectively isolated the channel from the historic flood plain. In addition, the natural meandering tendency of Whychus Creek that would allow it to move farther north through the City is constrained by modifications and incision that restrict the stream to it's eastward arc through town.

Below the Highway 20 Bridge, the gradient lessens and the channel displays depositional characteristics in a wider channel confined by berms and terraces. Downstream of the confluence with Indian Ford Creek, the left bank of Whychus Creek is confined by the bedrock and hill slopes of McKinney Butte. The stream follows a fault line as it cuts along the toe of the alluvial fan. Although much of this portion of the stream has been channelized north of its previous location, today's channel is stabilized by the bedrock features of McKinney Butte.

The bedrock features also provide habitat complexity. A narrow floodplain remains in contact with the current channel. Sediment is mostly transported through this reach, while the abandoned channel supports a diverse wetland community in places.

Ice formation and movement are active in the project area. Ice dams not only impede flow and cause flooding, but movement of ice can affect channel geometry and bank and bed stability. No written record of ice impacts to Whychus Creek was located, though land owners provided some information on ice events. Ice jams have occurred within the last few years at narrow points in the channel. These jams are known to exacerbate flooding upstream, and are suspected to cause some channel erosion as the ice moves. In addition, the ice disturbs riparian vegetation establishment on bars and terraces in and near the channel.

Other influences and processes associated with the watershed are related to a number of moraine dam lakes located in the headwaters of the watershed. As the glaciers associated with these lakes retreat, there is a real concern that the moraines impounding these lakes could fail, initiating a debris flow that would affect downstream channel conditions and processes. These failures have occurred in the basin before, the most recent being a failure of the Diller Lake moraine in 1970 that initiated a debris flow in the North Fork of Whychus Creek. Most of the channel impacts occurred well upstream of the project area. Current concern is focused on Carver Lake, located in the headwaters of the South Fork of Whychus Creek (Figure 1). The volume of this lake is slightly less than three times that of Diller Lake. The USGS (1987) suggests that a flow pulse of about 1,400 cfs near the project area may be possible, and that sediment carried to the project area would likely be in the form of fines and small gravel rather than boulders or cobbles.

2.3 Channel migration zone

Channel migration zone (CMZ) refers to those areas along a stream that have been occupied by the stream in the past; or that have a high likelihood of being either occupied by the stream in the near future (within an approximately 10 to 25 year time horizon), or are susceptible to channel erosion (Rapp and Abbe, 2003). Delineation of the channel migration zone (CMZ) can help reduce risks to life and property by highlighting those areas most at risk of channel erosion. Additionally, channel migration zone (CMZ) delineation can identify and help protect critical aquatic habitats.

We identified the channel migration zone (CMZ) throughout the project area following the Washington Department of Ecology guidelines (Rapp and Abbe, 2003). The channel migration zone (CMZ) consists of the historic channel migration zone plus the Avulsion Hazard Zone (surfaces which could be occupied by the channel) and the Erosion Hazard Area (areas subject to channel and hillslope erosion). To produce the final CMZ boundaries, the areas within these zones that have been modified to prevent channel migration or movement such as berms and rip-rap are removed. The removal of these modifications could change the CMZ boundaries. Given the developed nature of much of the project area, channel modifications play a critical

role in determining CMZ boundaries. For display purposes, these modifications as well as natural confining features are mapped together as the convex features shown in Figure 3.

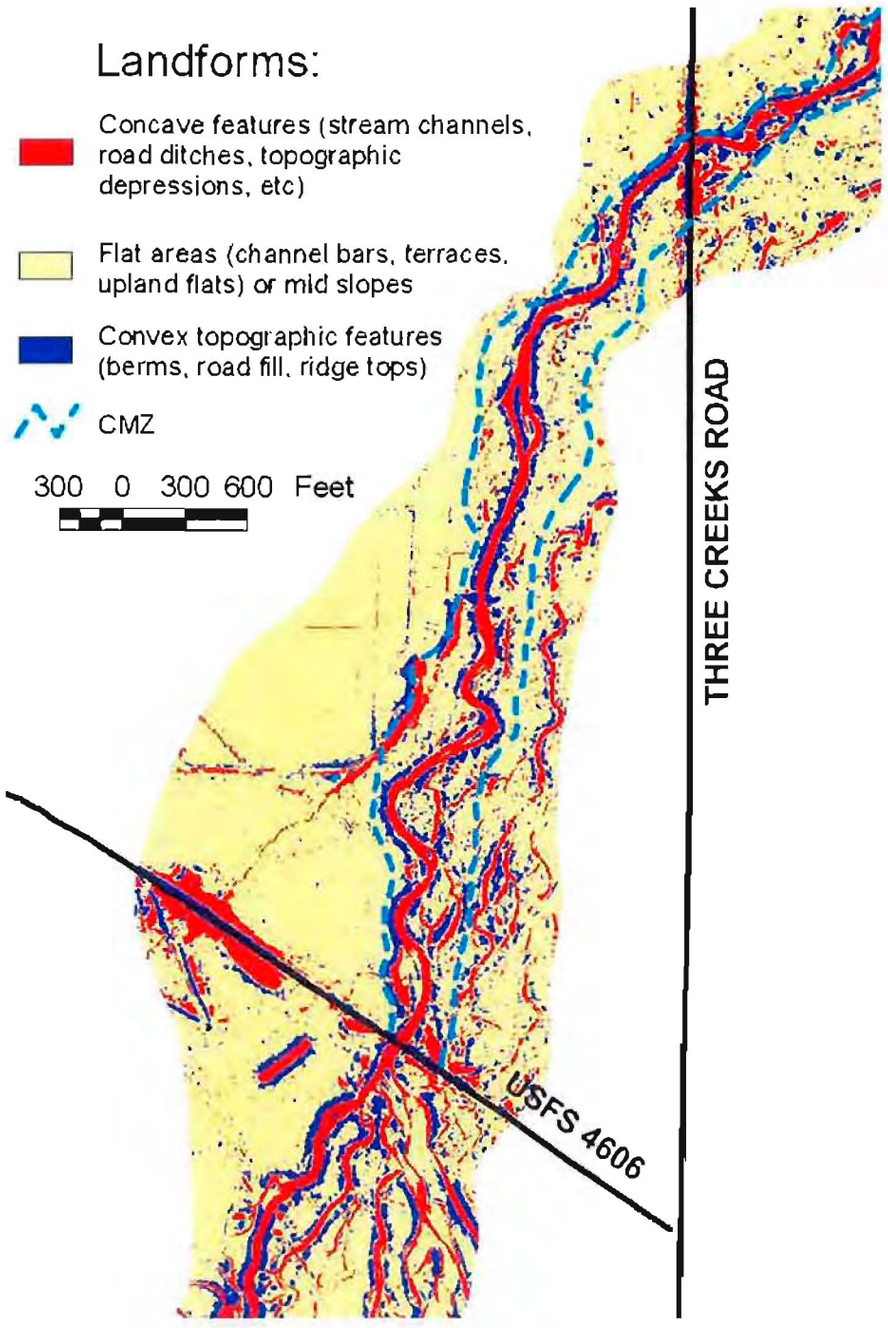


Figure 3. Example of landforms and channel migration zone delineation at upstream end of project area.

Delineation of a channel migration zone (CMZ) on an alluvial fan is difficult, given that, almost by definition, the entire fan should be considered part of the CMZ. In the case of Whychus Creek, this would result in the CMZ covering all of the fan area south and east of town. While delineating the entire alluvial fan as part of the CMZ may be correct in the strict geomorphic sense, this delineation does nothing to guide stream restoration and infrastructure protection efforts. Therefore, a more refined mapping was needed.

More refined mapping was conducted in the area south of town along Three Creeks Road (Figure 3). Signs of many discontinuous small channels (relic channels) are present across the alluvial fan on either side of Whychus Creek. Some of these are still active and hold water during flood flows. Many of these high flow channels were likely carved by the higher energy flows that once flowed down the creek prior to irrigation diversions. While these discontinuous channels currently accept flood water, the active stream channel is likely stable enough and lacks the energy to shift the thalweg[1] to one of these remnant high flow features, unless there is a change in the hydrologic or sediment regime. Therefore, this portion of the alluvial fan was excluded from the channel migration zone (CMZ) delineated for the purposes of this study.

Other areas which required extra scrutiny include segments whose channel margins and floodplains have not been modified. Normally, valley walls and abandoned terraces would help define the channel migration zone (CMZ). In a number of areas within the project areas, these features are absent or poorly defined, complicating delineation of the CMZ. In other areas, modifications such as berms, roads, and structures often define the CMZ. In these instances and in locations with resistant bank material, it is possible for the floodplain to be mapped outside of the CMZ. Flooding in these areas may occur, but the presence of stable and hardened banks would likely prevent movement of the channel. The final location of the CMZ was mapped giving consideration to permanent modifications that are unlikely to change over the medium term (10 to 25 years).

Overall, the channel migration zone (CMZ) delineated for this project[2] is meant to serve as a guide for probable channel position in reference to stream protection and restoration efforts. The delineation was done at a segment and project scale and is meant for general planning purposes. Unlike the FEMA floodplain demarcation, the CMZ mapping is largely a qualitative exercise that is not supported by hydraulic analyses. As such, the channel migration zone (CMZ) could be open to further study and refinement.

2.4 Hydrology

Whychus Creek drains an area of approximately 250 square miles, with elevations ranging from over 10,000 feet in the vicinity of the Three Sisters peaks, to approximately 2,100 feet at the confluence with the Deschutes River. Precipitation ranges from approximately 14 inches per year in the vicinity of the confluence with the Deschutes River, to over 100 inches in headwater areas. The project area experiences complex hydrology due to mixed peak flow generating

[1] Deepest portion of the channel in cross-section
[2] Refer to the project area base maps for CMZ location

processes (rain-on-snow, snowmelt, thunderstorms), significant withdrawals upstream of the project area during the peak flow period, the occurrence of ice flows / jams within the project area, and an increasing trend in summertime base flows due to recent flow restoration efforts.

Approximately two miles upstream of the project area the Three Sisters Irrigation District (TSID) diverts the majority of the summertime stream flow. Upstream of the TSID diversion Whychus Creek exhibits a hydrographic regime typical of eastside Cascade streams; experiencing the highest mean daily flows during the spring and early summer snowmelt season (Gage #14075000; Figure 4). Within the project area summertime flows are significantly reduced (Gage #14076050; Figure 4). The TSID diversion has little effect on the large magnitude peak flows (i.e., flows with a recurrence interval of greater than five years), but has a significant effect on smaller magnitude higher frequency events, reducing peak values by approximately 20 to 60%. Part of the reason for the small effect on the largest events may be attributable to seasonality, with the relatively larger rain-on-snow events occurring outside of the irrigation season.

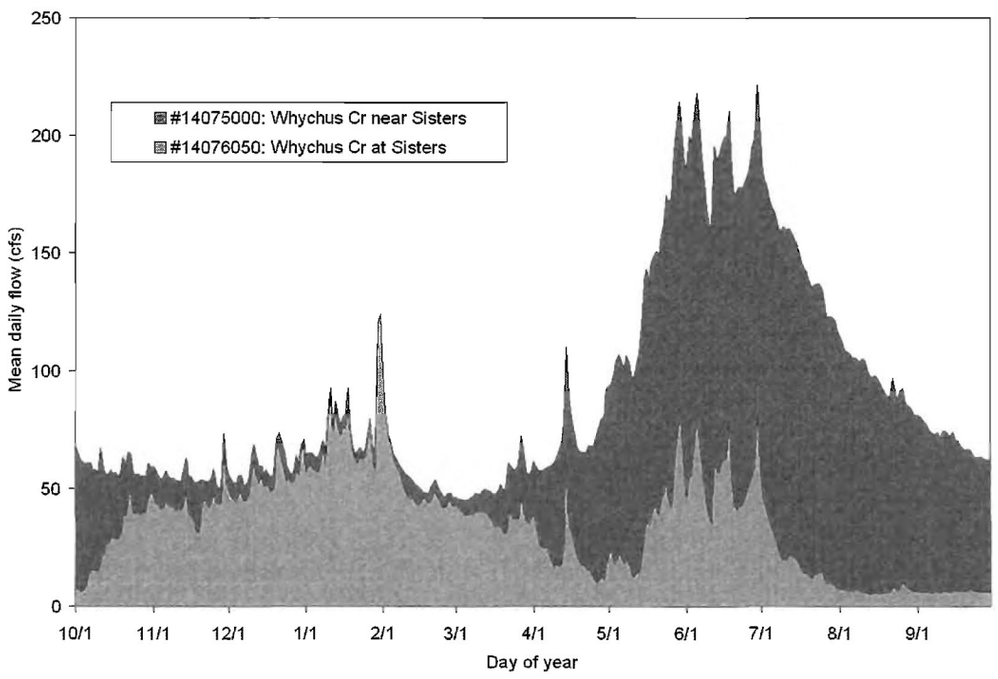


Figure 4. Mean daily flow comparison for the period 5/2000 - 9/2006 upstream of the TSID diversion (gage #14075000) and within the project reach (gage #14076050).

Several points of irrigation diversion occur within the project reach. None of these individually are greater than 1 cubic foot per second (cfs), and collectively account for less than 2 cfs. The majority of these are operated using small pumps within the stream, the exception being the diversion downstream of Elm Street, which consists of an approximately 10 foot high dam that diverts flow into a small canal that runs through town.

The United States Geologic Survey (USGS) has identified the project reach as a "losing reach" which is defined as a section of stream where surface flow is lost to groundwater (Garnett and Lite, 2004). The USGS regional groundwater flow model estimates that approximately 4 cfs are lost to groundwater within the project reach under steady state conditions. Field surveys (i.e., "seepage runs") conducted by OWRD between the Sisters stream gage and Camp Polk Road confirm these model results (LaMarche, pers. comm., 2008). Groundwater withdrawals within the vicinity of the project reach likely exacerbate losses to groundwater.

2.5 Aquatic habitat

Historically, anadromous and resident fish populations had free access to the lower Deschutes River and Whychus Creek. The Deschutes River upstream to Big Falls and Whychus Creek traditionally supported runs of summer steelhead and spring Chinook salmon. Whychus Creek was a major producer of summer steelhead.

The Pelton Round Butte Hydroelectric Project on the mainstem Deschutes River creates the primary barrier to anadromous fish attempting to reach spawning and rearing areas in the upper basin. In addition to the fish barrier downstream at the Pelton Round Butte Hydroelectric Project, habitat in Whychus Creek has been highly modified by reduced stream flows, passage barriers, unscreened diversions, riprapping and other channel alterations. In addition, Whychus Creek was heavily modified following the 1964 flood when the U.S. Army Corps of Engineers channelized 11 miles of the creek.

Although individual reaches vary, habitat is rated poor in certain reaches throughout the project area due to limited structural diversity, lack of large woody material (LWM), pools, undercut banks, and gravel sorting features (Spateholts, 2008). Reaches are rated fair to poor for spawning-to-emergence due to lack of pool tailouts and substrate that is cemented by fines. Summer rearing is rated poor due to lack of pool area, cover, flows, and temperature. Winter rearing is rated as good to fair due to the increase in flows that provide additional habitat space.

Hill and Quesada (2008) sampled fish populations at four locations in Whychus Creek as part of the Pelton Round Butte Hydroelectric Project license agreement. Species composition provides a qualitative assessment of the response of the fish community to habitat conditions. The percent of native redband trout is much lower in the Sisters UGB segment (approximately equivalent to Segment 2A; Figure 2), compared to three reaches downstream of the City of Sisters. The reduced number of redband trout is indicative of the poor habitat quality in this reach resulting from the channel modifications used to protect structures in this reach.

Water temperature in Whychus Creek has been extensively monitored (see for example Logan and Jones, 2007). The entire extent of Whychus Creek is slated for development of total maximum daily load (TMDL) allocations, and is on the State of Oregon Section 303(d) list of impaired waterways (DEQ, 2007). Current state temperature standards specify that the temperature should not exceed 18 °C throughout the year for salmon and trout rearing and

migration. The potential state temperature standard of 13°C would protect salmon and steelhead spawning for the period of October 15 through May 15.

A study conducted in 2007 by the Upper Deschutes Watershed Council (UDWC; Logan and Jones, 2007) evaluated nine temperature stations from the mouth upstream to the stream gage upstream of the Three Sisters Irrigation Diversion (TSID). Two of these stations with a long period of record occur within the project reach; one is located near the upstream project boundary, and the second is located at the USGS gage in the Sisters City Park (within segment 1l; Figure 2). Temperature criteria for rearing and migration are exceeded at stations downstream of the TSID diversion through the project reach. The highest rate of change during July occurred between the TSID diversion and the station at the USGS gage / Sisters City Park. The increase in temperature has been associated with the decrease in flow below the diversion.

Further analysis of the relationship between stream discharge and water temperature is being evaluated by the UDWC. Initial findings show a strong relationship between discharge and water temperature, suggesting the possibility of linking ODFW instream water rights to water temperature in the Sisters reach of Whychus Creek (Jones, 2008). While proposed restoration designs can improve stream temperatures by providing additional shading, the analysis performed by the UDWC indicates that water temperatures in the project area are impacted primarily by decreased summertime base flows.

Restoration of habitat in the Sisters reach of Whychus Creek is one part of a much larger effort to restore habitat in Whychus Creek related to reintroduction of anadromous fish in the Deschutes River basin above the Pelton Round Butte Hydroelectric Project and restoration of resident species. The reintroduction effort in the Deschutes River addresses spring Chinook salmon, summer steelhead, and sockeye salmon, with emphasis on steelhead and Chinook salmon in Whychus Creek.

Whychus Creek is considered to have a high potential for supporting self-sustaining populations of steelhead. Bull trout are present in lower Whychus Creek, and are known to forage upstream into the project area (Riehle, pers. comm., 2008). Enhancement designs will need to consider the needs of all life stages for summer steelhead, redband trout, and spring Chinook salmon. In addition, designs will need to address the primary limiting factors that include limited structural diversity and the lack of large woody material (LWM), pools, undercut banks, and gravel sorting features.

2.6 Riparian

Riparian (i.e., streamside) areas provide a range of ecological services such as providing stream shade, large woody material (LWM) inputs, bank stability sediment retention, and inputs of organic material that benefit instream food webs. The maximum width of the riparian zone included for analysis was defined as the maximum flood extent as mapped by FEMA (2007). Within the maximum spatial extent, the riparian zone was examined for the range of

geomorphic features present, including gravel/cobble bars, floodplain extent and upper terraces. These features are critical habitats for differing plant species and structures (trees, grasses / sedges, shrubs). The direct interaction of the stream channel and surrounding groundwater dictates the range of water availability for given plant species or communities. In addition, the interaction of the stream channel with the riparian zone at high flows dictates how plant species or communities establish themselves based on the amount of disturbance that occurs during these high flows.

Geomorphic features such as gravel / cobble bars, floodplain extent, and upper terraces were mapped within the defined riparian areas using available high-resolution topographic information (i.e., LiDAR bare earth imagery). The output from the mapping analysis provided a fine-scale view of relative ground elevations in the riparian zone compared to the stream channel. These data were manipulated to form different elevation zones based on their level of potential interaction with the stream channel (Figure 5).

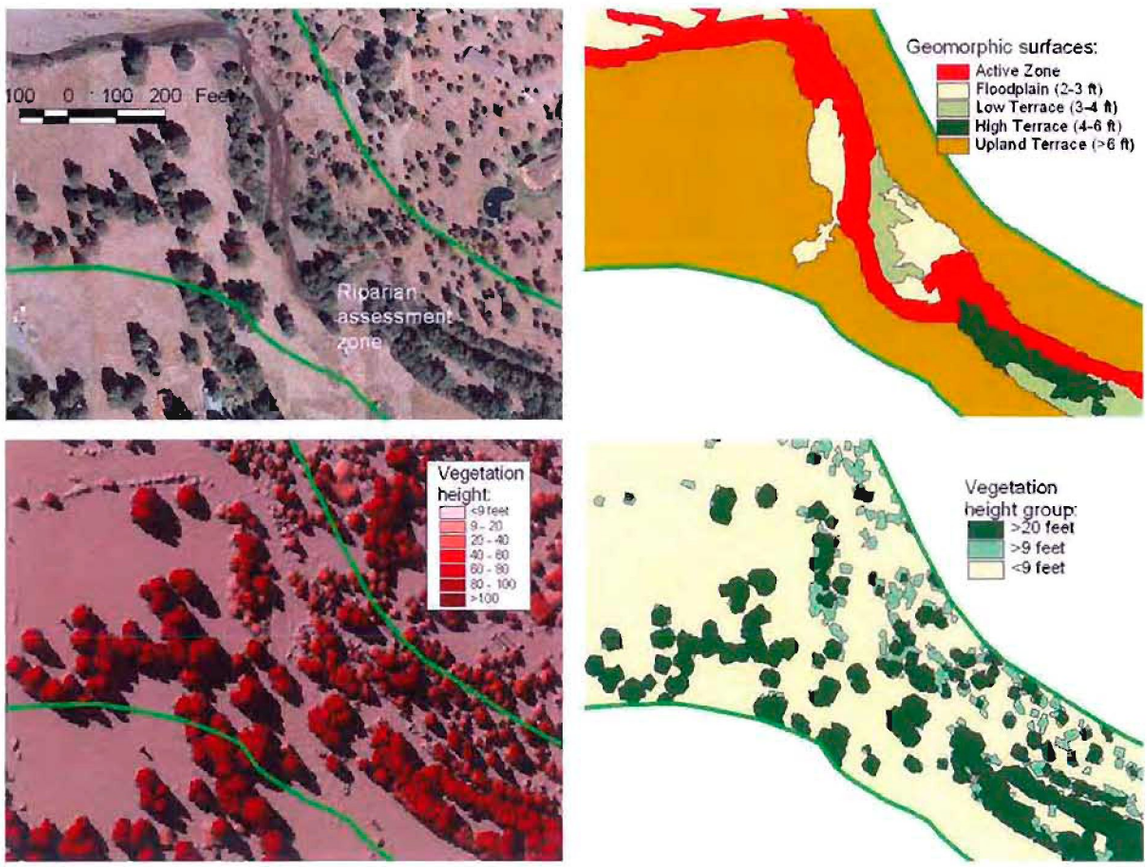


Figure 5. Example of geomorphic surfaces and vegetation heights derived from LiDAR data. This segment (Segment 3A) represents the closest example of a reference reach for the riparian condition and geomorphic surface interaction.

With the available LiDAR information for the project area, it is also possible to determine the height of the vegetation in the riparian zone. Based on these heights, vegetation types or communities can also be determined. Vegetation types were categorized into two height categories ≥20 ft ("large") and ≥9 ft ("small"), with each zone having specific abilities to provide stream shading, potential large woody material (LWM) recruitment, and potential zones for providing seed / sprouting stock to enhance riparian communities throughout management and restoration efforts. The ≥20 ft size class contained mostly tree structures. The smaller size class incorporated emerging vegetation on gravel bars, exposed banks, and human-made structures including houses and some parts of bridges.

The fine scale vegetation height maps can then be coupled with the fine-scale view of relative ground elevations in the riparian zone compared to the stream channel. These maps and groupings can be used to determine where, and at what distance from the channel, specific plant communities are found or are not found. In turn, the maps can be used to delineate areas that are most likely to respond to restoration based on connectivity to stream and shallow groundwater.

Often current riparian conditions are compared and contrasted with a number of other stream reaches that show typical riparian species composition and structure that functions well with the stream system. These "healthy" riparian reaches are often called reference reaches. However, because the Whychus Creek study area is dominated by an urban environment with considerable uses of berms, riprap and changes in hydrology, it is difficult to find reference reaches that display characteristics of undisturbed riparian zones. Hence it is necessary to develop desired future conditions for the riparian zones that are dependent upon restoration actions that are practical, and where conditions exist that would support or enhance the existing favorable riparian zones ecological conditions. For these reasons we present the riparian zones in context of current available area (geomorphic surfaces), highlighting plant community composition and structure that are current assets to build upon. Recommendations for enhancement that fall within the given constraints for each segment are also provided.

Examples of enhancing existing favorable riparian zones ecological conditions can be found in Segment 3A. In this segment, one can observe active interaction between the channel, floodplain low-terrace, high terrace and uplands with sedge / willow plant communities. Additional site-specific reference conditions for existing riparian zone conditions and opportunities for enhancement for each segment can be found in the appendices attached to this document.

3.0 Proposed Restoration Actions

3.1 Macro-scale actions

Three macro-scale approaches were considered for the project area:

- No action;
- Relocation of Whychus Creek from its present alignment to a location south and east of the City of Sisters; and
- Enhance Whychus Creek throughout the project area in its current alignment.

A continuation of the present parcel-by-parcel approach to property protection and development along Whychus Creek represents the "no action" alternative. This approach will very likely result in continued damage to downstream parcels, as well as degradation of aquatic habitats. Absent an overarching plan for the area, it would be reasonable to expect that landowners will protect their properties from bank erosion using the approaches employed by their neighbors; riprap and other bank hardening structures that will transfer sediment and erosive energies to downstream areas. The result for aquatic organisms will be continued degradation of habitat.

Relocation of Whychus Creek is considered based on the examination of the high resolution LiDAR topography data for the project area and surroundings. These data show that Whychus Creek has occupied many different locations across the alluvial fan over the recent geologic past. Relic channels can be observed in many locations, some of which still convey water at present. Given the physical setting, it seemed reasonable to consider an option where Whychus Creek was moved from its current alignment to a location south and east of the Sisters UGB (Figure 6). The advantages of such a move would include elimination of the bank erosion and flood hazards posed by Whychus Creek to landowners within the City. The newly constructed channel would likely occupy one of the old relic channels and could be constructed "off line", with flow introduced only after vegetation had become sufficiently established and channel conditions developed. The new channel would not be tightly constrained as the present one is between structures and other existing infrastructure. However, this alternative was dismissed as being unworkable, given a number of factors including:

- The high value that landowners and the City of Sisters place on proximity of the stream to their property and the City,
- The perceived difficulty in acquiring property and/or easements to develop the new channel,
- The significant cost, and
- The desire of the City to develop a portion of this area for future wastewater treatment (Figure 6)

Despite the low likelihood that the creek would be relocated to this area, there is evidence that the Lazy Z ditch currently acts as an overflow channel in high flood events. It would be wise for the City and County to limit any development in this area that would preclude using the ditch as an overflow channel at some point in the future, if deemed necessary. Further analysis will be needed to assess what modifications would be needed for the ditch to handle flood flows (e.g., channel capacity, configuration of head structure, capacity of road culverts, etc).

Based on the analysis of the two above alternatives, this report primarily focuses on enhancement of Whychus Creek along its current alignment through the City of Sisters.

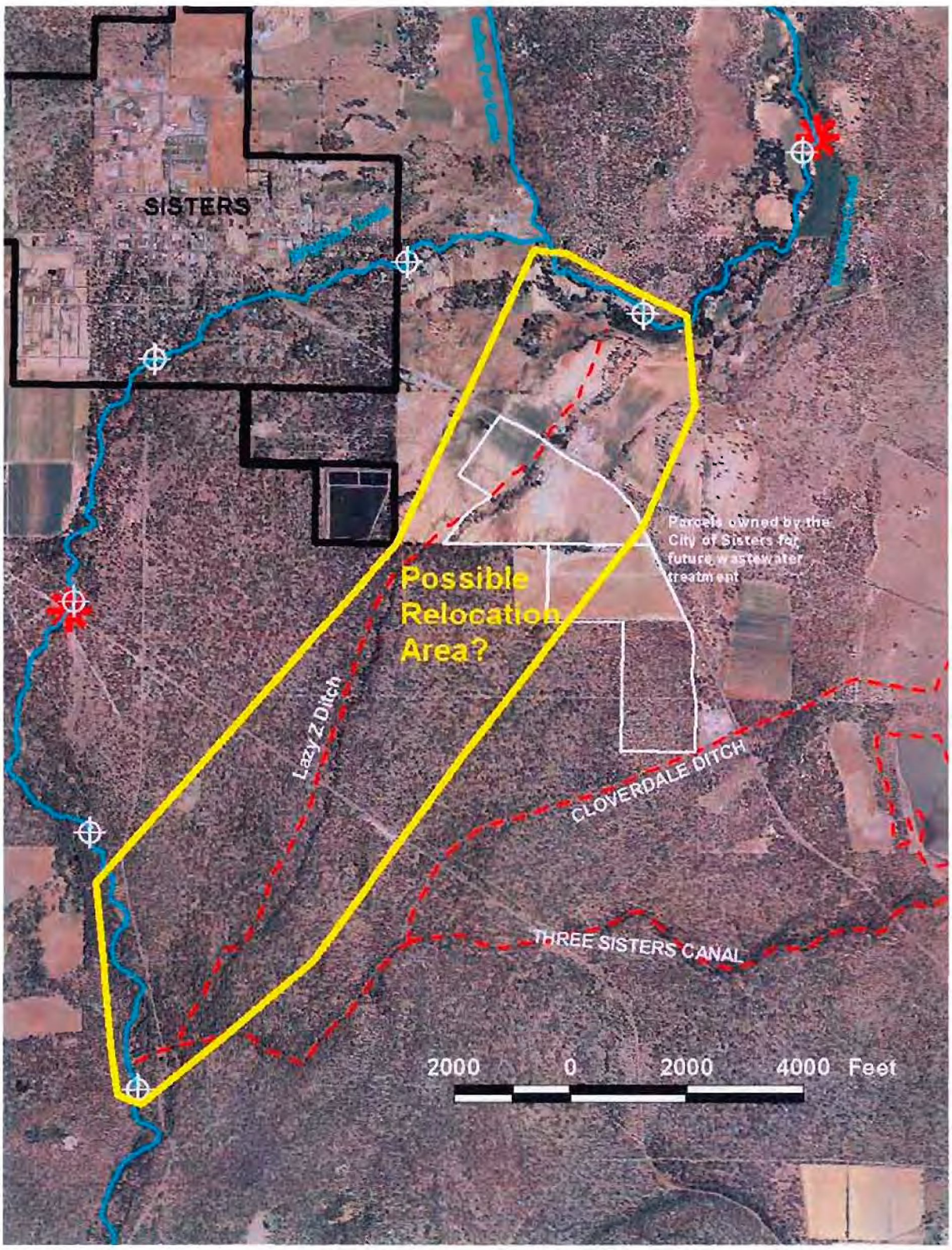


Figure 6. Possible area for relocation of Whychus Creek in the vicinity of Sisters.

3.2 Restoration goals and objectives

The overall goals of the project are to protect property along Whychus Creek while protecting and enhancing habitat for aquatic and riparian species. These objectives have been divided into two broad categories:

- Property protection through both in-channel and off-channel restoration actions; and
- Enhancement of channel and riparian function to benefit water quality, aquatic habitat and aquatic species.

To some extent these are artificial and overlapping divisions. In many instances improvements in one area like the riparian zone can have multiple benefits including property protection, water quality and aquatic habitat improvement. For example, increasing channel roughness may lead to more complex aquatic habitats, greater interaction between the stream and floodplain, and (ultimately) improved property protection.

3.2.1 Property protection

Property protection along Whychus Creek is one of the primary objectives of developing this Restoration and Management plan. Given the inherently high variability of flows in Whychus Creek, proposed actions to improve property protection cannot account for all potential river conditions that might arise in the future.

However pursuing the objectives laid out in this plan will have a net overall benefit to property protection by improving the overall functions of the stream channel, its riparian zone and its floodplains. The objectives below when met will help address the concerns of the City of Sisters and its inhabitants:

- Replace current piecemeal individual property protection measures with a comprehensive design plan.
- Minimize channel scour and bank erosion that threaten existing homes and other structures.
- Minimize the need to protect structures by preventing new construction, and removal of existing buildings, in high-risk areas.
- Where opportunities exist, reconnect Whychus Creek to its floodplain. This will maximize the area prone to flooding and will allow flood flows and accompanying energy to dissipate across the floodplain while allowing sediment deposition. These opportunities should be evaluated based on proximity to infrastructure and homes.
- Eliminate instream structures (e.g. dams and narrow bridges) that impair channel function and pose risks to property.

3.2.2 Channel and riparian function

While property protection objectives can be met by specific actions in and along properties adjoining Whychus Creek, many of these actions can also help improve channel and riparian function. The objectives below can help improve channel and riparian function:

- Enhance channel roughness. This can take the form of constructing material jams and placement of Large Woody Material (LWM). Increased channel roughness dissipates energy, thereby reducing erosion potential and creating habitat for aquatic species.
- Raise channel elevation where appropriate to increase water table elevation to access wet meadows, and to encourage riparian species establishment. Raising channel elevations can also increase off-channel habitats and create calm water refugia for fish.
- Improve sediment capture, storage and sorting in depositional areas. Improved sediment routing can reduce erosion potential and increase spawning habitat and quality.
- Reconnect high flow channels where appropriate to increase habitat area, groundwater recharge, and increased connectivity with the riparian zone.
- Convert existing habitats to more complex habitats (e.g., increase pocket pools, pool tailouts, etc.) to increase habitat quality.
- Decrease fish mortality (e.g., screen existing diversions).
- Improve fish passage throughout the study reach by eliminating or retrofitting partial or complete passage barriers.
- Protect existing functional riparian areas from actions that will preclude future active and passive restoration. Riparian areas can provide among other things shade, bank stability and food for aquatic species in the form of organic materials.
- Replace non-native plant communities, and denuded or sparsely vegetated areas, with native plant communities appropriate to locations in the riparian zone (i.e. proximity and elevation relative to water table).
- Eliminate existing invasive species and prevent the introduction of additional invasive species.
- Minimize or eliminate the thermal mass and lack of planting opportunities associated with widespread use of large rock riprap.
- Support and facilitate the transfer of permanent instream water rights to increase summer flows in Whychus Creek.

3.3 Key factors to project success

Any given action will have its own specific key factors that will allow the action to succeed in achieving intended objectives and goals. Listed below are the most significant factors influencing successful project implementation. These have been grouped by three primary categories:

- Willing and participative landowners

- Funding availability
- Physical / site considerations

3.3.1 Willing and participative landowners

Project implementation is of course impossible without the support and cooperation of landowners in the project area. Most of the area is in private ownership and project implementation will only be possible with buy-in from landowners. On public land, project implementation will need to be compatible with existing management direction.

Successful implementation will also be dependent on landownership patterns, the scale of a given project, and how it may interact with other creek reaches both up and downstream. Within the City of Sisters (Segments 1F – 2A; Figure 2), projects such as riprap removal and wood placement can affect relatively long sections of the stream. Since parcel sizes are small in these areas, opportunities exist to address many parcels at once if coordination can be achieved among multiple landowners.

In many situations there will be important trade-offs by each landowner when considering proposed actions in this plan. For example, reestablishment of native riparian communities along stream edges, coupled with bio-engineered bank stabilization methods, may address bank erosion and potential loss of property. These solutions may add value to a parcel by providing wildlife viewing opportunities and satisfy a given landowner's long-term objectives of property protection. However, the trade-off for all these benefits could be that while still having access to the stream, landowners may no longer have unrestricted views of Whychus Creek from their homes. In other situations the proposed actions such as functioning riparian corridors may limit specific land uses along the creek.

Some of these trade-offs can also take the form of both time and space commitments. In order to successfully implement some projects, there will need to be large commitments in time (longevity of the commitment) and space (amount of land that may be unavailable for other uses). In order to move forward with successful project implementation, it will be imperative to work with landowners on an ongoing basis to ensure that these commitments are well understood by all parties involved.

Education and outreach can be an effective tool to engage potential willing landowners. In addition, education and outreach can be very effective in helping to implement passive restoration recommendations. These types of recommendations often take the form of best management practices discussed in Section 4.6 of this report. Landowner incentive programs discussed in Section 5.0 may also help increase landowner participation.

3.3.2 Funding availability

Most proposed actions will have direct costs associated with them and funding will need to be secured prior to implementation. The reintroduction of chinook and sockeye salmon along with steelhead trout to their historic ranges in Whychus Creek and Lake Creek by Portland

General Electric (PGE), the Confederated Tribes of Warm Springs (Tribes), and the Oregon Department of Fish & Wildlife (ODFW) is generating a considerable amount of regulatory agency and community interest. This setting of broad agency and community interest presents a unique opportunity to capitalize on the momentum and current funding opportunities that are being made available to ensure success of the reintroduction efforts.

It will be possible to apply for some of these grant funding opportunities because many of the projects listed in this plan, while improving erosion control and property protection, will also have water quality, habitat quality and stream function benefits for both native and reintroduced anadromous fish species. At the same time, some proposed actions require further cost/benefit analysis to better define project costs relative to trade-offs for implementation. For example, the Timber Creek Bridge within Segment 2A will likely lead to increased upstream sediment deposition, which can lead to further bank erosion within this particularly sensitive reach. However, the bridge has not yet been completed, and this may provide an opportunity to either remove or retrofit the bridge to reduce upstream sedimentation and erosion issues.

3.3.3 Physical / site considerations

Consideration of physical site characteristics varies on a site-by-site basis, and will need to be considered when developing the implementation design. Some of the most prominent considerations identified when compiling the list of actions included:

- Construction access: Relatively small parcel size within the City of Sisters limits stream access.
- Channel grade changes: Removal or modification of structures that impair fish passage and restrict downstream sediment transport may cause the upstream channel to regrade which may degrade habitat.
- Elevational considerations: Much of the creek in the project area has been downcut, and in many locations unnaturally high banks will reduce the likelihood of success for projects involving revegetation.
- Planting environments: Much of the project area has been riprapped in the past. Planting opportunities and the likelihood of success will be limited in these areas unless the riprap can be removed and/or reconfigured.
- Hydraulics: Gravel placement projects will require hydraulic conditions that are compatible with in-channel gravel storage.
- Current summer low flows limit vegetation along the stream bank and may limit success of riparian revegetation projects. Current efforts to increase summertime instream flow levels are critical to the success of riparian enhancements

3.4 Project considerations

Most of the projects identified below are relatively independent and can be implemented as time and money allow. However, the success of several projects may be enhanced by the early

completion of certain upstream and/or downstream projects. The ideal sequencing of projects is identified in Table 1 below. Two projects that most affect others, and would ideally be completed first include the following:

- Action #9 , removal or modification of concrete barriers and boulder weir in Segment 1C: Removal or modification of these barriers could result in some stream grade readjustment, and redistribution of the sediments in upstream Segment 1B. Ideally, instream treatments in Segment 1B would not be implemented until the channel has stabilized from work done in Segment 1C.
- Action #31, comprehensive enhancement plan for the Creekside Development area: A package of treatments is proposed for the channel, banks and floodplain areas within the Creekside Development located in Segment 2A. Together these treatments may produce elevated short-term fine and coarse sediment inputs that may be transported downstream, resulting in some deposition and possibly delay of channel recovery in Segment 2B (primarily) and Reach 3. Ideally, downstream in-channel treatments would be sequenced to follow the implementation of Action #31 and subsequent downstream transport of sediments.

3.5 Proposed stream restoration Actions

This section provides a summary of the recommended restoration and enhancement actions within the Whychus Creek project area. These actions are based on the cross-disciplinary summary of geomorphology, hydrology, aquatic habitat and riparian conditions that is summarized in the appendices to this document. Table 1 provides a description for each proposed action. Please refer to the project area maps for locations of specific recommended actions.

Table 1. Proposed restoration actions.

Seg.	Action Item#	Map panel[3]	Action description	Further Description	Sequence	Notes and comments
	1	1	Modify the fill of USFS Road #4606 to reduce "funneling" of flow through old bridge abutments, and allow for flood flow dissipation across the floodplain.	-	Should follow Action item #4	
1A	2	-	Place Large Woody Material (LWM), root wads, and (limited) boulder placements.	See Section 3.6.1	-	
	3	1	Remove or perforate existing berms along the Creek.	See Section 3.6.2	-	
	4	1	Construct setback berms throughout reach, as needed to contain flood flows.	See Section 3.6.3	-	
	5	1	Replace existing riprap with bioengineered solutions.	Sec Section 3.6.4	-	
	6	1	Redesign/replace bridge at segment end.	Sec Section 3.6.5	-	
1B	7	-	Place LWM and root wads.	See Section 3.6.1	Dependent on action #9	
	8	2	Replace existing riprap with bioengineered solutions.	Sec Section 3.6.4	-	
1C	9	2	Remove and/or modify the concrete barrier in the left channel and boulder weir at the head of the right channel.	See Section 3.6.6	-	
	10	2	Replace existing riprap with bioengineered solutions.	Sec Section 3.6.4	-	
1D	11	-	Place LWM and root wads.	See Section 3.6.1	-	
1E	12	2	Enhance riparian vegetation including: upland tree species in the high terrace environments, riparian shrub plantings and cottonwoods in the low terraces, expansions of existing sedge and rush communities.	Sec Section 3.6.7	-	
	13	2	Replace existing riprap with bioengineered solutions.	Sec Section 3.6.4	-	
	14	2	Remove wooden control structure to open a tertiary channel located on the right bank. This appears to be a head gate for an irrigation diversion that is no longer used	-	-	
	15	2	Construct floodwater training structures needed to safely route flood flows back to the main channel (assumed end of floodplain reconnection zone initiated in sub-reach 1A).	Sec Section 3.6.8	Not needed if action #3 not implemented	
1F	16	2	Replace existing riprap with bioengineered solutions.	Sec Section 3.6.4	-	
	17	-	Implement riparian BMP program for landowners along corridor including signage and a public outreach program.	-	-	
	18	2	Expand right bank floodplain in undeveloped lot at Elm and Tyee Streets.	-	-	
	19	2	If landowners are willing, move left bank mobile homes away from the immediate stream channels.	-	-	
1G	20	3	Remove diversion dam and stabilize site using bioengineering techniques.	See Section 3.6.6	-	
	21	3	Enhance tertiary channel (including riparian buffer) on the right bank.	See Section 3.6.6	Ideally coincides with action #20	
	22	3	Replace existing riprap with bioengineered solutions.	Sec Section 3.6.4	Ideally coincides with action #20	
1H	23	3	Reestablish limited meander pattern through riprap removal, setbacks, and cooperative agreements with landowners (e.g. conservation easement). May include lot line adjustments, land swaps, etc to gain additional enhancement opportunities to restore the floodplain within the City road right-of-way areas.	-	-	
	24	3	Replant riparian hardwoods and sedge / rush meadow species.	Sec Section 3.6.7	-	
	25	-	Place instream boulder clusters	See Section 3.6.1	-	
	26	-	Implement riparian BMP program for landowners along corridor including signage and a public outreach program.	-	-	
1I	27	3	Replace multiple unconsolidated trail access to stream with single trail in campground, through planting of shrubs, placement of obstructions (large wood, rocks, etc.), and establishment of next-generation assemblage of trees (i.e. no compaction areas).	-	-	
	28	3	Implement instream structure (e.g. constructed riffle) downstream of City sewer line crossing to improve upstream fish passage.	-	-	

[3] Action items are identified on project area maps. Some items (e.g. LWM placement) are not appropriate to indicate on maps as the final location must be determined at the time of implementation

Table 1. Proposed restoration actions. (Continued)

Seg.	Action Item#	Map panel[3]	Action description	Further Description	Sequence	Notes and comments
	29	-	Boulder placements throughout segment.	See Section 3.6.1	-	
	30	3	Replace riprap through City Park with bioengineered alternative. May also be opportunity to create a wider meander belt as part of this project.	See Section 3.6.4	-	
2A	31	4	Comprehensive plan for entire segment includes: 1. Bioengineered bank protection (incorporates/reuses existing riprap as appropriate); 2. Plantings in areas where roughness elements are in place and where stream flow scour is slowed; 3. Identification and removal of structures (possibly even Timber Creek Bridge) that are unable to be protected; 4. Development of hydraulic model to evaluate the bank erosion flow, bridge, and debris flow scenarios; 5. Consider acquisition of properties that are at highest risk of erosion and flooding, particularly those north of Whychus Creek and adjacent to Hwy 20 that are in foreclosure and/or unfinished construction; 6. Widen active channel and floodway downstream of Timber Creek Bridge at two key pinch point locations: 1) in the vicinity of Tax Lots 1510100000303 and 302, and 2) at the bottom of the segment (Tax lots 301 and 304); 7. Set back berms to the greatest extent possible downstream of Timber Creek Bridge, removing and replacing riprap treatments with bioengineered bank treatments where needed; 8. Placement of whole-tree instream structures downstream of Timber Creek Bridge.	See Sections 3.6.1, 3.6.3, 3.6.4, 3.6.7, 3.6.10	-	
2B	32	5	Set back berms to the greatest extent possible, removing and replacing riprap treatments with bioengineered bank treatments where needed.	See Sections 3.6.3, 3.6.4	-	
	33	5	Extensive instream roughness treatments in the lower half of the segment (below the horse barn).	See Section 3.6.1	Ideally follows action #31	
	34	5	Aggressive plantings including whole tree plantings of sprouting species at instream structure points.	Sec Section 3.6.7	Ideally follows action #31	
	35	5	Move horse pens, hay barn, and manure piles away from the left bank.	-	-	
	36	5	Reestablish limited meander pattern through riprap removal, setbacks, and cooperative agreements with landowners (e.g. conservation easement) along left (north) bank.			
3A	37	-	Interaction with landowners regarding the value of overbank flows in floodplain environment.	-	-	
	38	5	Passive restoration of riparian and floodplain areas.	-	-	
	39	5	Replace existing riprap with bioengineered solutions.	Sec Section 3.6.4		
3B	40	5, 6	Remove riprap; where needed replace with bioengineered solutions that are designed to increase floodplain connectivity. Removal of berms and creating adequate setback is desirable in areas where the functioning of riparian vegetation will not be disturbed. Perforation of the berms long the right bank is another option to increase conveyance and riparian interaction.	See Sections 3.6.2, 3.6.3 and 3.6.4	-	
	41	-	Install engineered logjams.	See Section 3.6.1	Ideally follows action #31	
	42	-	Gravel augmentation in association with instream roughness elements such as trees and boulders.	See Sections 3.6.1 and 3.6.11	Ideally follows action #31	
	43	6	Small modifications to the outflow channel of a wetland pond (near highway).	See Section 3.6.12	-	
	44	6	Screen active diversion pumps.	-	-	
	45	6	Replace narrow bridge crossing.	See Section 3.6.5	-	
3C	46	-	Passive restoration / protection (e.g., conservation easements or other such instruments).	-	-	
	47	7	Setback dikes as needed to protect agricultural areas from floodwaters, while allowing inundation of restored floodplain.	See Section 3.6.3	-	
	48	7	Riparian plantings.	See Section 3.6.7	-	
	49	-	Add key LWM pieces.	See Section 3.6.1	Ideally follows action #31	
	50	7	Upgrade instream water diversion so that excavation is not necessary, or replace with a shallow groundwater well.	-		
	51	7	Remove riprap and replace with bioengineered solution for the hardened bank across from the existing diversion (left bank); establish riparian plantings as part of the solution.	See Section 3.6.4	-	
	52	7	Replace or abandon (alternate access route?) narrow bridge crossing.	See Section 3.6.5	-	

3.6 Action item descriptions

The purpose of this section is to provide additional information on the primary actions outlined in Table 1. Most of the conceptual drawings from this section are taken from the Washington Department of Natural Resources Stream Habitat Restoration Guidelines (WDFW, 2004), and Integrated Streambank Protection Guidelines (WDFW, 2003). These drawings provide examples of what some of the actions recommended in Table 1 might look like, and are provided for reference only. Implementation of many of the action items recommended in this Plan will entail more detailed engineering and analysis beyond what is contained herein.

3.6.1 LWM, root wad, and boulder placements

Large woody material (LWM) and boulder placements are identified as potential treatments in several segments. The primary purpose of these treatments is to provide scour leading to pool development, sorting of substrate and cover. Recommended treatments include placement of logs and root wads (Figure 7) and boulder clusters (Figure 8). The primary property concern associated with these treatments is the ability of the bridges throughout the reach to pass LWM. Therefore, we do not recommend construction of LWM jams upstream of the Timber Creek Bridge, located in Segment 2A (Figure 2). As part of LWM placement it will be necessary at the time of project design and implementation to evaluate downstream bridges for their ability to pass sediment and LWM from upstream. Consideration should be given to the necessity of anchoring upstream LWM placements.

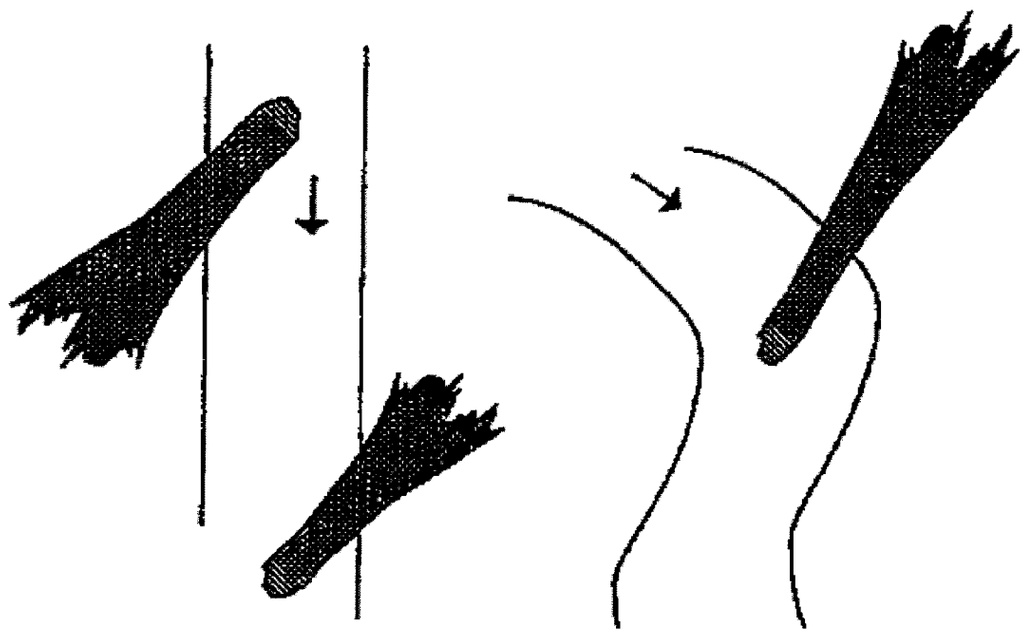


Figure 7. Conceptual drawing of large woody material placement (ODF, 1995). Pieces placed diaganol to flow can direct flow away (left) or towards (middle) bank. Pieces placed on meander bends (right) can enhance scour.

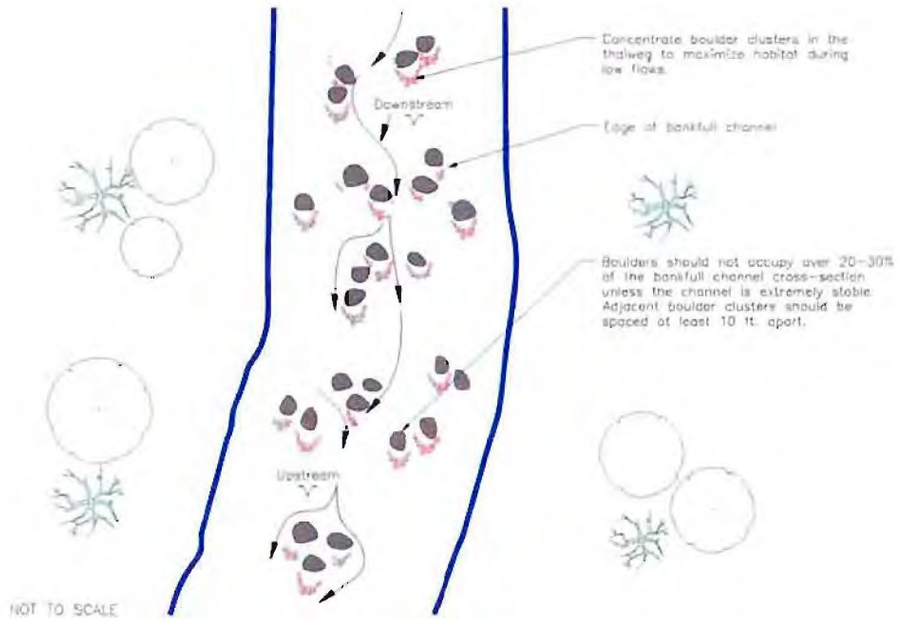


Figure 8. Conceptual drawing of boulder placement (WDFW, 2004).

3.6.2 Removal or perforation of existing berms.

In several segments of the project area berms consisting of stream bed material have been pushed up parallel to the channels, apparently for the purpose of constraining the channel to a single thread (see Figure 9). These berms disconnect the stream from potential floodplain areas. Reconnection of the stream and floodplain may be possible through removal or perforation of these berms in certain areas where deemed appropriate and beneficial.

Figure 9. Example of a berm in Segment 1A.

3.6.3 Setback berms

In some situations it may be advantageous to replace riprap and other streamside bank protection structures with new structures that are setback from the stream course far enough to allow channel migration, while still protecting infrastructure and other floodplain property (Figure 10 and 11.

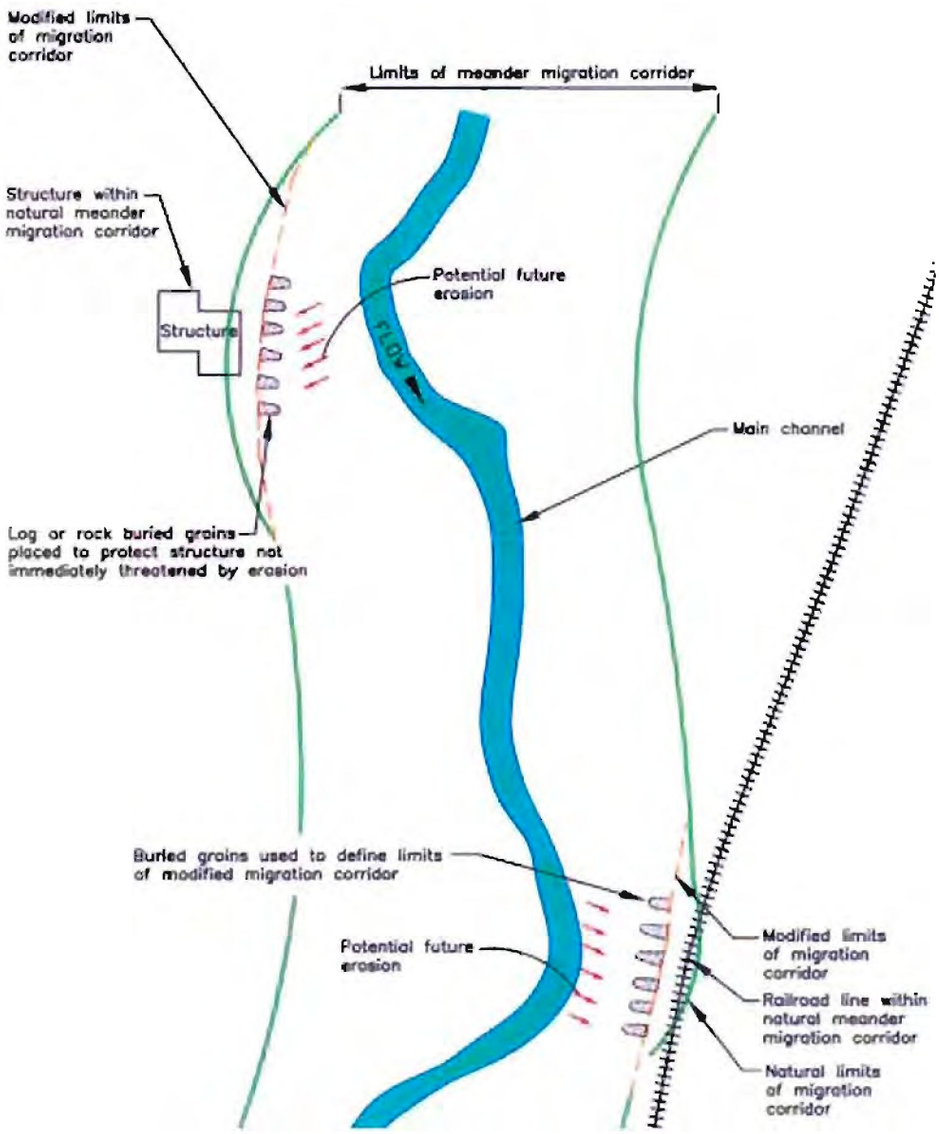


Figure 10. Conceptual drawing of setback berms used to increase the width of the stream corridor and floodplain (WDFW, 2003).

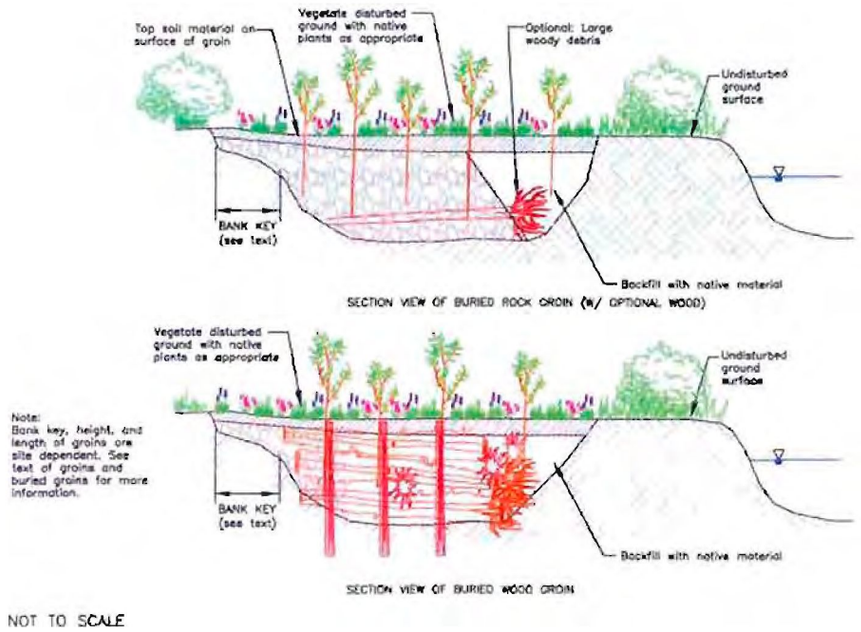


Figure 11. Conceptual drawing of buried groins used in a setback berm (WDFW, 2003).

3.6.4 Riprap alternatives

Throughout the project area riprap has been installed to address bank erosion concerns. In many situations it would be advantageous to downstream property owners, and for enhancement of aquatic and riparian habitat, to replace or modify these existing structures with bioengineered alternatives (see Figure 12, Figure 13 and 14).

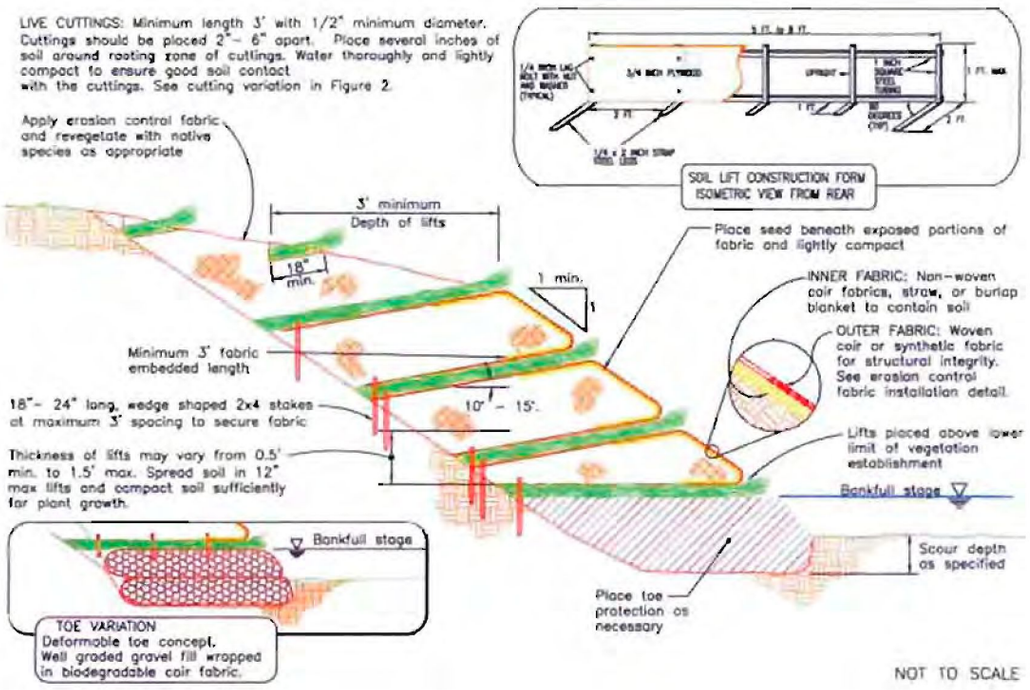


Figure 12. Soil reinforcement through the use of live cuttings (WDFW, 2003).

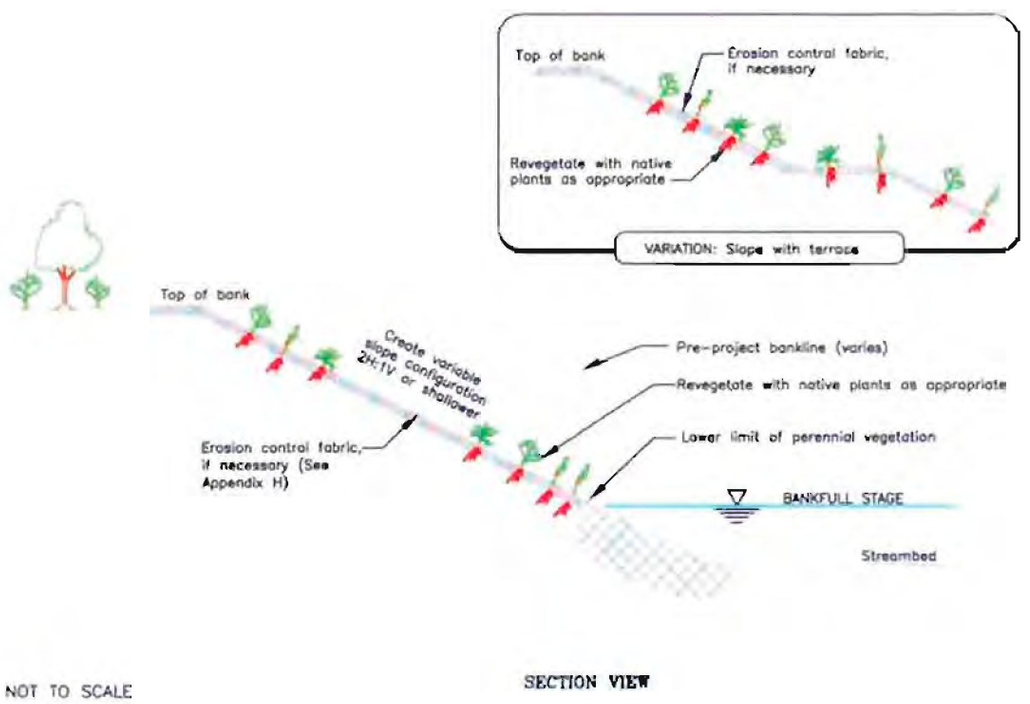
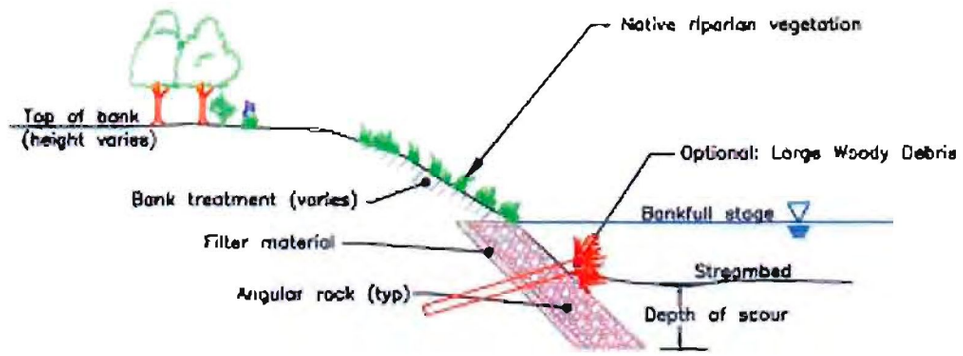
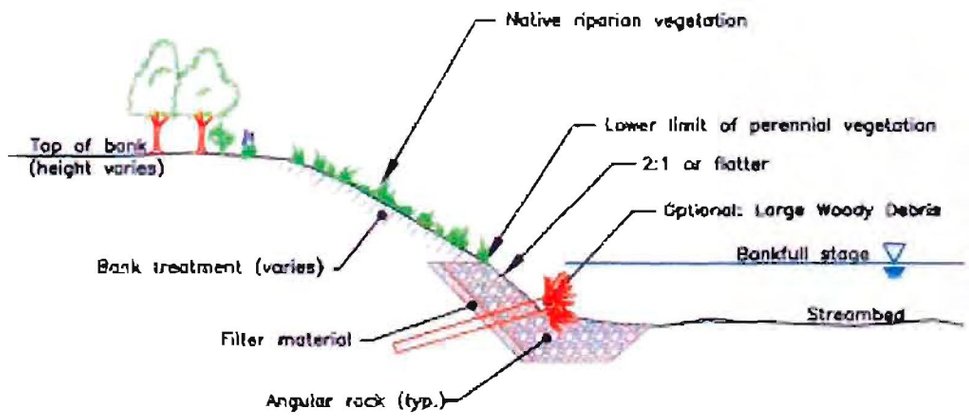


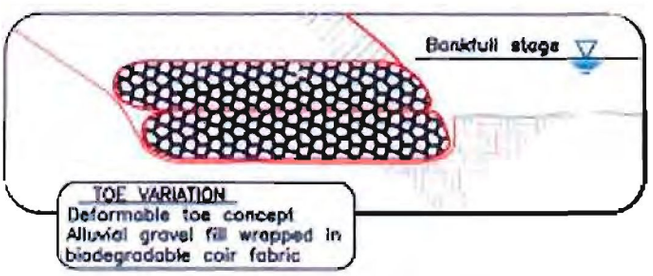
Figure 13. Conceptual drawing of bank reshaping and revegetation (WDFW 2003).



EXCAVATED TOE



LAUNCHABLE TOE



DEFORMABLE TOE

Figure 14. Conceptual drawing of roughened rock toe treatments (WDFW 2003).

3.6.5 Bridge replacement

A total of eight bridges[4] cross Whychus Creek within the project area. With the possible exception of the Highway 20 Bridge, all appear to be too narrow to pass LWM and other flood debris without danger of plugging. The bridge located at the downstream end of Segment 1A appears to be causing extensive deposition upstream of the bridge (Figure 15), and the narrow bridge abutments of the bridge in segment 3B is creating scour and bank erosion downstream of the site (Figure 15).

Figure 15. Bridge in Segment 1A showing deposition upstream of constriction (left), and narrow bridge in Segment 3B (right) causing downstream scour and bank erosion.

3.6.6 Remove Segment 1C barriers

Segment 1C is a short (~500 feet) segment that consists of a primary left bank channel, and a secondary right bank channel. The side channel has been blocked with a boulder weir (Figure 16) presumably to concentrate flow in the primary channel. However, the primary channel is blocked with a concrete weir that probably poses a barrier to upstream fish passage. It is not clear that the concrete structure serves any purpose other than as an aesthetic amenity, and removal or modification is recommended.

[4] Not including the foot bridge at the upstream end of the project area, or the bridge location at the downstream end which currently does not have a span.

Figure 16. Boulder weir blocking side channel (left), and concrete weir (right) in primary channel, Segment 1C.

3.6.7 Plantings

Riparian surfaces in several segments would be enhanced through herbaceous and woody plantings (Figure 17 and 18).

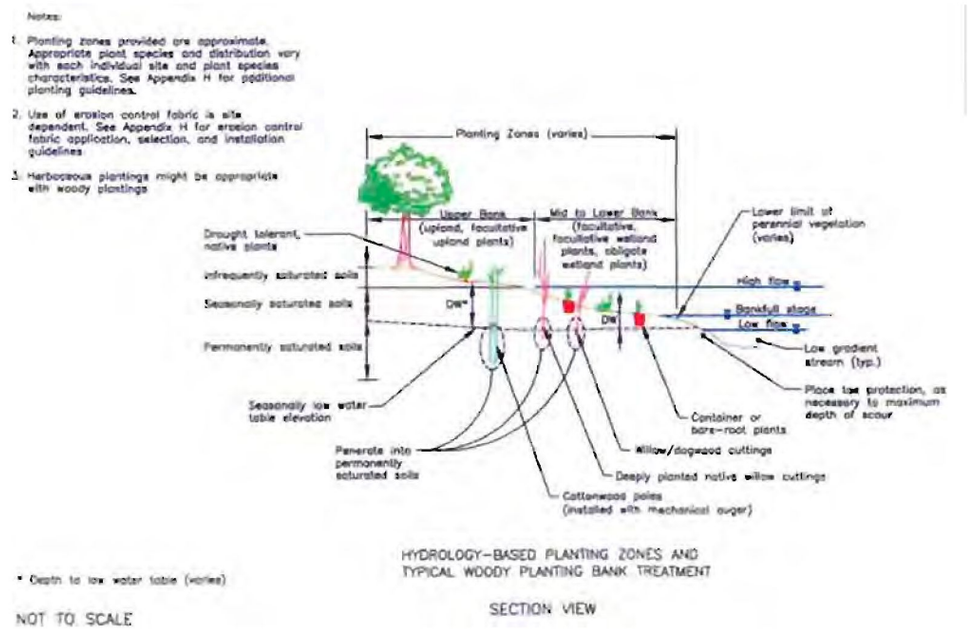


Figure 17. Conceptual drawing of woody plantings (WDFW, 2003).

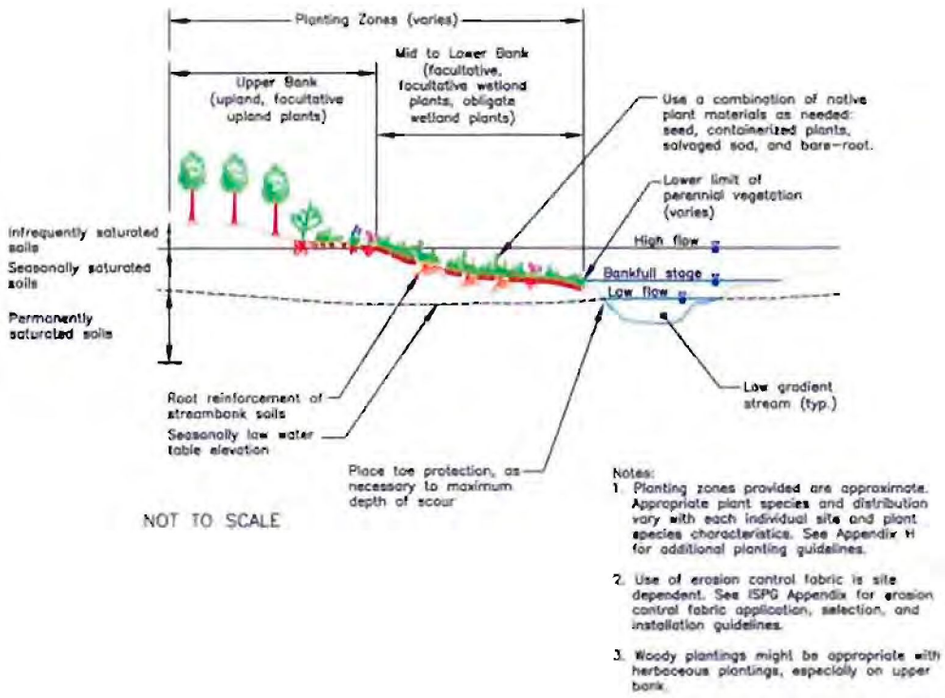


Figure 18. Conceptual drawing of riparian planting.

3.6.8 Floodwater training structures

Removal or perforation of berms is identified as a possible treatment in several segments in order to reestablish floodplain connections. In some cases, it will be necessary to construct floodplain grade control structures (see Figure 19) to bring floodplain flows back into the main channel. This is particularly important for the areas located upstream of the City of Sisters UGB boundary (Segments 1A – 1E; Figure 2).

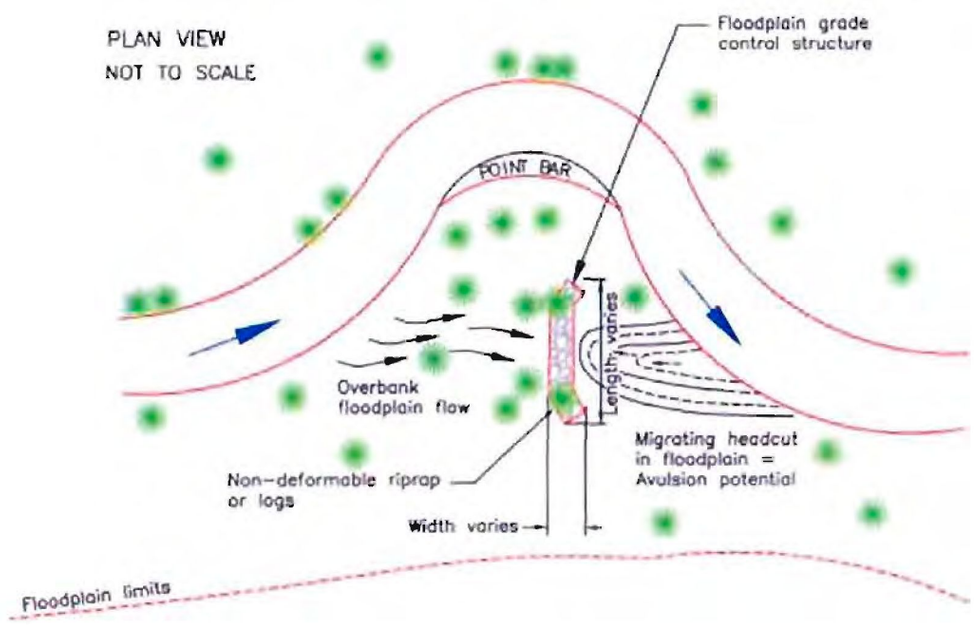


Figure 19. Conceptual drawing of floodplain grade control.

3.6.9 Remove irrigation diversion in Segment 1G

The irrigation diversion located in Segment 1G consists of a cross-channel dam with removable splashboards. The splashboards are in place during the irrigation season, trapping and settling large volumes of material upstream of the structure (Figure 20). A secondary channel diverts high flows around the structure, and a tertiary channel has developed on the right bank that shows evidence of recent scour and bank erosion (Figure 21). Removal of this irrigation diversion dam and enhancement of the tertiary channel is recommended.

Figure 20. Sedimentation behind irrigation diversion located in Segment 1G.

Figure 21. Tertiary channel adjacent to irrigation diversion in Segment 1G.

3.6.10 Widen active channel and floodway to eliminate pinch points

The floodway downstream of the Timber Creek Bridge (Segment 2A) has been significantly narrowed by placement of riprap on (primarily) the right bank (Figure 22). This area appears to trap ice flows, and may exacerbate deposition in the upstream portion of the segment.

Figure 22. Pinch point in Segment 2A downstream of Timber Creek Bridge.

3.6.11 Gravel placement

Gravel placement may enhance spawning opportunities in some segments. Gravel placement will need to coincide with the creation of structures to maintain gravel scour and sorting (Figure 23).

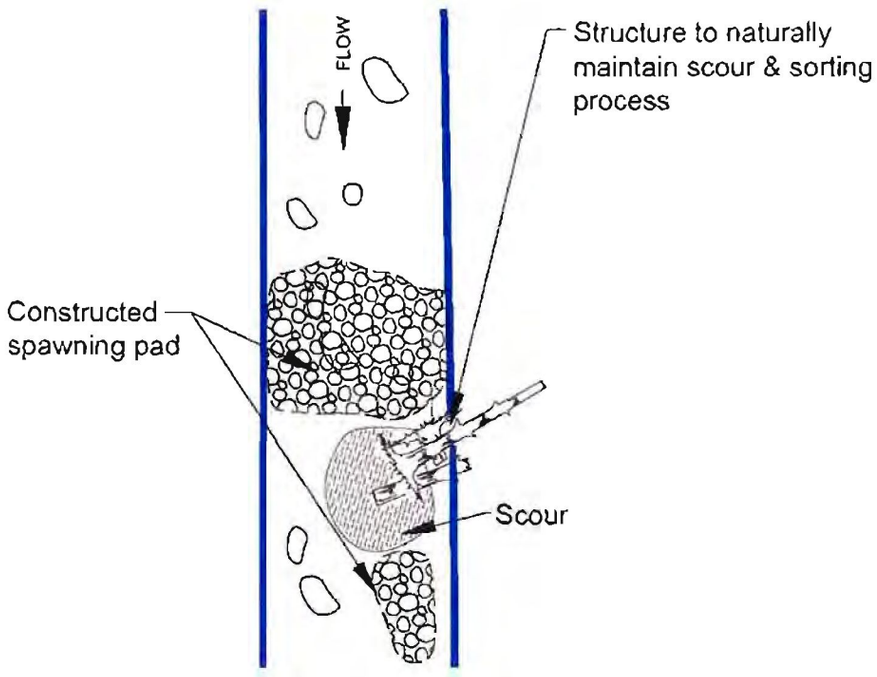


Figure 23. Conceptual drawing of gravel placement (WDFW, 2004).

3.6.12 Wetland outflow channel in Segment 3B

A small wetland is located on the right bank floodplain in Segment 3B (Figure 24). A small (~3 foot wide) channel connects the wetland with Whychus Creek. Modifications at the confluence with the creek may improved access for fish species to utilize this off channel habitat at high flows.

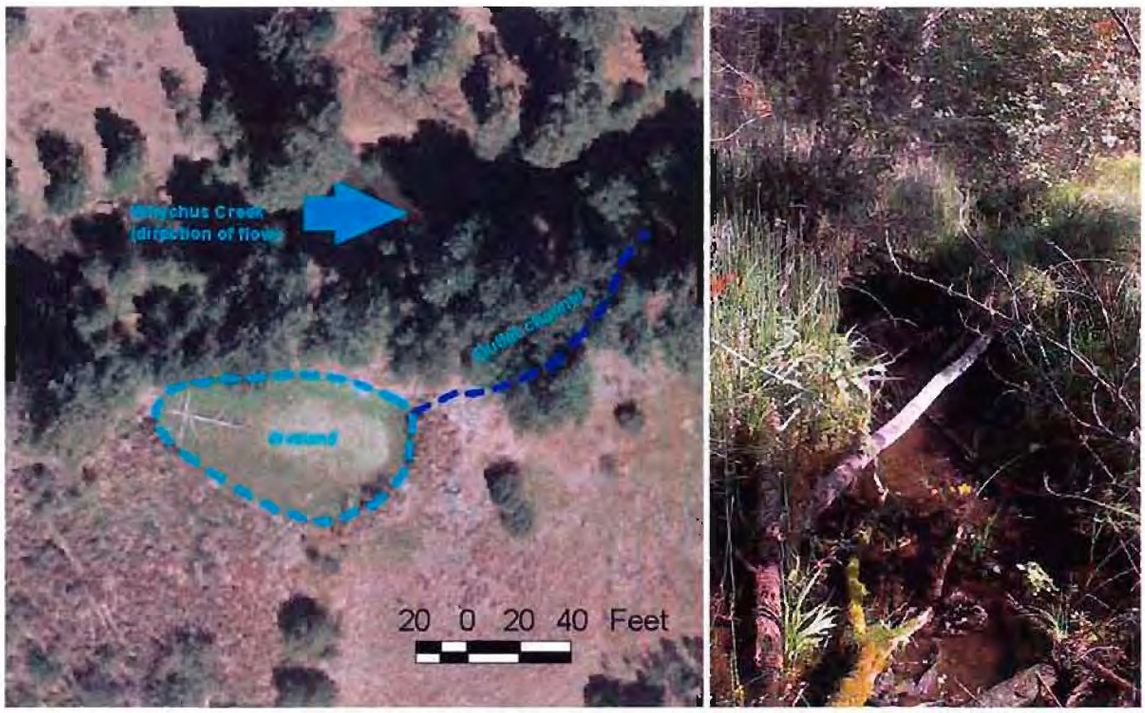


Figure 24. Wetland in Segment 3B with outlet channel (right) connecting to Whychus Creek.

3.7 Regulatory considerations for restoration actions

In order to ensure timely and successful project implementation, it is very important to consider regulatory and permitting conditions when considering the proposed actions summarized above. The cost and timing of the permitting process can vary widely depending on the type of project being proposed. Early discussions with the pertinent agencies will facilitate the process of obtaining permits and approvals for proposed actions.

Depending on the proposed actions, permits and approvals may be required from some if not all of the following agencies and entities:

- City of Sisters
- U.S. Army Corps of Engineers (Corps)
- U.S. Fish and Wildlife Service (USFWS)
- National Marine Fisheries Service (NMFS)
- Oregon Department of Fish and Wildlife (ODFW)
- Oregon Division of State Lands (DSL)

- Oregon Department Environmental Quality (DEQ)
- Department of Land Conservation and Development (DLCD)

4.0 Evaluation of City of Sisters Policies, Codes, and Other Regulatory Considerations

When developing restoration and management actions for an urban stream such as Whychus Creek, it is very important to not rely solely on scientific analyses to develop proposed actions. Instead it is critical to link this scientific framework with the social, political and policy frameworks that interplay in each community, in order to ensure that the proposed scientific recommendations will ultimately be understood and supported by the community as a whole.

The following sections evaluate various policy-level actions the City of Sisters could take that would help provide enhanced erosion and property protection while assisting with the long-term restoration of Whychus Creek. Specific actions evaluated in this chapter include:

- Adopting proposed changes to the Sisters Comprehensive Plan;
- Adopting changes to the City Development Code;
- Adopting additions to the City Development Code that could help protect private property adjacent to the stream and riparian areas; and
- Implementing best management practices (BMPs) and incentive programs for private property, water quality and stream habitat protection.

The various policy tools discussed in this section would each need further analysis by City staff prior to adoption and implementation, possibly including a Goal 5 Economic, Social, Environmental and Energy (ESEE) analysis as defined in Oregon Administrative Rules (OAR) 660-016-0005. A discussion of other regulatory considerations associated with proposed high priority restoration actions will be expanded and refined following the presentation of draft restoration and management actions to elected officials and members of the community in February and March 2009.

4.1 City of Sisters 2005 Comprehensive Plan

The Water Quality Model Code and Guidebook developed by the Oregon Departments of Land Conservation and Development (DLCD) and Environmental Quality (DEQ) in 2000 provides an excellent framework by which to evaluate the City of Sisters' existing policies and ordinances with respect to reducing impacts on water quality and aquatic habitat. In particular, the DLCD / DEQ report evaluates Statewide Planning Goals and their applicability to water quality, especially Goals 5 and 6 and to a lesser degree Goals 7, 11 and 12. The City of Sisters 2005 Comprehensive Plan (Plan) has been developed using the Statewide Planning Goals. The following sections evaluate how well the Comprehensive Plan addresses provisions

recommended in the DLCD / DEQ (2000) report that provide for enhanced water quality and aquatic habitat protections. The following sections also evaluate the Comprehensive Plan with respect to how well stream-side properties and riparian habitat are protected.

4.1.1 Analysis of selected Comprehensive Plan Chapters

4.1.2 Goal 5 Analysis

Statewide Planning Goal 5 and Chapter 5 of the Sisters Plan address natural resources, scenic and historic areas, and open spaces. Oregon Administrative Rules (OAR) adopted in 1996[5] require local governments to inventory and evaluate the following three significant Goal 5 resources related to water quality:

- Riparian corridors, including water and riparian areas and fish habitats;
- Wetlands; and
- Wildlife habitat.

State law also requires local governments to develop land use programs that protect these significant Goal 5 resources.

The first step in the Goal 5 process is to conduct an inventory of all Goal 5 resources that addresses the "adequacy" and "significance" of the resources[6]. Local governments may choose to skip these determinations for riparian corridors by adopting Goal 5 "safe harbor" requirements provided for in OAR 660-023-0020(2). These safe harbor requirements establish a specific setback distance of 50-feet from the top of each bank of fish-bearing streams that have an average annual flow of less than 1,000 cfs.[7] However, the safe harbor provision may not be sufficient to protect endangered fish and wildlife such as those found in Whychus Creek, or to meet Oregon Department of Environmental Quality requirements such as those specified in Total Maximum Daily Load (TMDL) implementation plans. Local governments must also conduct an "ESEE" analysis by evaluating the environmental, social, energy and economic consequences of allowing, limiting or prohibiting uses near a Goal 5 resource[8]. The safe harbor provisions for wetlands require a local wetlands inventory to be conducted using the standards and procedures in OAR 141-086-0110 to 0240. Significant wetlands must be protected from grading, excavation, placement of fill, and vegetation removal (DLCD and DEQ, 2000).

Background information in Section 5.2 of the Sisters Plan states that the City has completed an inventory of existing natural resources. Section 5.3 Findings provide data regarding the adequacy and significance of the Goal 5 resources, including the Flood Plain Zone that encompasses 26 gross acres of land identified by Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps as being in the 100-year floodplain of Whychus Creek.

[5] OAR 660, Division 23
[6] OAR 660-023-0030
[7] OAR 660-023-0090 (5)
[8] OAR 660-023-0040

However, the 100-year floodplain shown on the Zoning Map does not necessarily define where the creek channel is now, or where it might be in 100 years due to channel migration. This is because Whychus Creek historically spread out over a wide glacial outwash plain in the vicinity of the City, and the stream channel is subject to wide meander patterns where it is not contained by the placement of riprap (see appendices to this document for further analysis of this issue). In addition, the City does not currently have a riparian protection ordinance in place that could help protect the creek's riparian vegetation from disturbance, and help limit potential erosion issues on properties adjoining the creek. In Section 5.4 Policies, the Plan identifies two tasks under item 3 that address the protection of natural, riparian and scenic resources within the Sisters Urban Growth Boundary (UGB):

- *Task 3.a. The City shall develop a riparian protection program for Whychus Creek consistent with State Planning Goal 5; and*
- *Task 3.b. The Whychus Creek Flood Plain shall be managed according to Federal Emergency Management Agency (FEMA) regulations, as incorporated into the City of Sisters Development Code.*

Based on the above analysis, certain changes and additions to the pertinent sections of the Sisters Plan related to Goal 5 have been recommended (see Sections 4.2.1). Implementing theses changes and additions will better address water quality and aquatic habitat protection, riparian protection zones, and dynamic flood plain processes in the Whychus Creek channel migration zone. This will in turn help provide some erosion and property protection, while assisting the long-term restoration of Whychus Creek.

4.1.3 Goal 6 Analysis

Statewide Planning Goal 6 and Chapter 6 of the Sisters Plan address air, water, and land resource quality. This goal can be an important land use planning tool with respect to water quality protection because it requires that "all waste and process discharges from future development, when combined with such discharges from existing developments, shall not threaten to violate, or violate applicable state or federal environmental quality statues, rules and standards." By definition, pollutants carried by stormwater and impacts on habitat that result from stormwater flows are covered under state and federal water quality regulations, and Goal 6 requires jurisdictions to integrate compliance with these regulations within their comprehensive planning process (DLCD and DEQ, 2000). Goal 6 is particularly relevant for cities and counties where:

- habitat for threatened or endangered species is found within their jurisdiction (as in Sisters);[9]
- where water quality limited water bodies are located within their jurisdictions (as in Sisters);[10] and/or

[9] Whychus Creek contains populations of bull trout and summer steelhead, both federally listed as threatened species under the Endangered Species Act (ESA).

- for those jurisdictions that are subject to a Total Maximum Daily Load (TMDL) implementation plan required by the Oregon Department of Environmental Quality (DEQ).

Goal 6 Findings in Comprehensive Plan Section 6.3 include discussion of the excellent quality of the City's water supply, and the erratic flows in Whychus Creek, including summer low flows. Section 6.4.1 Policies includes subtasks to encourage water conservation through the use of native plants in landscaping, and to establish a noxious weed control program in coordination with Deschutes County. Other tasks in Section 6.4.2 state that Whychus Creek be protected in the Development Code, and that the City will cooperate with the restoration of instream flows in the creek.

Based on the above analysis, certain changes and additions to the pertinent sections of the Sisters Plan related to Goal 6 have been recommended (see Sections 4.2.2). Implementing theses changes and additions will help improve stormwater management in the City, help minimize water quality impacts to Whychus Creek, reduce inputs of sediment-laden storm runoff into the Creek, and reduce erosion of stream-side properties. This will in turn help provide increased property protection, while assisting with the long-term restoration of Whychus Creek.

4.1.4 Goal 7 Analysis

Statewide Planning Goal 7 and Chapter 7 of the Sisters Plan address natural disasters and hazards. Goal 7 does not specifically address water quality issues, but measures adopted in compliance with this goal can help improve water quality. For example, by protecting against floods and other natural hazards, local governments may limit development within floodways and reduce impervious surfaces that increase runoff and flooding (DLCD and DEQ, 2000).

Goal 7 Findings in Section 7.3 of the Sisters Comprehensive Plan include discussion of the Whychus Creek floodplain which is located within the City, and the 100-year floodplain boundaries that were remapped by FEMA in 1990. Section 7.4.1 Policies state that the *City shall regulate development in flood prone areas to protect life and property.* This section also includes six specific tasks related to the designation of, and uses allowed in the floodplain.

Based on the above analysis, certain changes and additions to the pertinent sections of the Sisters Plan related to Goal 7 have been recommended (see Sections 4.2.3). Implementing theses changes and additions will better maintain the natural hydrology and channel migration of Whychus Creek, help mitigate damage from natural disasters including flooding, and improve the management of stormwater runoff in the City. This will in turn help provide increased property protection while assisting with the long-term restoration of Whychus Creek.

[10] Whychus Creek is listed on the State of Oregon Section 303(d) list of impaired water bodies for exceeding state water temperature standards (DEQ, 2007).

4.1.5 Goal 11 Analysis

Statewide Planning Goal 11 and Chapter 11 of the Sisters Plan address public facilities and services, and requires among other things, planning for stormwater retention and conveyance which is typically addressed by a jurisdiction's stormwater master plan or engineered drainage plan. However, revised comprehensive plan policies can direct stormwater management policy to be more comprehensive with an emphasis on the protection and enhancement of water quality (DLCD and DEQ, 2000).

Background information presented in Comprehensive Plan Section 11.2 states that the City does not have a stormwater master plan, but requires all new construction to comply with Oregon Department of Environmental Quality (DEQ) stormwater management guidelines. The stormwater system constructed prior to 2001 consists mostly of drywells, which are now subject to more stringent permitting and monitoring requirements.

Based on the above analysis, certain changes and additions to the pertinent sections of the Sisters Plan related to Goal 11 have been recommended (see Sections 4.2.4). Implementing theses changes and additions will better address stormwater treatment and onsite stormwater retention in the City. This will in turn help provide increased property protection while assisting with the long-term restoration of Whychus Creek.

4.1.6 Goal 12 Analysis

Statewide Planning Goal 12 and Chapter 12 of the Sisters Plan address transportation, and recognize that the transportation system may have negative environmental impacts. This goal requires a jurisdiction's Transportation System Plan to "minimize adverse social, economic and environmental impacts and costs," and to not exceed the carrying capacity of water resources. In addition, Goal 12 states that transportation systems must "be consistent with state and federal standards for protection of air, land and water quality including ...the State Water Quality Management Plan"[11]. Also, transportation plan implementation requirements state that "Plans for new or for the improvement of major transportation facilities should identify the positive and negative impacts on...environmental quality" (DLCD and DEQ, 2000). Transportation effects on water quality are not currently addressed in the Sisters Comprehensive Plan, though alternative modes of travel (walking and biking) are encouraged in the City.

Based on the above analysis, certain changes and additions to the pertinent sections of the Sisters Plan related to Goal 12 have been recommended (see Sections 4.2.5). Implementing theses changes and additions will better address transportation system effects on water quality. This will in turn help provide increased property protection while assisting with the long-term restoration of Whychus Creek.

[11] OAR 660-012-0035 (3)(b)

4.2 Recommended changes to Sisters Comprehensive Plan

Based on the Sisters Comprehensive Plan analysis in Section 4.1. above, specific recommendations for changes are detailed below for Sisters Plan Goals 5, 6, 7, 11 and 12.

4.2.1 Goal 5 – Recommended Changes

1. In Comprehensive Plan Section 5.3 Findings, consider adding the following language modeled from the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000):

    - *Whychus Creek and its associated riparian vegetative community contribute to the health, safety, and general welfare in the City of Sisters UGB area. The stability of the natural systems and the vitality of the community depend on the excellent water quality and habitat provided by Whychus Creek.*
    - *Natural drainage ways such as Whychus Creek are significant natural resources that provide protection from flooding, treatment of stormwater, and help maintain stream morphology important for resident fish and macroinvertebrates.*
    - *Local fish and wildlife, some of which are endangered or threatened, depend on the excellent water quality and habitat function that is provided by Whychus Creek.*
    - *The ability for native soils to absorb and filter stormwater is essential to maintaining high quality ground and surface water resources. These functions must be preserved or their loss mitigated by future development.*

2. In Comprehensive Plan Section 5.4 Policies, consider adding the following language:

    - *Site-specific buffering, setback requirements, and best management practices (BMPs) may be required, as necessary, to enhance and protect stream-side properties as well as Whychus Creek riparian areas and channel migration zone.*

3. Pursue development of a riparian protection overlay zone, a riparian setback ordinance, a stream protection overlay zone, or a habitat protection ordinance for the Whychus Creek riparian corridor (see analysis of riparian / stream protection options in Section 4.5.1).

4.2.2 Goal 6 Recommended Changes

1. In Comprehensive Plan Section 6.3 Findings, consider adding the following language modeled from the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000):

    - *According to DEQ's 2004/2006 Water Quality Assessment, Whychus Creek is water quality limited for temperature. A Total Maximum Daily Load (TMDL) has been recommended for temperature in Whychus Creek which DEQ is beginning to develop.*
    - *Summer steelhead and bull trout have been listed as threatened species under the Endangered Species Act (ESA) by the National Marine Fisheries Service and U.S. Fish*

and Wildlife Service. Spawning, rearing and/or migration habitat for these species occurs in Whychus Creek within the City's boundaries.

- *Development activities permitted by the City of Sisters that result in harm to a threatened or endangered species, and fall outside the provisions for "incidental take" allowed by Section 4(d), a Section 7 consultation, or a Section 10 permit of the Endangered Species Act, could result in the City being held liable for a "take" under that Act.*
- *Reduction of open space, removal of vegetative cover, and development that increases the amount of impervious surfaces in the City can contribute significantly to increased stormwater peak flows and decreased water quality.*
- *Offsetting measures can reduce the negative effects of urban development on water quality and quantity. Example offsetting measures include reduction of stormwater runoff or maximization of infiltration, inclusion of landscaped buffer strips adjacent to new development, protection of the Whychus Creek floodplain and channel migration zone, preservation and improvement of streamside vegetation along Whychus Creek, and other development best management practices (BMPs).*

2. In Comprehensive Plan Section 6.4 Policies, consider adding the following language modeled from the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000):

    - *All development within the City of Sisters city limits and Urban Growth Boundary (UGB) shall comply with applicable state and federal water quality regulations.*
    - *To protect and enhance water quality as required by state and federal requirements, the City will implement provisions in the Central Oregon Stormwater Manual (2007), possibly through an update of the City's General Construction Standards.*

In addition to the recommended changes to the Comprehensive Plan for Goal 6, we recommend performing the following tasks:

a. *Regulate site planning for new development and construction to better control drainage, and to reduce, retain and treat stormwater runoff prior to discharge to Whychus Creek.*

b. *Require new construction to develop an erosion control plan that is consistent with "Chapter 9 – Erosion and Sediment Control Design" in the Central Oregon Stormwater Manual (2007) and /or the Oregon Department of Environmental Quality's Erosion and Sediment Control Manual (DEQ, 2005).*

c. *Protect existing riparian vegetation along stream banks for bank stabilization and stream shading benefits.*

d. *Increase riparian area buffer widths to address Total Maximum Daily Load (TMDL) requirements and other state and federal requirements, and to protect private property.*

e. *Regulate the location of permitted uses that generate, store or use hazardous wastes or materials, and that may have higher than ordinary impacts on water quality.*

f. *Reduce and treat stormwater runoff generated by City streets that may discharge to Whychus Creek.*

g. *Increase public awareness of techniques and practices private individuals can employ to help correct water quality and quantity problems.*

h. *Increase public awareness of polluting substances that affect surface and groundwater resources, minimizing their use, and encouraging the appropriate disposal of these substances.*

4.2.3 Goal 7 Recommended Changes

1. In Comprehensive Plan Section 7.3 Findings, consider adding the following language modeled from the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000):

    - *Increased amounts of stream sedimentation lead to a loss of instream storage of flood water, leading to widening of stream banks and more flooding.*
    - *Stormwater runoff mitigation techniques can significantly reduce Whychus Creek flooding frequency and peak flows associated with urban development in Sisters.*
    - *To maintain species habitat and to protect stream-side properties in Sisters, the natural hydrology of Whychus Creek should be maintained so that annual flow patterns remain the same after development as before development.*
    - *The natural meandering stream channel of Whychus Creek and its associated riparian areas provide essential flood storage capacity.*
    - *Riparian areas associated with Whychus Creek contain natural assets such as significant vegetation and wildlife habitat, and are valuable for water quality, open space and recreation purposes.*

2. In Comprehensive Plan Section 7.4 Policies, consider adding the following language modeled from the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000):

    - *The City shall require certain land-disturbing activities associated with site clearing, grading, construction and other improvements to employ erosion control practices to prevent increased stream sedimentation.*
    - *To the extent possible, the Whychus Creek floodplain shall be kept in a natural state to reduce flooding, protect and enhance water quality, and to protect and enhance native plant species.*
    - *Standards for new development shall require stormwater runoff to be infiltrated or detained onsite to the maximum extent practicable, or stored and treated in a regional facility to preserve the natural hydrograph and water quality of Whychus Creek.*
    - *Modify Policy 7.4.1 to say: The City shall regulate development in the 100-year floodplain and flood prone areas to protect life and property; to allow for transport of*

flood waters; to protect and enhance water quality; and to protect the economic, environmental, and open space qualities of the land and Whychus Creek.

4.2.4 Goal 11 Recommended Changes

1. In Comprehensive Plan Section 11.3 Findings, consider adding the following language modeled from the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000):

    - *Untreated stormwater discharge, and the loss of natural storage capacity due to increases in impervious surfaces and channelization of Whychus Creek, contribute to impaired water quality in the creek.*
    - *Improperly treated and/or stored stormwater can compromise the recovery of Endangered Species Act (ESA) listed bull trout and summer steelhead in Whychus Creek, and can lead to an illegal "take" of these protected species.*
    - *Effective stormwater treatment requires implementation of a range of programs including appropriate alterations to development patterns, on-site stormwater retention and treatment, and efforts to decrease impervious surfaces associated with new growth in Sisters.*

2. In Comprehensive Plan Section 11.4 Policies, consider adding the following language modeled from the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000):

    - *The City shall increase its efforts to protect and enhance water quality, including preserving natural drainage and hydrology features, and increase opportunities for on-site infiltration, detention, and treatment of stormwater through implementation of the Central Oregon Stormwater Manual (2007) in the development process.*
    - *The City shall take steps to minimize impacts to Whychus Creek water quality through the use of appropriate strategies as identified in the Central Oregon Stormwater Manual (2007).*

4.2.5 Goal 12 Recommended Changes

1. In Comprehensive Plan Section 12.3 Findings, consider adding the following language modeled from the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000):

    - *Highways, roads, streets in Sisters can have negative impacts on water quality by increasing both the quantity and velocity of runoff, and by collecting oil and other pollutants that are flushed into Whychus Creek when it rains.*
    - *Narrower local streets, standards that limit the amount of parking, and pervious paving surfaces (where practical) can reduce the amount of impervious surfaces in the City.*

2. In Comprehensive Plan Section 12.4 Policies, consider adding the following language modeled from the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000):

- *Sisters Transportation System Plan shall be consistent with other City goals and policies, including the goal of protecting and enhancing water quality.*
- *The Transportation System Plan shall promote walking and bicycling within the City to reduce the impacts of transportation on water quality.*

4.3 Analysis of City of Sisters Development Code Chapters

The following analysis of selected chapters in the City of Sisters Development Code provides recommended changes that could strengthen the codes' protection of private property, water quality and habitat values in Whychus Creek. These suggested additions are based on recommendations contained in the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000), the Central Oregon Stormwater Manual (2007), and other technical manuals dealing with stormwater treatment and erosion control best management practices (BMPs).

4.3.1 Development Code Chapter 2.6 – Flood Plain District: Analysis

The recently adopted Flood Plain District (City of Sisters Development Code, April 2008) is very comprehensive and closely follows the FEMA model ordinance for flood damage prevention. Section 2.6.100 Purpose (A) of the code states that the Flood Plain District zone "*intends to identify sections of the city subject to the hazards of 100 year periodic stream flooding as determined by the limits and extent of the Special Flood Hazard Area shown on Federal Emergency Management Agency (FEMA) Flood Insurance Map (FIRM) #41017C0245D, dated September 28, 2007 and associated Flood Insurance Study #19163CV000A, and any revision thereto, or more accurate studies, and to preclude future development or redevelopment that may suffer a loss of life or property in the subject area.*" Code language also states that "*the purpose of this chapter is to promote the public health, safety and general welfare, to maintain streams and floodplains in their natural state to the maximum extent possible so they reduce flood hazards, and to minimize public and private losses due to flood conditions in specific areas.*"

While this code is quite comprehensive, the City may want to consider incorporating additional provisions based on the recently completed channel migration zone (CMZ) mapping (see appendices to this document). Section 4.5.2 in this report provides both background and analysis of channel migration zone protection options. Additional recommended changes to the code are listed below in Section 4.4.

4.3.2 Development Code Chapter 3.2 – Landscape Conservation: Analysis

As stated in Section 3.2.100 of the Development Code: "The purpose of this chapter is to promote community health, safety and welfare by protecting natural vegetation, and setting development standards for landscaping, street trees, fences and walls." This section also acknowledges that "landscape areas help to control surface water drainage and can improve water quality..." Development Code Section 3.2.200 Landscape Conservation "prevents the indiscriminate removal of significant trees and other vegetation, including vegetation

associated with streams, wetlands and other protected natural resource areas." This section also cross-references Chapter 3.7 of the Code which regulates development in sensitive lands (see analysis of Code Chapter 3.7 below).

While this code is quite comprehensive, the City may want to consider incorporating additional provisions that better address conservation and restoration of native vegetation and soils. Recommended changes to the code can be found in Section 4.4.

4.3.3 Development Code Chapter 3.5 – Surface Water Management: Analysis

This section of the Development Code states that the section is currently "*reserved for surface water management standards that may be adopted by the City.*" To date no specific surface water management standards have been developed by the City. Recommended changes to the code can be found in Section 4.4.

4.3.4 Development Code Chapter 3.7 – Sensitive Lands: Analysis

This section of the Development Code is currently "*reserved for future design standards that regulate lands such as riparian corridors, steep slopes or other sensitive lands*" and is cross-referenced in Chapter 3.2 of the Code (see above). The Whychus Creek Flood Plain is identified as a Sensitive Land Area in the Code, and the Whychus Creek riparian area is recognized as a "*valuable resource and buffer.*" To date, the City has not initiated development of design standards that specifically regulate sensitive lands. Recommended changes to the code can be found in Section 4.4.

4.4 Recommended changes to Sisters Development Code

Based on the Sisters Development Code analysis in Section 4.3 above, recommended changes are detailed below for the specific codes that were analyzed.

4.4.1 Development Code Chapter 2.6 – Flood Plain District: Recommended Changes

1. In Code Section 2.6.100 (C) Purpose, consider adding the following language modeled from the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000):

    - *Protect and enhance water quality by restricting or prohibiting uses that cause increased flood heights or velocity, or that cause increased onsite or downstream erosion.*

2. Though federal regulations require an engineering certification that development in the floodway area will not cause a rise in the base flood elevation, the City should consider prohibiting any development or encroachment in the Flood Plain District because the 100-year floodplain as currently mapped may not reflect where the active channel has the potential to migrate (see channel migration zone discussion in Section 4.5.2), and loss or damage to structures should be avoided if possible.

3. In Development Code Table 2.6.120 (A) Land Uses Permitted in the Flood Plain District, private properties could be better protected by eliminating Permitted Uses #4 so that the repair or remodel of an existing structure within its existing footprint would not be allowed. The City should also consider a condemnation or buy-out option for existing buildings in the floodplain, particularly those that have been damaged by fire or floods. Similarly, to better protect private property, the City should consider eliminating conditional use approval of the expansion of existing dwellings in the 100-year floodplain (Conditional Uses #6).

4. In Code Section 2.6.130 Prohibited Uses (F), the width of the area where "removal of native vegetation on stream banks" is prohibited should be specified, and made consistent with the recommended riparian / stream protection overlay that is discussed in Section 4.5.1 below.

5. In Code Section 2.6.130 Prohibited Uses (H), specify the types of materials that should be prohibited from being dumped within the Flood Plain District (e.g., manure, pet waste, yard debris, grass clippings, wood chips, garbage, etc.) so that water quality in Whychus Creek is better protected.

6. In Code Section 2.6.150 (A.1) Setbacks (c), to better protect private property consider changing the language to say that "all portions of new structures shall be sited as far away as possible from the area of special flood hazard. However, in no case may new portions of structures be located less than a distance of ½ the depth of the lot away from the area of special flood hazard. As currently written, houses could be sited well within the special flood hazard area depending on the location and size of the lot.

7. In Code Section 2.6.150 (A.1) Setbacks (d), consider eliminating this language that existing dwellings located in the special flood hazard zone may be expanded. The 100-year floodplain as currently mapped may not reflect where the active channel has the potential to migrate, and loss or damage to structures should be avoided if possible (see Recommendation #3, above).

8. Code Section 2.6.150 (A.5) Utilities (b), allows new and replacement sanitary systems to be located in areas of special flood hazard. This appears to contradict Prohibited Uses in Section 2.6.130(H) Septic tanks and drain fields, and this subsection should be eliminated.

9. To better protect properties and structures, consider eliminating Code Section 2.6.150 (B) that allows development to encroach into the FEMA regulatory floodway if certified by a registered professional engineer. The 100-year floodplain as currently mapped may not include those areas where the active channel has the potential to move into (i.e., the channel migration zone). See appendices to this document for a discussion of the channel migration mapping that has been completed for Whychus Creek.

10. Code Section 2.6.150 (D.5) states that subdivision and partition proposals, for properties not entirely within the Flood Plain District or area of special flood hazard shall have

measures to prevent erosion and where applicable, stream bank enhancement methods incorporated into the subdivision design. This section should be modified to reference the erosion and sediment control measures specified in the Central Oregon Stormwater Manual (2007) and / or DEQ's Erosion and Sediment Control Manual (DEQ, 2005). Where applicable, subdivision designs should incorporate approved stream bank restoration methods such as those found in the State of Washington's Integrated Streambank Protection Guidelines (Washington State Aquatic Habitat Guidelines Program, 2002), or the Oregon Aquatic Habitat Restoration and Enhancement Guide (OWEB, 1999). Typical stream bank restoration designs are included in this report in Section 3.6.

11. In Code Section 2.6.160 Criteria for Approval (5), consider adding references to the erosion control and stream bank restoration technical manuals referenced in recommendation number 10, above.

4.4.2 Development Code Chapter 3.2 – Landscape Conservation: Recommended Changes

This code is quite protective of water quality and habitat as written, but could be enhanced by the additional reference to low impact development (LID) techniques and strategies contained in Chapter 11 of the Central Oregon Stormwater Manual (2007), particularly those related to the conservation and restoration of vegetation and soils (Section 11.3.1 in the Manual).

4.4.3 Development Code Chapter 3.5 – Surface Water Management: Recommended Changes

The City should consider adopting all or parts of the Central Oregon Stormwater Manual (2007). This comprehensive manual includes drainage design standards as well as erosion and sediment control measures.

4.4.4 Development Code Chapter 3.7 – Sensitive Lands: Recommended Changes

Consider adding the Whychus Creek channel migration zone (CMZ) as a Sensitive Land Area and property protection zone, and develop specific design standards to control uses within that area. Also, consider development of a riparian protection overlay zone, a riparian setback ordinance, a stream protection overlay zone, or a habitat and property protection ordinance for the Whychus Creek riparian corridor (see analysis of these options in Section 4.5.1 below).

4.5 Proposed additions to Sisters Development Code

Riparian / stream protection along with channel migration zone (CMZ) protection options offer the City of Sisters a number of opportunities that could benefit property owners and Whychus Creek. Some of these opportunities include:

- better protection of properties threatened by stream bank erosion and/or outright channel relocation;
- protecting water quality;
- lowering stream temperatures;
- providing habitat and cover for fish and avian species; and
- providing inputs of wood and leaf debris that are beneficial for fish and aquatic invertebrates.

Section 4.5.1 and 4.5.2 below give a brief overview of riparian /stream and channel migration zone protection options, and how other communities in the Pacific Northwest have employed overlay zones to provide long-term sustainable management of creeks, protect property from excessive stream bank erosion, provide recreational and aesthetic community benefits, enhance the natural resource values, and comply with the federal Endangered Species Act and other natural resource regulations.

Section 4.5.3 discusses a possible combination of these two protection options, a Stream Protection District, that could be implemented by the City of Sisters to achieve the long-term sustainable management of Whychus Creek.

4.5.1 Riparian / Stream Protection overview

Aquatic buffers and their associated regulatory setbacks are environmental management tools that can reduce the impacts of land use activities on aquatic resources including streams, riparian areas and wetland habitats. These buffers serve as natural boundaries that help provide flood control, stream bank stabilization, and protect water quality by filtering overland flow of pollutants, sediment, and nutrients prior to discharge to water bodies. Other benefits of buffers include stream temperature control, providing habitat and cover for fish and avian species, and providing inputs of wood and leaf debris that are beneficial for fish and aquatic invertebrates. Extensive research has been done on the effective width of aquatic buffers and how wide they need to be to accomplish various management objectives. Minimum buffer width recommendations vary greatly between 15 to over 500 feet, though research has shown that buffers should be at least 90 to 300 feet wide on each side of a stream or river for effective water quality and aquatic habitat protection (Mayer et al., 2005).

Examples of aquatic buffers that have been implemented by Oregon jurisdictions include natural resource overlays (City of Hood River example), habitat protection overlays (Portland area Metro example), stream protection overlays (Hood River County example), and the Willamette Greenway Overlay Zone adopted by the City of Salem. The Stream Protection Overlay Zone (Article 42) adopted by Hood River County in 2004 may be one of the better model ordinances for the City of Sisters to consider if the intent is to comply with Goal 5 Safe Harbor Provisions (Hood River County, 2004). The stated purposes of the Hood River County Stream Protection Overlay Zone are:

- *"To implement the goals and policies of the Hood River County Comprehensive Plan for the protection and conservation of fish and wildlife areas and habitat, and rivers, streams and riparian areas."*
- *"To protect and restore Hood River County's water areas, streams and riparian areas, thereby protecting and restoring the hydrologic, ecologic and land conservation functions these areas provide."*
- *"To accommodate the historical lateral migration of stream channels due to natural processes."*
- *"To protect water areas, fish habitat, and adjacent riparian areas and to control erosion, limit sedimentation, and reduce the effects of flooding."*
- *"To establish clear and objective standards that allow reasonable economic use of property while protecting fish-bearing streams and their riparian areas."*

Chapter 4 of the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000) includes a model riparian protection overlay that also meets Goal 5 Safe Harbor Provisions. The primary purposes of this overlay are to protect and enhance water quality; prevent property damage during floods and storms; limit development activity in designated riparian corridors; protect native plant species; maintain and enhance fish and wildlife habitats; and conserve scenic and recreational values of riparian areas (DLCD and DEQ, 2000). This code recommends a riparian overlay zone that extends 50 feet back from the top of each bank for streams with flows less than 1,000 cubic feet per second (cfs), and setbacks of 75 feet or more for stream flows greater than 1,000 cfs. Activities not allowed within the model code riparian protection overlay include removal of vegetation, building activities including grading and paving, land partitions and property line adjustments, site maintenance including the spraying of pesticides or herbicides, and hazardous tree removal (DLCD and DEQ, 2000).

Riparian protection language that meets the Goal 5 Safe Harbor Provisions may need to be modified when a community determines that a greater amount of protection is needed based on Goal 6 findings that identify the presence of federally listed fish species (such as in Whychus Creek) or a water quality impaired stream (particularly one listed for temperature such as Whychus Creek). For these situations, The Water Quality Model Code and Guidebook (Section 4.3.9) recommends development of a water quality protection overlay with a buffer width of at least 100 feet (measured from the top of stream bank), with additional area added for streams over 1,000 cfs, or if steep slopes are present within 200 feet of the stream that could drain into the stream (DLCD and DEQ, 2000).

Recommended limitations on use within the recommended water quality protection overlay vary according to designated uses allowed in three contiguous zones. Within the "streamside zone" (minimum of 25 feet recommended from the top of the stream bank), the physical and ecological integrity of the stream system should be protected by having undisturbed native vegetation present, and only highly restrictive uses allowed such as unpaved footpaths and flood control structures. The "middle zone," which extends from the outer edge of the streamside zone a recommended minimum of 50 feet further upland, is intended to maintain

and enhance mature native vegetation. Allowable uses in this zone may include biking and hiking trails, stormwater treatment facilities, and limited tree removal primarily for safety purposes. The "outer zone" extends a minimum recommended distance of 25 feet from the outer edge of the middle zone to the nearest permanent structure. This zone prevents encroachment into the water quality overlay zone by development, provides an opportunity for treatment of sheet flow stormwater runoff, and encourages the planting of native vegetation to increase the total width of the buffer (DLCD and DEQ, 2000).

4.5.2 Channel Migration Zone Protection overview

A channel migration zone (CMZ) is an area of variable width that includes the current stream channel plus the adjacent areas through which the channel has migrated, or is likely to migrate, within a given timeframe, and thus could be considered a property protection zone. Channel migration zone areas represent a type of flood hazard to people and structures because of possible stream bank erosion and / or outright channel relocation, not necessarily because of the potential for flood water inundation in these areas (King County, 2004). Although both channel migration and flood inundation are hazards due to flooding, there is no specific correlation between the mapped boundaries of each of these areas. The area within a channel migration zone may extend beyond the 100-year floodplain, and / or the 100-year floodplain may extend beyond the channel migration zone (King County, 2004). Within the channel migration zone tentatively mapped for Whychus Creek (see appendices to this document), approximately 60 % of the channel migration zone falls within the 100-year floodplain and floodway.

King County, Washington Critical Areas Ordinance includes sections that apply to flood hazard areas and channel migration zones. Specifically, Chapter 21A-24-275 addresses development within mapped channel migration zones. This code identifies two hazard areas associated with channel migration zones: a severe hazard area being the area that lies within the channel's probably migration over the next 100 years, and a moderate hazard area being the area that lies between the area designated as severe and the outer boundary of the channel migration area. Limited man-made alterations are allowed within each of these areas, with more restrictive requirements applied to the severe hazard areas.

Mason County, Washington recently amended their Flood Damage Prevention Ordinance to establish, among other things, regulations that apply to the channel migration zone and avulsion potential zones in the Skokomish River Valley (Mason County Ordinance 87-08, 2008). Analysis done in support of this ordinance showed that the channel migration zone essentially mirrored the 100-yr floodplain boundary, and was the area in which the river might move to within 50 years under normal erosion conditions (Board of Mason County Commissioner's Proceedings, July 17, 2007). Regulations adopted for the channel migration zone state that there would be no new construction or other development in this area, with the exception that some development might be allowed after an evaluation of possible flooding impacts to new structures (Mason County, 2008).

4.5.3 *Recommended "Stream Protection District" adoption*

By adopting a Stream Protection District along Whychus Creek, the City of Sisters would create an overlay zone that would provide better protection for properties threatened by stream bank erosion and/or outright channel relocation. This overlay zone would also address concerns noted in the analysis of the Sisters Comprehensive Plan Goal 6 in Section 4.1.1 related to degraded water quality (temperature), and the presence of federally listed bull trout and summer steelhead within the City limits and UGB.

The Stream Protection District would incorporate the existing Flood Plain District (Development Code Chapter 2.6) with the mapped channel migration zone for Whychus Creek that is discussed in Section 2.3. To ensure adequate protection of homes and property within the Sisters UGB, the outer edge of the Stream Protection District could be mapped as the existing floodplain boundary or the channel migration zone boundary, whichever is furthest away from the existing Whychus Creek stream channel. The King County and Mason County channel migration ordinances discussed above provide good examples of what types of development might be considered in those areas located outside a 100-year floodplain, but inside a channel migration or property protection zone.

The City should also consider applying more stringent property protection measures within the existing Flood Plain District (see recommended changes in Section 4.4), and slightly less restrictive measures in those areas located between the 100-year floodplain boundary and the mapped channel migration zone boundary.

The Stream Protection District would need to include clear goals and objectives for the protection of property, riparian habitat, instream habitat, and water quality. Technical data and detailed mapping of riparian habitat adjacent to Whychus Creek (provided in the appendices to this document) should be used to develop specific widths of each of the zones recommended in the DLCD / DEQ model ordinance.

4.6 Implementation of best management practices

4.6.1 *Overview*

Effective property, water quality and habitat protection can be achieved through regulatory and non-regulatory, incentive based implementation of structural and nonstructural best management practices (BMPs) that address restoration of native riparian communities, increased water temperatures, erosion and sedimentation control, reduction of stormwater runoff volume, and reduction of pollutant inputs. A good summary of the effectiveness of best management practices is provided in Chapter 4 of the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000). Best management practices found to be effective for increased water temperature include: water quality and environmentally sound design; stream and wetland buffers; addition and retention of trees throughout the watershed; and hillside protection overlays. An excellent resource of best management practices for stormwater

management can be found at the following link: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm.

There are a number of technical manuals that address effective erosion and sediment controls including the Central Oregon Stormwater Manual (2007), the DEQ Erosion and Sediment Control Manual (2005), and the ODOT Erosion Control Manual (2005). Best management practices found to be effective for increased erosion and sedimentation include: impervious surface reduction; water quality and environmentally sound design; stream and wetland buffers; addition and retention of trees throughout the watershed; use and retention of native vegetation; hillside protection overlays; farm animal management; and various structural stormwater treatment systems including wet ponds, constructed wetlands, sedimentation basins, trap catch basins, dry and wet swales, and vegetated filter strips (DLCD and DEQ, 2000).

There are also many examples of information and outreach materials that can be used to help the general public better understand the importance of implementing nonstructural best management practices on their own property. Several example fact sheets on nonpoint source pollution control and the effects of urban development on salmon and trout can be found in Chapter 5 of the Water Quality Model Code and Guidebook (DLCD and DEQ, 2000). This chapter also lists many internet resources that can be accessed for more information, including the Center for Watershed Protection (www.cwp.org), Nonpoint Education for Municipal Officials (www.nemo.uconn.edu), and the EPA Nonpoint Source Outreach Toolbox (www.epa.gov/nps/toolbox).

4.6.2 Recommendation

The City should modify the Development Code as recommended in Section 4.4 above to require the implementation of effective erosion and sediment controls during construction, as well as the implementation of structural best management practices designed to mitigate the impact of stormwater runoff to Whychus Creek and to encourage protection of property. The City should also consider developing a series of educational brochures and / or flyers, modeled after existing examples, to help the general public better understand the importance of protecting the water quality, habitat, and property values of the Whychus Creek corridor. These informational materials should address riparian protection and restoration, erosion control, and preventing discharges of nonpoint source pollutants from properties located adjacent to the creek.

5.0 Landowner Tools

5.1 Incentive programs for water quality, stream habitat, and property protection

5.1.1 *Overview*

There are a variety of land conservation incentive programs that can be developed by local jurisdictions to enable landowners to implement low cost, high value solutions for improving riparian habitat, minimizing stream bank erosion, protecting stream water quality and habitat, and protecting streamside properties. Incentives may include programs that offset the cost of native riparian plants for those landowners who agree to riparian restoration planting on their properties. Other incentive programs include offering stormwater rate credits or property tax credits to landowners who implement nonpoint pollution controls or habitat protection best management practices on their properties. Developers could be encouraged to participate in land conservation programs by offering transferable development rights or density credits in exchange for open space / critical area protection. A good summary and analysis of various land conservation incentives can be found in the Center for Watershed Protection's Better Site Design: A Handbook for Changing Development Rules in Your Community, Principle No. 21 (CWP, 1998).

The Portland Metro "Nature in Neighborhood" Program has developed a cost incentive program that offers grants to support individual, nonprofit and government-sponsored restoration, enhancement, and education efforts in regional watersheds. Funds for the program are provided by Metro excise taxes collected on solid waste disposal during the last several years. As of 2008, Metro has awarded $1.23 million to support 42 nonprofit community groups, schools, businesses, and local governments who have completed 64 projects in the region. Metro also has a "Nature in Neighborhood" capital grants program that provides funding for capital projects that "re-green and re-nature neighborhoods." These programs provide good models of local grant programs that could be implemented by the City of Sisters. More information on these programs can be found on the Metro web site at www.oregonmetro.gov/index.cfm.

The Oregon Department of Fish and Wildlife (ODFW) has created a resource document titled The Oregon Conservation Strategy (ODFW, 2008) that lists various incentive and assistance programs that private landowners can use to protect fish, wildlife and habitat in the state. This document can be downloaded from the agency's web site at www.dfw.state.or.us/conservationstrategy. Listed in the document is the "Riparian Lands Tax Incentive Program" implemented by ODFW through Oregon Administrative Rules (OAR) 635-430. The intent of this incentive program is to "*provide landowners with tax incentives to protect, conserve, or restore healthy riparian habitat on private lands adjacent to perennial and intermittent streams*"[12]. Any landowner wanting to enroll in this tax incentive program must

[12] OAR 635-430-0300

apply to the applicable county tax assessor and to ODFW following requirements specified in OAR 635-430-0360. The width of the riparian land proposed for tax exemption must be sufficient to provide "*long-term stream bank stability, erosion control, water quality, large wood recruitment, fish and wildlife habitat protection, conservation or restoration, and other functions deemed important to healthy aquatic systems*"[13]. A key component of the landowner's application is a Riparian Management Plan developed by the applicant, possibly with assistance from a local city or county. The goal of this plan is to ensure the protection, conservation, and/or restoration of healthy riparian habitat that will provide:

- Sufficient shade to moderate water and air temperatures;
- Adequate native vegetative cover to reduce stream bank erosion, provide organic material input, enhance water quality, and provide for the delivery of large wood to the stream channel;
- Sufficient in-channel large wood to promote complex stream habitat conditions (e.g., pools and riffles); and
- Habitat for native fish and wildlife.

5.1.2 Recommendation

The City should consider developing a cost-share incentive program that could help fund riparian restoration projects on streamside properties within the City limits and Urban Growth Boundary. A variety of restoration actions could be implemented by Sisters land owners and volunteers including noxious weed and trash removal, and the planting of native riparian trees and shrubs to protect and enhance properties, and to provide habitat and water quality benefits to Whychus Creek. The City should also distribute information about the ODFW Riparian Lands Tax Incentive Program to local residents owning land adjacent to Whychus Creek who might be eligible to take advantage of this tax incentive program.

5.2 Contact information

For those landowners interested in implementing proposed actions laid out in this report that will both protect property and stream health simultaneously, there are a number of resources available to landowners to help manage, fund and implement these projects. The Upper Deschutes Watershed Council has partnered with local landowners in the Whychus Creek watershed, and with a number of local agencies and non-profits including the Oregon Department of Fish and Wildlife (ODFW), the Deschutes River Conservancy (DRC) and the Deschutes Land Trust (DLT) to implement a number of on-the-ground projects similar to those proposed in this plan.

[13] OAR 635-430-0320

Below is a list of the potential partners, area of expertise, and contact information should landowners be interested in pursuing partnerships to implement some of the proposed actions outlined in this plan.

Project Management, Funding, Permitting and Project Implementation:

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Upper Deschutes Watershed Council
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scott@deschutesrc.org
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bnye@deschuteslandtrust.org
541-330-0017

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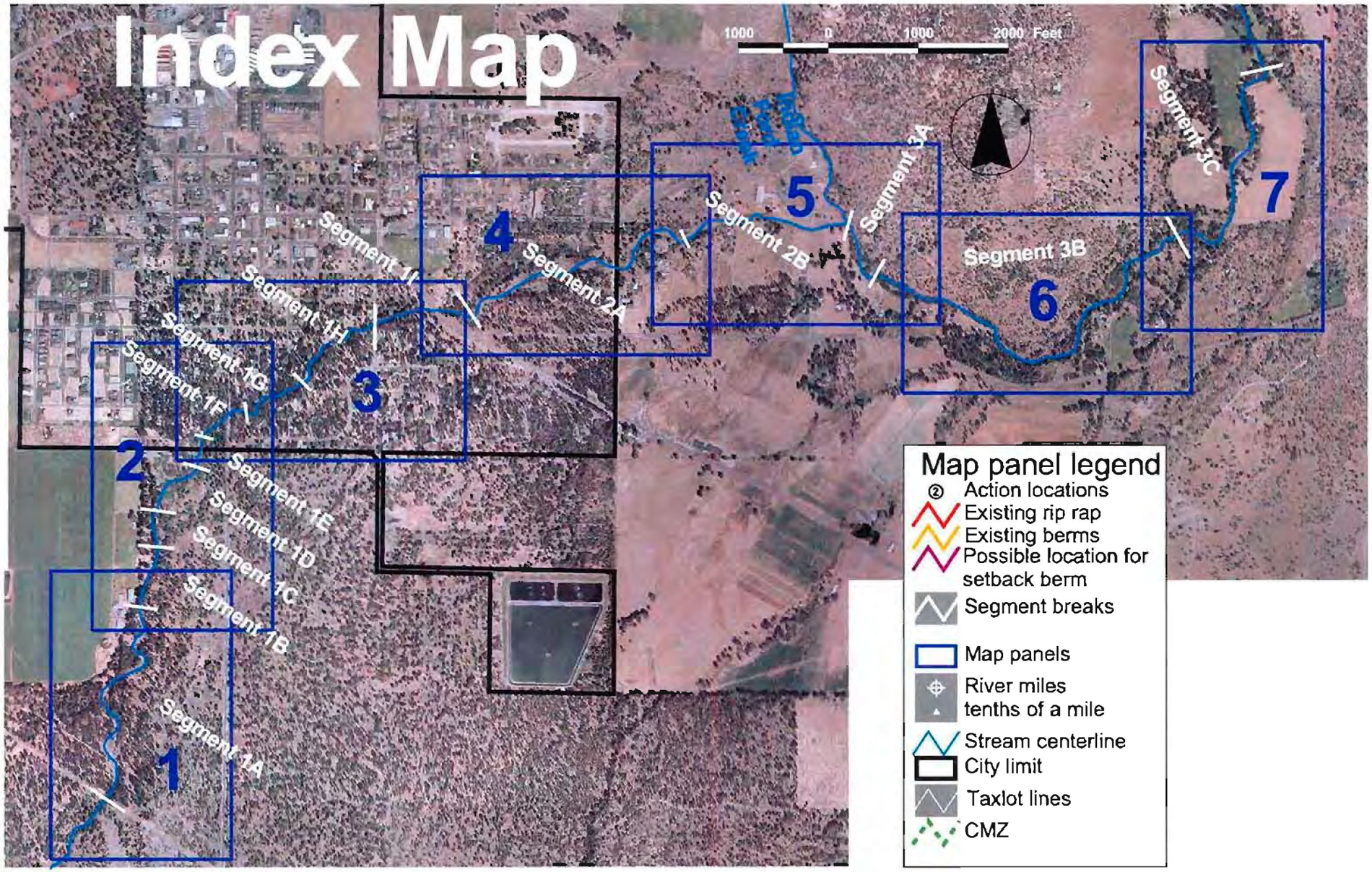
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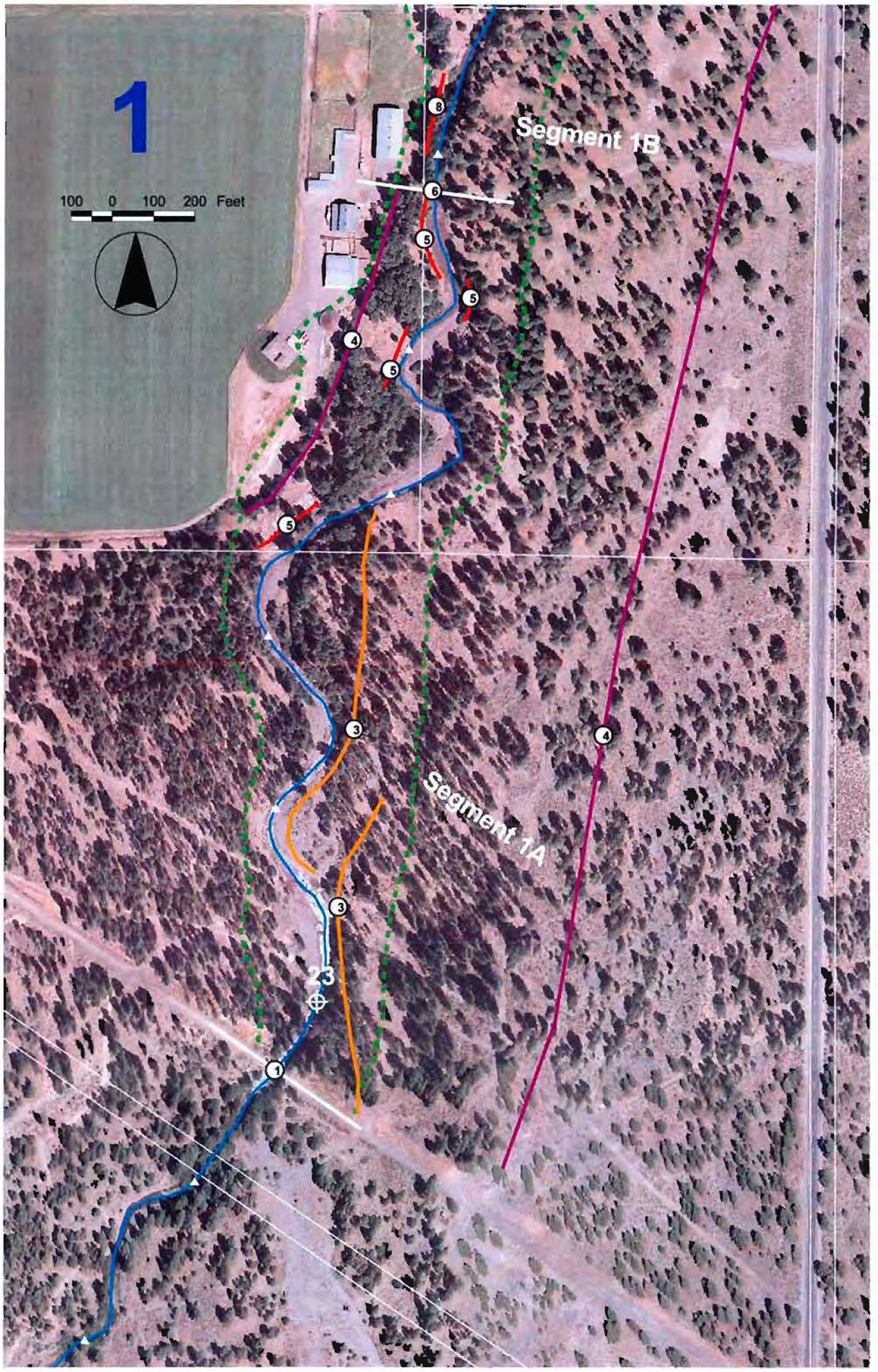
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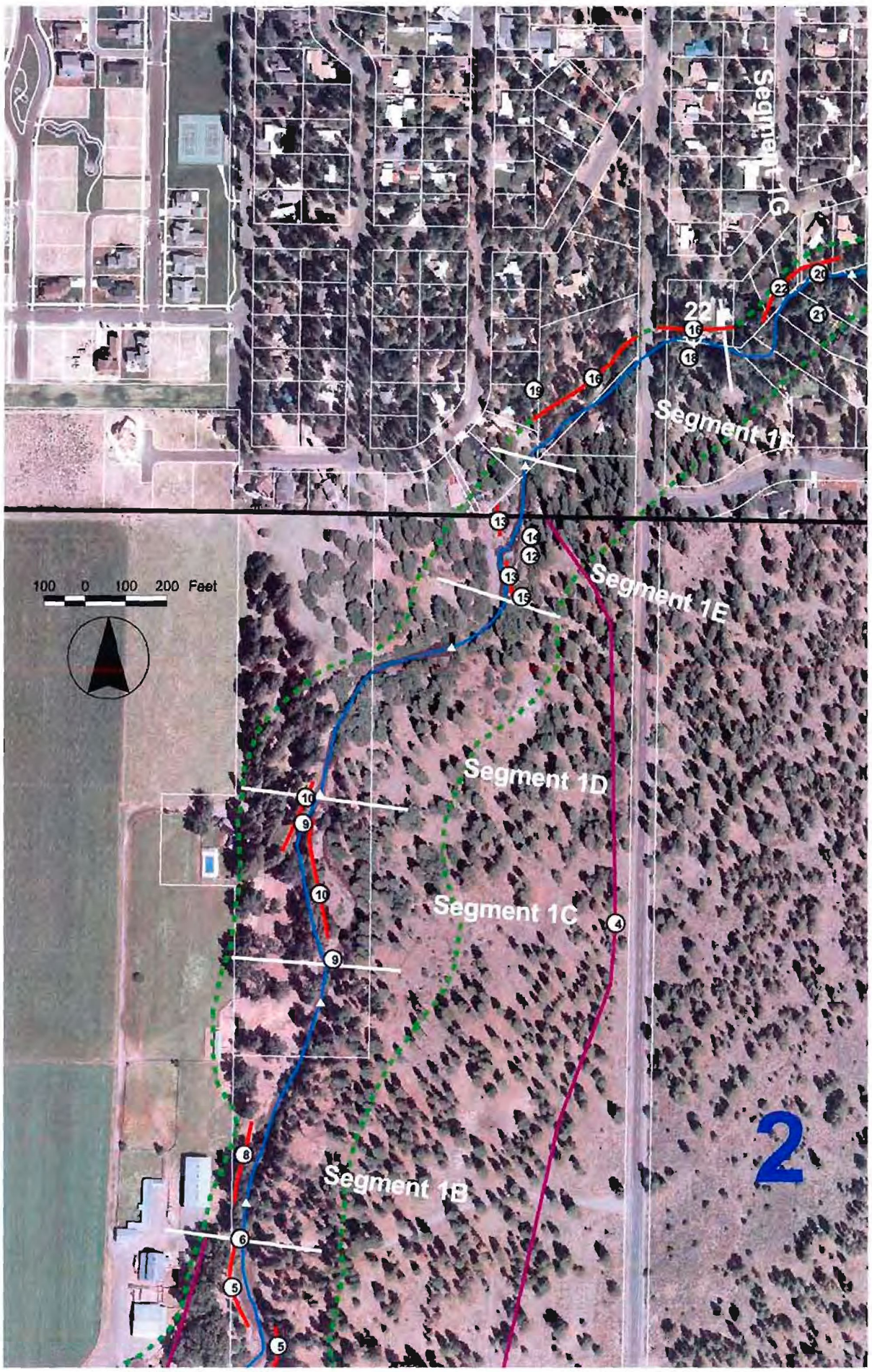
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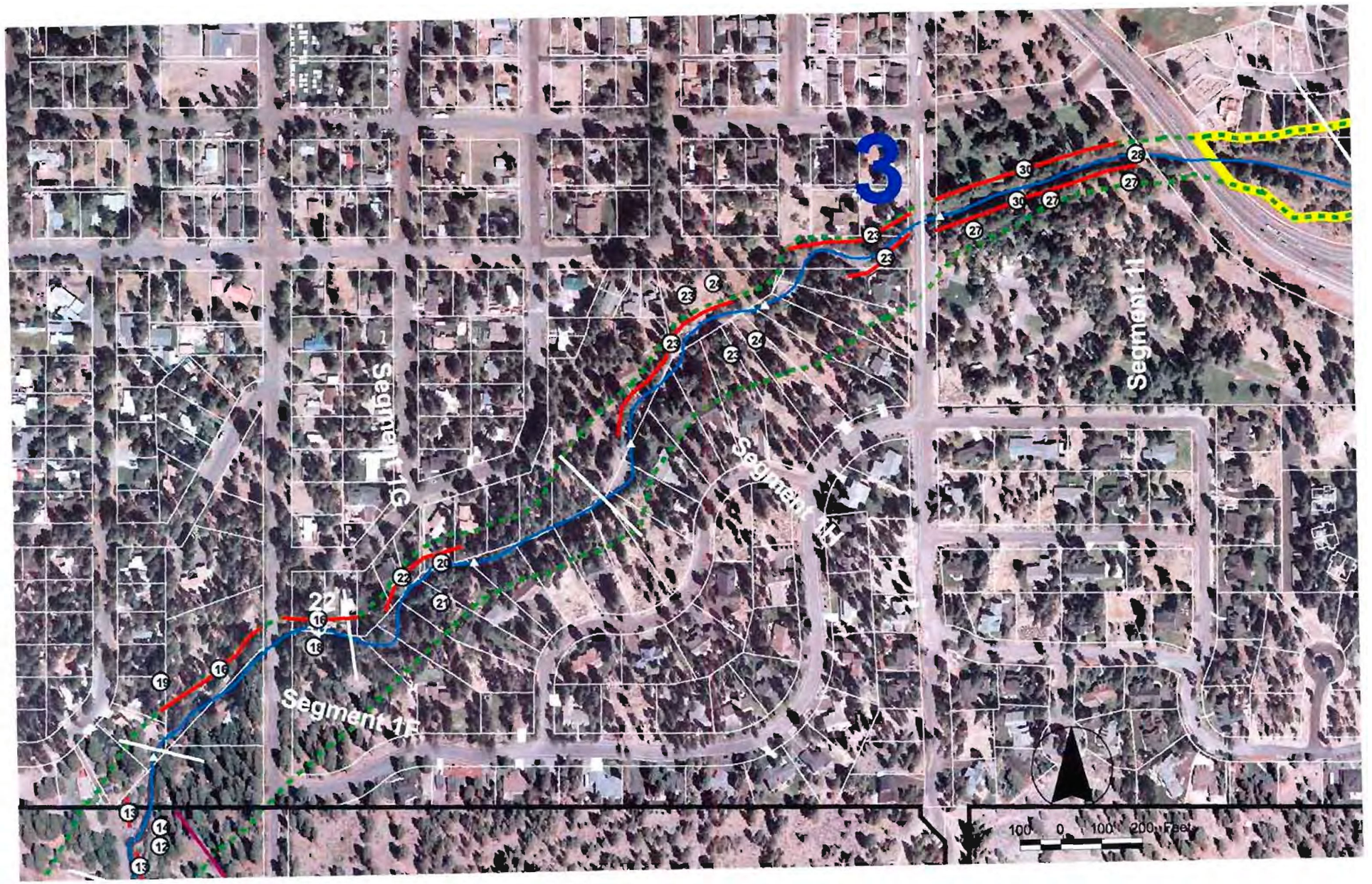
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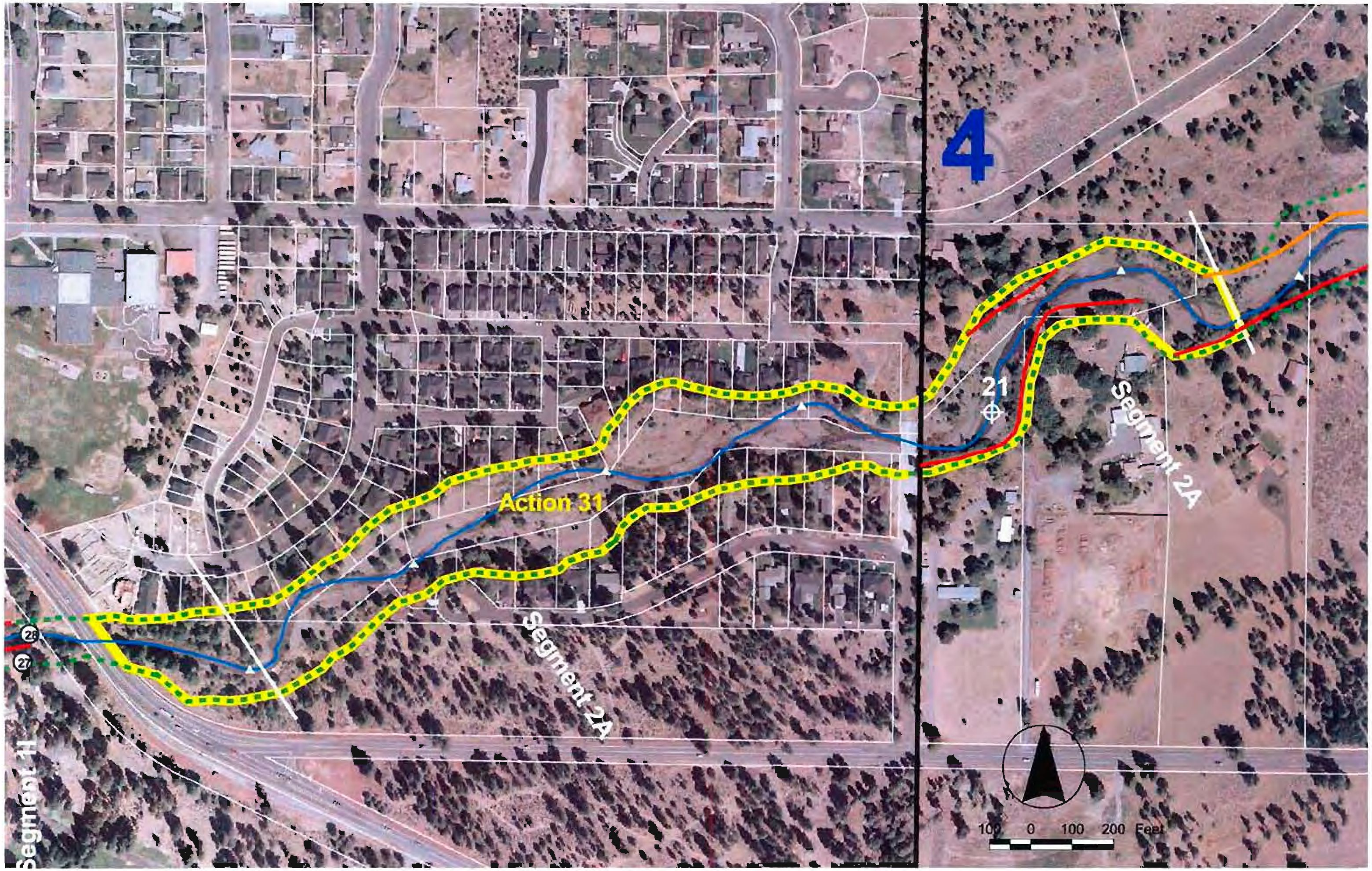

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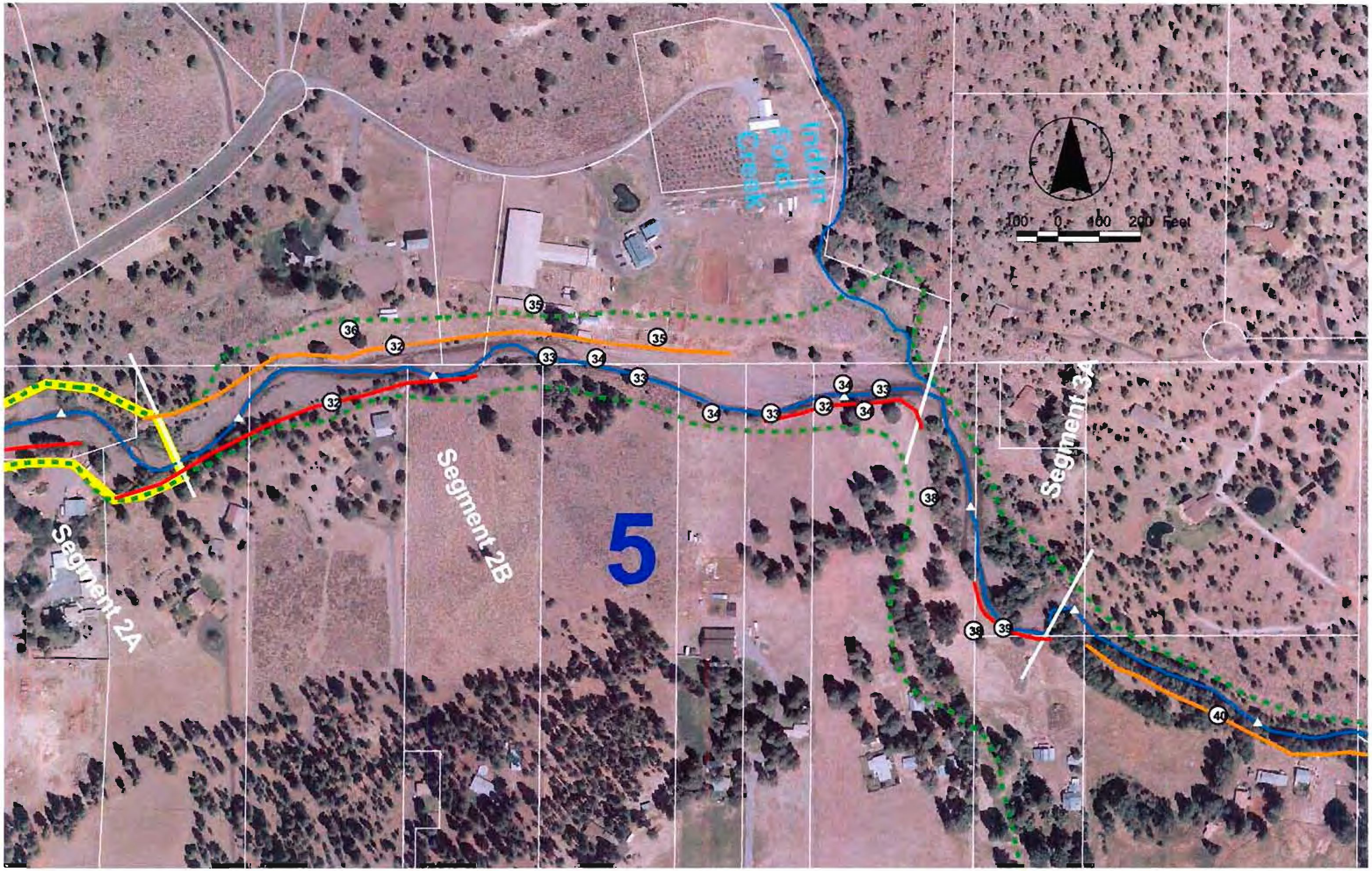

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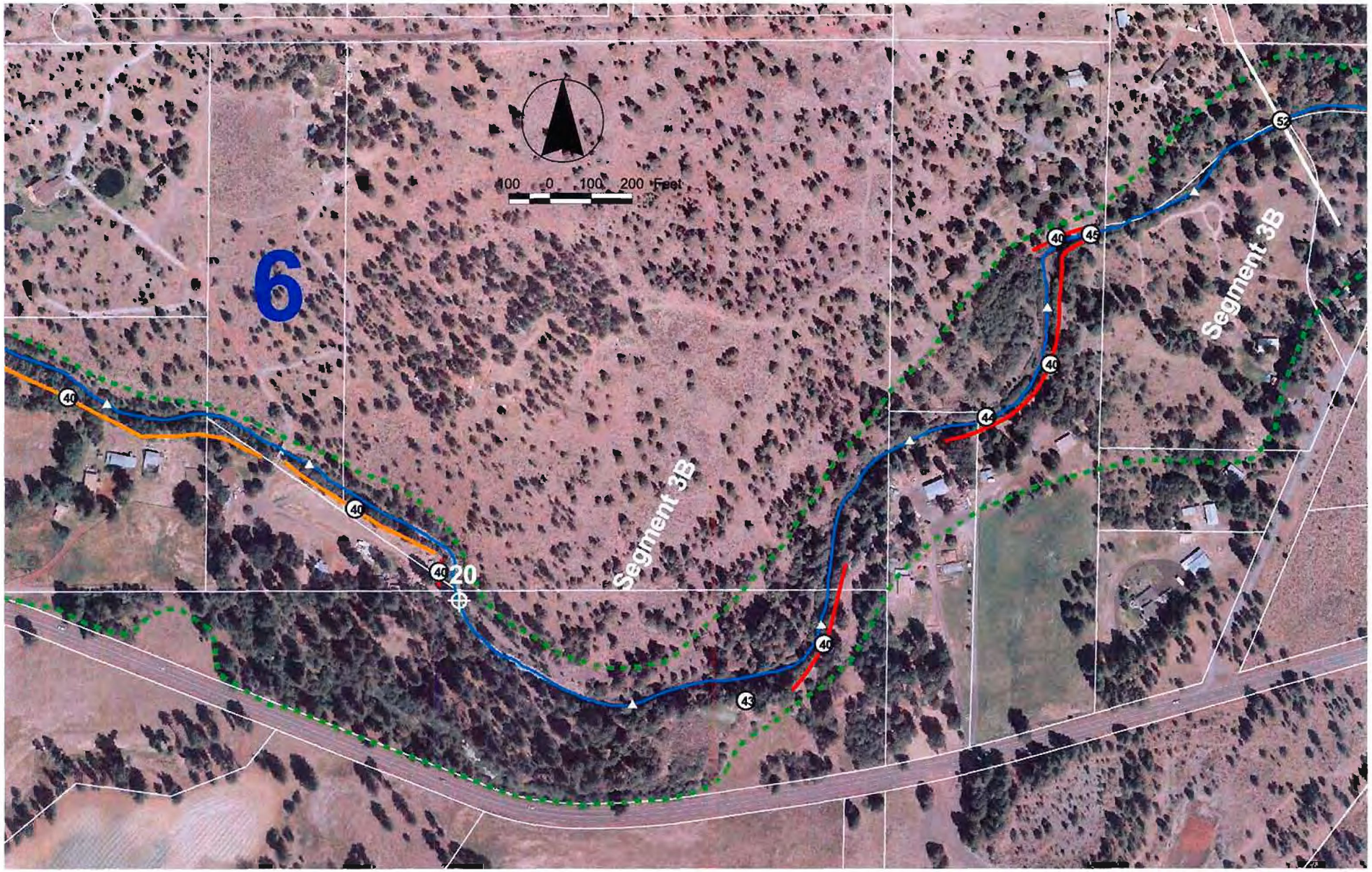
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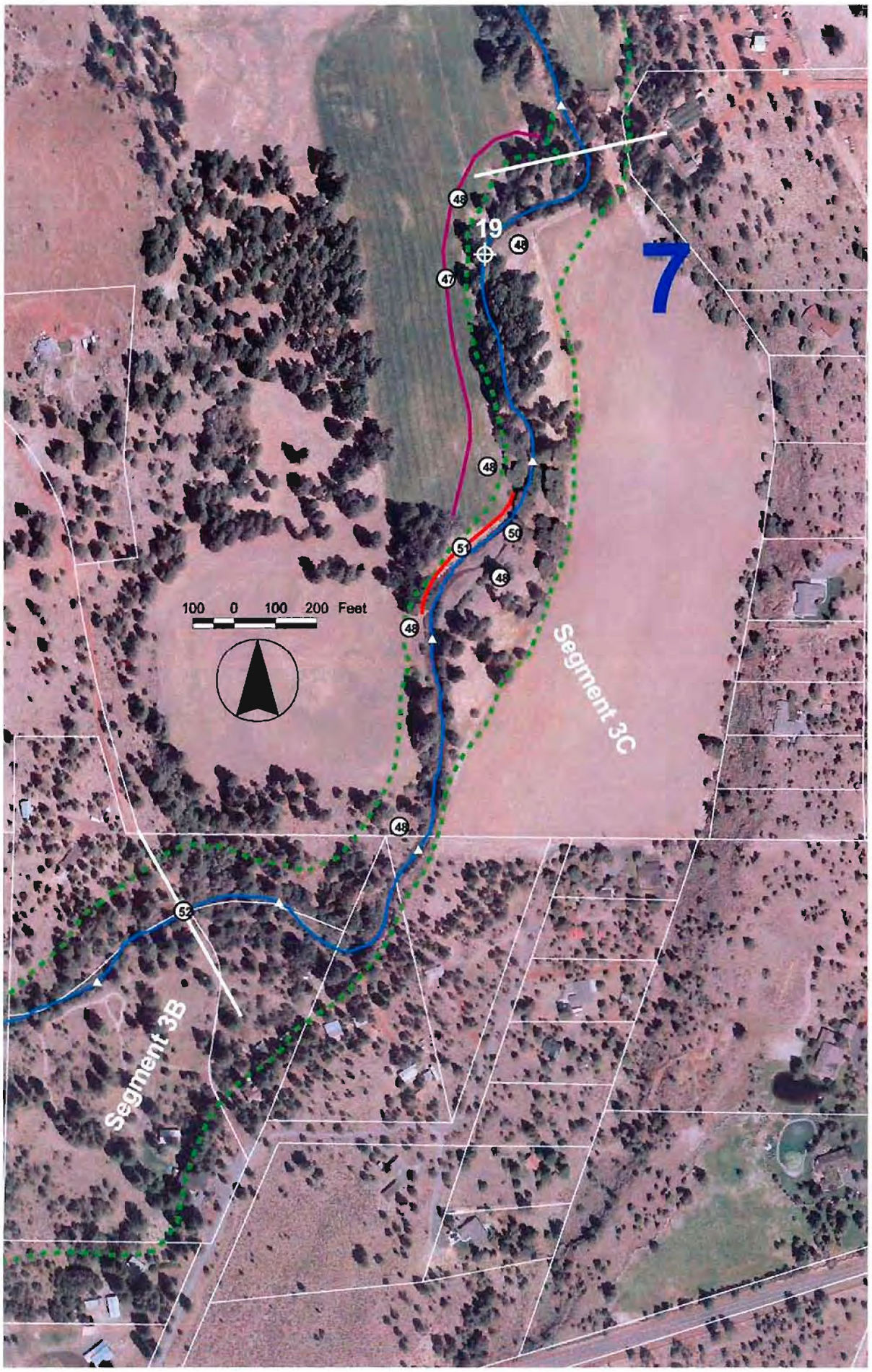
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Watershed Professionals Network, LLC
Technical Report

Whychus Creek Restoration and Management Plan – Appendices
June 2009

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Funders:

Oregon Watershed Enhancement Board
City of Sisters

Table of Contents

List of Figures

List of Tables

1.0 Existing Conditions Summaries

1.1 Ownership

Land ownership within the project area is primarily private (Figure 1). The U.S. Forest Service (USFS) manages lands along the upstream end of the project area, and the City of Sisters (City) owns a parcel of land along both sides of the creek immediately upstream of the Highway 20 Bridge. The State of Oregon owns a parcel along the creek downstream of Highway 20.

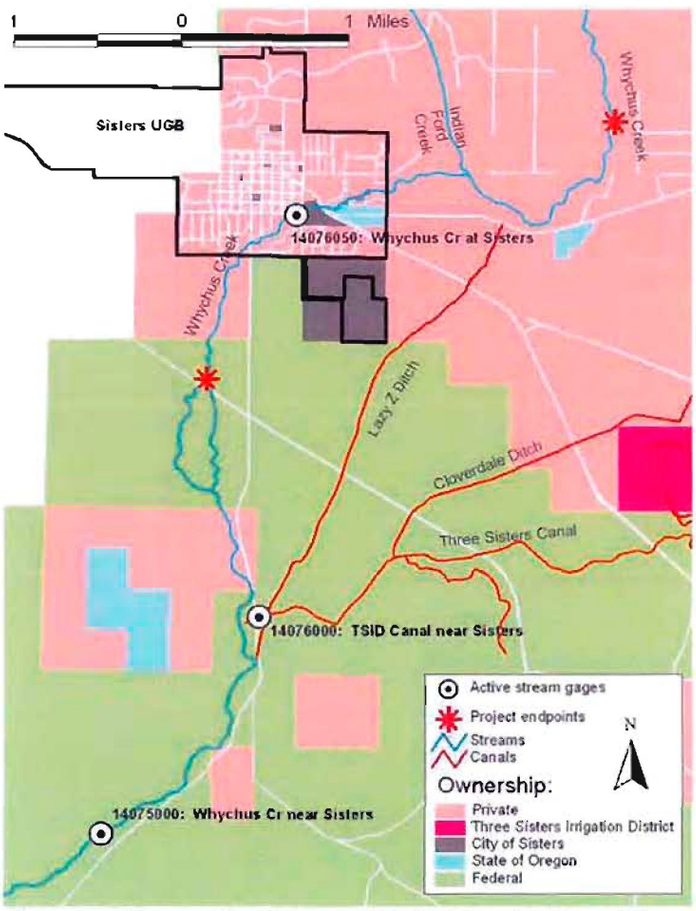


Figure 1. Generalized ownership in the vicinity of the project area (data source: Deschutes County Tax Lot GIS coverage).

1.2 Geologic Setting

The region has a long and complex history dominated by volcanic activity that stretches from the Eocene through the Holocene Epochs. The study area is located near the boundary between the High Cascade geomorphic province to the west and the Upper Deschutes Basin to the east.

The Upper Deschutes Basin is a depositional basin filled with lava flows and volcaniclastic material known as the Deschutes Formation, derived primarily from the Cascade Mountain range to the west. To the north and east, the volcaniclastic material of the basin fill lapped onto uplands composed of older Oligocene to Miocene volcanic material of the John Day and Clarno Formations. The John Day Formation likely underlies most of the Upper Deschutes Basin.

In the late Miocene to early Pliocene of the High Cascade Mountains subsided into a graben bounded on the east by the Sisters and Green Ridge fault zones and on the west by the Horse Creek fault zone. Thus the central portion of the Upper Deschutes Basin was robbed of its source of volcaniclastic sediments that had inundated the basin (Sherrod et al., 2004; Smith, 1991). The Sisters fault zone consists of many faults that trend northwest. The most recent movement on these faults has been roughly estimated at 25,000 years ago. In the Sisters area the faults that likely cut the Deschutes Formation are buried beneath younger glacial outwash deposits that consist of cobbles and pebbles in a sandy matrix. These deposits have been attributed to Cabot Creek glaciation that is subdivided into the Suttle Lake and Canyon Creek glacial advances. Most of the study area has been mapped as Pleistocene outwash of Suttle Lake advance (Figure 2, Table 1; map unit Qos). The estimated age of the Suttle Lake glacial advance is 20,000 years ago.

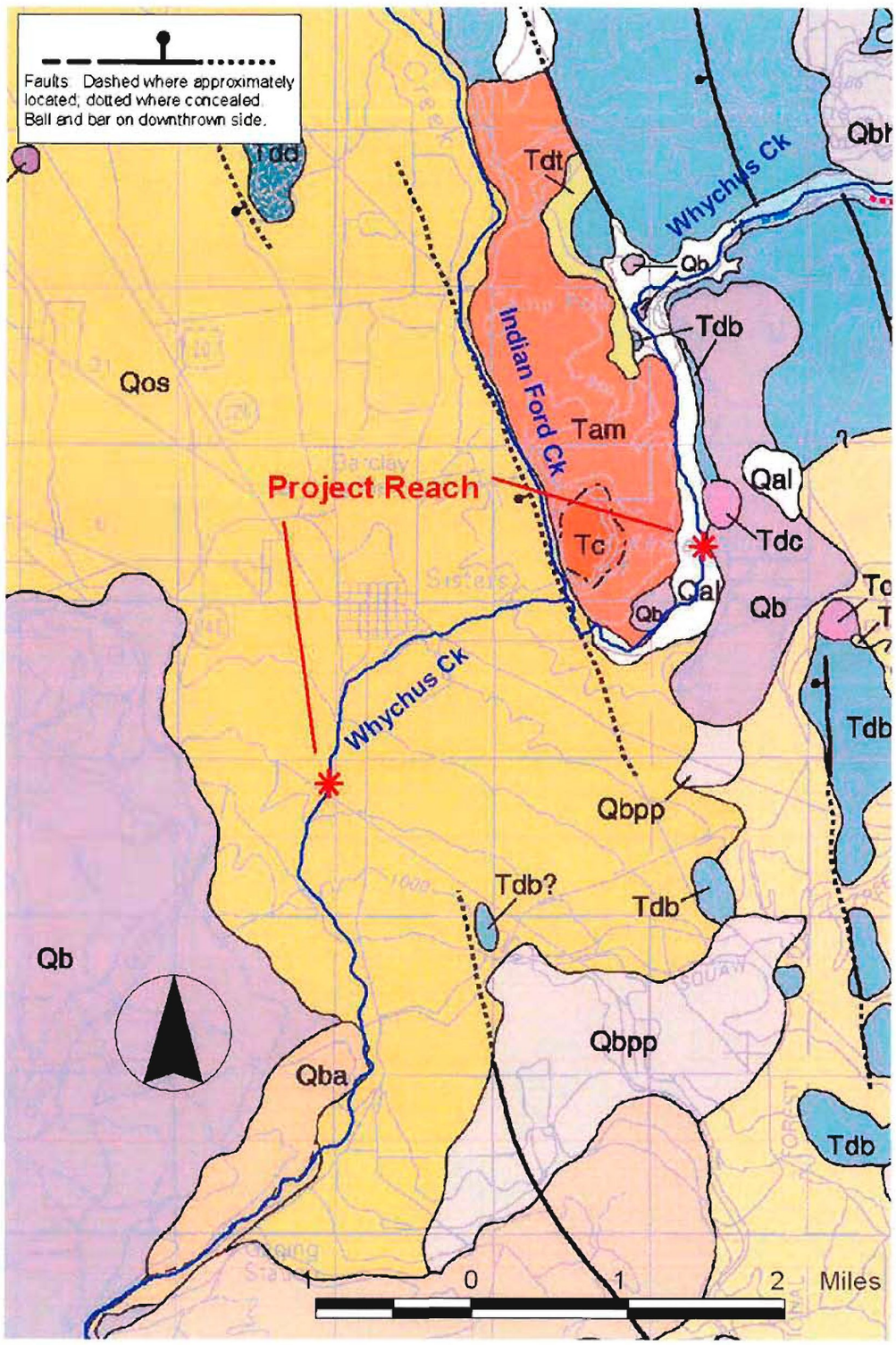


Figure 2. Geology in the vicinity of the project area (from Sherrod et al., 2004).

Table 1. Description of map units in the vicinity of the project area (from Sherrod et al., 2004).

SURFICIAL DEPOSITS	
Qal	**Alluvium (Holocene and Pleistocene)**—Unconsolidated deposits of sand and gravel along streams and in valley bottoms
Qos	**Outwash of Suttle Lake advance (Pleis tocene)**
VOLCANIC ROCKS AND DEPOSITS OF THE CAS CADE RANGE AND NEWBERRY VOLCANO	
Basalt of the Cascade Range and Newberry volcano	
Qb	**Basalt (Holocene? and Pleistocene)**—Moderately porphyritic to aphyric, light- to dark-gray lava flows and flow breccia found through out Cascade Range and areas to east. Chiefly 50–52 percent SiO_2 but includes rocks with as little as 48 percent SiO_2, especially east of Cascade Range. Phenocrysts commonly olivine and plagioclase; clinopyroxene is uncommon. Age chiefly Pleistocene, but first three units may be Holocene. Divided lo cal ly into:
Qbh	**Basalt of Henkle Butte (Pleistocene)**— Olivine-bearing lava flows
Qbpp	**Basalt of Plainview (Pleistocene)**—Widespread lava flows exposed on east side of Cascade Range near Sisters and in Deep Canyon. Contains as much as 20 percent plagioclase phenocrysts (Taylor and Ferns, 1995). Vent buried by younger flows in upslope area of Cascade Range south of Sisters town. Normal-polarity magnetization; overlies Desert Spring Tuff and therefore is young er than about 0.6 Ma
Basaltic andesite of the Cascade Range	
Qba	**Basaltic andesite (Holocene? and Pleis tocene)**— Slightly porphyritic to aphyric, light- to dark-gray lava flows and flow breccia. Forms much of High Cascades throughout map area. Chiefly Pleistocene, but youngest unit may be Holocene in age, and second youngest unit may be partly Holocene. Possesses normal-polarity magnetization; age young er than 0.78 Ma. Oldest isotopic age is 0.63±0.09 Ma (whole rock, K-Ar) from scoria in as so ci at ed cinder cone (Qc, part) 1.5 km west of Triangle Hill (Hill, 1992a), but unit was emplaced as numerous lava flows from multiple vents that span a broad time pe ri od. Divided locally into:
Qbabp	**Basaltic andesite of Black Pine Spring (Pleis tocene)**—Nearly aphyric lava, with less than 1 percent small phenocrysts of pla gio clase. Contains 54–55 percent SiO_2 (Taylor, 1987). Erupted from cinder cone 1 km southwest of Black Pine Spring campground. Dis placed near its terminus by segment of Sisters fault zone. Overlain by Shevlin Park Tuff. Nor mal-polarity magnetization and younger than 0.78 Ma
VOLCANIC AND SEDIMENTARY ROCKS IN THE DESCHUTES BASIN	
Tam	**Andesite of McKinney Butte (Pliocene)**— Aphyric high-iron andesite lava, also with un usu al ly high concentration of Na; average of four analyses indicates about 60 percent SiO_2, 11 percent FeO, and 6 percent Na_2O (E.M. Taylor, unpub. data). Brick-red weath er ing. Magnetic polarity uncertain; total of ten fluxgate magnetometer measurements at different localities produced mixed re sults, all with low magnetic intensity. Po tas si um-argon age is 3.3±0.2 Ma (whole rock; Armstrong and others, 1975)
Tdb	**Basalt**—Medium- to dark-gray, fine- to me di um-grained, open-textured to compact olivine basalt, chiefly forming lava flows. Erupt ed from small to moderatesized cin der cones (unit Tdc). Includes basaltic andes ite and andesite not mapped sep a rate ly. Ba sal tic andesite may form as much as 30 percent of unit, but we have too few chem i cal analyses and flow-by-flow mapping to define the compositional proportions more thor ough ly. Basaltic andesite may pre dom i nate at Green Ridge, along north-central edge of map. Andesite is probably less than 5 per cent throughout area. Queried for lava of uncertain stratigraphic assignment south of Sisters. Colored line shows extent of de pos its where exposed within Deschutes For ma tion sed i men ta ry strata (unit Tds) along can yon walls of Deschutes River and its trib u tar ies. Locally divided into:
Tdd	**Dacite**—Lava of eroded dome north of Sis ters
Tdt	**Ash-flow tuff**—Partially to moderately weld ed pyroclastic-flow deposits. Most contain scoria and pumiceous lapilli and bombs ranging in composition from andesite to rhyolite. Colored line shows extent of de pos its where exposed within Deschutes For ma tion sed i men ta ry strata (unit Tds) along can yon walls of Deschutes River and its trib u tar ies. Locally divided into:
VENT DEPOSITS AND INTRUSIONS	
Tc	**Cinder deposits (Pliocene)**—Cinder deposits mark ing vent for andesite of McKinney Butte (unit Tam), north of Sisters
Tdc	**Cinder deposits of Deschutes Formation (Pliocene and Miocene)**—Basalt and ba sal tic andesite scoria and lava, forming cones and ir reg u lar accumulation of cinders. Marks vents for lava flows in Deschutes For ma tion. Major cinder cones for one Deschutes Formation lava sequence, the basalt of Tetherow Butte, are shown with labels Tdc and (Tdbt)

Whychus Creek flows northeast across the glacial outwash plain until it comes up against McKinney Butte and turns to the southeast to flow around the butte. On the east side of the butte the creek flows northeast along the east flank of a low ridge that extends northwest from McKinney Butte. McKinney Butte and the ridge consist of Tertiary cinders and andesite lava flows (Figure 2, Table 1; map units Tam and Tc). Both sides of the ridge may be bounded by northwest trending faults of the Sisters fault zone that are buried beneath the outwash deposits on the west and recent Whychus Creek alluvium on the east. Only on the east side of McKinney Butte and the ridge is the course of Whychus Creek possibly controlled by a fault.

The LIDAR images of the study area[1] clearly show many abandoned stream channels to the south and east of the current Whychus Creek channel. Whychus Creek's channel has migrated across the outwash plain in a northwesterly direction. As the creek migrated across the outwash plain its course was likely influence by buried paleo-channels that it intersected within the glacial outwash deposit. East of McKinney Butte, the creek channel is confined between the andesite lava flows of McKinney Butte and a Quaternary basalt flow that caps the bluff to the east.

1.3 Geomorphic Framework

This section summarizes the geomorphic framework for the Sisters reach of Whychus Creek. This information presented is necessary to understand possible geomorphic-related restoration and management actions that will be developed in Section 4 of this report, and to provide geomorphic values necessary for the development of instream restoration actions.

1.3.1 Geomorphic Setting

Through the project area, Whychus Creek occupies a transitional landscape position. Approximately three miles above the project area, the stream exits a 100 foot wide canyon with a gradient of about three percent[2]. Reaches of sediment deposition exist, although these upstream portions of the watershed are primarily source and transport areas for the abundant supply of sediment the stream carries. The stream displays alluvial fan characteristics as it leaves the confining canyon walls, lessening its gradient and creating split channels across the fan. As is typical of alluvial fans, the stream channel slope displays a concave signature as it transitions from hillslope to the glacial outwash plain. These transitional reaches are often the site of significant sediment deposition as stream energy is reduced by the decreasing slope and increasing channel width. The City is located within such a transitional reach, where a multitude of geomorphic processes are associated with the reduction in stream energy.

Naturally functioning stream processes on alluvial fans are associated with relatively frequent channel change in response to in-channel deposition. The convex landform of the fan promotes the formation of distributory channels that route flood flows away from the dominant channel. This is in contrast to typical valley floodplain functioning, where high flow

[1] See LiDAR base map of project area
[2] See LiDAR overview map

channels discharge back to the dominant channel. This distinction is central to understanding the functioning of Whychus Creek through the project area. The disconnection of high flow distributory channels greatly influences the dynamic interactions between high flow energy and available sediment that are the drivers of channel form and aquatic habitat. Concentration of flood flows within the confined stream corridor has generally resulted in increased channel capacity and correspondingly decreased channel complexity.

The upper portions of the project area above the City exhibit the most complex combination of geomorphic processes. Extensive cobble/gravel bars and islands indicate that deposition of routed sediment is occurring. At the same time, these deposits are helping to force the stream laterally, as evidenced by active bank erosion on the outside of every major bend in the channel. The stream is trying to achieve a stable, slightly meandering pattern.

Through town, the stream has been channelized and narrowed, resulting in a sediment transport reach lacking in habitat diversity. Channelization, removal of roughness elements, and the reduction in spring peak flows associated with water withdrawals upstream have created a stream not likely to assume a broad multi-thread presence across the fan. Incision and modifications have effectively isolated the channel from the historic flood plain. In addition, this somewhat constrained position is influenced by the stream's eastward arc through town as the channel tries to move north. Below the Highway 20 Bridge, the gradient lessens and the channel displays depositional characteristics in a wider channel confined by berms and terraces.

Downstream of the confluence with Indian Ford Creek, the left bank of Whychus Creek is confined by the bedrock and hill slopes of McKinney Butte. The stream follows a fault line as it cuts along the toe of the alluvial fan. Although much of this portion of the stream has been channelized north of its previous location, today's channel utilizes the bedrock features as channel stabilizing and habitat complexity elements. A narrow floodplain remains in contact with the current channel. Sediment is mostly transported through this reach, while the abandoned channel supports a diverse wetland community in places.

The subtle changes and man-made features used to define individual segments would generally not result in a change of Rosgen stream types between segments. The majority of the channel network within the project area would be considered a Rosgen C_3 or C_4 type channel. The fan landscape present in the upper portion of the system suggests that portions of the channel network possess characteristics of a weak D type channel, primarily multiple channels. Development and the confining features of McKinney Butte reduce the sinuosity and the width/depth ratio, producing channels that possess an entrenchment ratio lower than the typical type C channel.

In addition to the geomorphic processes associated with sediment, flow, and human influence, ice formation and movement are active in the project area (Figure 3). Ice dams not only impede flow and cause flooding, but movement of ice can affect channel geometry and bank and bed stability. No written record of ice impacts to Whychus Creek was located, though land owners provided some information on ice events. Ice jams have occurred within the last

few years at narrow points in the channel (see Segment Descriptions). These jams are known to exacerbate flooding upstream, and are suspected to cause some channel erosion as the ice moves. In addition, the ice disturbs riparian vegetation establishment on bars and terraces in and near the channel.

Figure 3. Ice jam in Whychus Creek in 2004. Location is downstream of City limits and upstream of Indian Ford Creek confluence.

Other influences and processes associated with the watershed are related to a number of moraine dam lakes located in the headwaters of the watershed. As the glaciers associated with these lakes retreat, there is a real concern that the moraines impounding these lakes could fail, initiating a debris flow that would affect downstream channel conditions and processes. These failures have occurred in the basin before, the most recent being a failure of the Diller Lake moraine in 1970, which initiated a debris flow in the North Fork of Whychus Creek. Most of the channel impacts occurred well upstream of the project area, but a sediment laden pulse of flow (approximately 1,000 cubic feet per second (cfs)) increased water levels in the City of Sisters by about one foot (O'Connor et. al., 2001). The USGS has determined that the future likelihood of similar events occurring in the Sisters volcanic region is "highly likely" (O'Connor et. al., 2001).

The current concern is centered on Carver Lake, located in the headwaters of the South Fork of Whychus Creek. The volume of this lake is slightly less than three times that of Diller Lake. Although the USGS modeling does not present estimated flows associated with a dam failure within the project area, extrapolation indicates that a flow pulse of about 1,400 cfs near the

project area may be possible. Sediment carried to the project area would likely be in the form of fines and small gravel rather than boulders or cobbles.

If this event were to occur, impacts to the project area would be extremely difficult to model. Deposition and erosion associated with the debris flow, particularly above the project area, could alter channel location and flow patterns as well as sediment delivery. Determination of future channel condition is beyond the scope of this project, and would be dictated by how the upper watershed responds to the debris flow.

1.3.2 Reach/Segment Descriptions

Properly designed restoration actions utilize the channel processes present to improve stream condition. To achieve this, the stream is divided into reaches with each reach further divided into segments based on geomorphic conditions and processes. While we must place a line on a map to delineate reach and segment breaks, these lines most often represent a transition zone rather than a discrete point. In addition, some segments are broken out due to human actions such as weirs that have significantly altered channel conditions and processes.

Within the project area, the stream is divided into three reaches, starting with Reach 1 which extends from the upstream project boundary (at USFS Road 4606) to immediately downstream of the Highway 20 Bridge (Figure 4 and Figure 5). This is the steepest reach (0.87% slope), and acts primarily as a sediment transport corridor although some sediment is stored in the upper segments. Through town, stream characteristics and processes are heavily influenced by channel modifications. Reach 1 is divided into nine segments, which are described below.

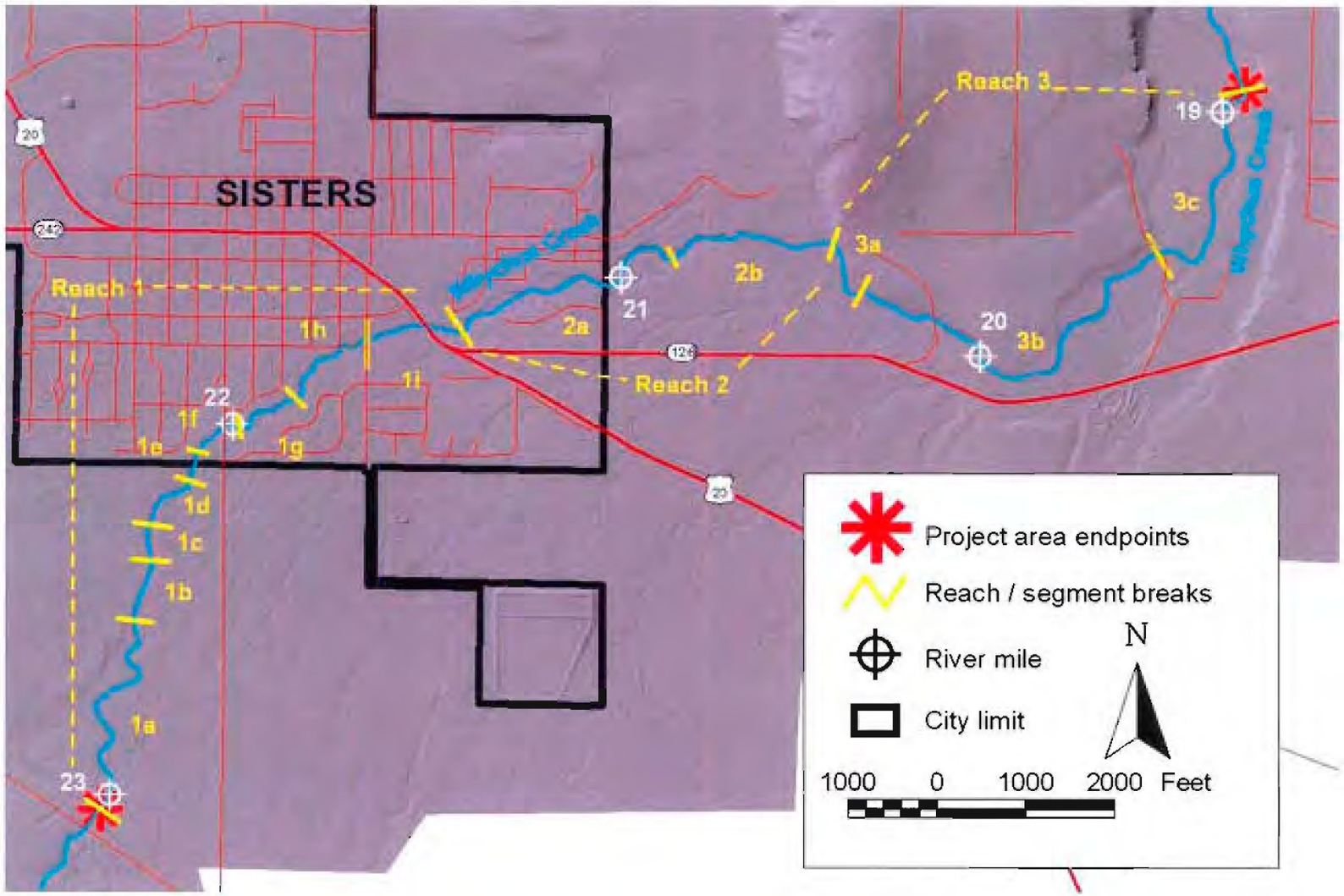


Figure 4. Reach and segment breaks (LiDAR topography base).

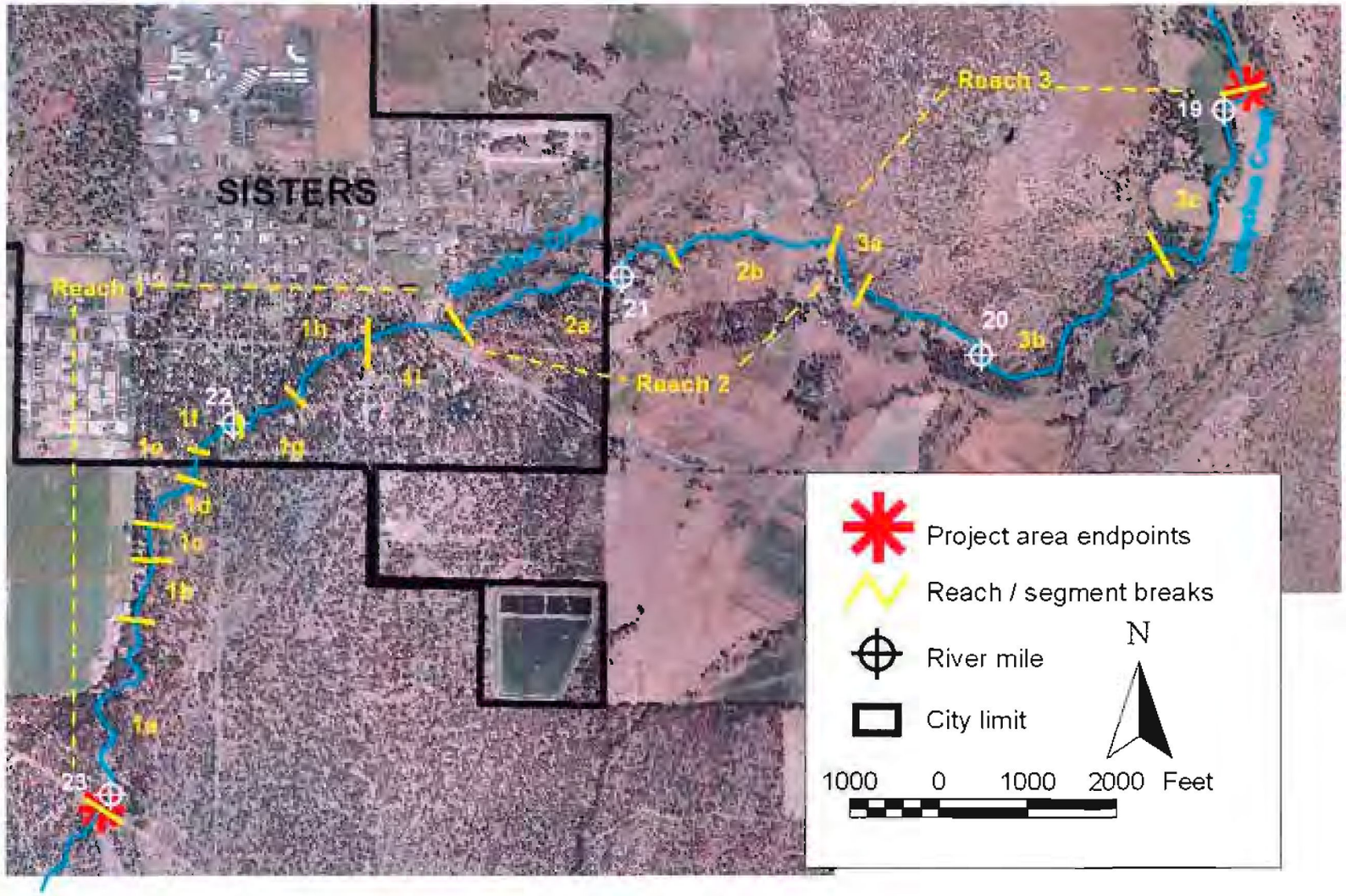


Figure 5. Reach and segment breaks (orthophoto base).

Reach 2 extends from Reach 1 down to the confluence with Indian Ford Creek. The lower half of this deposition reach was relocated south approximately 1,000 feet and straightened 50 to 60 years ago. It is a simplistic system with little instream habitat or riparian diversity, and is divided into two segments.

Reach 3 extends from the confluence with Indian Ford Creek downstream to the end of the project area, and is divided into three segments. The upper half of the reach was straightened from a highly sinuous channel approximately 50 years ago. The current channel is very stable, with channel roughness in the form of boulders and bedrock present in the upper half. Most sediment entering the reach would be transported downstream. The lower half of the reach is characterized by a moderately incised, relatively straight channel flowing through a broad (approximately 1,000 foot wide) valley.

The following presents a brief description of the segments by reach. Please refer to Figure 4 and Figure 5, and to the project area base maps for greater detail on locations of reach and segment breaks.

Reach 1

Segment	**1A**
Length	**3,740 feet**
Gradient	**0.71%**
Morphology	**Weak pool/riffle, deposition and transport**
Human Influence	**Limited riprap and straightening**
Photos	**Numbered 1 - 23**[3]

Segment 1A lies at the upper extent of the project area where multiple geomorphic processes are occurring. This pool/riffle segment is actively eroding the outside of each of the weak meander bends, while nearly continuous cobble bars suggest a combination deposition/transport environment. Although the segment is classified as a pool/riffle system, the lack of channel roughness elements limits the development of deep pools. This limited amount of local energy concentration by the stream also inhibits gravel sorting. While cobble and gravel are the primary substrate, fines are found throughout the bed. Where present, root wads and large woody debris (LWD) are effective features to focus energy and improve habitat diversity.

The cobble and gravel substrate is suitable for salmonid spawning, but the lack of pools, pool complexity, and cover elements limit the juvenile rearing habitat. The eroding outside bends do not allow for development of undercut banks. Most of the pools present are associated with boulders used for bank protection that have been undercut by erosion and lack cover.

[3] http://whychus.com/working/photo/reach1/index.htm

Although discontinuous berming and limited riprap have been utilized[4] to restrict lateral movement and isolate higher floodplain terraces and high flow channels, the segment is relatively unconfined compared to other segments in the project area. The bridge (accessing the Sokol property) at the downstream end of the segment acts as a high flow constriction and is experiencing scour at the right bank.

Photos from 1943 and the early 1950's show a stream with large lateral bars and only a very slight meander. By the late 1950's and after the 1964 flood, the stream was straightened slightly and berms were constructed. Since that time, the stream is attempting to reestablish a more sinuous form with increases in meander amplitude, as well as riparian growth on higher bars and terraces. Compared to 1951, today's meander amplitude at the top of the segment has increased by about 60 feet.

Segment	**1B**
Length	**700 feet**
Gradient	**0.40%**
Morphology	**Plane bed, transport**
Human Influence	**Limited riprap**
Photos	**Numbered 24a – 24c**

Segment 1B is a very simple segment from a geomorphic standpoint. The primarily single thread plane bed channel is incised into the fan with limited flood plain surfaces. The lack of roughness elements severely limits habitat diversity in the form of gravel retention/sorting, pool development, and channel complexity. Habitat cover is improved over Reach 1A due to the narrower vegetated stream bank and stabilized riprap material. Sediment is efficiently routed through this segment as evidenced by the lack of bars.

The weir and channel modification located at the boundary of Segments 1B and 1C acts as a grade control structure for Segment 1B, creating a strikingly low gradient relative to the adjacent segments. This further simplifies the geomorphic processes at work. Overall channel form and location have remained similar for the last 60 years.

Segment	**1C**
Length	**430 feet**
Gradient	**1.26%**
Morphology	**Weak pool/riffle, deposition**
Human Influence	**Weir, riprap over half of segment**
Photos	**Numbered 25-30**

[4] See Landform map

Segment 1C is a short segment delineated largely due to the impacts of channel modification in this area. The segment possesses a split channel with a four foot high weir placed in the left channel that acts as a control for upstream sections. The right channel is steeper and is dominated by boulders. The shifting sediment bar at the top of the channel split, as well as manipulation of large boulders here has caused the lateral movement of flow. While the overall gradient is relatively steep compared to other segments, most of the drop is associated with the weir.

Prior to construction of the weir, the 1951 photo shows a single thread channel through this segment. It is likely that the segment was historically a sediment transport reach similar to Segment 1B. The weir and associated sediment deposition have widened the channel upstream of the weir and allowed the development of two distinct channels. Although the boulders placed in the channel to force flow to the left channel appear relatively new, it is likely that some channel realignment began in the 1960's, with portions of the flow shifting between the two channels.

Habitat is altered by the recent, and assumed recurring maintenance (excavation) of the channel upstream from the weir, the riprapped banks, and maintenance associated with maintaining flow in the main channel.

Fish Passage Barrier (Id # 7): The structure is identified in the UDWC Diversion-Barrier Inventory (UDWC Personal Communication, 2008). The height of the dam is approximately four feet. The inventory indicates that it is not listed as a fish passage barrier by OWRD, but has not been evaluated by ODFW. At observed base flows, the dam height exceeds the general criteria of six inch jump height and is therefore likely a barrier to juvenile salmonid fish.

Segment	**1D**
Length	**720 feet**
Gradient	**0.89%**
Morphology	**Plane bed, transport**
Human Influence	**70% of segment straightened and relocated**
Photos	**Numbered 30a – 30c**

This segment is a transport section very similar in character to Segment 1B. Segment 1D has been subject to straightening and relocation during the mid 1960's. Approximately 70% of the channel was straightened including removal of two meanders along the north bank. The resulting channel is stable but lacking in roughness elements and habitat diversity. The channel is likely becoming more incised over time.

The straightened channel is narrower, concentrating the base flow and slightly increasing overall water depth. Overhead canopy provides shade and cover. The riprap material is vegetated and provides some limited pools along the bank margin.

Segment	**1E**
Length	**370 feet**
Gradient	**1.19%**
Morphology	**Weak pool/riffle, deposition**
Human Influence	**Extensive riprap extending into the channel**
Photos	**Numbered 31 - 36**

Currently, this segment acts as a deposition zone associated with a number of rock barbs and riprap associated with past water diversions. Although the 1953 photos shows instream structures impounding flow and sediment, it appears that the amount of sediment is greater today. The placed rock has constricted the channel, further reducing energy upstream of the modifications.

Segment 1E has maintained roughly the same position and dimension over the last 60 years. Periodic changes to cobble bar configuration have occurred, causing a multi or single channel signature. The boulders and rock placed in the channel provide some channel roughness and develop some gravel sorting and shallow pool development. Downstream of this site the channel is narrowed and shaded providing some habitat cover.

Segment	**1F**
Length	**590 feet**
Gradient	**0.54%**
Morphology	**Plane bed, transport**
Human Influence	**Limited straightening, extensive riprap and channel encroachment**
Photos	**Numbered 38 – 39a**

This transport reach is similar in character to Segments 1B and 1D. As is typical with transport reaches, the nearly plane bed segment is stable. Development has occurred on both sides of the channel leaving a limited floodplain. This segment is slightly more incised than upstream areas, with steeper banks approximately six to eight feet in height. A few boulders are the only channel roughness elements in a segment with little habitat diversity and extensively riprapped banks. Other than the bank armoring, it appears that some straightening of the right hand bend upstream of Elm Street bridge occurred in the late 1950's and mid 1960's, moving the stream south less than 50 feet.

The large boulders used for bank stabilization create some pool habitat and cover. However, these pools lack complexity and therefore provide minimal quality habitat. Substrate composition is gravel and cobble providing potential spawning gravel and juvenile hiding cover if other habitat elements were available.

Segment **1G**

Length	**800 feet**
Gradient	**1.06%**
Morphology	**Plane bed, extensive deposition**
Human Influence	**Weir, channel encroachment, riprap**
Photos	**Numbered 42 - 49**

This segment is broken out primarily because of the Leithauser irrigation diversion dam located in the middle of the segment. This three foot high impoundment has caused a large (~250 foot long) sediment plug upstream of the structure that has been seasonally present for over 60 years. Sediment is mostly fines and gravel, a testimony to the low energy nature of this segment. Fines are also being released from behind the dam, with downstream segments containing a higher percentage of fines than upstream segments. At the dam site there are three channels: the main channel; a steep 12 foot wide boulder and rip rap overflow channel; and a rapidly eroding four foot wide fish passage channel along the right bank. The total channel width is approximately three times that of upstream and downstream segments.

In addition to extensive riprap along the left bank, the upper three-quarters of this segment was straightened in the 1960's, moving the channel about 50 feet while removing two slight bends. The position of the lower portion of segment is largely unchanged.

Fish Passage Barrier (Id # 8): The structure is identified in the UDWC Diversion-Barrier Inventory (UDWC Personal Communication, 2008). The inventory indicates that it is not listed as a fish passage barrier by OWRD, and has not been evaluated by ODFW. At observed base flows, the dam height exceeds the general criteria of six inch jump height and is therefore likely a barrier to juvenile salmonid fish.

Segment	**1H**
Length	**1,190 feet**
Gradient	**0.82%**
Morphology	**Weak pool/riffle, mostly transport**
Human Influence	**Channel encroachment and riprap throughout**
Photos	**Numbered 51 - 57**

Although this reach displays primarily transport characteristics, sufficient deposition has occurred to form a number of lateral bars because of the weak pool/riffle system. A slight meander pattern is present, allowing a slightly more diverse form than upstream segments. Few roughness elements are present to interact with available mobile sediment and promote habitat complexity. The channel narrows and the banks steepen towards the downstream end of the segment. Most of the left bank is riprapped, but the homes are set further back from the creek than segments immediately upstream. The substrate contains a high percentage of fines associated with the upstream Leithauser dam.

Overall, the location of the channel has remained unchanged over the last 60 years, with encroachment along the north bank narrowing the channel through the 1960's. Additionally, a slight straightening of the sharp corner below the Locust Avenue Bridge occurred during that time period.

Segment	**1l**
Length	**1,120 feet**
Gradient	**0.74%**
Morphology	**Plane bed, transport**
Human Influence	**Bank armoring throughout**
Photos	**Numbered 58 - 62**

This segment is located through the Sisters City Park and extends immediately downstream of the Highway 20 bridge. It is an incised, straight transport reach disconnected from any floodplain. The channel bed is roughly eight feet below the adjacent terraces. Few obstructions to flow are present in this low diversity segment. Fines from the upstream segments are present along the channel margin, but the main channel is cobble and gravel. The channel appears similar in photos from the 1950's, but it is likely that the stream has downcut some over time

The narrowed channel through this reach provides some increased depth at base flows and the canopy provides shade and cover. As with the upstream reaches, pool forming features are lacking.

Reach 2

Segment	**2A**
Length	**2,950 feet**
Gradient	**0.80%**
Morphology	**Weak pool/riffle**
Human Influence	**Entire segment straightened, extensive riprap**
Photos	**Numbered 01 - 43**[5]

This dynamic reach acts primarily as a deposition reach, with a series of three pinch points (associated with the Timber Creek Bridge and two hardened fills in the channel/floodplain. Ice dams have formed at the location of at least one of these constrictions (approximately 500 feet downstream of the Timber Creek Bridge), where the channel is narrowed by hardened fill material to a width of about 50 feet. The constrictions appear to cause significant backwatering and deposition at extreme high flows (particularly when associated with the

[5] http://whychus.com/working/photo/reach2/index.htm

formation of ice jams), building extensive bars within the segment. Subsequent moderate high flows, at which the constrictions do not cause backwatering, appear to cause gradual incision and meander development through the previously deposited bars.

Between the pinch points, multiple bars occupy positions between one and four feet above the channel. The bars increase in size towards the downstream end of the segment as gradient lessens. Although there is minor gravel sorting associated with lateral thalweg movement, the lack of roughness elements has prevented the development of deep pools or a diverse instream habitat.

Extensive riprap delineates the stream corridor and floodway. Within the bank full channel width of approximately 170 ft, the channel is slowly creating a weak pool/riffle sequence with slight meanders developing through relatively recently deposited bars. Channel and riparian characteristics upstream of the Timber Creek Bridge are consistent with channel recovery in a depositional reach in the aftermath of a large flood.

In the 1940's and 1950's, the channel was contained roughly within the floodway boundaries of today. The channel in the lower half of the segment was located in approximately the same location as today. The upper half of the segment occupied the entire floodway with three meander bends. After the 1964 flood, the entire segment was straightened with a bulldozer leaving a constructed 75 foot wide channel with continuous berms. Since this straightening, channel lateral movement has increased with the establishment of weak meanders. The berms have been largely buried, transported downstream, or pushed to the edge of the floodway where abundant riprap and some log protection measures have been utilized. The inconsistent and varying bank hardening measures have added to the dynamic nature of the segment.

The quantity of pool habitat is currently limited by the weak meander pattern and lack of LWD or other pool forming features within the channel. Extensive riprap and installation of wood bank protection logs prevents pool development and cover along these banks. Some pool development is occurring where riparian vegetation is taking hold along stream banks. Substrate is comprised of cobble and gravel with few boulders except those associated with bank stabilization structures. The wider channel width and growth of vegetation in this reach provides opportunities for improving instream habitat.

Segment	**2B**
Length	**1,980 feet**
Gradient	**0.62%**
Morphology	**Plane bed**
Human Influence	**Entire channel relocated and straightened**
Photos	**Numbered 45 – 58**

This plane bed simplified segment acts as a deposition area with a high width to depth ratio. The segment has a lower gradient than upstream segments which encourages sediment deposition. Channel width varies from about 100 feet to 150 feet at the downstream end of the segment. The channel is bordered by terraces five to eight feet in elevation above the channel. Similar to Segment 2A upstream, the channel is trying to form meanders as it sorts gravel and cobble bars, however, the lower gradient and energy compared to upstream, and confining berms, has hindered the development of channel complexity features.

This entire segment was relocated sometime between 1951 and 1959. The previous channel flowed in a northeasterly direction through a series of two to three poorly developed meanders, joining Indian Ford Creek approximately 1,000 feet north of the current confluence. Early photos show an area of deposition and large active sediment bars within a channel possessing a high width/depth ratio. Following relocation, the position and form of the channel have changed little, other than from the reworking of existing cobble and gravel bars.

Aquatic habitat is limited by the wide channel, shallow water depth, and straight channel. The steep erosive banks on the north side are not allowing development of undercutting or overhanging banks that provide cover. Pools are minimal and other cover elements are missing so rearing habitat is poor. Shade from canopy is minimal due to the wide channel and limited riparian vegetation growing on the wide gravel bars.

Reach 3

Segment	**3A**
Length	**750 feet**
Gradient	**0.89%**
Morphology	**Pool/riffle**
Human Influence	**Moderate channel straightening**
Photos	**Numbered 01 - 05**[6]

This segment is strongly influenced by the andesite bedrock of McKinney Butte that defines the left channel bank. The channel presents one of the most well developed pool/riffle systems in the project area, largely due to energy concentration afforded by the bedrock and tree/root ball complexes. The channel is moderately sinuous and possesses stable cobble bars and multiple terraces as well as deep pools and sorted gravel lenses. A small (three foot wide) high flow channel is present against the right bank terrace. The channel was straightened in the 1960's, decreasing the amplitude of two meander bends.

Aquatic habitat is improved in this reach with the increase in pools associated with the moderate meander pattern, bedrock, and tree roots. These features provide gravel sorting

[6] http://whychus.com/working/photo/reach3/index.htm

resulting in some limited pockets of easily moved gravel. Cover is associated with the increased frequency of wood in the channel and limited undercut banks.

Segment	**3B**
Length	**4,610 feet**
Gradient	**0.72%**
Morphology	**Plane bed, weak pool riffle**
Human Influence	**Lower two-thirds of segment channel relocated and straightened**
Photos	**Numbered 06 – 37**

This segment differs from upstream reaches in a number of ways, primarily due to the constraint on the left bank imposed by the andesite bedrock and hill slopes of McKinney Butte. Instead of flowing down the fan over glacial outwash, this segment moves perpendicular to the fan in an alluvial valley. This has given the stream structure and a more diverse instream habitat than elsewhere.

Currently, the segment is a channelized stable transport zone exhibiting plane bed morphology with few cobble/gravel bars. The channelized stream has downcut to bedrock in many places, with infrequent scour pools associated with this bedform. Extensive diking on the right side of the creek severely limits the accessible or potential floodplain.

Despite its current stability, this segment has undergone the most radical straightening and channelization of any within the project reach. Prior to straightening, the channel was a meandering low gradient stream within a 400 to 600 foot floodway between McKinney Butte on the left bank and Highway 126 on the right bank. The channel was moved north against the hillslope of the McKinney Butte sometime in the late 1950's, or in the 1960's. The former channel is now a diverse wetland fed by overbank streamflow and shallow groundwater moving north.

The stabilized narrow channel at the upper end of this segment provides some rearing habitat not encountered in upstream reaches. The decreased channel width has led to increased water depth in this reach at low flows. Bedrock and boulders form pools within the channel and the tree canopy provides dense shade to the stream. In the lower portion of the reach the canopy opens up with ponderosa pine and riparian vegetation stabilizing the stream banks. Rearing habitat is improved with some undercut banks forming, and root wads interacting with the stream at low flows.

Segment	**3C**
Length	**2,660 feet**
Gradient	**0.89%**
Morphology	**Plane bed**
Human Influence	**Straightening likely, significant riprap**

Photos **Numbered 38 – 62**

Segment 3C lies at the downstream end of the project area and is characterized by a stable bed capable of transporting all substrate sizes. It is slightly steeper than the segment upstream. A few gravel bars are present in the lower end of the segment. Although the segment is similar to Segment 3B, the stream is no longer confined on the left bank by McKinney Butte. Instead, terraces six to ten feet in height confine the channel and limited (20 to 40 foot wide) floodway. Significant amounts of riprap are present, especially on the left bank. Channel location and form appear unchanged over the last 60 years. It is possible that straightening occurred prior to this.

There is limited bank undercutting occurring on vegetated stream banks with the combination developing habitat cover. Stream banks that are riprapped or vertically eroding are not developing pools or cover habitat. There is some limited development of scour pools but pool habitat complexity is low. The extensive riprap prevents bank habitat development. Channel excavation to maintain an irrigation pump withdrawal point has altered that section of the creek.

Diversion (Id # 9): The diversion is identified in the UDWC Diversion-Barrier Inventory (UDWC Personal Communication, 2008). The intake is at the end of an excavated side channel with no associated structure, and therefore not a fish passage barrier.

1.4 Channel Migration Zone Mapping

The 2003 Washington Department of Ecology document describing a framework for establishing channel migration zones was used as a general guide to determine the boundaries of the Whychus Creek CMZ (Rapp, C.F. and T.B. Abbe, 2003). This methodology advocates that the CMZ consists of the historic CMZ plus the Avulsion Hazard Zone (surfaces which could be occupied by the channel) and the Erosion Hazard Area (areas subject to channel and hillslope erosion). The areas within these zones that have been modified to prevent channel encroachment are removed to produce the final CMZ, and the removal of these modifications could change the CMZ. Given the developed nature of much of the project area, channel modifications play a critical role in determining CMZ boundaries. For display purposes, these modifications as well as natural confining features are mapped together as the convex features shown in Figure 6.

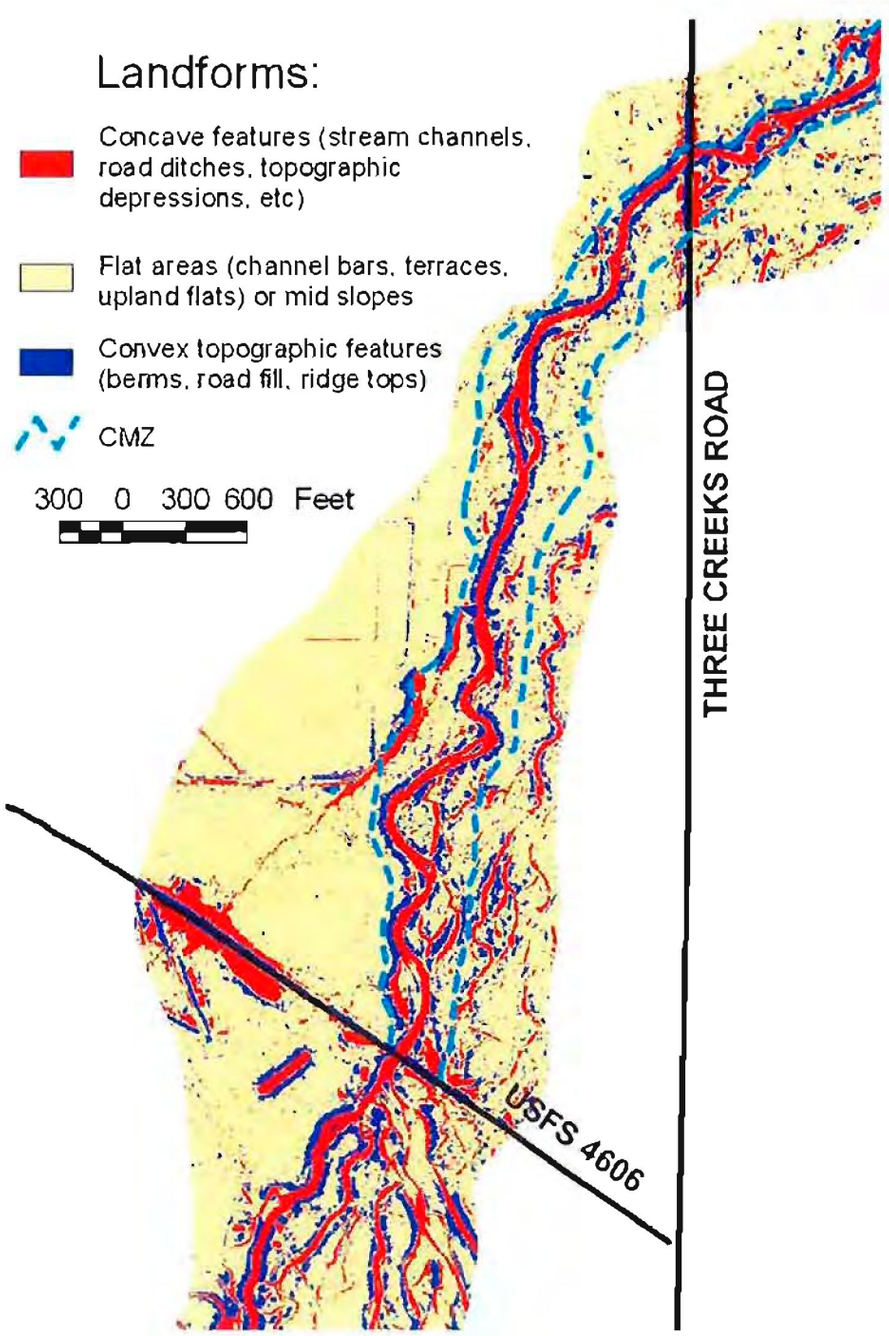


Figure 6. Example of landforms and channel migration zone delineation at upstream end of project area. Refer to Landform Map for additional information for entire project area.

Section 3.2 of this report contains information by segment concerning channel modifications and restoration.

Sources of information used to characterize the CMZ included aerial photos from 1943, 1951, 1959, 1962, 1966, 1974, 1984, 1987, 1995, 2000, and 2005; geology and soil maps; FEMA mapping; LiDAR mapping; as well as field verification.

The Washington methodology recognizes the unique challenges of delineating alluvial fan CMZs. Almost by definition, the entire alluvial fan is considered part of the CMZ. In the case of Whychus Creek, this CMZ would cover all of the fan area south and east of town. While delineating the entire alluvial fan as part of the CMZ may be correct in the strict geomorphic sense, this declaration does nothing to guide stream restoration and infrastructure protection efforts. Therefore, a more refined mapping is needed.

The largest area in question is south of town along Three Creeks Road (east and south of Reach 1; Figure 6). Many discontinuous small channel signatures are present across the alluvial fan. Some of these are still active and hold water during flood flows. Many of these high flow channels were likely carved by the higher energy flows available prior to irrigation diversions. While these discontinuous channels currently accept flood water, the active stream channel is likely stable enough and lacks the energy to shift the thalweg to one of these remnant high flow features, unless there is a change in the hydrologic or sediment regime. Therefore, this portion of the alluvial fan was excluded from the CMZ delineated for the purposes of this study.

Other areas, which required extra scrutiny, include segments whose channel margins and floodplains are not defined by modifications. Normally, valley walls and abandoned terraces would help define the CMZ. In a number of areas within the project areas, these features are absent or poorly defined, complicating delineation of the CMZ.

In order to overcome these difficulties, a number of resources were consulted. Signature vegetation and subtle topographic breaks were used to help define the CMZ. As the natural channel form of these channels includes a slight to moderate degree of meandering and splitting, an attempt was made to define the potential meander amplitude and thus the CMZ. This was estimated by using the relationship between channel width and meander geometry as well as measurements of meanders cutoff by channelization within the project area. In other areas, modifications such as berms, roads, and structures often define the CMZ. In these instances and in locations with resistant bank material, it is possible for the floodplain to be mapped outside of the CMZ. Flooding in these areas may occur, but the presence of stable and hardened banks would likely prevent movement of the channel.

Overall, the CMZ delineated for this project[7] is meant to serve as a guide for probable channel position in reference to stream protection and restoration efforts. The delineation was done at a segment and project scale and is meant for general planning purposes. It is not presented as a lot by lot land use mechanism to dictate property use. Unlike the FEMA floodplain demarcation, the CMZ designation is largely a qualitative exercise which is not supported by hydraulic analyses. As such, the CMZ could be open to further study and refinement.

As stated earlier, a wider CMZ could be established that would include developed areas currently protected from channel encroachment. Given the long history of modifications within the basin, the extent of this wider CMZ is not considered appropriate unless complete relocation of the stream through the project area is deemed feasible. However, it may be worthwhile to identify those dikes that are not protecting any existing infrastructure, and evaluate the feasibility of removing these features.

1.5 Hydrologic Framework and Design Flow Analysis

This section summarizes the hydrologic regime, water withdrawals, and preliminary design flows for the project area. The purpose of this section is to summarize natural and human-influenced hydrologic processes affecting the project reach. This information is necessary to understand possible flow-related restoration and management actions that are presented in Section 4, and to provide design discharge values necessary for the development of instream restoration actions.

1.5.1 Hydrologic Regime

Whychus Creek drains an area of approximately 250 square miles on the eastern slopes of the Cascade Mountains. Elevations range from over 10,000 feet in the vicinity of the Three Sisters peaks, to approximately 2,100 feet at the confluence with the Deschutes River (Figure 7). Mean watershed elevation is approximately 4,300 feet overall[8]. Precipitation has a strong correlation with elevation and longitude, and ranges from approximately 14 inches per year in the vicinity of the confluence with the Deschutes River, to over 100 inches in headwater areas[9] (Figure 7). Vegetation patterns correlate well with precipitation and elevation. Areas downstream and east of the project reach within the Deschutes River Valley Level IV Ecoregion consist primarily of juniper rangelands (Figure 7). The majority of the watershed falls within the Ponderosa pine/bitterbrush woodland type, with the headwaters consisting of montane, subalpine, and alpine forest.

[7] Refer to the project area base maps for CMZ location
[8] As calculated from 1/3 arc-second digital elevation model (DEM) data: http://seamless.usgs.gov
[9] Precipitation data from http://prism.oregonstate.edu/

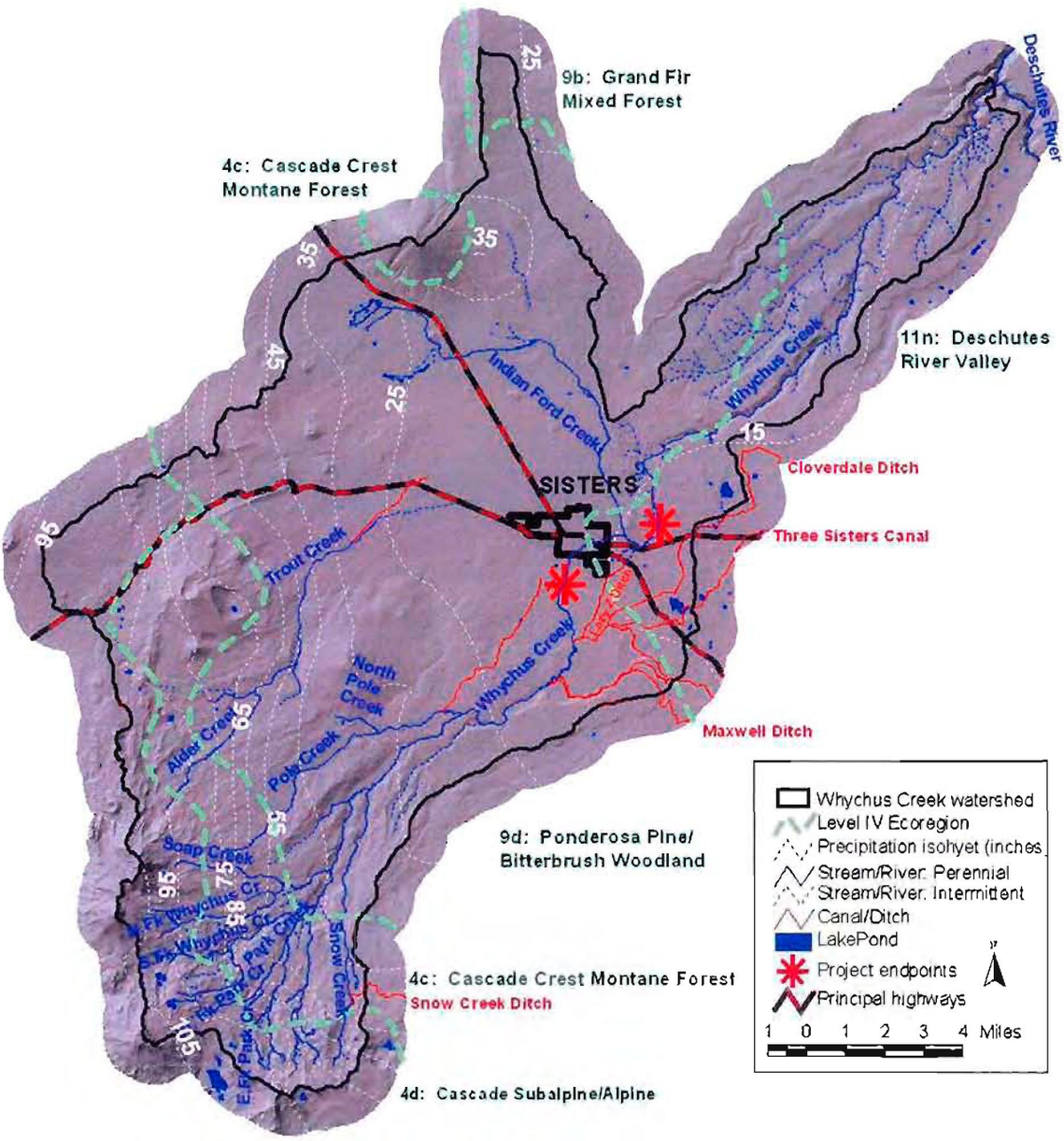


Figure 7. Overview map of Whychus Creek watershed.

Three active stream gages are located within or upstream of the project area (Figure 1). The period of record for each gage is given in Table 2. Information from these gages was used in the following characterization of stream flow conditions.

Table 2. Stream gages within the vicinity of the project area, and period of record.

Gage Number / Name	Period of Record
14075000: Whychus Cr near Sisters	07/1906 ~ 09/2006
14076000: TSID Canal near Sisters	04/1924 ~ 09/2006
14076050: Whychus Cr at Sisters	05/2000 ~ 09/2006

Upstream of the significant water diversions, Whychus Creek exhibits a hydrographic regime typical of eastside Cascade streams; experiencing the highest mean daily flows during the spring and early summer snowmelt season (Gage #14075000; Figure 8). Annual peak flows upstream of the Three Sisters Irrigation District (TSID) diversion are approximately split between wintertime rain-on-snow events (which include the events of greatest magnitude) and spring-snowmelt peak flows (Figure 9). There appears to be at least two annual events that were driven by summertime convective storms; these represent approximately 2% of the total annual peak flow events.

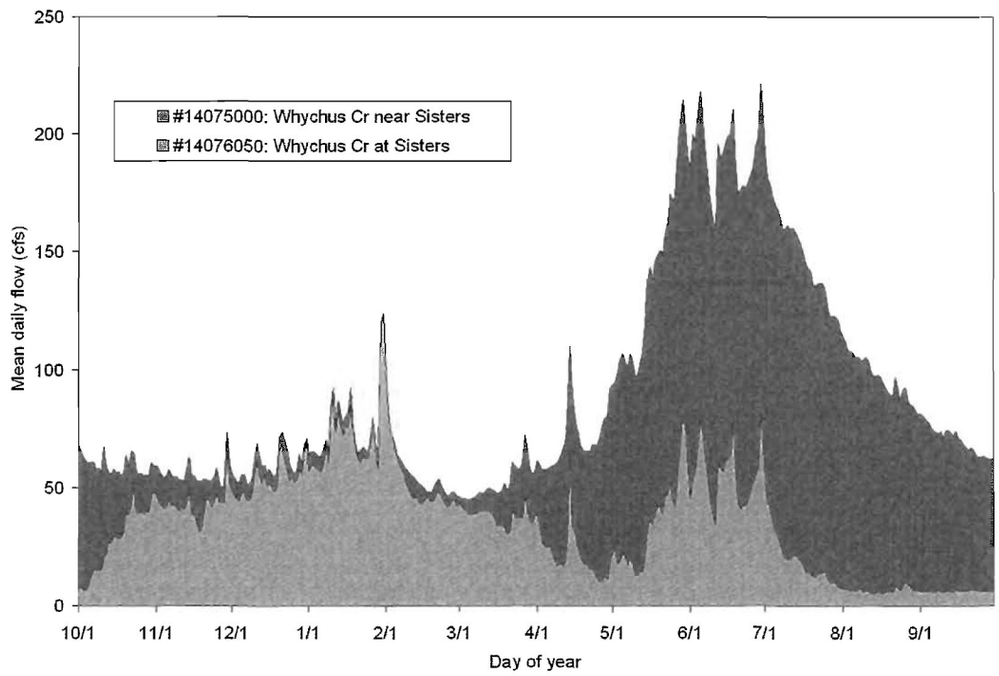


Figure 8. Mean daily flow comparison for the period 5/2000 - 9/2006 upstream of the TSID diversion (gage #14075000) and within the project reach (gage #14076050).

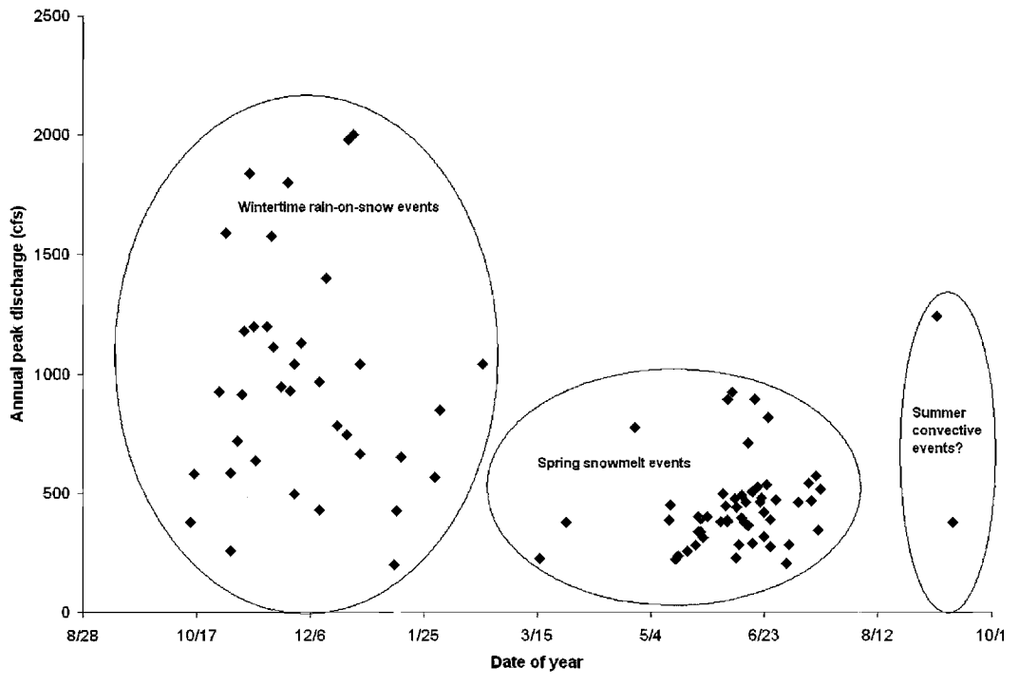


Figure 9. Distribution of annual peak flows at gage 14075000

The flood history for Whychus Creek is illustrated on Figure 10. This figure shows annual peak flows at gage #14075000, located upstream of the TSID diversion, as well as calculated peak flow values in Whychus Creek downstream of the diversion. Calculated flow values were assembled by the USFS, and provided by the UDWC for this analysis (Senkier, pers. comm., 2008). The TSID diversion appears to have little effect on the large magnitude flows (i.e., flows with a recurrence interval of greater than five years), but has a significant effect on smaller magnitude higher frequency events, reducing peak values by approximately 20 to 60%. Part of the reason for the small effect on the largest events may be attributable to seasonality, with the relatively larger rain-on-snow events occurring outside of the irrigation season (Figure 9).

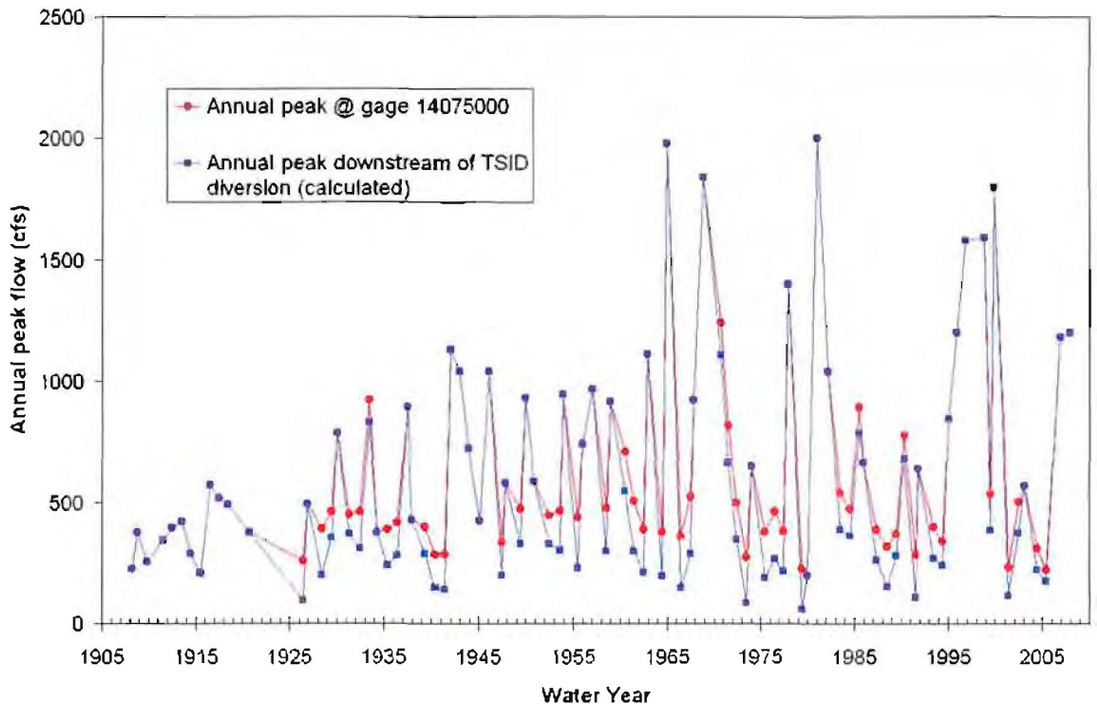


Figure 10. Annual peak flow series

Of further note in Figure 10 is that the ten largest events have occurred from water year 1965 to present. It is unknown whether this pattern is due to more severe weather conditions over approximately the past 45 years, due to changes in conditions within the contributing area, or simply due to a change in the way the data were collected prior to 1965.

1.5.2 Water Withdrawals

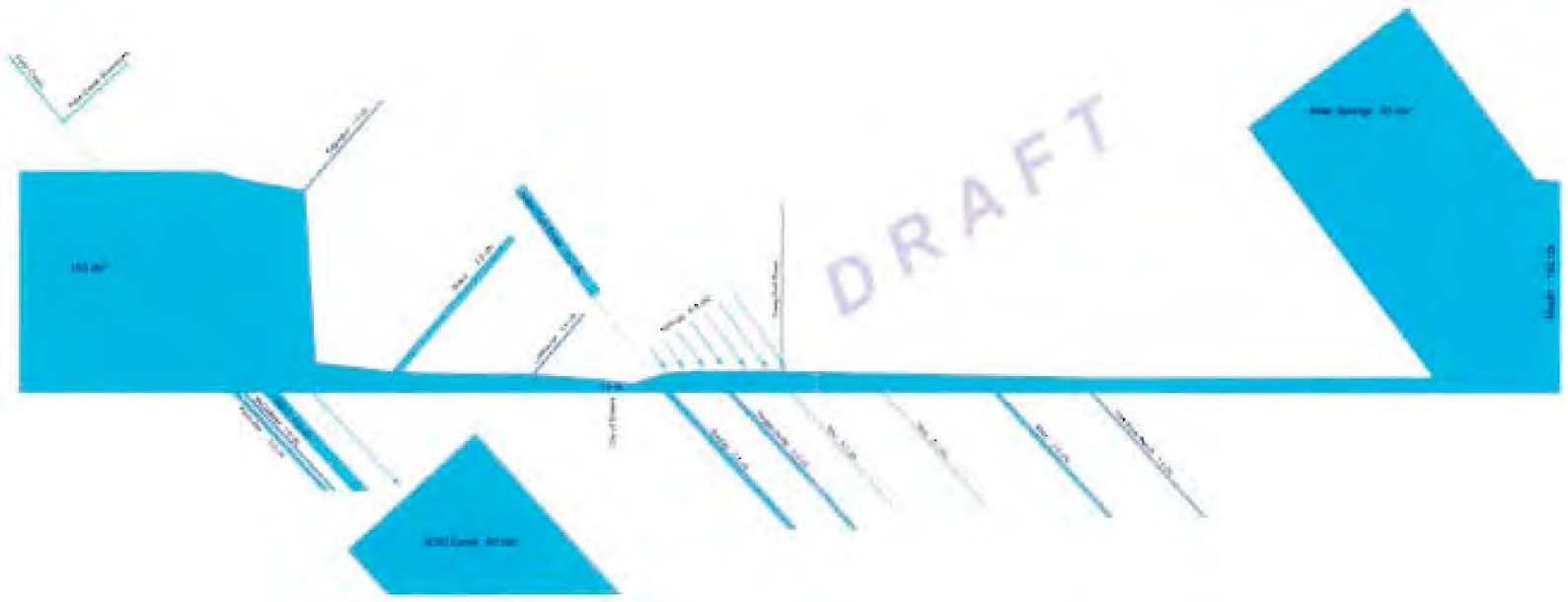
The Oregon Water Resources Department (OWRD) identifies 303 water rights within the Whychus Creek watershed[10]. These water rights encompass 362 individual points of diversion. Of these, approximately 50% are from a surface water source, 40% are from groundwater, and 10% are for water storage. If fully utilized, these water rights total approximately 390 cfs of instantaneous flow[11] with and additional 1,850 acre-feet of storage. Of the total instantaneous flow, approximately 70% is for irrigation purposes. In the last several years, significant efforts have been made to increase the summer base flows in Whychus Creek. There is approximately 8 to 9 cfs of permanently protected instream water rights during the summer months, with average annual instream leasing totaling 6 cfs.

TSID manages the principal diversions upstream of the project area (Figure 1, Figure 7, Figure 11). Water rights associated with these diversions allow for the diversion of up to 90 % of the natural flow within Whychus Creek, although typically there is from 2 to 10 cfs of flow

[10] http://www.wrd.state.or.us/OWRD/WR/wris.shtml
[11] On August 1st

remaining during summer months (Figure 8). Recent changes in management practices have resulted in steady increases in summertime base flow (Figure 12).

Figure 11. Schematic of typical August flows for Whychus Creek[12]. Horizontal axis is scaled to represent distance along Whychus Creek. Vertical axis is scaled to represent magnitude of flow addition or subtraction. Values marked with an asterisk indicates measured flows; all others are estimated.



[12] Created August 11, 2004 by Jonathan LaMarche and Jason Eklund, OWRD.

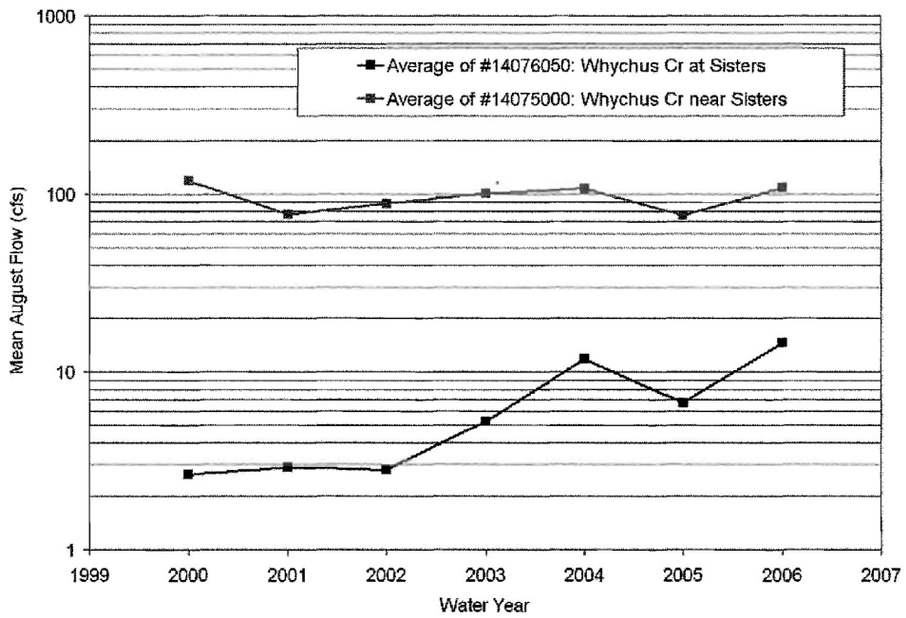


Figure 12. Mean August flows upstream of, and within, the project reach.

The OWRD maps six points of diversion for water rights from Whychus Creek within the project reach (Figure 13). None of these individually are greater than 1 cfs, and collectively account for less than 2 cfs. Several of these diversions are either no longer used, or were not observed in the filed (Table 3). In addition, we observed four additional diversions that do not appear to correspond to mapped diversion points (Figure 13, Table 3). The majority of these are operated using small pumps within the stream, the exception being the diversion downstream of Elm Street (the Leithauser diversion), which consists of an approximately 10 foot high dam that diverts flow into a small canal that runs through town.

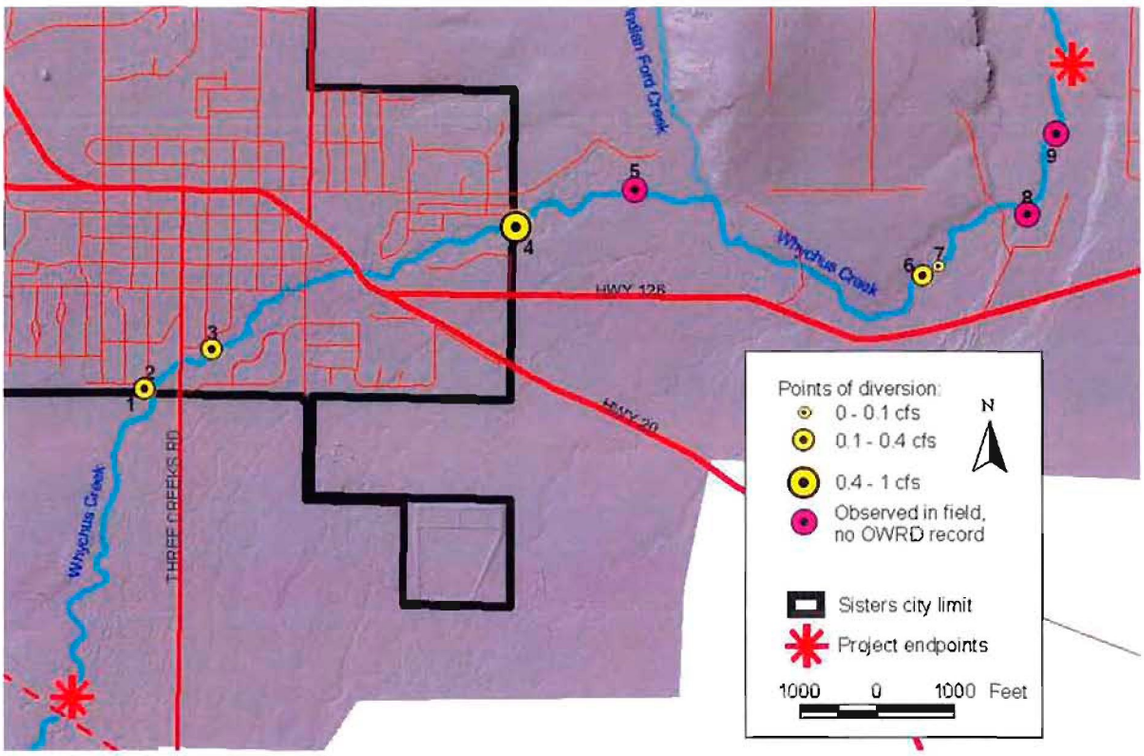


Figure 13. Points of diversion along Whychus Creek within the project reach.

Table 3. Points of diversion along Whychus Creek.

Map #	Cert. #	Name[13]	use	Priority date	Rate (cfs)	Notes
1	50477	S S Johnson Co.	Irrigation	12/31/1885	0.002	No longer used. According to the DRC, the water rights associated with this diversion have been quit claimed.
2	75841	Hitchcock, Ethel	Irrigation	12/31/1885	0.11	No longer used. According to the DRC, the water rights associated with this diversion have been quit claimed.
3	75879	Mccaffery, Rachael	Irrigation & Domestic	12/31/1885	0.284	Observed in field. This is the "Leithauser" diversion
4	1878	Mckinney, J O	Irrigation	05/13/1913	0.93	Not observed in field
5	-	-	-	-	-	Observed in field
6	1175	Bowman, Joseph D	Irrigation	01/08/1914	0.38	Not observed in field
7	47588	Trowbridge, Ira Jack	Irrigation	06/20/1975	0.05	Observed in field
8	-	-	-	-	-	Observed in field
9	-	-	-	-	-	Observed in field

[13] Names given here are original water right holder; current owner is usually different

1.5.3 *Groundwater / Surface Water Interactions*

The United States Geologic Survey (USGS) has identified the project reach as a "losing reach" which is defined as a section of stream where surface flow is lost to groundwater (Gannett and Lite, 2004). The USGS regional groundwater flow model estimates that approximately 4 cfs are lost to groundwater within the project reach under steady state conditions. Field surveys (i.e., "seepage runs") conducted by OWRD between the Sisters stream gage and Camp Polk Road confirm these model results (LaMarche, pers. comm., 2008). Groundwater withdrawals within the vicinity of the project reach likely exacerbate losses to groundwater.

1.5.4 *Preliminary Design Flows*

Preliminary design flows were estimated for both Whychus Creek at gage #1407500 (i.e., above the TSID diversion), and using the calculated values for Whychus Creek downstream of the gage (Table 4). Values were calculated using USGS standard methodologies (Flynn et al., 2006). As discussed above, only those events with a recurrence interval of less than five years are different above and below the diversion (Figure 14).

Table 4. Preliminary design flows.

Station - 14075000 Whychus Creek near Sisters						
Annual exceedance probability	RI (years)	Bulletin 17B Estimate (cfs)	Systematic record (cfs)	"Expected probability" estimate (cfs)	Lower 95% conf. Limit for Bull. 17B est (cfs)	Upper 95% conf. Limit for Bull. 17B est (cfs)
0.995	1.005	162.9	170.9	158.6	133.4	191.7
0.99	1.0101	179.7	186.6	175.7	148.8	209.5
0.95	1.0526	239.2	243.2	236.4	204.6	272.5
0.9	1.1111	282	284.1	279.8	245.4	317.4
0.8	1.25	348.2	347.9	346.8	308.7	387.1
0.6667	1.4999	429	426.4	428.2	385.8	473.1
0.5	2	540.5	536	540.5	490.5	595
0.4292	2.3299	597.1	592	597.5	542.5	658.4
0.2	5	881.5	877.9	886.1	793.7	992.6
0.1	10	1162	1166	1174	1029	1341
0.04	25	1584	1608	1616	1369	1891
0.02	50	1952	2002	2010	1657	2389
0.01	100	2369	2456	2467	1975	2970
0.005	200	2844	2981	2997	2330	3647
0.002	500	3570	3799	3833	2860	4716

Station - 14075000 Whychus Creek near Sisters downstream of TSID diversion						
Annual exceedance probability	RI (years)	Bulletin 17B Estimate (cfs)	Systematic record (cfs)	"Expected probability" estimate (cfs)	Lower 95% conf. Limit for Bull. 17B est (cfs)	Upper 95% conf. Limit for Bull. 17B est (cfs)
0.995	1.005	55.6	54.6	52.4	40.3	72.1
0.99	1.0101	68.4	67.5	65.3	50.8	87
0.95	1.0526	119.7	119.1	117.2	95	145.1
0.9	1.1111	160.7	160.4	158.6	131.5	190.5
0.8	1.25	228.9	229.1	227.3	193.3	265.6
0.6667	1.4999	317.3	318.1	316.4	273.9	363.9
0.5	2	445.3	446.8	445.3	388.7	510.3
0.4292	2.3299	511.9	513.5	512.4	447.3	588.6
0.2	5	854.9	855.6	860.4	736.5	1012
0.1	10	1196	1193	1211	1010	1460
0.04	25	1703	1692	1742	1400	2158
0.02	50	2136	2113	2204	1723	2778
0.01	100	2614	2577	2723	2071	3483
0.005	200	3141	3085	3308	2447	4281
0.002	500	3918	3828	4192	2989	5491

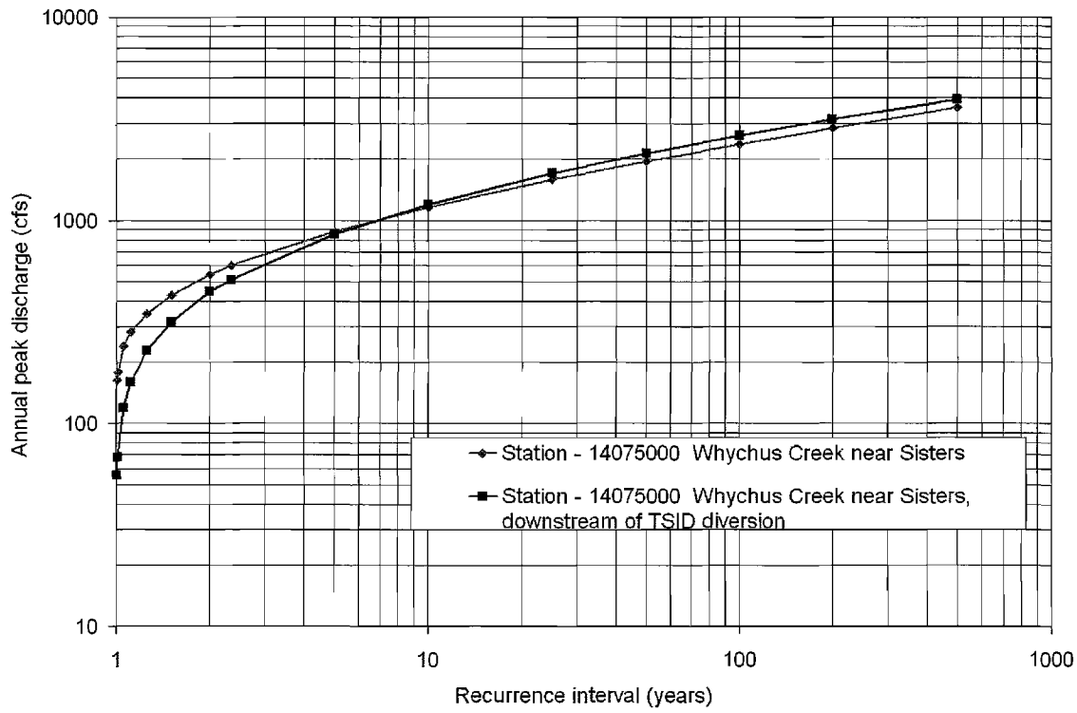


Figure 14. Design flows (Bulletin 17B estimates) above and below the TSID diversion on Whychus Creek.

1.6 Aquatic Habitat Conditions

This section addresses the initial evaluation of aquatic habitat conditions in the project area based on existing information and field review in September 2008. This information is necessary to understand possible aquatic habitat-related restoration and management actions that will be developed in subsequent sections of this report, and to provide habitat values necessary for the development of instream restoration actions. More detailed information on habitat conditions will be integrated into the restoration plan from the Aquatic Habitat Inventory completed in this reach by the Oregon Department of Fish and Wildlife (ODFW) in the 2008 field season. For developing the restoration plan we are interested in characterizing the existing habitat condition in comparison to the desired future condition, which will be used as Fisheries Design Guidelines.

1.6.1 Background

Restoration of habitat in the Sisters reach of Whychus Creek is one part of a much larger effort to restore habitat in Whychus Creek related to reintroduction of anadromous fish in the Deschutes River basin above the Pelton Round Butte Hydroelectric Project (PRB) and restoration of resident species. The reintroduction effort in the Deschutes River addresses spring Chinook salmon (*Oncorhynchus*

tshawytscha), summer steelhead (*Oncorhynchus mykiss*), and sockeye salmon (*Oncorhynchus nerka)*, with emphasis on steelhead and Chinook salmon in Whychus Creek. Whychus Creek is considered to have a high potential for supporting self-sustaining populations of steelhead and was therefore targeted for releases of steelhead fry in May 2007 and May 2008 (Hodgson, 2008). Over 250,000 hatchery reared fry were released into Whychus Creek at eight locations downstream of Sisters, Oregon (as well as reaches in McKay Creek, Ochoco Creek, and the Crooked River). The 2008 release in Whychus Creek and the Crooked River basin is intended to produce enough naturally produced smolts to test fish passage effectiveness downstream through Lake Billy Chinook and into the Selective Water Withdrawal facility at the PRB project. The draft Reintroduction Plan (CTWSRO-BNR and ODFW, 2007) anticipates annual releases of fry during Phase 2 to supplement natural fish production associated with the returns of adult fish.

The Upper Deschutes Watershed Council (UDWC), Deschutes River Conservancy (DRC), and the Deschutes Land Trust (DLT) coordinate the Upper Deschutes Habitat Restoration Plan (Nye, 2008). As part of this plan, the UDWC is working on stream restoration projects in the Sisters reach (addressed in part by this project), the DLT's Camp Polk Meadows Preserve area, the Rimrock Ranch reach, and fish passage projects throughout Whychus Creek. The DRC manages an instream leasing program that has increased base flows in Whychus Creek, and the DLT has acquired properties along Whychus Creek for conservation and restoration.

1.6.2 Fisheries Management Objectives

Historically, anadromous and resident fish populations had free access to the lower Deschutes River and Whychus Creek. The Deschutes River upstream to Big Falls and Whychus Creek traditionally supported runs of summer steelhead and spring Chinook salmon. Whychus Creek was a major producer of summer steelhead. In the 1950's, the number of steelhead counted in Whychus Creek ranged from 62 to a high of 619 in 1953; counts dwindled to zero in the late 1960's. Spring Chinook salmon spawning ground counts were conducted in Whychus Creek through 1960. Records of spawning salmon and redds in Squaw (Whychus) Creek from 1951 to 1960 showed a high count of 30 in 1951 and 0 by 1960 (ODFW, 2003).

The PRB Dam on the mainstem Deschutes River creates the primary barrier to anadromous fish attempting to reach spawning and rearing areas in the upper basin. Completed in 1964, the project was constructed with passage facilities, however, unsuccessful collection of downstream migrants resulted in abandonment of passage attempts, and hatchery operations were implemented to mitigate lost salmon and steelhead production in upstream areas. The FERC License issued in 2005 for the PRB project requires construction of a selective water withdrawal and downstream fish passage facility at Round Butte Dam, and upstream passage accomplished by trap-and-haul of adult fish. In addition to the fish barrier downstream at the PRB project, habitat in Whychus Creek has been highly modified by reduced stream flows, passage barriers,

unscreened diversions, riprapping and other channel alterations. In addition, Whychus Creek was heavily modified following the 1964 flood when 11 miles of the creek were channelized by the U.S. Army Corps of Engineers (Corps).

Fisheries management objectives are described in the ODFW Anadromous Fish and Bull Trout Management Plan for the Upper Deschutes River Subbasin (ODFW, 2003). The objectives are to manage for native summer steelhead, native spring Chinook, naturally produced bull trout (Salvelinus confluentus), and naturally produced sustainable populations of Pacific lamprey (Lampetra tridentata) consistent with the Native Fish Conservation Policy (OAR 635007-0503). Bull trout are present in lower Whychus Creek, and are known to forage upstream into the Whychus study area (Riehle, pers. comm., 2008). Conservation goals for bull trout address populations in Warm Springs River, Shitike Creek, and the Metolius River subbasin. Sockeye salmon will be managed for hatchery and naturally produced sockeye in the Metolius River and tributaries, but not in Whychus Creek.

In summary, general fishery objectives for the Whychus Creek Restoration Project should focus on all life stages for summer steelhead, native redband trout, and spring Chinook salmon. Focusing on these species will also adequately address the habitat needs of foraging bull trout that may range into the project area.

1.6.3 Habitat Quality

Fisheries habitat surveys have been completed by the U.S. Forest Service (USFS) and ODFW in Whychus Creek and used by ODFW, USFS, and Portland General Electric (PGE) to evaluate habitat suitability and salmonid production capability as summarized in the 2007 annual report and 2008 work plan for the PRB Native Fish Monitoring Plan (Spateholts, 2008). These habitat surveys and analyses provide a good characterization of the current habitat quality and habitat potential, and can be used to set general habitat targets for the restoration project.

HabRate (Figure 15) is a spreadsheet model developed for the Middle Deschutes River that rates the potential quality of stream habitat for the early life stage of salmon and steelhead (Burke et al., 2003). Survey data describing the existing condition of the habitat is compared to habitat requirements to identify limiting factors. The habitat requirements evaluation focuses on early life history stages (spawning, egg survival, emergence, summer rearing, and winter rearing) to rate the quality of reaches as poor, fair, or good based on attributes relating to stream substrate, habitat unit type, cover, gradient, temperature, and flow that are derived from literature on desired habitat conditions. Spawning-to-emergence is modeled as one life stage because of the similar habitat requirements. The model provides a limiting factor assessment of early life stage survival by comparing existing habitat condition to salmonid habitat requirements. The model outputs therefore provide an evaluation of existing habitat conditions in comparison to desired habitat conditions, which can be used to describe qualitative habitat objectives for the restoration project.

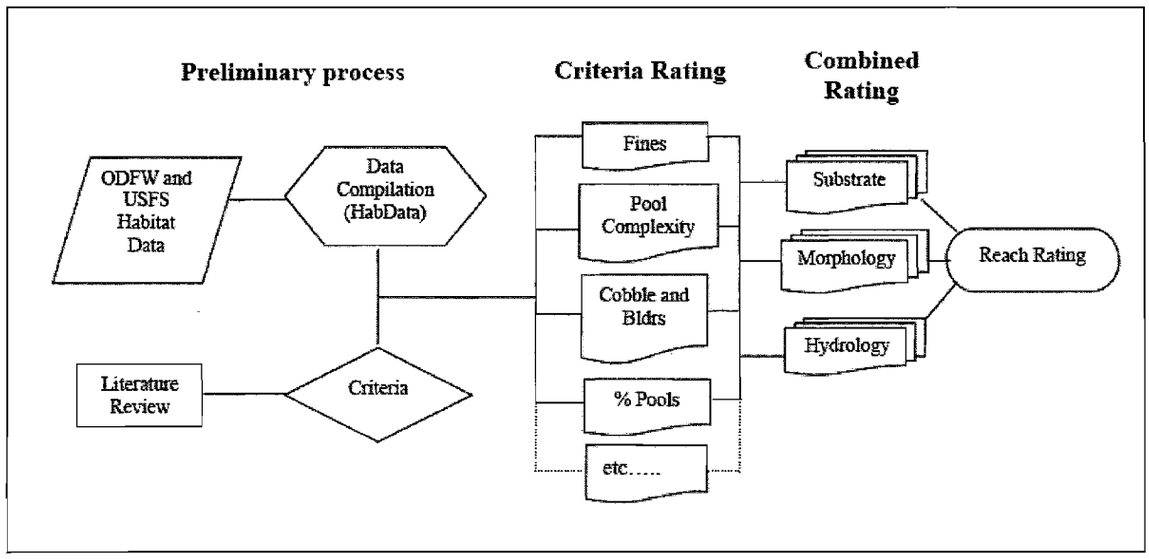


Figure 15. Flowchart depicting reach habitat rating used in the HabRate model (from Burke et al., 2003)

The HabRate methodology was revised and used during the PRB relicensing process to assess potential production of salmon and steelhead in the Middle Deschutes River (Spateholts, 2008). Habitat survey data collected in 2007 in the basin were included in this update, but Whychus Creek was not part of the 2007 surveys. For the Sisters reach of Whychus Creek this evaluation is based on the ODFW habitat survey completed in 1997. The expectation is that habitat in this reach has changed (improved) in the last ten years because of increased base flows. During the 2008 field season ODFW Aquatic Habitat Inventory staff collected data in Whychus Creek. These data are expected to be available in approximately February 2009 (?), and will be used by the WPN team in a more detailed assessment to develop the Whychus Creek Restoration Plan.

Habitat condition rating is summarized in the Native Fish Monitoring 2007 Annual Report (Appendix D, Spateholts, 2008). The steelhead habitat rating is used for illustrating the comparison of existing habitat conditions (1999 base data) to early life stages. The expected use of the habitat by life stage is illustrated in Figure 16.

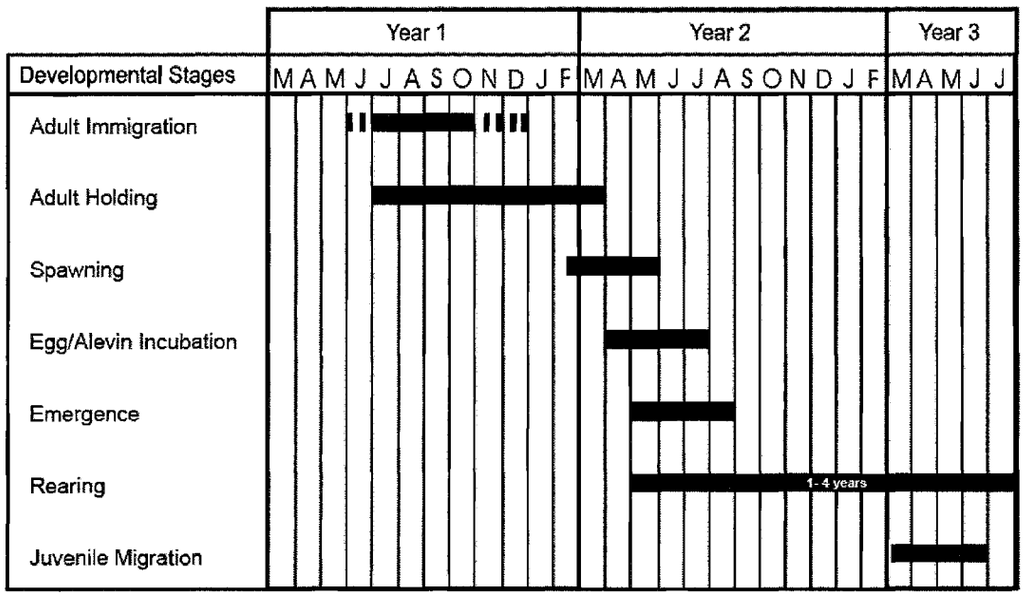


Figure 16. Seasonal occurrence of Deschutes River summer steelhead in freshwater by life history stage (from Cramer and Beamesderfer, 2002).

HabRate Reaches 9 to 12, numbered downstream to upstream, generally overlay geomorphic reaches used in the WPN field assessment as shown in

Table 5. The WPN geomorphic reaches are numbered 1 to 3, upstream to downstream, with sub-reaches designations based on channel characteristics and restoration opportunities[14]. Reach 1 extends from FS Road 4606 above the City of Sisters to immediately below the Highway 20 bridge in Sisters; Reach 2 extends downstream from the Highway 20 bridge to the confluence with Indian Ford Creek; and Reach 3 extends approximately 1.4 miles downstream to the end of the project study area. The reaches do not line up exactly, but the HabRate evaluation is applicable to the habitat conditions observed in the field.

Table 5. Habitat rating for steelhead, early life stages (from Spateholts, 2008).

WPN Geomorphic Reach	HabRate Reach	HabRate length (km)	Spawning to Emergence	Age 0 + Summer	Age 0+ Winter	Age 1+ Summer	Age 1+ Winter
Reach 1a through 2a	12	4	Fair	Poor	Good	Poor	Good
Reach 2b	11	1.2	Fair	Poor	Good	Poor	Good
Reach 3b	10	0.9	Poor	Poor	Fair	Poor	Fair
Reach 3c	9	0.8	Fair	Poor	Fair	Poor	Fair

[14] See base maps for reach and segment locations

These ratings reflect the general conditions observed in the field in September. Although individual reaches vary, habitat is rated poor in certain reaches throughout the project area due to limited structural diversity, lack of LWD, pools, undercut banks, and gravel sorting features. Reaches are rated fair to poor for spawning-to-emergence due to lack of pool tailouts and substrate that is cemented by fines. Summer rearing is rated poor due to lack of pool area, cover, flows, and temperature. Winter rearing is rated as good to fair due to the increase in flows that provide additional habitat space.

1.6.4 *Fish Populations*

Hill and Quesada (2008) sampled fish populations at four locations in Whychus Creek as part of the PRB license agreement. Species composition provides a qualitative assessment of the response of the fish community to habitat conditions (Figure 17). The percent of native redband trout is much lower in the Sisters UGB segment (Reach 4/WPN Reach 2a), compared to the three reaches downstream of the City of Sisters. The reduced number of redband trout is indicative of the poor habitat quality in this reach resulting from the channel modifications used to protect structures in this reach. Fish population sampling has been conducted in Whychus Creek annually from 2002 to 2007. These data will be useful for future comparison of pre- and post project implementation.

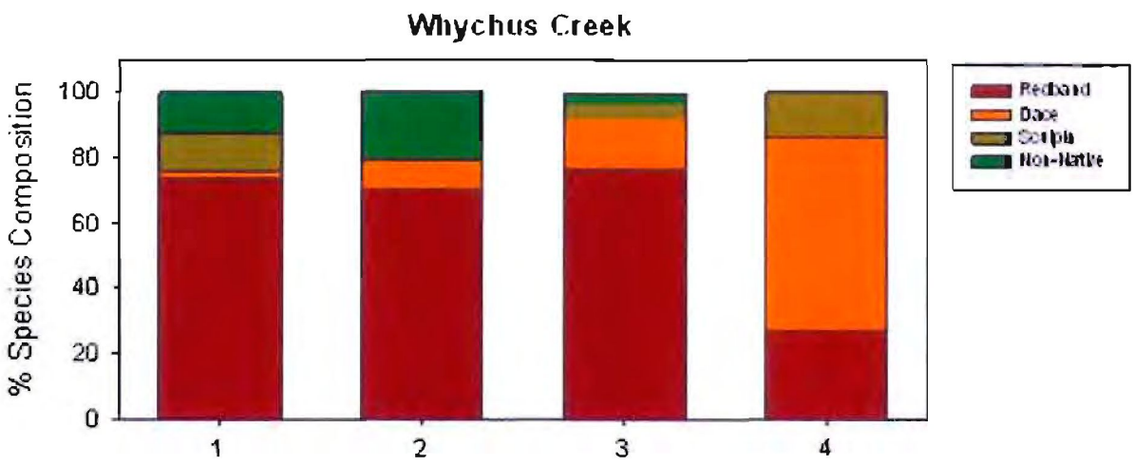


Figure 17. Species composition from first pass electrofishing in August, 2007 (Hill and Quesada, 2008). Reach 1 – Rkm 2.5, Alder Springs area; Reach 2 – Rkm 9; Reach 3 – Rkm 25.5, Camp Polk; Reach 4 – Rkm 34.5, downstream of Highway 20 in Sisters.

1.6.5 *Guidelines for Aquatic Habitat*

Habitat requirements used as the basis for the reach ratings in HabRate provide a method for developing general habitat targets for the Whychus Creek Restoration

Project. Substrate composition, residual pool depth, pool complexity, cover, gradient, stream temperature and flow conditions are used as variables in the model to evaluate habitat suitability (Table 6). Pool complexity and cover are comprised of multiple habitat characteristics (pool complexity: pool depth, LWD, undercut banks, and presence of boulders; cover: percent cobble/boulders, percent undercut, LWD, and large boulders.)

Table 6. Reach attributes used in rating life stages of spring chinook salmon and steelhead trout (from Burke et al., 2003).

Spawning, Incubation, Emergence	Summer Rearing	Overwintering
% Fines	% Fines	% Fines
% Gravel		
% Cobble	% Cobble and Boulders	% Cobble and Boulders
% Pools	% Pools	% Pools
Residual Pool Depth		
	Pool Complexity (chinook only)	Pool Complexity
	Cover	Cover
Gradient	Gradient	Gradient
Temperature	Temperature	
Flow	Flow	Flow

The habitat requirements for early life stages of steelhead are summarized in Table 7. The "Target" column is the description of "Good" habitat from HabRate as described in the report by Burke et al. (2003). The model uses habitat targets that reflect differences in habitat requirements between Chinook salmon and steelhead. However, the general direction for the desired future condition for aquatic habitat is sufficiently described by these targets.

Table 7. Example fish habitat design guidelines based on steelhead trout requirements (from Burke et al., 2003).

Life Stage	Characteristic	Target
Spawning-to-Emergence	Substrate Composition	Fines ≤ 10% Gravel ≥ 30% Cobble 10 - 30 %
	Habitat (Pool Tailouts)	40 – 60%
	Residual Pool Depth	≥ 0.2 m
	Temperature	6.0 – 12.5 ° Celsius
	Flows	50 – 100% of base flows
Summer Rearing 0+	Substrate	Fines ≤ 10% Cobble & Boulder ≥ 20%
	Pool Area	40 – 60 %
	Additional Cover Desired	% Undercut ≥ 15 % LWD/100m ≥ 20% Boulders/100m ≥ 20%
	Temperature	10 – 13 degree °Celsius
	Flows	50 – 100% of base flows
Overwintering 0+	Additional factors	
	Pool Complexity	Complex rating of 3
	Habitat (gradient)	Pools and riffles with cover (< 4% gradient)
Migration Barriers	Provide upstream fish passage for juvenile salmonids – barriers evaluated individually.	Fish Passage Criteria in Oregon Administrative Rules, OAR 635-412-0035.

1.6.6 Water Quality: Temperature

Water temperature in Whychus Creek has been extensively monitored as indicated by the data record (Table 8). A summary of these data are provided in the UDWC technical report completed by Logan and Jones (2007). In developing a restoration design we will determine if further temperature modeling in relationship to riparian and canopy conditions is useful and within the scope of work.

The entire extent of Whychus Creek is slated for development of total maximum daily load (TMDL) allocations and is on the State of Oregon Section 303(d) list of impaired waterways (DEQ, 2007). Current state temperature standards are that the temperature should not exceed 18 °C throughout the year for salmon and trout rearing and migration. The potential state temperature standard of 13°C would protect salmon and steelhead spawning for the period of October 15 through May 15.

Table 8. Period of record for summertime water temperature data.

Station_id	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Years
WC_018-25							1		1	1	1	1	1	6
WC_019-50			1	1	1	1	1	1	1	1	1	1	1	11
WC_024-25			1	1	1	1	1	1	1	1	1	1	1	11
WC_026-00			1	1	1	1		1	1	1	1		1	9
WC_030-25	1	1	1	1	1	1		1	1	1	1	1	1	12
IFC_003-25								1	1	1				3
WCt1_000-25								1						1

Note to Table: WC 026.00 Whychus Creek 4606 Rd, footbridge
WC 024.25 Whychus Creek City Park, d/s gauge

The 2007 UDWC study evaluated nine temperature stations from the mouth upstream to the stream gage upstream of the TSID diversion. Two of these stations with a long period of record occur within the project reach: WC-026.00 is located near the upstream project boundary, and WC-024.50 is located near the end of WPN Reach 1 at the USGS gage in the Sisters City Park (Figure 18).

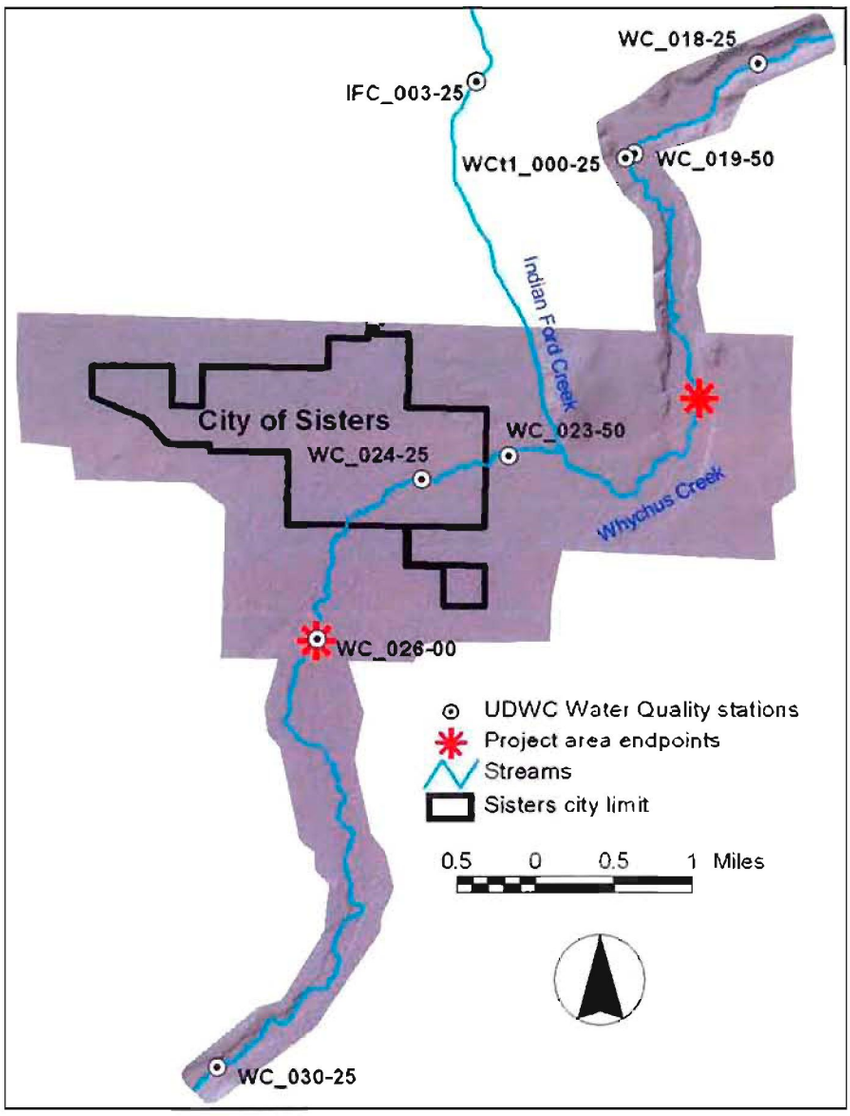


Figure 18. Location of temperature monitoring stations with data maintained in the UDWC regional database.

The 7-Day maximum temperature plot (Figure 19) shows temperature exceedence of criteria for rearing and migration at stations downstream of the TSID diversion through the Sisters project reach, Station WC 024.25, and then a decrease of water temperature below Alder Springs. Logan and Jones (2007) also found the highest rate of change during July occurred between the TSID diversion and the station at the USGS gage/Sisters City Park. The increase in temperature has been associated with the decrease in flow below the diversion.

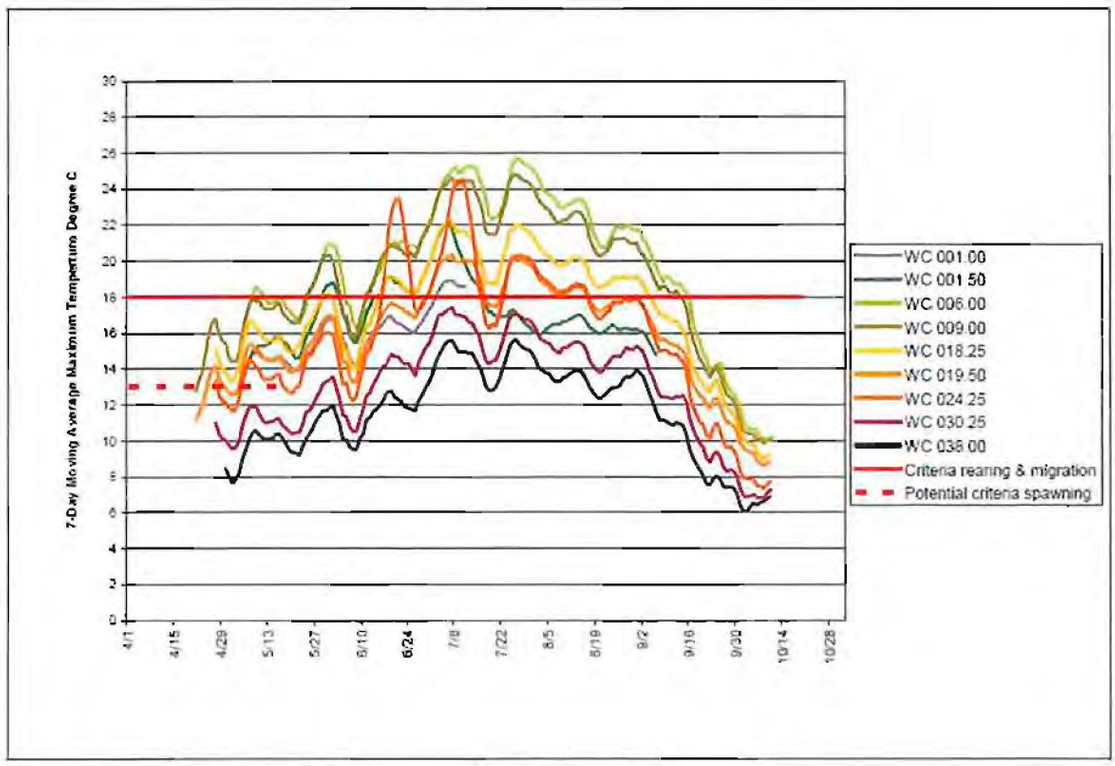


Figure 19. Seven day max temperature summary for 2007 (from Logan and Jones, 2007).

Further analysis of the relationship between stream discharge and water temperature is being evaluated by UDWC. Initial findings show a strong relationship between discharge and water temperature, suggesting the possibility of linking ODFW instream water rights to water temperature in the Sisters reach of Whychus Creek (Jones, 2008).

1.7 Riparian Conditions

The purpose of this section is to document the initial evaluation of the riparian conditions for the project area. This evaluation was made using available GIS resources, including fine-scale aerial imagery and LiDAR coverage. A qualitative diagnostic review of riparian zone functioning was made in the field during the week of September 24th, 2008. This information is necessary to understand possible riparian-related restoration and management actions that are discussed in Section 4, and to provide riparian values necessary for the development of instream restoration actions.

This analysis of riparian habitat conditions is focused to be effective for developing the Riparian Design Guidelines in the restoration plan, where current conditions will be

contrasted with a range of desired future conditions. These desired future conditions will rely on physical and social constraints associated with the stream restoration priorities and goals, including those of fisheries, hydrology, and channel geomorphology resources. This addresses the current conditions of the riparian zones only, and provides a qualitative and quantitative review of the current "assets" (i.e. well-functioning processes) and issues to address in the restoration plan.

1.7.1 Definition of the Riparian Zone

There is tremendous variation in ecological processes found in the land area adjacent to the stream channel. Definitions of riparian zones have often followed regulatory guidelines, where riparian buffer areas must be in place to balance land uses with necessary ecosystem *services*, such as providing stream shade, large woody debris (LWD) inputs, bank stability sediment retention, and inputs of organic material that benefit instream food webs. Simple assignment of a fixed-buffer width and coarse-scale mapping of the vegetation types is useful with watershed level assessments, but these fixed buffers are not appropriate for the level of detail required for developing riparian design criteria in a restoration plan. Specific questions to define the spatial extent of the riparian zone include the following:

- What dominant process or disturbance event(s) shape the riparian/ interface zone with the stream channel?
- What morphological features are present, and what is their physical relationship to the stream channel?
- Can the area be divided into reaches or sub-reaches that describe like channel processes that would have similar influence on the riparian zone?
- What patterns and trends in plant species composition and structure indicate direct stream interaction with the vegetation?

1.7.2 Spatial Extent

The *maximum width* of the riparian zone was defined on the basis of a potential flood following a hypothetical failure of the glacial moraine at Carver Lake (USGS, 1987; O'Connor et al., 2001). Though the entire study area is an alluvial fan and could therefore be considered to be a large "shifting riparian zone" following large scale disturbances, we focused our spatial extent to the potential floodway identified for the main channel of Whychus Creek, which assumes that 75% of the flow from a mass failure at Carver Lake will occur in this area (FEMA, 2007). The GIS outputs from this study were used to delineate the latitudinal extent of the riparian zone[15] (Figure 20).

[15] also see project area base maps for finer-resolution delineation of the FEMA flood zones

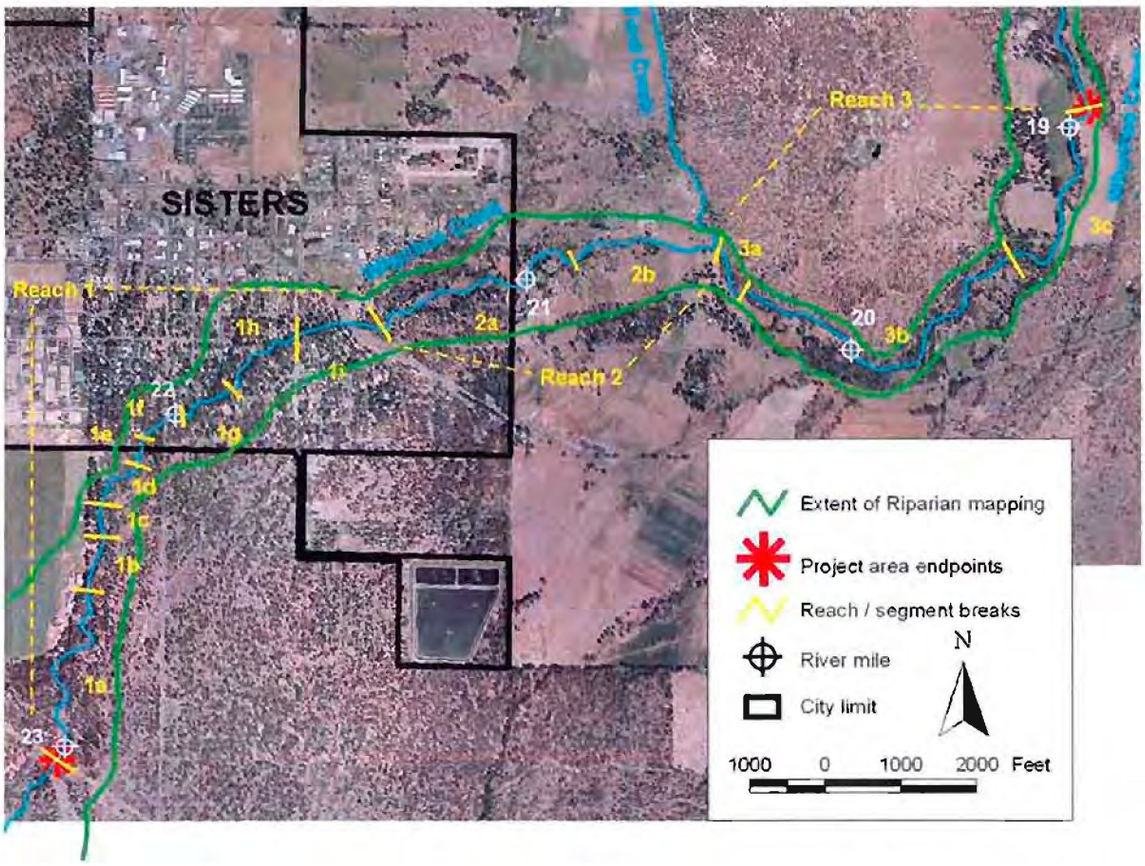


Figure 20. Extent of riparian zone mapped for this project.

The longitudinal extent is defined as beginning at the upstream intersection of the crossing at Forest Service Road 4606, and extending downstream to a bridge abutment on the Bradley Ranch (approximately River Mile 19). Within the bounds described, the analysis area includes approximately 427 acres.

1.7.3 Geomorphic Features

Within the maximum spatial extent, the riparian zone was examined for the range of geomorphic features present, including gravel/cobble bars, floodplain extent, and upper terraces. These features are critical habitat units for differing plant species and structures (trees, grasses / sedges, shrubs), as the direct interaction of the stream channel and groundwater availability dictates the range of disturbance patterns and water availability for a given species or community.

Geomorphic features were quantified within the riparian zone following a cross-sectional analysis with the stream channel, using available LiDAR bare earth imagery.

The thalweg of the stream channel was delineated from the LiDAR, and latitudinal cross sections spanning the width of the riparian zone were made at each node ("origin") along this thalweg channel line. The cross sections sampled the elevation from the LiDAR imagery; raw elevation numbers were relativized to the raw elevation of the thalweg at the origin. The output from this analysis provided a fine-scale view of the elevational dimensions of the riparian zone, relative to the stream channel. These data were manipulated to form polygons approximately one-quarter acre in size. Polygons were classified for the levels of potential interaction with the stream channel, on the basis of their relative elevation to the thalweg (Figure 21, Table 9).

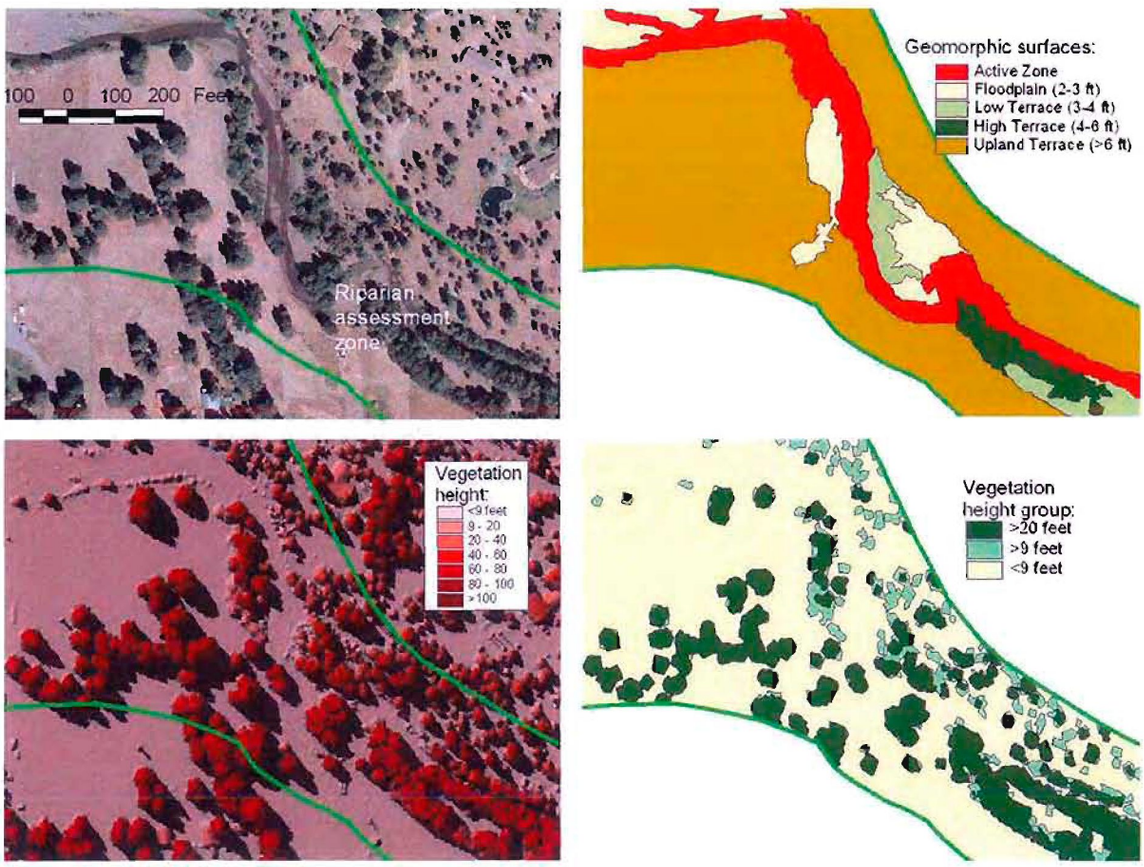


Figure 21. Example of geomorphic surfaces and vegetation heights derived from LiDARdata. This segment (Segment 3A) represents the closest example of a reference reach for the riparian condition and geomorphic surface interaction.

Table 9. Summary of geomorphic surfaces found within the riparian zone for the entire analysis area.

Interaction	Description	Acres	% of Riparian Zone
High	Active Zone (0-3 ft)	39.8	9%
Moderate	Low Terrace (3-4 ft)	20.3	5%
Low	High Terrace (4-6 ft)	24.9	6%
None	Upland Terrace (>6 ft)	341.4	80%
	Total	426.3	

1.7.4 Riparian Composition & Structure

Species composition and information about stand densities has been mapped for the analysis area and the greater Upper Deschutes Basin (Lamb, pers. comm., 2008). The information contained within these files provided a broad-scale assessment of the major vegetation types within the area, including areas of conifers, hardwoods, shrubs, grasses and other vegetative or land cover features found within a discrete riparian buffer zone. We chose to utilize this information for descriptive purposes only in our assessment, as the scale of delineation was too coarse to provide Design Criteria outcomes associated with this project. More detailed qualitative assessments of site-level species composition are presented in the Stream Segments section below. It is particularly noted that there were incidents of non-native and invasive species throughout the analysis area. For the purposes of this analysis, best management practices (BMPs) involving invasive/non-native species will be made in the design criteria. The compositional focus in this analysis was to identify riparian assets and opportunities for use in restoration.

LiDAR information available for the project area includes bare earth and top height resolution imagery. From these two grids, it is possible to calculate the difference in height to simulate high-resolution texture information of the vegetation, structures, and other land cover forms within the riparian zone. Quantitative analysis of the heights and ground truthing indicated there were two logical break points to develop "functional features" that would serve stream shading, potential LWD recruitment, and potential zones for providing seed / sprouting stock to enhance riparian communities (i.e. anchor points for resource enhancement/restoration). The two height profiles chosen were heights ≥20 ft ("large") and ≥9 ft ("small"). The LiDAR coverage was converted to a polygon coverage, and data smoothing yielded minimum polygon sizes of ~200 ft^2 for structures ≥20 ft and ~100 ft^2 for the ≥9 ft size class. The ≥20 ft size class contained mostly tree structures. The smaller size class had smaller minimum polygon sizes in order to preserve resolution of emergent vegetation on gravel bars, exposed banks, etc. The smaller size class also incorporated human-made structures, including houses, some parts of bridges, etc. that were outside of the active zone—these were particularly abundant within the urban growth boundary.

Coupled with the geomorphic surface polygons, the fine-scale height maps provide a site-specific detail of canopy cover for each size class. These data, coupled with compositional information are reported in the Stream Segments section below.

1.7.5 Reference Conditions

Often the current riparian conditions are compared and contrasted with a suite of reference conditions, involving species composition, structure and how they function with the stream system. The utility of reference reaches or individual conditions is dependant upon the underlying constraints of current and future land use, and changes to the hydraulic and hydrologic processes inherent in the system. Because the analysis area of Whychus Creek is dominated by an urban environment with considerable uses of berms, riprap and changes in hydrology, the constraint of prescribing riparian conditions on an historical (i.e. pre-Columbian) condition without land use is not practical. Hence it is necessary to develop desired future conditions for the riparian zones that is dependent upon what restorative measures can be made that are practical, and where conditions exist that would support or enhance the baseline ecological condition of the riparian zones. For these reasons we present the riparian zones in context of current available area (geomorphic surfaces), highlighting plant community composition and structure that are current *assets* to a restoration system (i.e. internal reference conditions), and recommendations for enhancement that fall within the given constraints for each segment.

Examples of high level functioning of active geomorphic surfaces with sedge / willow dominance can be found in Segment 3A below. Additional site-specific reference conditions for surfaces and communities are described as areas of opportunity for each segment in the section below.

1.7.6 Stream Segments

The analysis area has been divided into three distinct reaches, comprising of segments that share geomorphologic characteristics or land uses[16]. Each stream segment beginning and end point was extrapolated perpendicular to the stream channel to delineate the riparian zone. These segments represent logical breaks by which to summarize information, including total areas within the riparian zone (Table 10), and areas of high, mid, or low interaction, based on geomorphic surfaces (Table 11).

[16] See Geomorphic Framework Section 2.3

Table 10. Summary of riparian zone acres within each stream segment.

Segment	Acres	% Reach	% Total
1A	81.4	39%	19%
1B	17.5	8%	4%
1C	6.9	3%	2%
1D	8.7	4%	2%
1E	5.1	2%	1%
1F	11.4	5%	3%
1G	19.2	9%	5%
1H	34.0	16%	8%
1I	23.9	11%	6%
2A	64.9	61%	15%
2B	41.9	39%	10%
3A	5.8	5%	1%
3B	59.0	53%	14%
3C	46.6	42%	11%
Total	426.3		

Table 11. Segment-level breakdown of interactive surface area. Segment 3A is used as a proxy for reference conditions for surfaces of high interaction.

	High Interaction		Moderate Interaction		Low Interaction		No Interaction	
Segment	Acres	% Reach	Acres	% Reach	Acres	% Reach	Acres	% Reach
1A	7.4	9%	8.1	10%	5.0	6%	61.0	75%
1B	1.8	10%	1.7	10%	3.2	18%	10.9	62%
1C	1.5	22%	0.7	10%	1.2	17%	3.5	51%
1D	0.9	10%			0.5	6%	7.3	84%
1E	0.5	9%			0.8	15%	3.9	76%
1F	1.1	9%	1.3	12%	2.2	19%	6.8	60%
1G	1.9	10%	1.3	7%	3.0	16%	13.1	68%
1H	1.5	5%	0.7	2%	0.7	2%	31.1	91%
1I	1.6	6%					22.3	94%
2A	7.6	12%	1.8	3%	0.5	1%	55.0	85%
2B	4.5	11%	0.2	0%	1.5	3%	35.8	85%
3A	1.9	33%	0.3	5%	0.0	0%	3.6	61%
3B	4.0	7%	2.7	5%	1.9	3%	50.5	86%
3C	3.9	8%	1.5	3%	4.5	10%	36.6	79%
Total Acres	39.8		20.3		24.9		341.4	

Using the potential interaction descriptor for each geomorphic surface (high, moderate, low and no interaction), canopy cover was calculated for trees ≥20 ft in height and for all structures ≥9 ft in height (Table 12). These values are quantitative descriptors that have specific relevance for shade, LWD recruitment potential, allocthonous inputs, bank stability, and population structure.

Table 12. Percent cover for each geomorphic surface, calculated for trees ≥20 ft and all structures ≥9 ft in height.[17]

	High Interaction		Moderate Interaction		Low Interaction		No Interaction	
Segment	≥20 ft	≥9 ft	≥20 ft	≥9 ft	≥20 ft	≥9 ft	≥20 ft	≥9 ft
1A	30%	45%	41%	54%	43%	58%	24%	32%
1B	36%	45%	25%	28%	29%	31%	13%	17%
1C	31%	41%	44%	47%	39%	42%	36%	43%
1D	22%	37%			48%	78%	38%	46%
1E	12%	26%			28%	57%	32%	48%
1F	36%	52%	55%	63%	54%	63%	43%	54%
1G	38%	67%	55%	68%	29%	46%	31%	48%
1H	29%	47%	41%	56%	60%	76%	26%	42%
1I	35%	54%					27%	36%
2A	8%	16%	16%	33%	38%	55%	20%	36%
2B	2%	7%	13%	25%	0%	1%	9%	15%
3A	25%	37%	30%	42%	100%	100%	17%	29%
3B	28%	55%	53%	77%	43%	59%	28%	79%
3C	20%	37%	34%	40%	30%	35%	24%	30%

In the Segment Description narrative below, the availability and spatial extent of sites having higher interaction (Table 11) is used in tandem with canopy cover estimates (Table 12) to gauge riparian functions and identify opportunities for riparian enhancement[18]. Reference to the attached maps[19] will identify areas of potential interaction and berms that may block that interaction.

1.7.7 Segment Descriptions, Reach 1

Segment 1A

This segment is within Forest Service management and has relatively large and contiguous patches of interactive areas throughout the riparian zone. This segment has the largest riparian zone area for both Reach 1 (81 acres) and the entire study area (19% of total). Road access with evidence of parking and campfires are present in areas of potential moderate interaction; soil compaction is beginning to threaten large ponderosa pine trees in this zone. Active plantings are observed in this segment, with hardwood plantings (willows) in the near stream/gravel bar area on the left bank. A berm bisects an active cobble bar; plantings of ponderosa pine up gradient are part of the restoration effort. It is unclear as to the interaction of this floodplain area during high flows, though the elevation is within one to two feet of the thalweg (active zone).

[17] May include houses and other infrastructure, especially in the Low and No Interaction zones.
[18] Narrative below follows *Riparian Diagnostic Matrix* context from project scope.
[19] See Landform map

The cobble bars contain young hardwood establishment; age structures indicate a missing mid-aged cohort. There is high evidence of scouring disturbance on cottonwood communities, and where the few pieces of LWD are retained, vegetation establishment is providing some age structure diversity; young cottonwoods are able to avoid scour disturbance until age structure allows them to resist scour flow (Figure 22).

Figure 22. Evidence of LWD which allows some mid-cohort hardwood establishment and expansion of grasses and sedges immediately upstream from the cobble bar.

In the upper terraces, ponderosa pine and large cottonwoods persist, especially in areas of moderate interaction where dry side channels are present. In areas of eroding banks (left bank >6 ft high), some establishment of hardwoods and sedges provides opportunities for expansion to improve bank stability. Cover for trees ≥20 ft is quite high for all zones of potential stream channel interaction (Table 12).

Berms built on cobble bars appear to be inhibiting interaction with the stream channel, yielding young / emergent size structures on the active cobble bars, with older resistant age structure in adjacent areas immediately upslope of the berm. These berms could

be contributing to increased stream power, which limits opportunities for species to establish and resist scour disturbance in the inner portion of the bars, hence limiting the mid-cohort of hardwood species, particularly cottonwoods, throughout the segment.

Overall condition: There is ample stock for establishment of multi-cohort hardwood species on the cobble bars. The limiting factor appears to be berms that limit the complete interaction of the bars at various stages of flow. Additionally, LWD is limiting to provide bank structure and roughness elements to allow for scour-resistant age structures to persist.

Segment 1B

The active channel is controlled by berm structures on both banks. The riparian vegetation is serving well for providing stream shade, though the interactive zone is highly restricted in the current wetted channel section. Multi-cohort stands of cottonwood are not present; age structures are limited to older classes (Figure 23).

A relatively large land area within the riparian zone is in high and moderate interactive zones (10% each), with 18% at elevations marking low interaction potential. Most of these areas are not within the current active channel, and are relegated to a legacy (or potentially seasonally active) channel approximately 300 feet to the east. Well-established quaking aspen / ponderosa pine / snowberry communities suggest good interaction with groundwater in this area outside the main channel.

Berms on the left bank protect infrastructure and cut off a relatively large (~200 ft wide, 325 ft long) moderate and low potentially interactive terrace. Applications to engage the potentially interactive zones on the right bank would require removal of a berm and reestablish channel structures. Available vegetation resources follow a wide mesic gradient, and as such, would likely respond quickly to active restoration.

Figure 23. Typical view of Segment 1B; note relatively narrow interactive area and presence of berms on both banks.

Overall condition: The lack of roughness and high berms on the right are the two major limiting factors in this segment. Stream shade appears to be high (~36%) when structures ≥20 ft are reviewed in the active zone.

Segment 1C

The dominant process in this split channel segment is the presence of a four foot high weir in the left channel and a barrier limiting flow to the right channel (Figure 24). The right channel has a steep gradient (likely due to weir); despite this gradient, a substantial area of interactive floodplain and low terrace is present, accessible by the right channel flow (Figure 25). Large berms likely prevent interaction, even at high flows. Bank erosion is occurring at points in the right channel; well-established ponderosa pine and thick mid-cohort cottonwoods appear to protect most banks and limit failures.

A potentially interactive floodplain and low terrace connects off of the right bank to the section found in Segment 1B. Good vegetative patterns of aspen, established cottonwoods and ponderosa pine overstories are present in these areas (canopy cover ~44%). Berms and the barrier on the right channel/right bank are limiting the

interaction with the stream channel. The left bank plant communities are encroaching within a private property boundary and infrastructure. Berms are installed to cut off the left bank floodplain and low terrace communities from direct interaction with the stream channel.

Figure 24. Top of Segment 1C; constructed weir is to the left; other channel to the right. Vegetation intact, though restricted from interaction due to berms throughout.

Figure 25. Looking upstream to split channel in Segment 1C. Riparian vegetation in right channel (left in view) provides hardwood and conifer stock for enhancement; berms and diversion restricts the interaction.

Overall Condition: The riparian shade appears to be adequate for the first portion of this segment, and for areas currently outside the active stream channel zone. High flow energy at the downstream extent appears to increase scour frequencies and intensities, and is limiting to early- and mid-cohort establishment on gravel bars. Current vegetation along the banks is of sufficient size to limit active erosion in the right channel section. Any restoration of floodplain engagement on the right bank will be continuous with upstream segments.

Segment 1D

This segment is similar to Segment 1B, though missing areas of potentially moderate interaction (i.e. floodplain to high terrace is very abrupt). One area on the right bank (Figure 26) contains some evidence of activity, with some mesic species co-dominant with ponderosa pine. The presence of riprap and berm surfaces has limited the potential for interaction in this zone. This represents the downstream extent for opportunity to connect the floodplain on the right bank, as the segment is possibly

more incised, berms are higher in elevation relative to the stream channel, and the majority of the riparian zone in this segment is in upland terrace (>6 ft above stream).

Where present in the small active areas, alder and willow patches increase in abundance and establishment success in this segment. Sedges and rushes are in good numbers where interaction is high (active).

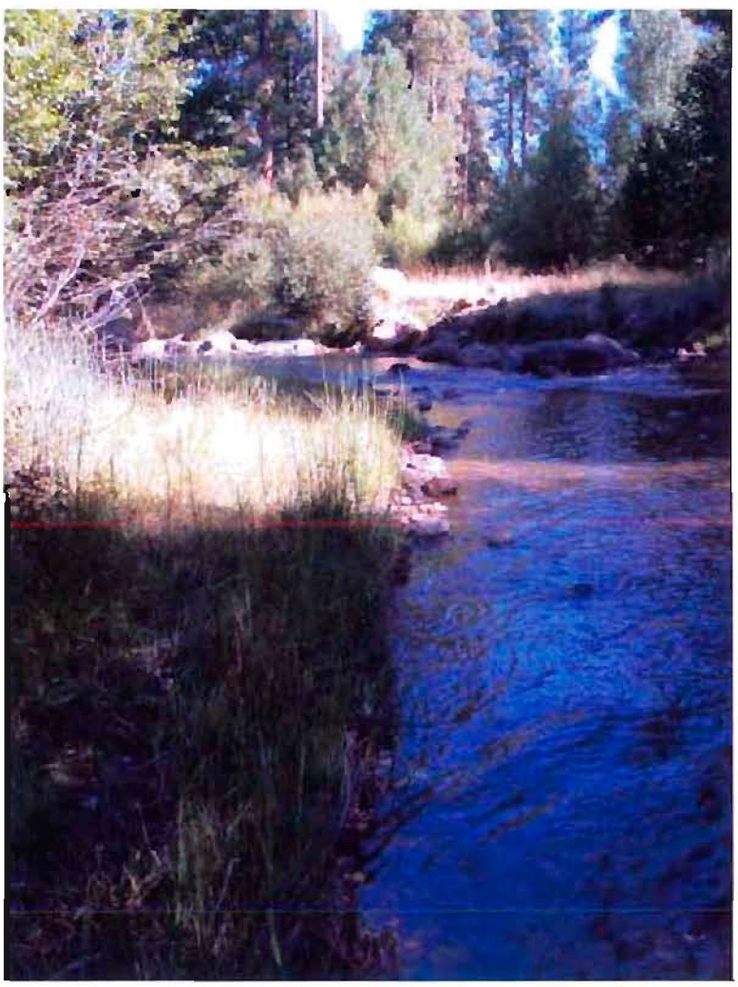


Figure 26. Narrow active zone and potential floodplain habitat in Segment 1D.

Overall Condition: The active riparian zone is simplified and narrow through this segment. Species composition is sufficient to support healthy riparian floodplain species and structure (willows, cottonwood, alder, ponderosa pine), though berms on both banks have restricted movement of the stream channel. One small area of high terrace (low interactive area, 0.5 acres) represents the downstream extent of

connecting viable floodplain areas along the right bank. Shade values in this area are high (48% for ≥20 ft trees) and could provide additional habitat.

Segment 1E

This segment is heavily engineered with riprap, prior water diversions, and rock barbs. There is a split channel with reasonably good diversity of riparian age structures; a relatively large (0.8 acre) high terrace is present on both banks. The left bank is incident with a house structure and is blocked by berms and riprap; the right bank has areas of high activity and a side channel (Figure 27). This tertiary channel has good numbers of wetland obligate sedges and rushes; younger age structure alder is plentiful in this area to provide stability, structure and nitrogen inputs.

Figure 27. Upstream extent of Segment 1E. Note alder and side channel on extreme right bank with potential for low-moderate interaction. House structure is in areas of low interaction to the floodplain.

Overall Condition: The upper extent of the reach is dominated by human-made processes. This severely limits the native vegetation on the left bank, though areas are available for active plantings to increase interaction of the floodplain and terraces. The right bank has opportunities for increasing activity in a tertiary channel; the riparian

vegetation provides good cover (28% over ≥20 ft in height) and stability to do so. Overall for the segment, the active areas have relatively low cover for structures ≥20 ft in height (12%). This segment represents the beginning of extensive development on both banks.

Segment 1F

This segment runs through developed neighborhoods and the active riparian zone is limited to the wetted channel (Figure 28). Additional areas have potential for interaction, though these areas are outside of the channel, separated by riprap and berms, and are situated near established homes.

The riparian vegetation along the active channel has very high cover for trees ≥20 ft in height (38%). Structures themselves contribute to shade through this segment. Ground cover vegetation is limited to a thin strip of some grasses/sedges where narrow floodplains exist or where sediment has collected on riprap structures.

Figure 28. Typical view of Segment 1F. Note non-existent floodplains and rapid transitions to upland terraces limit width of interactive riparian zone.

Overall Condition: This reach has high riparian shade, though few (if any) opportunities for floodplain enhancement. Instream structures are lacking and forming mechanisms for sedge meadow floodplains are unlikely in this reach, due to stream constraints.

Segment 1G

The dominant process in this reach is the presence of the Leithauser irrigation diversion dam and the very large sediment plug upstream of the dam. A very steep side channel is present, with a tertiary channel (about two to three feet wide) at the extreme right bank (Figure 29). As with the previous segment, there are a fair number of acres in potentially interactive zones, though all of these are in housing developments. The tertiary channel has evidence of a three foot head cut; existing root wads are stabilizing the bank in this area.

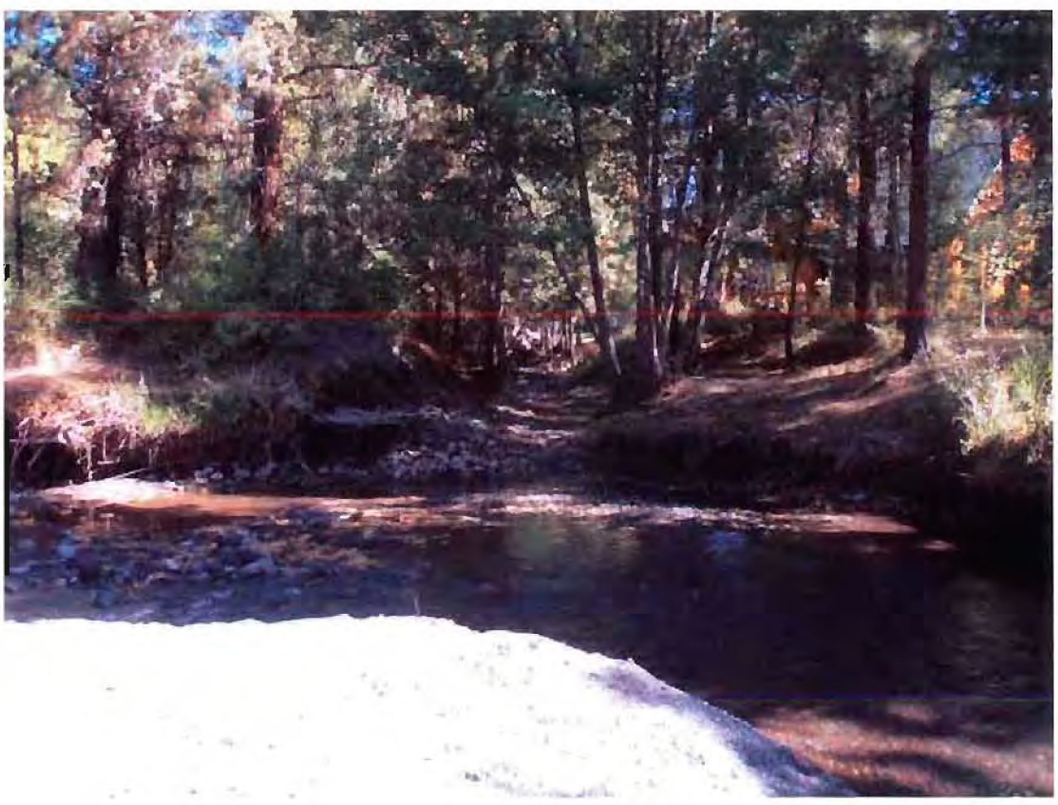


Figure 29. Upstream extent of tertiary channel in Segment 1G.

Canopy cover is adequate for the active zone in this segment (38%); mixed hardwood species dominate the active riparian zone and provide bank stability functions as well as a constant source of leaf litter to the system. BMPs involving tree planting (cottonwoods and alder), "backyard management," and other factors are

recommended in this and adjacent segments to maintain the functions of the narrow riparian zone and minimize non-native species introductions and active removal by landowners.

Overall Condition: The active riparian zone is extremely narrow and guarded on both banks by berms and riprap. Activation or enhancement of the secondary and tertiary channel is highly recommended, though the Leithauser dam is dominating substrate deposition, flow, and other processes that would affect any riparian restoration treatments.

Segment 1H

The riparian zone for this segment is highly restricted to the active channel as riprap and berms heavily dictate geomorphic surface diversity (Figure 30). The active zone contains several areas that are showing a meander plane form with some gravel / sand lens deposits. Some riparian obligate graminoids are present throughout, with overstory canopies of alder, cottonwood and ponderosa pine. Instream wood was found in several locations, serving minor function in enhancing the gravel/sand lens deposits. However, the constraints associated with the riprap and berms highly reduce the opportunity for floodplain interaction without intense restoration efforts.

Of particular note, yellow flag iris (*Iris pseudacorus*) was found in this segment on some of the meander sediment deposits. Riparian design criteria BMPs include recommendations to alert homeowners to reduce threats of non-native and invasive species in the system.

Figure 30. Riprap and berms severely limit interaction beyond the wetted channel.

Overall Condition: The segment has moderate shade (29%) and riparian tree resources that would prove to be beneficial for enhancement. The most limiting factor to riparian enhancement is the riprap and lack of a riparian floodplain.

Segment 1l

Located in the Sisters City Park, the riparian zone in this segment is the most severely limited for interaction beyond the wetted channel. Banks are heavily shaded (54% ≥9 ft height) and stable, though banks rapidly transition upslope to upland terrace (≥6 ft).

Very small areas of bank instability occur, particularly on the right bank near the campground (Figure 31). It is likely that some large ponderosa pine trees will contribute root structures to stabilize any increases in bank erosion. Structures are in place in some areas to discourage campers from directly accessing the stream; this access has created small paths that deliver sediment directly to the stream. Shrub buffer zones from the stream edge would increase stability and further discourage erosion from people walking to the stream.

Figure 31. Area of bank instability. Plantings that also discourage people walking to stream would minimize erosion.

Overall Condition: The riparian zone is limited to the active channel; trees within the narrow active zone are supplying excellent shade and stability to the stream. Any restoration efforts in this area to recreate active floodplain would require tremendous excavation and cost.

1.7.8 Segment Descriptions, Reach 2

Segment 2A

This segment is confined by riprap and other structures at a wider latitudinal spacing than in prior segments (Figure 32). The additional riparian zone "allocation" (between riprap) has allowed for a very dynamic system with large cobble bars containing various stages of riparian tree establishment. As with segments upstream of the urban growth boundary, focused flow has contributed to very high-force scour events, showing clear evidence of the scour-damage-deposition-sprout-establish sequence with cottonwoods and alders. This sequence typically forms multi-cohort stands that stabilize bars and

banks, provide shade, and allow for continuous recruitment to larger size classes, where community establishment is large enough to resist scour and damage.

Figure 32. Typical view of Segment 2A with development constraints on both banks.

The community structure and composition is such that it appears to favor younger size classes and cohorts, indicating that stream flow may routinely exceed the "scour-damage" threshold (Figure 33). Canopy cover in the active zones reflects this, with 8% (≥20 ft height) and 16% (≥9 ft height) cover on open gravel bars. Areas of moderate interaction double in cover (16% and 33%), and low interactive areas double again in cover to 38% and 55%, respectively. Age structures in the moderate and low interaction zones could likely achieve higher cover estimates if in-stream roughness elements (LWD in particular) increased or were nominally present. Currently the roughness elements appear to be small-diameter debris flows that collect en-masse on younger cohort cottonwoods and alders. This does provide sprouting / establishment areas behind the debris flows, but evidence suggests that high-power scour events occur before full establishment can take place.

Figure 33. Example community structure in the interactive zone. This is evidence of the scour-damage-deposition-sprout/establish cycle – note cohort is biased to younger size classes in the foreground (leading edge), structures increase in size in the background (trailing edge). Stream roughness elements can slow flow and lower disturbance sizes and intensities on interactive gravel bars.

At the lower extent of the reach, the old channel is evident, and there are large areas of aspen and cottonwoods that are present in an isolated floodplain (isolated due to berms and riprap) off of the left bank. This area has potential for reintegration with the stream channel and expansion of riparian function.

Overall condition: This highly dynamic segment contains many native processes that contribute to high degrees of riparian function. However, the relationship between available floodplain (i.e. between riprap) and stream power in this segment appears to exceed the ability for riparian tree and shrub structures to resist stream scour. Hence, age structures are younger in nature, shade is lower, and direct inputs of LWD are limiting. Efforts to slow flow and/or decrease the frequency of high flow / high power events will allow for enhanced riparian functioning, including the establishment of sedges and rushes in low power areas. Seed stock is present for natural regeneration and reestablishment following stream channel modifications designed to increase roughness.

Segment 2B

This segment has the lowest riparian cover and complexity of all segments reviewed in the analysis area. There were few significant floodplain or other interactive terraces present in the segment. In addition, historic straightening of this segment produced large berms on both banks, and complexity dramatically reduced downstream. Instream features, including small gravel bar deposits have some riparian obligate species, though western juniper and upland obligate shrubs were found on several sand lenses in the middle of the stream channel in the lower half of this segment[20].

There was one example in this segment of how instream complexity can have a beneficial effect on riparian and stream functioning (Figure 34). This area at the very top of the segment created a small split channel and showed good floodplain development with multi-cohort hardwood structures. It should also be noted there was a significant berm that was perpendicular to this area, extending laterally to the left bank riprap. Removal of this berm would allow for additional riparian development immediately downstream.

Figure 34. Wood deposited along interactive bank, building riparian sedge meadows and enhancing multi-cohort growth of hardwoods.

[20] These small features would likely have been mapped as "Low" or "No" interaction zones in the middle of the stream channel (i.e. ≥4 ft). However, for utility in this scale of restoration design, the minimum polygon size for mapping geomorphic surfaces was 0.25 acres.

Aside from this feature, the majority of the segment had little vegetation or instream structure components to provide substrate for riparian development (Figure 35). The downstream extent of this segment had some minor hardwoods (willows and cottonwood) that established in riprap, as well as few areas where small pieces of wood have slowed flow and small sprouts of cottonwood and sedge patches were able to persist (several square feet in size). However, no substantial communities were present.

Overall Condition: This segment is severely limited in riparian resources and instream structures to promote riparian establishment. Extensive restoration efforts to provide instream roughness will be required prior to successful establishment. Exposure will also likely require active irrigation to promote growth and health of riparian plantings.

Figure 35. Typical view of segment 2B.

1.7.9 Segment Descriptions, Reach 3

Segment 3A

In marked contrast to the upstream segment (2B), this segment has high complexity, excellent cover in the interactive zones, and high levels of species diversity (Figure 36). The interactive riparian zones are all highly developed and in all stages of succession /

disturbance. From a strict vegetation / interaction standpoint, this section provides a good reference for riparian structure, composition, and interaction with floodplain and gravel / cobble bars, including examples of dead material interactions with graminoids. The species composition of a sedge / willow dominated floodplain represents a relatively intact reference condition for the project area.

Though a relatively small segment, the level of highly interactive surfaces occupies the highest proportion of the entire riparian zone (33%). Moderately interactive areas appear to be active and unobstructed during seasonally high flow events. The high proportion of riparian zone interaction in this segment should be considered as a reference condition for the riparian zones in the analysis area. High levels of interaction provide surfaces for sedge / willow meadows to become dominant, and provide additional floodplain habitat available for fish.

Figure 36. Example of high diversity of willows and sedges that occupy the relatively large highly interactive zone.

Overall Condition: This segment has excellent riparian conditions with good levels of shade, and little to no evidence of grazing pressures or other disturbances that would

limit riparian productivity. Sedge / willow meadows are dominant and are at excellent levels of interaction with the stream channel. This condition should be considered as a model for the reference condition for the analysis area.

Segment 3B

This segment flows mostly west to east, with the southern aspect lined with a very tall berm and tall tree structures (Figure 37). As such, stream shading in this segment is relatively high, especially in the moderate and low interactive zones. Canopy cover ranged from 53 and 43% in these zones (respectively), though topographic shade likely had a large influence on effective shade. This contributes to excellent allocthonous inputs from hardwood sources.

Figure 37. Upstream extent of cottonwood gallery on elevated floodplain.

Due to prior stream straightening efforts, the zones of interaction are few, narrow and long. The left bank proximity to McKinney Butte, and the large berm (10 to 12 feet high) on nearly the entire right bank, contributes to the lack of interactive surfaces in the riparian zone (Figure 38). A floodplain community with mid-diameter cottonwoods on the right bank at the beginning of the reach

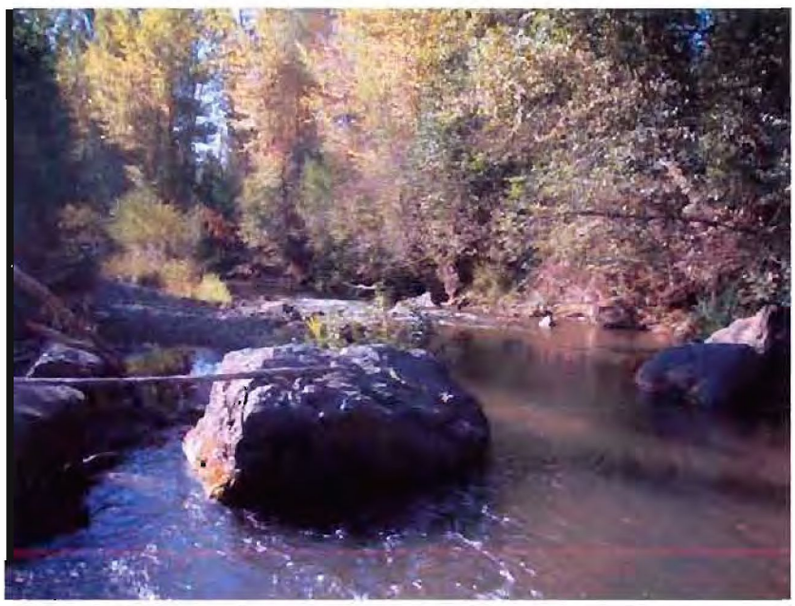


Figure 38. Typical view of stream channel with cottonwood/ alder structures lining the ~12 ft berm on the right bank.

shows signs of interaction at high flows. Additional stream roughness elements (LWD) to increase engagement in this area would build additional interactive zones along the stream channel.

The interactive surfaces increase downstream, with a narrow zone that is connected to a wetland community approximately 12 feet above the stream channel. This provides steady flow to the stream channel from an apparent remnant channel that occurred prior to straightening through this section.

Overall Condition: The riparian cover and cottonwood gallery stands are well structured, with multi-cohorts represented. The vegetation dominance is limited to trees, as few areas exist with ample substrate (bedrock is dominant) that are able to support graminoid floodplain communities. This zone is further narrowed by a large berm on the right bank and McKinney Butte on the left bank. Specific areas exist where increases in the interactive zones may be developed with LWD placement and low berm removal (left bank at the end of the reach).

Segment 3C

This segment is similar to upstream reaches in that the floodplain confinement is through riprap (McKinney Butte influence decreases in this segment). A very large and potentially interactive zone exists at the beginning of the reach (left bank), but is not currently connected to the stream channel. Beyond this, three small potential interactive zones (~0.5 acres) are present in this segment, though berms have been placed to minimize stream influence.

The riparian vegetation is best described as a narrow gallery consisting of only a few very large trees (cottonwoods and ponderosa pine) in depth (Figure 39). There is little evidence of active regeneration in this gallery area, suggesting stream shade could be limited with the loss of even one these trees every 100 feet. There was evidence of downed trees in the stream channel, though they were removed or altered and were not able to integrate with the stream channel.

Figure 39. Example of gallery forest vegetation. Note very small zones exist (right bank) capable of supporting sedge/ grass communities.

Overall Condition: The overstory vegetation was providing adequate shade to the reach, though regeneration was limited, particularly in areas adjacent to working farmland. Where LWD was present, there was good formation of bars that were readily populated by sedges and/or small hardwoods. Scour appears to be very low in this area

and supporting a cottonwood gallery with grass/sedge meadow would appear to be highly functional in this segment.

2.0 Field notes

2.1 Reach 1:

Segment 1A

Morphology Summary

Length	3,740 feet
Gradient	0.71%
Morphology	Weak pool/riffle, deposition and transport
Human Influence	Limited riprap and straightening

Restoration Assets

This segment has minimum development and is under management of the USFS. High-flow channels dominate this area, with an historic meander pattern that is largely intact. Current restoration efforts, and active education and outreach are in place for increasing shade on cobble/gravel bars. The spawning substrate is favorable, and there is abundant stock available for riparian vegetation expansion.

Problems / Issues to Address

Lack of roughness elements in this section has resulted in moderate embededdness, lack of substrate sorting, and minimal instream habitat components (pool tail crests, pocket pools, deep pools, etc). Instream wood components are few, but they are effective where they are present. Bank erosion sites were present on the outside edge of every meander, ranging between 2 ft and 9 ft in length. Riprap was in place in four locales, though use of riprap was very minimal. The bars are expending energy and the banks are moderately stable, which is limiting the sorting / roughness elements of the system. The vegetation establishment reflects this with a missing mid-aged cohort in the near-channel environment. Shade is limiting as the scour effects are maintaining a younger age structure of cottonwoods; upland obligate species are invading areas where discontinuous berms have disconnected the riparian zone and altered the morphology and hydrology of the system.

The bridge at the end of the segment is structurally undersized, and is resulting in significant sediment deposition upstream of the bridge. In addition, the bridge abutments are undercut (right bank) suggesting the structure is at risk for failure.

Opportunities / Potential Actions

Two major potential actions exist to improve functioning: establishment of roughness elements and floodplain reconnection / flood management. This can be accomplished through installation of key large wood debris (LWD) and root wads, with the design to increase roughness elements to aid in sediment capture and sorting, creation of pools, and allowing for overbank flows to reconnect the floodplain. Use of boulder materials as structural components should be limited to minimize thermal mass.

Reconnection of existing high flow channels along the right bank can greatly increase habitat area, groundwater recharge, and increased connectivity with the riparian zone. This can be accomplished through installation of wood and the removal or perforation of existing berms to increase flood capacity and connectivity.

Current riprap should be replaced with bioengineered solutions. The bridge at the end of the segment should be redesigned and/or replaced.

Range of Constraints

Any added material (LWD, root wads, etc) is a concern for downstream reaches, in particular bridges and structures. The reactivation of high-flow channels may contribute to fish stranding during high flow conditions. Active planting efforts will require irrigation maintenance or successful reactivation of the floodplain prior to establishment success.

Segment 1B

Morphology Summary

Length	700 feet
Gradient	0.40%
Morphology	Plane bed, transport
Human Influence	Limited riprap

Restoration Assets

This section has minimum development, with the right bank mostly undeveloped. The section is heavily shaded (especially the right bank). There is riprap present (left bank), though it is stable and moderately vegetated.

There are aspens in the high floodplain / terrace that indicate possible groundwater interactions with the stream channel. The current seed stock is abundant for sedge and rush establishment and expansion; cottonwoods are abundant with opportunities for expansion without additional planting.

The substrate is mobile and has high potential for spawning materials.

Problems / Issues to Address

This segment is highly simplified with no meanders present. There are minor berms blocking additional interaction with the floodplain. The stream gradient is artificially maintained by the control structure (Segment 1C).

Key habitat components are lacking, including few pocket pools, deep pools and absent tail crests. Few root wads and boulders were present, adding a few deep pools in this section. The channel is generally straight, incised, lacking bed roughness, and is controlled by riprap on the left bank.

Opportunities / Potential Actions

Installation of wood and/or root wads is a necessary component to increase instream complexity and roughness, and to reconnect the floodplain. Mechanisms or BMPs for bank stability that are agreeable to adjacent private landowners is important in minimizing the effects of riprap on the system. Recommended mechanisms include riprap replacement and bioengineering solutions.

Outcomes of actions should focus on sediment capture, storage and sorting, increases in pool scour, and increases in meander within the stream banks. Reconnection of the floodplain via use of roughness elements should focus on the engagement of the existing channel with the spring / riparian vegetation within 30-50 ft of the right bank; these actions should be designed to transfer energy from the left bank (away from private structures/ property). This increased high flow / flood management is a carryover from the upper segment (1A), focused on additional benefits of shallow aquifer recharge and riparian regeneration favoring mesic species compositions.

Range of Constraints

Restoration of overland flow scenarios is limited to the right bank. Riprap replacement on the left bank with bioengineered solutions will require landowner cooperation, and understanding that the solutions will be of benefit for the long term. Use of conservation easements or other such instruments are potential mechanisms for project success.

Segment 1C

Morphology Summary

Length	430 feet
Gradient	1.26%
Morphology	Weak pool/riffle, deposition
Human Influence	Weir, riprap over half of segment

Restoration Assets

This short segment is a split-channel system, with increases the possibility of habitat quantity. There are roughness elements present in the segment as well as moderate shade and diversity to provide good anchor points for natural maintenance / establishment. One landowner controls this segment, and opportunities to improve floodplain development on the right bank are contiguous with upstream segments.

Problems / Issues to Address

The major issue with this segment is that the split channel is blocked (right channel) and all flow is diverted to a structure that poses a barrier to fish passage (left channel). The left channel is manipulated with rock and concrete and appears to require maintenance and retrofitting to allow for fish passage.

The right channel is positioned at a high gradient, and (upon removal of blockage) could increase likelihood of fish stranding.

Opportunities / Potential Actions

The primary action is to remove and/or modify the concrete barrier in the left channel. Actions to send the majority of the flow in the right channel (and even abandon the left channel all together) would dramatically increase fish passage probabilities.

Modification of the concrete barrier to increase fish passage is another alternative, though the redirection of flow through the right channel is important as it will increase the potential to provide slow moving refugia in this segment. Prior to these actions, the sediment transfer in both channels (and the potential for each) would need to be evaluated.

Floodplain reconnection along the right bank should follow recommendations to connect with the upper segments (1B).

Range of Constraints

As with all restoration actions, landowner cooperation constrains the levels of changes to the stream channel and to the concrete structure. Similar for upstream reaches, restoration activities involving floodplain restoration could be accomplished via cooperative agreements and conservation easements.

Other constraints are the potential for development of head cuts upstream of this segment, as well as potential failure along the right bank of the right channel, at a bending point (currently supported by a ponderosa pine).

Segment 1D

Morphology Summary

Length	720 feet
Gradient	0.89%
Morphology	Plane bed, transport
Human Influence	70% of segment straightened and relocated

Restoration Assets

The assets are similar to segment 1B, though this segment represents the downstream end of potential enhancement opportunities for floodplain interactivity (right bank).

Problems / Issues to Address

This segment has similar issues to segment 1B, though there is more riprap with increased numbers of landowners. A 6-inch steel pipe across the streambed is exposed and appears to be vulnerable for breaking away.

Opportunities / Potential Actions

As in segment 1B, installation of wood and/or root wads is a necessary component to increase instream complexity and roughness, and to reconnect the floodplain. Mechanisms or BMPs for bank stability that are agreeable to adjacent private landowners are important to minimize the effects of riprap on the system. Recommended mechanisms include riprap replacement and bioengineering solutions.

Outcomes of actions should focus on sediment capture, storage and sorting, increases in pool scour, and increases in meander within the stream banks. Reconnection of the floodplain via use of roughness elements should focus on the engagement of the existing channel with riparian vegetation within 30-50 ft of the right bank; these actions should be designed to transfer energy from the left bank (away from private structures/ property). This increased high flow/ flood management is a carryover from the upper segments, focused on additional benefits of shallow aquifer recharge and riparian regeneration favoring mesic species compositions.

Range of Constraints

Restoration of overland flow scenarios is limited to the right bank. Riprap replacement on the left bank with bioengineered solutions will require landowner cooperation, and understanding that the solutions will be of benefit for the long term. Use of conservation easements or other such instruments are potential mechanisms for project success.

Segment 1E

Morphology Summary

Length	370 feet
Gradient	1.19%
Morphology	Weak pool/riffle, deposition
Human Influence	Extensive riprap extending into the channel

Restoration Assets

There is high habitat diversity and complexity in this segment, with scour pools, multiple side channels, and good riparian mid-cohort species structures available. Some substrate sorting is occurring, allowing for streambed complexity.

Problems / Issues to Address

The segment exhibits higher width-depth ratios, and the lack of multiple cohorts is limiting current and long-term shade, further increasing thermal exposure risks. Weed species are increasingly more common than the upstream reaches.

Riprap and berms in this area are heavily controlling the stream and potential restoration actions. A head gate structure in the right bank side channel is blocking a tertiary channel flow.

Opportunities / Potential Actions

Maintenance and enhancement of the riparian vegetation should include targeted species to increase shade in the inner and outer riparian zone (high terrace environments with upland tree species). Plantings and expansions of existing sedges and rushes would increase the inner zone stability; areas on the left bank would benefit from riparian shrub plantings and cottonwoods to increase stream shade and stability. In addition to shade and stability, vegetation treatments should also be designed to serve as a buffer between upper reach floodplain reconnection activities and the UGB. This segment could potentially serve as the point for return flows from the floodplain along the right bank.

Replacement of large riprap structures with bioengineered solutions would minimize the thermal capacity considerations with large rock, and would provide for increased inner riparian zone habitat. Removal of the wooden control structure to open the tertiary channel (right bank) would increase potential fisheries habitat, and provide additional anchor points for riparian vegetation establishment and expansion.

Range of Constraints

This segment is the upstream extent of the City Limits. There is high-density development on both banks. The history of the past diversion, and need to maintain the diversion, is one constraint to increasing habitat in the tertiary channels.

Segment 1F

Morphology Summary

Length	590 feet
Gradient	0.54%
Morphology	Plane bed, transport
Human Influence	Limited straightening, extensive riprap and channel encroachment

Restoration Assets

This segment has good riparian shade, with very high cover for trees >20 ft in height. Replanting opportunities are limited to available land area. The right bank is less developed than the left bank. Boulders within the stream are providing some development of deep pools.

One undeveloped parcel along the right bank (at Elm and Tyee Streets) offers an anchor point for lateral enhancement.

Problems / Issues to Address

Berms and riprap on either side of the stream channel has severely limited the potential for an active floodplain.

The bridge at Elm Street appears to create a backwater at bedload moving flows, causing coarse sediment deposition and reducing channel capacity. The bridge also appears too low to pass a debris jam under high flow conditions.

Opportunities / Potential Actions

There are a few available areas on the right bank that could be used to increase lateral expansion of the stream channel. The undeveloped lot at Elm and Tyee Streets could be utilized for expansion of the right bank floodplain. Evaluations of the Elm Street Bridge are recommended in context of potential upstream wood structure placements.

Properties on the left bank appear to have potentially mobile housing structures. Potentials for removal from the immediate stream channels should be considered if left bank floodplain enhancement is a high priority.

The primary restoration item is to replace the riprap with bioengineered structures, adding to instream complexity and slowing water flow while armoring stream banks.

Establishment of riparian BMPs along the entire corridor could increase awareness of the need to reduce non-native plants, and the value of riparian vegetation for decreasing nutrient and other unwanted inputs. Appropriate signage and a public outreach program are avenues for passive restoration.

Range of Constraints

The Elm Street Bridge is well established, and any modification would be costly and likely involve a long public process. Multiple landowner cooperation is key in the implementation process for both active (e.g. riprap replacement) and passive (e.g. implementing BMPs) restoration projects.

Segment 1G

Morphology Summary

Length	800 feet
Gradient	1.06%
Morphology	Plane bed, extensive deposition
Human Influence	Weir, channel encroachment, riprap

Restoration Assets

This section has moderate shade and shade potential, an intact meander patter in the planeform geometry, and side channels present for potential increases in fisheries habitat area. There have been discussions leading to the potential for landowner cooperation in modifying or removing the existing irrigation diversion.

Problems / Issues to Address

The diversion structure dominates how this segment functions. There are excessive fines and sediments associated immediately upstream of the structure that require annual maintenance removal. The diversion and the bypass channel are at high gradients and are both potential fish passage barriers.

The segment is developed along both banks; restoration options in the tertiary channel would require creating a buffer area back from the stream channel, as well as eliminating a deep scour hole that likely limits fish passage.

Riprap is present throughout.

Opportunities / Potential Actions

The primary recommended action is to remove the irrigation diversion structure and allow sufficient time and flow for the sediment plug to flush downstream. This structure may alter restoration options/ potential actions upstream, and these opportunities should be reevaluated following clearing of the legacy sediment.

The tertiary channel on the right bank is a potential liability for landowners, given the active scour that appears to be occurring. Appropriate use of buffer areas should be considered between the landowners and the stream channel if this channel is to be maintained.

Riprap removal and replacement with bioengineering solutions will add complexity and additional habitat to the system.

Range of Constraints

The diversion structure is a factor that controls restoration options in this segment as well as upstream. The level of cooperation and decision by the landowner to remove, or dramatically alter the diversion is a critical piece affecting restoration design and success.

The segment is within the City limits, with high density development on both banks. There is excessive use of riprap throughout, with homes on the left bank that are exceedingly close to the stream.

Segment 1H

Morphology Summary

Length	1,190 feet
Gradient	0.82%
Morphology	Weak pool/riffle, mostly transport
Human Influence	Channel encroachment and riprap throughout

Restoration Assets

Also within the City limits, development in this section is generally located farther from the creek than in the upstream segments. There is interaction with root wads (live and

dead), and some minor pools are formed around these and a few boulders; the meanders in the planeform geometry add the formation of small meander-scour pools. Pools would likely increase in quantity and quality following the flushing of fines should the diversion structure upstream be removed (Segment 1G).

Problems / Issues to Address

The deposition of fines from the diversion structure upstream has severely limited quality spawning gravels and pools. Though some root wads are present, instream wood and bank roughness is limiting throughout. Stream shade is moderate, though severe restriction of the floodplain due to riprap and berms limits the quantity and quality of shade for the long term.

There is a higher occurrence of non-native plant species in this segment located (or potentially originating from) the stream-side edge of backyards.

Opportunities / Potential Actions

There is potential for the restoration of the meander pattern with use of riprap removal, setbacks, and cooperative agreements with landowners (e.g. conservation easements). Replanting of riparian hardwoods and sedge / rush meadow species would be successful with restored meander patterns and equilibrium of upstream sediment flows from the diversion (Segment 1G).

Lot line adjustments, land swaps, or other avenues should be explored to gain additional enhancement opportunities to restore the floodplain within the City road right-of-way areas.

Additions of instream boulder clusters would create additional scour pools.

BMPs for invasive species are recommended with outreach materials (as in upstream segments).

Range of Constraints

The location of the Locus Avenue Bridge limits the use of LWD without solid anchoring.

High numbers of landowners requires a united effort for restoration; restoration design and success is dependent upon the outcome of the diversion structure upstream.

Segment 1l

Morphology Summary

Length	1,120 feet
Gradient	0.74%
Morphology	Plane bed, transport
Human Influence	Bank armoring throughout

Restoration Assets

The entire segment is on City property, allowing for a range of opportunities to enhance educational value of the stream. The reach has excellent shade and mostly stable banks throughout.

Problems / Issues to Address

The segment is short, straight, and bounded by bridges, which limits the value of planeform changes. Restoration efforts for floodplain connectivity will directly influence shade and require considerable excavation due to bank height.

There is some evidence of bank erosion due to trails from the campground, with fine-scale delivery to the stream. Large (bulldozer) trails in the downstream extent (below Highway 20) are vectors for non-native species and sediment.

An concrete-armored sewer line located upstream of the Hwy 20 Bridge near the end of the segment is a potential fish barrier.

High amounts of fines are found on the cobble substrates.

Opportunities / Potential Actions

Bank stability could be enhanced through planting of shrubs and placement of obstructions (large wood, rocks, etc.) to discourage unconsolidated trails from the campground. Single trails designed to minimize sediment flow could allow access. Planting of shrubs and encouragement of next-generation cohorts of trees (i.e. eliminate compaction areas) would improve riparian zone shading for the long term.

Improvement of fish passage at the sewer line crossing could be accomplished through use of instream structures (e.g. step pools). Additional pool development through boulder additions would increase pocket pools throughout segment.

Obliterate bulldozer trails in the lower sections; use of planting and increased floodplain enhancement in this area is possible.

Routine garbage removal from the creek is recommended.

Range of Constraints

This segment has very limited length between the bridges, and the incised channel is disconnected from the floodplain. Opportunities for restoration of the meander planeform geometry into the floodplain are not possible without significant expense and excavation.

2.2 Reach 2:

Segment 2A

Morphology Summary

Length	2,950 feet
Gradient	0.80%
Morphology	Weak pool/riffle
Human Influence	Entire segment straightened, extensive riprap

Restoration Assets

This segment has a low gradient and is one of the least confined segments in the study area. It has been highly responsive to instream and/or bank treatments, showing evidence of natural recovery throughout, and having multi-cohorts of riparian species present when considered at the segment scale.

The few placements of rough LWD (natural or human caused) have created an excellent response in the formation of deep pools, interactive floodplain, and stream shade. Sedge establishment is also evident where LWD or root wads are present (in small patches), through trapping and sprouting mechanisms.

The majority of the active channel is within public land boundaries. This area is of high exposure and concern to landowners, increasing the potential for willing landowners to engage in a restoration plan.

Problems / Issues to Address

The active channel is bound by many houses within or adjacent to the channel migration zone above the Timber Creek Bridge. Individual bank hardening treatments have occurred without a consistent overall plan. These hardening treatments have dramatically decreased channel roughness and natural bank lines, leading to excess stream energy that is transferred downstream to create additional erosion sites. Installation of riprap at these downstream sites likewise transfers the energy farther downstream, creating a haphazard pattern in bank hardening (and needs for stability).

The segment lacks habitat complexes including pools and instream cover. The bank treatments are not creating fish habitat as currently implemented; the smoothing effect likewise does not provide for adequate sorting for spawning habitat.

Riparian shading is limited, and becomes increasingly limited downstream. Scour events are maintaining a young cohort near the stream channel, with very little sedge establishment due to lack of roughness.

The Timber Creek Bridge (currently unfinished) has a low clearance (88 inches at high point) with a center pier (42 inches at high point). The bridge acts as a pinch point that inhibits floodway capacity by trapping debris, limits stream flow, and deposits gravels upstream.

The stream elevation drops below Timber Creek Bridge, contributing to losses of connectivity of the cobble bars with the stream channel.

The streambed elevation is 3 ft below the historic channel at a channelization point (lower end), complicating reconnection strategies.

A second channel constriction zone due to riprap and berms is located at the lower end, which has contributed to ice dam formation and deposition upstream. A third pinch point is present at the bottom of the segment, caused by a high vertical profile groin (top elevation point even with the riprap berm). This pinch point contributes to immediate erosion on the right bank and additional deposition problems.

The upstream bank hardening, with three successive pinch points downstream, is complicating the depositional dynamics within this reach.

Opportunities / Potential Actions

Focus on the segment above the Timber Creek Bridge to develop a comprehensive restoration design to allow for maximum stream function and property protection that:

- Increases in-channel roughness;

- Uses bioengineered designs to allow for structure protection, bank stability and roughness;
- Supports plantings in areas where roughness elements are in place and where stream flow scour is slowed; and
- Considers a timeline for other potential actions upstream and downstream (e.g. Leithauser diversion actions).

For the comprehensive restoration design to be successful, the existing and planned bank hardening treatments will need to be upgraded to meet the overall design criteria.[21] Currently planned projects should be postponed that do not meet the criteria; any interim emergency bank treatments should be limited to inexpensive instream channel and riparian treatments to hasten cobble bar connectivity.

Structures, including the Timber Creek Bridge, that are unable to be protected under the design should also be considered for removal. The comprehensive restoration design should also develop a hydraulic model to evaluate the bank erosion flow, bridge, and debris flow scenarios.

Downstream of the Timber Creek Bridge, it is desirable to expand the active floodplain to increase connection with the stream channel in two key pinch point areas. The first is an ice flow constriction point (Tax Lots 1510100000303 and 302), and the second is at the bottom of the segment where there is a large boulder groin constriction (Tax lots 301 and 304).

In general, below the bridge it is advisable to obtain easements or permissions to set back berms to the greatest extent possible, removing and replacing riprap treatments with bioengineered bank treatments where needed. Placement of whole tree structures instream is desirable to capture sediment and build sedge meadow floodplains that transition upgradient to cottonwood / alder communities (i.e. add bank stability and increase shade).

Range of Constraints

Without a radical change to the configuration of the upstream reaches, this segment represents the first depositional segment for the entire project area (i.e. the downstream end of transport reaches).

Numerous landowners will require significant outreach for developing the comprehensive restoration design plan.

The Timber Creek Bridge and near-stream developments severely limit opportunities for restoration in this segment.

[21] These criteria are discussed in further detail, as the area of focus for this project.

Below the Timber Creek Bridge, the extent of landowner cooperation (easements, lot line adjustments, etc) will dictate the types and extent of additional opportunities for enhancements.

Segment 2B

Morphology Summary

Length	1,980 feet
Gradient	0.62%
Morphology	Plane bed
Human Influence	Entire channel relocated and straightened

Restoration Assets

There are few landowners in this segment, streamlining needs for broad-based stakeholder participation.

There are few structures (buildings, etc.) along the right bank, allowing for opportunities to use larger instream structures (e.g., LWD, boulders, etc.) that will not threaten existing infrastructure.

Problems / Issues to Address

The segment has been channelized and is constrained by berms that are as high as 8 ft from the channel bed. The channel has considerable bank erosion, inadequate meander width, and lack of instream roughness. Few habitat elements are available and stream cover is exceptionally low. There are disconnected gravel bars within the channel zone that are preventing the establishment of riparian vegetation (adequate stock is also missing); some of these bars have been disconnected long enough to allow for establishment of upland obligate species (western juniper and rabbitbrush).

Opportunities / Potential Actions

Maximizing the floodprone width in this segment is desired to accommodate upstream restoration designs (i.e. allow for material flow and deposition from upstream to this segment). Use of easements and establishment of setback berms are example mechanisms to increase available riparian zone interaction.

The lower half of the segment (below the horse barn), extensive instream roughness treatments to capture sediment, increase water table elevation, and increase activity to

the gravel bars are required to allow for aggressive planting to increase shade in this segment. Whole tree plantings of sprouting species at instream structure points are desired for rapid establishment.

Considerations for moving horse pens, the hay barn, and existing manure piles away from the left bank will allow for channel widening and limit flooding.

Range of Constraints

The reestablishment of the pre-1950's alignment of the stream (left bank at top of segment) is probably not a practical solution.

Relative to the current thalweg, the right bank is too high for channel migration in the right bank direction.

There are exceedingly low levels of riparian species establishment in the segment. Structure additions to increase connectivity to the gravel bars will likely be difficult. Any planting in these zones will result in low success without fixed irrigation.

2.3 Reach 3:

Segment 3A

Morphology Summary

Length	750 feet
Gradient	0.89%
Morphology	Pool/riffle
Human Influence	Moderate channel straightening

Restoration Assets

This segment has excellent habitat diversity, including very deep pools associated with bedrock, root wads, and whole trees. The riparian zone is highly developed in all stages of succession and disturbance. This can provide a reference view for diverse riparian structure, composition, and interaction with the floodplain and gravel bars, particularly for some of the desired floodplain dynamics for segments 2A and 2B. Reference examples of coarse wood material and sedge establishment are also present in this segment.

Problems / Issues to Address

There are localized areas along the right bank where riprap removal and replacement with bioengineered solutions should be considered.

A BMP needs to be created that would allow overbank flow in the floodplain environment that would discourage placement of debris that blocks flows.

Opportunities / Potential Actions

Interaction with landowners regarding the value of overbank flows in the floodplain environment will provide a passive restoration option to increase floodplain connectivity.

Range of Constraints

This segment is downstream of proposed intensive restoration recommendations.

Segment 3B

Morphology Summary

Length	4,610 feet
Gradient	0.72%
Morphology	Plane bed, weak pool riffle
Human Influence	Lower two-thirds of segment channel relocated and straightened

Restoration Assets

This segment has excellent shade and standing sources of wood material, with high levels of allocthonous inputs. There is minimal development in this segment, with relatively large lot sizes and low levels of encroachment into the riparian zone. There is an elevated floodplain / terrace with quality vegetation components and diversity (high stand density) that appears to remain relatively active with the stream channel. There are many opportunities to expand and utilize small floodplain / terrace areas throughout.

Boulders and bedrock are the dominant habitat forming features, providing scour pools dispersed throughout the segment; bedrock is acting as the vertical grade control in this segment. The width : depth ratios are favorable where roughness elements are

present; evidence of springs throughout indicate there is good interaction with groundwater.

Problems / Issues to Address

The straightened and channelized segment lacks full connectivity with the floodplain, which threatens the floodplain functioning and persistence. Lack of instream and low levels of larger diameter standing trees are limiting the functions of LWD for pool development, instream cover components, and sorting of gravels. Recruitment of hardwoods is evident, though for the longer term this interaction will not serve for channel development.

Berms at the channel margin dominate the right bank. This has led to the exclusion of the floodplain and to overly stable banks. A small berm on the left bank appears to block linkages of a dome seep to the stream system; the presence of aspen and sedge meadows indicates high groundwater tables in this area. The Kelleher Bridge (Tax Lot 1510110001001, located 527 ft upstream of the downstream project boundary) serves as a constraint / pinch point for conveyance.

Opportunities / Potential Actions

Where possible, removal of riprap and replacement with bioengineered solutions will increase floodplain connectivity. Removal of berms and creating adequate setback is desirable in areas where the functioning of riparian vegetation will not be disturbed. Perforation of the berms long the right bank is another option to increase conveyance and riparian interaction. Alluvium augmentation is a suggested action to increase instream habitat quality.

There is an opportunity to make small modifications to the outflow channel of a wetland pond (near highway) that is designed to provide side channel rearing habitat. The Stafford home is within the floodway and potential migration zone.

Other actions include screening for active diversion pumps (Kelleher) and the removal/ redesign of the Kelleher access bridge.

Range of Constraints

This section has very limited channel movement, with a discontinuous and small floodplain and terrace structure in relation to the stream channel length and width.

Removal or other modifications to the long berm structures will require collaboration with the landowners, with potential setbacks to allow for stream channel movement.

The integrity of the existing pond and wetland should be maintained.

Landowners require stream crossing access – methods of consolidating access points should be explored to minimize crossing structures.

Segment 3C

Morphology Summary

Length	2,660 feet
Gradient	0.89%
Morphology	Plane bed
Human Influence	Straightening likely, significant riprap

Restoration Assets

There is a single landowner for the length of this segment, with no development or structures within the floodprone area. Water quality appears high, as does the quality of the shade provided by very large conifer and hardwood galleries. Some channel complexity is evident; there is a narrow floodway that is accessible for restoration efforts and riparian forest enhancement.

Problems / Issues to Address

The segment is moderately incised, with bank hardening and riprap present. A power pole is within the floodprone area, and will likely need to be moved and fortified outside the area. There is evidence of annual excavation associated with irrigation diversions.

There is a very narrow active riparian zone, with the gallery forest providing shade within ~20 ft of the stream edge; losses of a single tree have created gaps where no shade is present. In areas where trees have fallen down, the wood and root wads were removed from the stream, with the empty holes filled with gravel to stabilize the bank.

At the lower end of the segment, a bridge structure abutment and approach ramp are consider limiting the floodway capacity.

Opportunities / Potential Actions

Conservation easements or other such instruments are recommended to expand the riparian corridor, utilizing the area to plant and expand the riparian forest components (cottonwood and ponderosa pine). Adding key LWD pieces to add to instream complexity will augment the riparian interaction.

Upgrade or move the point of diversion so that stream channel excavation is not necessary, or replace with a shallow groundwater well.

Remove riprap and replace with bioengineered solution for the hardened bank across from the existing diversion (left bank), and establish riparian plantings as part of the solution.

Investigate other designs and needs for the bridge crossing.

Range of Constraints

The current conditions provide a narrow floodway available for riparian expansion.

Any restoration or enhancement will require cooperative agreements and meeting the requirements of the single landowner.

3.0 Who to contact for additional information

Below is a list of contacts with areas of expertise, and contact information should landowners or the general public have any further question.

Project Management, Funding, Permitting and Project Implementation:

Mathias Perle, Project Manager
Upper Deschutes Watershed Council
P.O. Box 1812
Bend, OR 97709
mperle@restorethedeschutes.org
541-382-6103 ext. 37

Wildlife & Fish Management, Habitat Improvement and Project Funding:

Ted Wise, District Fish Biologist
Oregon Department of Fish & Wildlife
61374 Parrell Road
Bend, OR 97702
Ted.G.Wise@state.or.us
541-388-6365 ext. 233

Water Conservation, Water Right Leasing, Water Bank and Project Funding:

Scott McCaulou, Program Manager
Deschutes River Conservancy

700 NW Hill Street
Bend, OR 97701
scott@deschutesrc.org
541-382-4077 ext.17

Conservation Easements:

Brad Nye, Conservation Director
Deschutes Land Trust
210 NW Irving Avenue, Suite 102
Bend, OR 97701
bnye@deschuteslandtrust.org
541-330-0017

4.0 References

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Exhibit D
Planning Commission Resolution 2010-09
Including Staff Report and Findings

A RESOLUTION OF THE PLANNING COMMISSION OF THE CITY OF SISTERS STATE OF OREGON PLANNING COMMISSION RESOLUTION PC 2010-09

THE CITY OF SISTERS PLANNING COMMISSION DOES HEREBY FIND AND RESOLVE THAT:

WHEREAS, the City of Sisters proposes to adopt the Whychus Creek Management Plan and amend the Comprehensive Plan (Goals 2, 5, 6, 7, 11 and 12) to reduce impacts on water quality and aquatic habitat, more heavily emphasize the presence of listed species in the creek and the City's commitment to stormwater management and the protection of the creek, and to incorporate the proposed Whychus Creek Restoration and Management Plan. The overall objective of the Whychus Creek Restoration and Management Plan was to develop restoration, management, and policy-level actions that will protect properties while restoring the proper functioning of the creek system; and,

WHEREAS, CP 10-03 includes incorporating the Whychus Creek Restoration and Management Plan into Goal 2 of the Comprehensive Plan to acknowledge it as a document to help reduce impacts to water quality and aquatic habitat, emphasize the presence of listed species in the creek and identify the City's commitment to stormwater management and the protection of the creek and surrounding properties.

WHEREAS, in accordance to the provisions found in the Sisters Development Code Table 4.1.200 and Section 4.1.600, the proposed adoption of the Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments are processed as a Type IV application; and,

WHEREAS, the Department of Land Conservation and Development (DLCD) received the Notice of Proposed Amendment at least 45-days prior to the first evidentiary hearing; and,

WHEREAS, after due notice, a public hearing on the proposed project was held before the Sisters Planning Commission on December 16, 2010, at which time findings were reviewed, witnesses were heard and evidence was received.

NOW, THEREFORE, BE IT RESOLVED THAT THE CITY OF SISTERS PLANNING COMMISSION FINDS THAT:

1. Notice has been given in the time and in the manner required by state law and city code; and,
2. The findings of fact on this matter are located in the staff report dated December 16, 2010, herewith attached and by this reference incorporated herein as Exhibit A.

NOW THEREFORE, BE IT FURTHER RESOLVED THAT BASED ON THE AFOREMENTIONED FINDINGS, THE PLANNING COMMISSION HEREBY FINDS AND RECOMMENDS THAT THE CITY COUNCIL ADOPT THE WHYCHUS CREEK RESTORATION AND MANAGEMENT PLAN AND COMPREHENSIVE PLAN AMENDMENT 10-03 SUBJECT TO THE FOLLOWING EXHIBITS:

Exhibit A - Staff Report dated December 16, 2010
Exhibit B – Whychus Creek Restoration and Management Plan date June 2009
Exhibit C - Comprehensive Plan Amendments
Exhibit D - Planning Commission recommended change to Goal 5

CITY OF SISTERS

Planning Commission Resolution

(RECOMMENDED BY THE PLANNING COMMISSION DECEMBER 16, 2010)

THE FOREGOING RESOLUTION IS HEREBY ADOPTED THIS 16th DAY OF DECEMBER 2010.

Members of the Commission: Gentry, Holzman, Auerbach, Layne, Protas, Roberts and Tewalt

AYES:	(7)
NOES:	(0)
ABSENT:	(0)
ABSTAIN:	(0)

Signed: David Gentry, Chairperson

CITY OF SISTERS

Planning Commission Resolution

(RECOMMENDED BY THE PLANNING COMMISSION DECEMBER 16, 2010)

EXHIBIT A
STAFF REPORT

CITY OF SISTERS

STAFF REPORT

Exhibit A

File #:	CP10-03
Applicant:	City of Sisters
Request:	The City of Sisters proposes to adopt the Whychus Creek Restoration and Management Plan and amend the Comprehensive Plan to reduce impacts on water quality and aquatic habitat, more heavily emphasize the presence of listed species in the creek and the City's commitment to stormwater management and the protection of the creek, and to incorporate the proposed Whychus Creek Restoration and Management Plan. The overall objective of the Whychus Creek Restoration and Management Plan was to develop restoration, management, and policy-level actions that will protect properties while restoring the proper functioning of the creek system.
Hearing Date:	December 16, 2010
Location:	City wide
Planner:	Pauline Hardie, Community Development Director

I. Staff Recommendation

Planning Commission recommendation of adoption of the Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments to the City Council. Adoption of proposed Plan and Comprehensive Plan amendments along with their associated findings will amend the City's Comprehensive Plan to conform to Statewide Planning goals including 2, 5, 6, 7, 11 and 12.

II. Background

In 2008, the City of Sisters partnered with the Upper Deschutes Watershed Council to fund a Whychus Creek Restoration and Management Plan, which was completed in June 2009. The overall objective of the plan was to develop restoration, management, and policy-level actions that will protect properties while restoring the proper functioning of the creek system. The proximity of the creek to homes has led to bank erosion and threats to property, safety, and the health of the creek and the endangered species that inhabit the creek. The City has a long-term interest in the management of Whychus Creek to protect property, provide recreational and aesthetic community benefits, enhance natural resource values, and

comply with the federal Endangered Species Act (ESA) and other natural resource regulations.

The Whychus Creek Restoration and Management Plan makes recommendations for amendments to both the Comprehensive Plan and the Development Code. Development Code amendments must be consistent with the requirements and policies of the Comprehensive Plan, so amending the Comprehensive Plan is a first step toward future Development Code amendments. Many of these recommendations are based on the Water Quality Model Code and Guidebook, which is published by the Oregon Department of Land Conservation and Development in conjunction with the Department of Environmental Quality.

III. Conclusionary Findings

Chapter 4.1 Types of Reviews and Procedures

Required Findings

According to Table 4.1.200 the proposed adoption of the Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments shall be processed as a Type IV Procedure (Legislative). Notice of the project was sent to the Department of Land and Conservation Development 45 days prior to the first evidentiary hearing date. Notice was also sent on November 29, 2010 to the Sisters Ranger District Forest Service, Oregon Department of Fish and Wildlife, U.S. Forest Service, US Fish and Wildlife Service, Oregon Department of Transportation, National Marine Fisheries Service, Oregon Department of Environmental Quality and Oregon Department of Water Resources. Notice was also posted in the Nugget newspaper on December 1, 2010.

4.1.600.E. Decision-Making Considerations. The recommendation by the Planning Commission and the decision by the City Council shall be based on consideration of the following factors:

1. **Approval of the request is consistent with the Statewide Planning Goals;**
   The proposed Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments are consistent with the Statewide Planning Goals as discussed below.

   GOAL 1: CITIZEN INVOLVEMENT ***To develop a citizen involvement program that insures the opportunity for citizens to be involved in all phases of the planning process.***
   The plan was developed in close coordination with the Upper Deschutes Watershed Council, Watershed Professionals Network and an advisory team including the City of Sisters, US Forest Service, Oregon Department of Fish and Wildlife, US Fish and Wildlife Service, National Marine Fisheries Service, and the Confederated Tribe of Warm Springs. Several community meetings were held including one on March 17, 2009 and September 10, 2009 and the Upper Deschutes Watershed Council and Committee for Citizen Involvement held a neighborhood meeting about the proposed restoration action planning for residents in the Timbercreek and Creekside subdivisions.

GOAL 2: LAND USE PLANNING To establish a land use planning process and policy framework as a basis for all decision and actions related to use of land and to assure an adequate factual base for such decisions and actions.
Goal 2 outlines the basic procedures of Oregon's statewide planning program. It says that land use decisions are to be made in accordance with a comprehensive plan, and that suitable "implementation ordinances" to put the plan's policies into effect must be adopted. It requires that plans be based on "factual information"; that local plans and ordinances be coordinated with those of other jurisdictions and agencies; and that plans be reviewed periodically and amended as needed. CP 10-03 includes incorporating the Whychus Creek Restoration and Management Plan into Goal 2 of the Comprehensive Plan to acknowledge it as a document to help reduce impacts to water quality and aquatic habitat, emphasize the presence of listed species in the creek and identify the City's commitment to stormwater management and the protection of the creek and surrounding properties.

Goal 3: AGRICULTURAL LANDS ***To preserve and maintain agricultural lands.***

Finding: The proposed Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments do not affect any agricultural lands. As such, the requirements of Goal 3 are not applicable to the proposal.

Goal 4: FOREST LANDS ***To conserve forest lands by maintaining the forest land base and to protect the state's forest economy by making possible economically efficient forest practices that assure the continuous growing and harvesting of forest tree species as the leading use on forest land consistent with sound management of soil, air, water, and fish and wildlife resources and to provide for recreational opportunities and agriculture.***

Finding: The proposed Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments do not affect any lands zoned or designated for forest uses. As such, the requirements of Goal 4 are not applicable to the application.

Goal 5: NATUAL RESOURCES, SCENIC AND HISTORIC AREAS, AND OPEN SPACES ***To protect natural resources and conserve scenic and historic areas and open spaces.***
Goal 5 requires local governments to adopt programs that will protect natural resources and conserve scenic, historic, and open space resources for present and future generations. These resources promote a healthy environment and natural landscape that contributes to Oregon's livability.

The City completed an inventory of existing natural resources with the adoption of the 2005 Comprehensive Plan and the data is contained in Goal of the Comprehensive Plan. Although Sisters inventories are not consistent with the current Goal 5 rule, the City's Comprehensive Plan is compliant with the rule because there is no trigger for the city to update our inventories. OAR 660-023 requires specific Goal 5 resources to be reviewed and amended at each periodic review. However, cities with a population less

than 10,000 are exempt from periodic review. Further direction on protecting these resources is provided in Oregon Administrative rule (OAR) 660-023.

Adoption the Whychus Creek Restoration and Management Plan and the proposed Comprehensive Plan amendments to Goal 5 will better address water quality and aquatic habitat protection, riparian protections zones and dynamic flood plain processes in the Whychus Creek channel migration zone.

Goal 6: AIR, WATER AND LAND RESOURCES QUALITY ***To maintain and improve the quality of the air, water and land resources of the state.***
This goal can be an important land use planning tool with respect to water quality protection because it requires that "all waste and process discharges from future development, when combined with such discharges from existing developments, shall not threaten to violate, or violate applicable state or federal environmental quality statues, rules and standards". Goal 6 is particularly relevant for Sisters because Whychus Creek contains populations of bull trout and summer steelhead, both federally listed as threatened species under the Endangered Species Act (ESA) and where water quality limited water bodies are located within their jurisdictions. Adopting the Whychus Creek Restoration and Management Plan and the proposed changes to the Comprehensive Plan will guide improvements to stormwater management in the City, help minimize water quality impacts to Whychus Creek, reduce inputs of sediment-laden storm runoff into the Creek, and reduce erosion of stream-side properties.

GOAL 7: AREAS SUBJECT TO NATURAL HAZARDS ***To protect people and property from natural hazards.***
Goal 7 requires local governments to adopt comprehensive plans that reduce risk to people and property from natural hazards including floods. Statewide Planning Goal 7 does not specifically address water quality issues, but measures adopted in compliance with this goal can help improve water quality. For example, by protecting against floods and other natural hazards, local governments may limit development within floodways and reduce impervious surfaces that increase runoff and flooding (DLCD and DE Q. 2000)

Adopting the Whychus Creek Restoration and Management Plan and the proposed changes to the Comprehensive Plan Goal 7 will help maintain the natural hydrology and channel migration of Whychus Creek, help mitigate damage from natural disasters including flooding, and improve the management of stormwater runoff in the City.

Goal 8: RECREATION NEEDS ***To satisfy the recreational needs of the citizens of the state and visitors and, where appropriate, to provide for the siting of necessary recreational facilities including destination resorts.***

The City of Sisters has a long term goal of restoring Whychus Creek while providing recreational and aesthetic opportunities. The Whychus Creek Restoration and Management Plan acknowledges the recreational opportunities; however, focuses on the restoration and management of the creek and property protection. No specific requirements of Goal 8 are identified in the Whychus Creek Restoration and Management Plan; therefore Goal 8 does not apply.

Goal 9: ECONOMIC DEVELOPMENT ***To provide adequate opportunities throughout the state for a variety of economic activities vital to the health, welfare, and prosperity of Oregon's citizens.***

The proposed Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments do not address economic opportunities. As such, the requirements of Goal 9 are not applicable to the proposal.

Goal 10: HOUSING ***To provide for the housing needs of citizens of the state.***
The proposed Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments do not address housing needs. As such, the requirements of Goal 10 are not applicable to the application.

GOAL 11: PUBLIC FACILITIES AND SERVICES ***To plan and develop a timely, orderly and efficient arrangement of public facilities and services to serve as a framework for urban and rural development.***
Goal 11 calls for efficient planning of public services such as sewers, storm drainage water, law enforcement, and fire protection. Adoption of the Whychus Creek Restoration and Management Plan and the proposed Comprehensive Plan amendments to Goal 11 will better address stormwater treatment and onsite stormwater retention in the City. It will also help set policies that protect and enhance the City's water quality.

GOAL 12: TRANSPORTATION ***To provide and encourage a safe, convenient and economic transportation system.***
Goal 12 aims to provide "a safe, convenient and economic transportation system." It also shall minimize adverse social, economic and environmental impacts and costs. The 2010 Transportation System Plan recognizes the need to decrease reliance on the automobile and increase the use of other modes including walking and bicycling to minimize transportation system impacts on the environment. The adoption of the Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments will address transportation system effects on water quality.

Goal 13: ENERGY CONSERVATION To conserve energy.
The proposed Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments are not related to energy conservation. As such, the requirements of Goal 13 are not applicable to the proposal.

Goal 14: URBANIZATION To provide for an orderly and efficient transition from rural to urban land use, to accommodate urban population and urban employment inside urban growth boundaries, to ensure efficient use of land, and to provide for livable communities. The proposed Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments do not address urbanization. As such, the requirements of Goal 14 are not applicable to the proposal.

Goal 15, Willamette River Greenway, Goal 16 Estuarine Resources, Goal 17 Coastal Shorelands, Goal 18 Beaches and Dunes, and Goal 19 Ocean Resources

Goals 15, 16, 17, 18, and 19 are not related to the proposed Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments

2. Approval of the request is consistent with the Comprehensive Plan;
Proposed amendments to the Comprehensive Plan include Goal 2, 5, 6, 7, 11 and 12 are necessary to reflect the adoption of the proposed Whychus Creek Restoration and Management Plan. The following section provides an evaluation of the proposal's compliance with the current Sisters Comprehensive Plan policies and relevant sections.

Part I
Introduction

The 2005 Sisters Comprehensive Plan is intended to be an adaptable, living document. The following findings demonstrate that the proposed Plan amendments comply with and implement many of the Plan's existing policies. The Whychus Creek Restoration and Management Plan will assist in implementing practical strategies that respond to bank erosion, property protection, and years of "fixes" that have happened since adoption of the Comprehensive Plan. The Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments identify opportunities for the enhancement and restoration of the creek throughout the project area.

Part II
Citizen Involvement

Finding: As provided under a previous finding addressing compliance with Statewide Planning Goal 1, the Whychus Creek Restoration and Management Plan was developed with opportunities for citizen involvement in the Plan through community and neighborhood meetings.

Part III
General Goals and Objectives

The following discusses how the proposed amendments address the General Goals and Objectives of the Comprehensive Plan. More detailed findings addressing specific goals and policies of the Sisters Comprehensive Plan are presented in subsequent areas of this recommendation.

5. **To protect natural resources and conserve scenic and historic areas and open spaces.**

   Adopting the Whychus Creek Restoration and Management Plan will help identify ways to protect and enhance the creek.

6. **To maintain and improve the quality of the air, water and land resources of the City.** Adopting the Whychus Creek Restoration and Management Plan will help reduce impacts on the quality of the water.

7. **To protect people and property from natural hazards.** Increased amounts of stream sedimentation lead to a loss of instream storage of flood water, leading to widening of stream banks and more flooding. The Whychus Creek Restoration and Management

Plan provides a summary of the recommended restoration actions that reduce property risk.

Part V
Comprehensive Plan Goals, Findings, & Policies

Goal 6: Air, Water, Land Resource Quality

6.3 FINDINGS

Whychus Creek flows can be erratic and the 100-year flood plain identified by the Flood Plain District is necessary to prevent possible losses to life and property. The portion of Whychus Creek within the UGB has reduced flow, 1.86 cubic feet per second, during the time water is withdrawn for irrigation purposes. There are local efforts to increase creek flows.

6.4 POLICIES

Task - The City shall cooperate with the restoration of in-stream water flow rights to Whychus Creek.

The Whychus Creek Restoration and Management Plan supports the transfer of permanent instream water rights to increase summer flows in the creek. This will improve channel and riparian function.

Goal 7: Natural Disasters and Hazards

The Whychus Creek Restoration and Management Plan and associated amendments identify ways to better maintain the natural hydrology and channel migration of the creek, help mitigate damage from natural disasters including flooding, and improve the management of stormwater runoff in the City. This will help provide increased property protection while assisting with the long-term restoration of Whychus Creek. This complies with the Statewide Planning Goal 7.

3. **The property and affected area is presently provided with adequate public facilities, services and transportation networks to support the use, or such facilities, services and transportation networks are planned to be provided concurrently with the development of the property. The applicant shall update City of Sisters Master Plans for Water, Sewer, Parks and Transportation Systems subject to City Council approval, to reflect impacts of the rezoning on those facilities and long-range plans. The applicant must demonstrate that the property and affected area shall be served with adequate public facilities, services and transportation networks to support maximum anticipated levels and densities of use allowed by the District without adversely impacting current levels of service provided to existing users; or applicant's proposal to provide concurrently with the development of the property such facilities, services and transportation networks needed to support maximum anticipated level and density of use allowed by the District without adversely impacting current levels of service provided to existing users;**

   The Whychus Creek Restoration and Management Plan acknowledges that the creek is a naturally dynamic system; that development patterns have put properties at risk; and that decades of "fixes" have made the problems worse. The Whychus Creek Restoration and Management Plan identifies opportunities for the enhancement and restoration of the

developed reaches of Whychus Creek throughout the project area. The Plan is intended to provide a management strategy that plans holistically through the entire project area, applies latest technology and approaches that have successfully been implemented by other communities, and promotes fixes that protect property and stream health. These strategies will help existing and future development.

4. **Compliance with 4.7.600, Transportation Planning Rule (TPR) Compliance.** Because the Whychus Creek Restoration and Management Plan and amendments do not pertain to a specific development proposal, or affect a specific transportation facility, Criteria 4 does not apply to the application.

IV. Public Comments

Department of Land and Conservation Development, Sisters Ranger District Forest Service, Oregon Department of Fish and Wildlife, U.S. Forest Service, US Fish and Wildlife Service, Oregon Department of Transportation, National Marine Fisheries Service, Oregon Department of Environmental Quality and Oregon Department of Water Resources were sent a notice about the proposed adoption of the Whychus Creek Restoration and Management Plan and Comprehensive Plan amendments. DLCD has suggested changes to Goal 5 which are incorporated into the Comprehensive Plan. No other comments were received during the comment period.

V. Exhibits

The following exhibits make up the record in this matter (these are contained in file CP10-03 and are available for review at the City of Sisters City Hall):

1. DLCD Notice submitted 10/04/10
2. Notice mailed to affected agencies dated November 29, 2010
3. Whychus Creek Restoration and Management Plan June 2009
4. Letter from DLCD dated November 29, 2010
5. Email from Karen Swirsky, DLCD Central Oregon Regional Representative dated November 22 and December 7, 2010
6. Email from Amanda Punton, DLCD Natural Resource Specialist dated November 24, 2010

CITY OF SISTERS

Planning Commission Resolution

(RECOMMENDED BY THE PLANNING COMMISSION DECEMBER 16, 2010)

EXHIBIT B
WHYCHUS CREEK RESTORATION AND MANAGEMENT PLAN
DATED JUNE 2009

PLEASE SEE ORINANCE NO. 401 EXHIBIT C

CITY OF SISTERS

Planning Commission Resolution

(RECOMMENDED BY THE PLANNING COMMISSION DECEMBER 16, 2010)

EXHIBIT C
COMPREHENSIVE PLAN AMENDMENTS

PLEASE SEE ORINANCE NO. 401 EXHIBIT A

CITY OF SISTERS

Planning Commission Resolution

(RECOMMENDED BY THE PLANNING COMMISSION DECEMBER 16, 2010)

EXHIBIT D
PLANNING COMMISSION RECOMMENDED CHANGE TO GOAL 5

5.2 BACKGROUND

The City of Sisters is virtually surrounded by National Forest Service and agricultural land. The surrounding open spaces separate Sisters from neighboring communities and provide much of the unique character and identity found in the City. In addition, the rural and forest setting of the Sisters area is important to the quality of life and economic development of the community.

DELETE

~~Goal 5 requires local government to adopt programs that will protect natural resources and conserve scenic, historic, and open space resources for present and future generations. These resources promote a healthy environment and natural landscape that contributes to Oregon's and Sister's livability. The City has completed this an inventory of existing natural resources and the data is contained within this Chapter. OAR 660-023 requires specific Goal 5 resources to be reviewed and amended at each periodic review. However, cities with a population less than 10,000 are exempt from periodic review. Further direction on protecting these resources is provided in Oregon Administrative rule (OAR) 660-023.~~

REPLACE WITH THE FOLLOWING LANGUAGE

Goal 5 requires local government to adopt programs that will protect natural resources and conserve scenic, historic, and open space resources for present and future generations. These resources promote a healthy environment and natural landscape that contributes to Oregon's and Sister's livability. The City's inventory of existing natural resources and the data is contained within this Chapter. The inventories could be updated in accordance with OAR 660-023 if the city finds that updated inventory information would be valuable. However, the City is not required to amend its inventories since cities with a population less than 10,000 are exempt from periodic review. Further direction on protecting these resources is provided in Oregon Administrative rule (OAR) 660-023.

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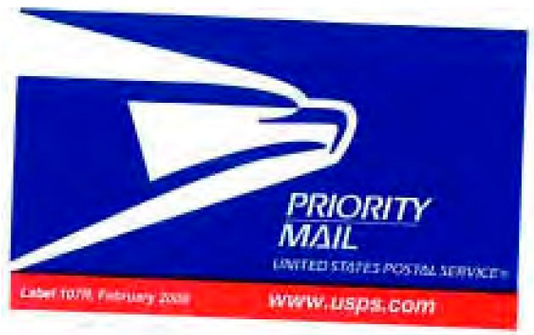

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Attention: Plan Amendment Specialist
Department of Land Conservation &
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635 Capitol Street NE, Suite 150
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