12-4-2009

Ex. 280-US-436

River Design Group, Inc

MIDDLE SPRAGUE RIVER ASSESSMENT AND FUGATT PROPERTY CONCEPTUAL DESIGN

Prepared for:

U.S. Fish & Wildlife Service
Klamath Basin Ecosystem Restoration Office
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Klamath Falls, OR 97603

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Sprague River, Oregon 97639

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August, 2006

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1.0 INTRODUCTION

The Fugatt family with funds provided by U.S. Fish & Wildlife Service (USFWS) retained River Design Group, Inc. (RDG) to evaluate a 6.7 mile section of the Sprague River (referred to hereafter as the Middle Sprague River) near the Town of Sprague River, Oregon (Figure 1-1). The Middle Sprague River Assessment was completed in March 2004. A more detailed survey and assessment was completed on the Fugatt property, located downstream of Sprague River, in September 2005. This report summarizes the Middle Sprague River's historical and existing conditions, and proposes potential river corridor restoration concepts intended to improve water quality, aquatic habitat diversity, and river channel stability.

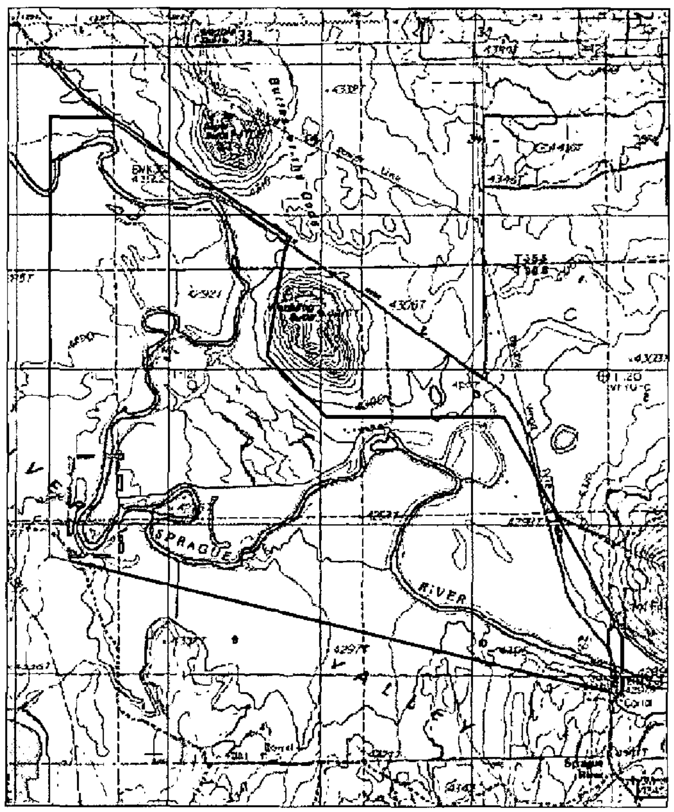

Figure 1-1. The Middle Sprague River Assessment area is highlighted by the red solid line box. The Fugatt property reach is highlighted by the dash line box.

1.1 Project Background

The Middle Sprague River is characterized by dynamic river corridor conditions. Past investigations have evaluated the Sprague River in an effort to describe probable historical, present-day, and potential future conditions. To aid in this assessment, RDG relied on three bodies of information. First, *The Master Plan for the Restoration of the Sprague and Sycan Rivers near Beatty, Oregon* (Water Consulting, Inc., 2002), was consulted for information on vegetation conditions, fisheries, and hydrology. Secondly, *The Draft Upper Klamath Lake Drainage Total*

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Maximum Daily Load (TMDL) and Water Quality Management Plan (Oregon Department of Environmental Quality, 2002) was used to provide background information on river response to land use effects. The third body of information was the Sprague River LIDAR and Bathymetry Survey (Klamath Tribes, 2004). These documents are briefly summarized in the following sections.

1.1.1 Sprague and Sycan River Master Plan (2002)

Contracted by the USFWS-KBERO, Water Consulting, Inc. (WCI) completed an evaluation of the Sprague River and the Sycan River in the vicinity of Beatty, Oregon (WCI, 2002). The master plan document was the product of an extensive field investigation of the Sprague River and Sycan River in the vicinity of Beatty. Work tasks completed for the master plan included reference reach surveys; United States Geological Survey (USGS) gage station calibration and flood series analyses; fish habitat and riparian vegetation condition evaluations; and restoration project prioritization plan. A detailed discussion of historical and existing channel morphology, fish habitat, water quality, and riparian vegetation conditions was presented. The assessment also proposed potential treatments and possible project locations for restoring impaired sections of the Sprague River corridor. Conclusions and restoration concepts provided in the Master Plan are applicable to the Middle Sprague River.

1.1.2 Upper Klamath Lake TMDL (2002)

In May 2002, the Oregon Department of Environmental Quality prepared the Upper Klamath Lake Drainage Total Maximum Daily Load and Water Quality Management Plan, pursuant to the Federal Clean Water Act. The TMDL estimated that the Sprague River is a major contributor of phosphorus to Upper Klamath Lake, accounting for approximately 51 percent of the total input and 26.5 percent of the total annual external phosphorus load (Kann and Walker, 1999). A significant portion of the bound phosphorous was determined to be delivered during peak runoff events when stream bank erosion rates are highest (Gearhart et al., 1995). The study further evaluated the stream temperature regime, which was identified as a water-quality limiting factor for the Sprague River. Anthropogenic-related increases in stream temperature were attributed to conversion of riparian vegetation and channel widening that have collectively increased channel width-to-depth ratios and reduced effective stream shading. Additionally, low summer discharge due to irrigation diversions and decreased thermal assimilative capacity were also identified as potential causes of increased stream temperature. The TMDL established water quality and restoration goals for streams and lakes of the Upper Klamath Lake drainage.

1.1.3 Sprague River Bathymetry and LIDAR Survey (2004)

The Klamath Tribes contracted with Watershed Sciences, Inc. and Max Depth Aquatics, Inc. to complete a channel bathymetry survey and a light detection and ranging (LIDAR) survey of the floodplain. The dataset provides a continuous surface of the channel and floodplain. The dataset was used for this assessment to evaluate channel dimensions and channel-floodplain characteristics through the reach.

1.2 Project Goals

The overall goal of the Middle Sprague River Assessment is to evaluate existing river corridor conditions in a section of the Sprague River corridor downstream from the town of Sprague River. The Fugatt property was surveyed in an effort to detail existing channel conditions as well as to provide potential restoration options. Restoration practices are intended to improve river functions that would benefit aquatic species, water quality, and waterfowl. The following project goals for the Middle Sprague River Assessment were developed in conjunction with the USFWS, RDG and private landowners.

1. Evaluate existing channel, fish habitat, and riparian conditions on a 6.7 mile reach of the Sprague River extending from the Sprague River Road bridge downstream to Township 35S, Range 10E, Section 32.

2. Develop conceptual restoration design plans that will specify the location(s) and type(s) of passive and active restoration practices.

3. Complete a channel survey on the Fugatt property to characterize existing river conditions.

4. Prepare a report describing the existing and potential resource conditions, restoration alternatives for the assessment area and the Fugatt property, and approximate cost estimates for implementation of restoration alternatives.

2.0 METHODS

The following sections detail the methods employed by RDG to complete the Middle Sprague River Assessment. Methods included both remote sensing and field techniques.

2.1 Remote Sensing

RDG prepared a series of eight base maps for the project. The base maps included aerial photographs from the 1998 photo series. The air photos were mosaiced and rectified using Digital Imaging Made Easy (DIME) software. Diming the air photos provided one continuous base map as well as seven more detailed individual base maps useful for field assessment. The rectified imagery permitted remote measuring of channel morphology.

General Land Office (GLO) maps from 1866 and 1873 and air photos from 1940 were reviewed to evaluate historical channel conditions. GLO maps are considered to be relatively accurate in depicting historical channel locations. GLO surveys in the western United States typically predated substantial human alteration of the natural landscape. The 1940 air photos capture the river corridor conditions after nearly 100 years of European-American habitation of the Sprague River watershed. Many of the suspected dramatic land use-related impacts (e.g. sheep and cattle grazing) to the river corridor had occurred by 1940. However, the 1940 air photos captured the river corridor prior to the post-World War II period that was characterized by increasing agricultural use and residential development in the watershed.

The LIDAR dataset was used to evaluate the existing channel conditions. ArcGIS Version 9.1 (ESRI, 2005a) and ArcGIS extensions, Spatial Analyst (ESRI, 2005b) and 3D Analyst (ESRI, 2005c) were employed for cutting cross sections and producing three dimensional visualization figures. Microsoft Excel was used to evaluate cross section data exported from the LIDAR dataset.

Field data were evaluated using programs including Autodesk AutoCAD and Microsoft Excel. Real-time discharge measurements collected by the U.S. Geological Station's (USGS) Chiloquin gage (#11501000) and the U.S. Bureau of Reclamation's Beatty gage (#11497500) were also accessed.

2.2 Field Methods

RDG completed a field assessment of the Middle Sprague River project area March 13-15, 2004. RDG canoed from the Sprague River Road bridge downstream to the Fugatt property (Township 36S, Range 10E, Sections 5 and 6). RDG walked the Sprague River from the Fugatt property downstream to the Greswell property (Township 35S, Range 10E, Section 32). The field assessment included portions of the Sprague River in Township 36S, Range 10E, Sections 3, 4, 5, 8, 9, 10, 11; and Township 35S, Range 10E, Sections 32 and 33. The entire project area is included on the USGS Sprague River West quad map.

Qualitative observations related to channel, floodplain, riparian, and aquatic habitat conditions were recorded during the reach assessment. Human-made structures were noted on the base maps. Ground photos were also taken.

A Trimble R8 GPS RTK unit was used to complete a channel survey on the Fugatt property on September 28, 2005. The survey extended from the upstream property line, downstream to below the Fugatt's pump house. A discharge measurement was also completed. Ground photos were taken to characterize the Fugatt project area.

3.0 ASSESSMENT AREA CONDITIONS

The following sections present a discussion of the existing conditions of the assessment area.

3.1 Climate

The climate of the Sprague River sub-basin is moderated by the Cascade Range and strongly influenced by post-maritime storm tracks from the Pacific Ocean to the northwest. Because of the lower mountains east of the basin, the rain shadow is less pronounced than other regions east of the Cascades (Quigley and Arbelbide, 1997). Summers are typically dry with high temperatures and moderately long growing seasons followed by wet winters and low temperatures (Akins, 1970). The annual precipitation ranges from 16 inches in the valley bottoms to over 50 inches at the watershed divide (Atlas of Oregon, 2001). Precipitation primarily takes the form of winter snows, spring rains, and summer thunderstorms with a steep seasonal gradient from moist winters and springs to very dry summers and fall conditions.

3.2 Hydrology

The Sprague River watershed area at the Sprague River Road bridge is approximately 1,297 square miles. Elevations range from approximately 4,290 on the Sprague River floodplain to over 8,000 feet in the headwaters. The Sprague River watershed is located east of the Cascade Mountains with the headwaters originating north and east of the project area. Annual water yield is approximately 116,000 acre-feet per year for the Sycan River gage and 229,000 acre feet per year for the Sprague River gage near Beatty upstream of the confluence. Annual water yield of the Sprague River at the Chiloquin gage is approximately 427,000 acre-feet per year.

The annual hydrograph of the Sprague River exhibits a snowmelt runoff hydrograph characterized by periodic rain-on-snow (ROS) events in that the snowmelt runoff. Numerous peak flows during the mid-winter months represent the greatest floods during the period of record. ROS-related peak flows are of short duration when compared to the more extended flows that occur during the spring snowmelt runoff period.

A bankfull discharge analysis for the Sprague River was completed to evaluate the dominant discharge that forms and maintains the channel system over time (WCI, 2002). This discharge occurs most years for a short time period and can be roughly equated to the mean annual peak discharge. Commonly, a 1.5-year return interval is associated with the bankfull discharge. Calibration of bankfull discharge using empirical, analytical, and analog-based procedures is necessary for design purposes and for adequately assessing both existing and potential channel conditions.

Four methods were employed to estimate the bankfull discharge for the Sycan and Sprague rivers (WCI, 2002). Methods included:

1. Analysis of historical gage data collected at the USGS gaging station (stations #11497500, #11499100, and #11501000) on the Sycan and Sprague rivers. The gaging station data were analyzed using log-Pearson III distribution for the entire period of record, combining the USGS and OWRD data when necessary;

2. USGS regional equations (Harris and Hubbard, 1983);

3. USDA Forest Service regional equations (Bakke et al., 2000); and

4. Field calibration at the Sycan River and Sprague River gaging stations using field data including channel cross-sections, longitudinal profiles, water surface slopes, and bed material sampling. Field calibration of the Sprague River near Chiloquin has not been completed.

The results of the bankfull discharge estimations are summarized in Table 3-1.

Table 3-1. Estimated bankfull discharge results for the Sycan River and Sprague River gage stations.

Location and Drainage Area	USGS Station No.	Log-Pearson III (cfs)	USGS Equation (cfs)	USDA-FS Equation (cfs)	Field Calibration (cfs)
Sprague River Near Beatty (Drainage Area: 513mi²)	11497500	950	900	790	850
CSM (CFS/Drainage Area)		1.85	1.75	1.54	1.49
Sycan River below Snake Cr. (Drainage Area: 568 mi²)	11499100	720	1,000	850	500
CSM (CFS/Drainage Area)		1.24	1.74	1.50	0.88
Sprague River at Chiloquin (Drainage Area: 1580 mi²)	11501000	1,800	2,200	1,810	1,800
CSM (CFS/Drainage Area)		1.14	1.42	1.15	1.14

The flood frequency analysis applied a Log-Pearson type III analysis incorporating USGS gage streamflow gaging data for the period of record (Table 3-2). The analyses correlated well with a similar analysis done by the USFS in the early 1990s.

Table 3-2. Flood frequency results for the Sycan River and Sprague River gaging stations.

	Recurrence Interval (yrs)								
Location	1.5	2.0	5	10	20	50	100	200	500
Sycan River	720	1,180	2,770	3,970	5,130	6,590	7,620	8,570	9,714
Sprague River near Beatty	950	1,265	2,350	3,250	4,250	5,740	7,010	8,420	10,510
Sprague River near Chiloquin	1,800	2,040	3,980	5,650	8,250	10,560	13,180	16,170	20,730

3.3 Sprague River Geomorphology

A geomorphic assessment was completed using both field observations and remote sensing. The field assessment and a review of the 1940 and 1998 aerial photography series was conducted to evaluate existing and potential conditions, and factors limiting channel stability. Field data collection was limited to the Fugatt property. Field data collection included a longitudinal channel profile, channel cross-sections, and a discharge measurement. Hydraulic models were completed to evaluate existing channel capacity, channel roughness, and velocity.

3.3.1 Historical River Corridor Conditions

The Sprague River in the assessment area has changed over time in response to both human activities and natural river processes. Because many of the changes to the Sprague River corridor occurred prior to the 1940 air photo series and few records accurately document the river corridor conditions, the following discussion is based on observations made in other portions of the Sprague River. Widespread sheep and cattle grazing in the Upper Klamath Basin, extensive agriculture on the Sprague River floodplain, and physical modification of the river corridor for flood control, timber exportation, and transportation are believed to be the primary causes of river and floodplain changes in the Sprague River valley. Prior to the arrival of European-Americans in the Sprague River watershed, native people of the Klamath Tribe inhabited the region (Howe, 1969; Lane and Lane, 1981). The Sprague River provided the native population with fish, mollusks, and wildlife for food and clothing. Annual spawning migrations of anadramous salmon and steelhead (Lane and Lane, 1981), as well as the spawning migration of freshwater Lost River and shortnose suckers provided bountiful food for tribal members. Lithic scatters and relict home sites suggest the importance of fresh water springs to the native people who inhabited the area (Howe, 1969).

Prior to European-American homesteading in the basin, the Sprague River was likely a sinuous river with an expansive floodplain. Floodplain wetlands would have absorbed overbank flows during the spring freshet and rain-on-snow events that frequent the basin. Floodwaters would have recharged underlying aquifers as well as been released by the floodplain back to the Sprague River. Beavers likely inhabited the river corridor in great numbers prior to widespread trapping in the 19th century. Beaver colonies on tributaries and side channels to the Sprague

River would have trapped sediment and increased the extent of the saturated floodplain. A multi-story riparian zone likely paralleled the channel and increased floodplain stability. Vegetation would have included an understory of sedges (e.g. Nebraska sedge) and rushes, and a shrub layer dominated by willows. Areas of the Sprague River also supported a discontinuous canopy comprised of aspen and black cottonwood. Remnants of the likely historical riparian zone remain in the Beatty Gap reach and the Braymill reach of the Sprague River. The extent of the Sprague River's historical canopy layer is unclear. However, the historical riparian condition was more diverse than the present condition.

Drier uplands and higher elevation areas of the Sprague River floodplain hosted a vegetation community dominated by sage brush (e.g. species), Ponderosa pine, and juniper. While these xeric systems remain largely intact, agriculture production, grazing, and depressed ground water aquifers are believed to have modified the historical conditions. Dryland and irrigated crops, pasture, and residential development have displaced native plant communities. Invasive weed species have also colonized riparian and upland areas of the Sprague River.

3.3.2 Existing River Corridor Conditions

With the arrival of European-Americans in the early 1800s, the historical condition of the Sprague River corridor began to change. As the leader of a Hudson's Bay Company trapping and exploring expedition seeking furs and a river route to the San Francisco Bay, Peter Skeen Ogden is recognized as the first European-American to have traversed and remarked on the Klamath Indians and the Sprague River basin (Howe, 1969). Later travelers including John C. Fremont and Lieutenant R.S. Williamson explored the region for an appropriate railroad route extending from the Sacramento Valley to the Columbia River.

With the arrival of European-Americans in Klamath Country, the Sprague River watershed was homesteaded. The Sprague River floodplain was cultivated for crops and modified for livestock pasture. Large herds of sheep and cattle grazed the lush riparian vegetation. It is unknown to what extent grazing has modified the vegetation community, though the contemporary riparian condition is believed to be a remnant of the historical condition.

Structural modifications of the river corridor are evident. A floodplain levee paralleling sections of the Sprague River confine flows and limit the historical interaction of the river and floodplain (Figure 3-1). Irrigation drains and ditches extend the agricultural season by draining the saturated ground in the spring and watering crops in the summer. Remnants of low head dams and bridges remain in the focus reach although the structures no longer serve their intended purposes.

Figure 3-1. A three dimensional image of the Sprague River south of the Sprague River Highway (left) and a ground photograph of approximately the same location (right). A floodplain levee bordering the west side of the channel limits the river's access to the adjacent floodplain.

Existing river corridor conditions reflect the human land uses that have altered the river corridor as well as occasional high magnitude flood events that inundate the valley bottom. Channel changes over time have included channel widening, channel meander cut-offs, and progression of floodplain avulsion channels. Channel widening is most pronounced in the vicinity of two remnant dams that occur in the project area. The channel has widened as it attempts to compensate for the cross section area that has been reduced due to the in-stream obstructions. Remnants of a box manufacturing mill remain on Sprague River floodplain downstream from the Sprague River Road Bridge (Figure 3-2).

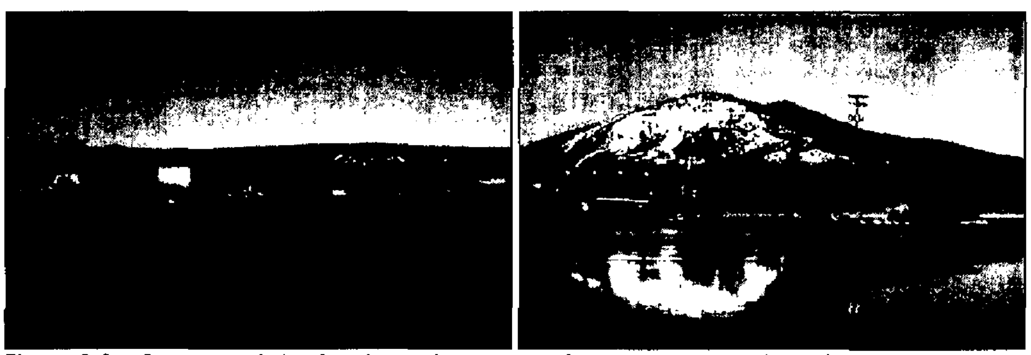

Figure 3-2. Remnants of the foundation from a manufacturing facility (left) and an old dam (right) continue to influence the Sprague River.

Five channel avulsions evident during the 2004 field assessment have displayed varying levels of development since the 1940 air photos (see Appendix A). Two meanders that served as the primary channel in 1940 have been hydrologically disconnected from the existing channel alignment. The first cut-off, located from station 120+00 to 125+00 (Figure 3-3, see Appendix B for stationing) is now a backwater wetland. The cut-off resulted in the loss of approximately 3,300 ft of channel and has increased the local channel gradient resulting in higher water velocities and greater stream energy. A meander cut-off from station 285+00 to 286+00 resulted in the loss of 1,615 ft of channel (Figure 3-4).

Figure 3-3. An air photo of the abandoned meander from station 120+00 to 125+00 (left). A ground photo of the downstream confluence of the abandoned channel and the active channel (right).

Figure 3-4. An abandoned meander on the Sprague River from station 285+00 to 286+00 shown in three dimensions from the LIDAR dataset (left). A ground photograph of the drainage/irrigation ditch paralleling the channel (right) illustrates the converted floodplain conditions. The red arrow on the LIDAR imagery denotes the direction and location of the ground photograph.

Two additional meanders that are progressing towards abandonment include meanders at station 136+00 and station 210+00. Another channel avulsion has initiated immediately downstream from the assessment area. Loss of these meanders will further reduce the channel length. A shorter channel conveys flows at a higher velocity resulting in greater stream energy and erosion potential. Table 3-3 displays the status of abandoned meanders and the related channel losses.

Table 3-3. Four avulsion channels in the assessment area and the effect on channel length. Over time, the length of channel lost due to avulsions will be approximately 84% in the assessment area due to these four avulsions.

Location	Status	Pre-avulsion Channel Length (ft)	Post-avulsion Channel Length (ft)	Length of Channel Lost (ft)	New Channel Length as Percentage of Pre-avulsion Channel Length
120+00 to 125+00	Meander Disconnected	3,700	385	3,315	10%
136+00 to 147+00	Avulsion Progressing	1,200	675	525	56%
210+00 to 212+00	Avulsion Progressing	2,700	100	2,600	4%
285+00 to 286+00	Meander Disconnected	2,000	385	1,615	2%
Total		9,600	1,545	8,055	16%

Several floodplain channels have become more evident since 1940. Expanding floodplain channels, over time, may capture increasing amounts of river flow and may ultimately form an avulsion channel. While floodplain channels increase floodplain habitat diversity and provide floodwater relief, they may also indicate the potential for a meander cut-off. The most prominent floodplain channel network in the focus reach extends from station 96+00 across the floodplain to station 179+00. Main channel capture would result in the loss of 1.5 miles of channel. Although the probability of such an event occurring is low in any given year, the probability of this occurrence increases over time as the floodplain channel expands in volume.

The existing channel morphology in the assessment reach was evaluated using the LIDAR dataset. Figure 3-5 shows the cross section location. Figure 3-6 illustrates example channel cross-sections. Table 3-4 compares the dimensions for the selected channel cross sections. In general, sampled locations characterized by a single channel had a smaller cross section area, narrower width, and a greater mean depth compared to multiple channel sites. Multiple channel sites were typically related to meander cut-off locations or where human activities had influenced the channel. Channel dimensions sampled from multiple channel sites generally had greater cross section areas, wider channels, and shallower mean depths. Maximum channel depths were similar between the two channel classes suggesting that flows maintain the maximum channel depth in both single and multiple channel locations. At three locations where the river has abandoned historical meanders (Cross section 5, Cross section 8, and Cross section 11), the historical channel segments have filled and the more recently formed avulsion channels maintain deeper and larger channels. Floodplain levees located on the west floodplain adjacent to the channel limits floodwater access to the floodplain.

Figure 3-5. The location of the channel cross sections in the assessment reach. Representative cross sections are provided in Figure 3-6.

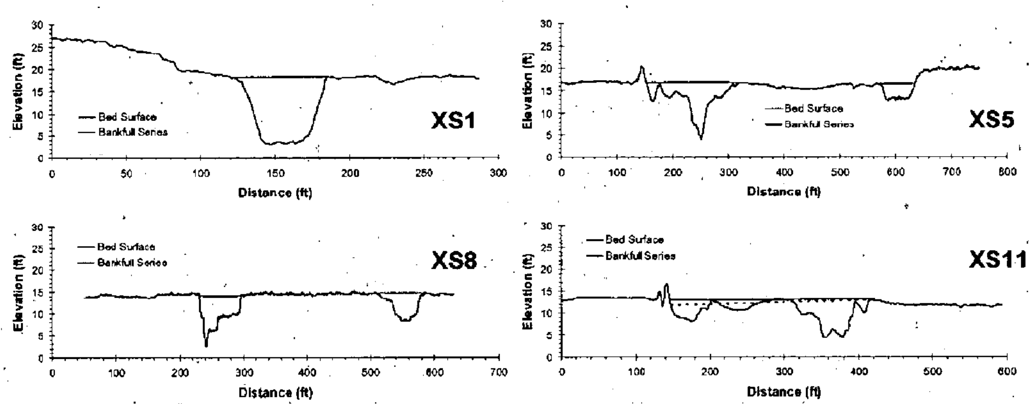

Figure 3-6. Example channel cross sections from the assessment reach. XS1 represents an example single channel location. The other cross sections have multiple channels. Floodplain peaks on the left bank of XS5 and XS11 are floodplain levees. The graphs are vertically exaggerated. The distance for XS1 is substantially shorter than the other cross sections and therefore the channel image is magnified.

Table 3-4. Bankfull channel characteristics for cross sections through the assessment reach. Average channel dimensions vary according to the number of channels. Values in brackets represent 1 standard deviation.

Cross Section	Single/Multiple Channels	Channel Width (ft)	Channel Area (ft^2)	Mean Depth (ft)	Max Depth (ft)
XS1	Single	64.7	646.3	10.0	15.3
XS2	Single	81.4	539.3	6.6	10.3
XS3	Single	74.8	420.2	5.6	9.1
XS4	Single	125.0	536.4	4.3	10.6
XS5	Multiple	165.4	634.0	3.8	12.9
XS6	Multiple	171.0	440.7	2.6	10.5
XS7	Single	134.9	448.5	3.3	9.6
XS8	Multiple	141.7	648.0	4.6	9.1
XS9	Single	120.2	295.9	2.5	5.9
XS10	Single	75.7	363.5	4.8	8.8
XS11	Multiple	273.7	750.7	2.7	8.7
XS12	Single	64.5	301.4	4.7	8.3
XS13	Single	115.4	428.1	3.7	9.8
Ave. Single Channel Sites	9	95.2 (28.2)	442.2 (116.2)	5.1 (2.2)	9.7 (2.5)
Ave. Multiple Channel Sites	4	188.0 (58.6)	618.3 (129.3)	3.4 (1.0)	10.3 (1.9)

It is unknown how the current channel compares to the historical condition. However, degraded riparian vegetation conditions, in-stream structures, and floodplain levees appear to have hastened channel instability and the frequency of meander cut-offs in the assessed reach. These conditions have lowered the river corridor's resistance to high magnitude flood events. Loss of bank stabilizing vegetation, reduction in the channel cross-section area due to in-stream structures, and confinement of flood flows to the active channel by the levees increases the potential for channel instability. The interaction among these variables may also have combined effects on the river corridor.

It is evident from field data and aerial photo review that vegetation conversion, likely attributed to livestock grazing and/or direct removal, has resulted in displacement of riparian vegetation and caused substantial channel widening in some locations. Once riparian vegetation is displaced and/or removed and stream banks lose their competency to resist the erosive forces produced in the channel during high runoff periods, the stream banks succumb to lateral erosion, gravitational collapse, and fluvial entrainment. Over time, and primarily due to accelerated stream bank erosion and down stream meander migration, formation of channel avulsions can occur, resulting in a channel that is steeper than the original channel grade.

3.4 Riparian Vegetation and Wetland Conditions

Riparian vegetation and wetland conditions vary throughout the assessment area. Soil conditions, topography, and hydrologic factors influence plant species' distribution. Historically, a community of grasses and willows likely occupied low-lying swales and stream banks. The forb and shrub community provided floodplain roughness promoting fine sediment deposition on the floodplain during overbank flows. Bank-stabilizing vegetation would have also made the floodplain more resistant to overland flow scour. Drier locations at slightly higher elevations potentially supported aspen and cottonwoods.

Review of the 1940 air photos suggests shrubs were more common in the past relative to the present condition, though the riparian condition appeared to be suppressed by 1940. Altered floodplain and wetland hydrology is largely related to a floodplain levee located on the southwestern side of the channel and the presence of irrigation drains and ditches. Areas that historically may have been dry after the recession of floodwaters now remain wet through most years due to irrigation practices and trapping of surface water behind the levee system. Floodplain channels and depressions retain water on the floodplain, providing diverse riparian habitat for waterfowl and other wildlife.

3.5 Soils

Fluvial and volcanic events have especially influenced basin geomorphology (Akins, 1970). Soils along the Sprague River are poorly drained and formed in alluvium with varying amounts of ash. Nearly level soil surfaces occur on all floodplains. Low soil permeability and frequent clay lenses influence the shallow water table. The water table is typically between 0 and 4 feet below the surface of active floodplains in this portion of the Sprague River although depths to the water table are influenced by pumping, land surface modifications, and floodplain morphology. Normal plant rooting depths reflect water table levels and are typically 60 inches or more. Extensive livestock grazing and agricultural activities over the past century have resulted in compacted soils throughout the project area. Soil compaction has likely impeded the transfer of water in the soil matrix. Soils associated with agricultural areas are often drier due to altered stream hydrology, excavated drainage channels, and ground hardening by livestock (WCI, 2002).

3.6 Fish and Wildlife Resources

The Klamath River Basin hosts two endangered endemic fish species, the Lost River sucker *Deltistes luxatus,* and shortnose sucker *Chasmistes brevirostris.* Once abundant in Upper Klamath Lake, these species have suffered precipitous population declines over the past century largely caused by water development in the Upper Klamath Lake Basin. Both sucker species were classified as federally endangered under the Endangered Species Act in 1988 (USFWS, 1988). The species' critical habitat was classified in 1994.

Upper Klamath Lake supports the largest populations of endangered Lost River (LRS) and shortnose (SNS) suckers in the Klamath Basin (USBR, 2002a). With large-scale water and land development activities in recent decades, the focus sucker populations have declined significantly. The rapid population declines have been attributed to impaired water quality in the Upper Klamath Lake Drainage, water development, and past fishing pressure.

Historically, the endangered sucker species used several Upper Klamath Lake tributaries for spawning and larval rearing. Due to basin-wide habitat degradation, the Williamson and Sprague rivers are the only Upper Klamath Lake tributaries that continue to support substantial sucker spawning (USFWS, 2001). Sprague River sucker spawning habitat is currently impaired by water quality degradation, flow reductions, sedimentation, habitat loss, and fish passage barriers.

The Upper Klamath Lake Drainage fish community has been largely impacted by water development and water quality degradation in the watershed. Basin-wide water development for irrigation and flood control has impaired aquatic and riparian habitat conditions, led to fish entrainment in diversion canals, and modified the basin hydrology.

Fish habitat in the Sprague River project areas is currently functioning below its biological and physical potential. Past grazing management and channel modifications have removed bank-protecting riparian vegetation, simplifying bank margin habitat and destabilizing the channel. These modifications have led to increased bank erosion and sediment inputs, and degraded fish habitat. Riparian vegetation and woody debris, the historical habitat-creating components in the Sprague River watershed, are now infrequent. Channel habitat features created by riffle-pool channel morphology are limited in the project areas. Channel profiles are typically continuous glides with minimal in-stream habitat heterogeneity. Habitat heterogeneity is critical for maintaining a greater number of species and age-classes and better reflects the likely historical channel condition.

Lateral bank erosion and input of fine sediment to the focus reaches have furthered homogenized fish habitat. In-stream fine sediment deposition typically reduces pool depths, fills interstitial substrate spaces critical for sucker larvae survival and macroinvertebrate production, and degrades water quality. The over-widened main stem and tributary channels exacerbate these conditions as the entrenched channels are now largely disconnected from the floodplain terrace, a condition that increases lateral bank failure and in-stream fine sediment deposition. Fine sediment deposition in the Sprague River may also impair the quality of groundwater springs important for sucker spawning.

Klamath large scale suckers *Catostomus snyderi*, Lost River suckers, and shortnose suckers historically used groundwater springs in the Sprague River and tributaries for spawning. Klamath redband trout *Oncorhynchus mykiss newberrii* and bull trout *Salvelinus confluentus*, likely used this section of the Sprague River in the past as a migration corridor and to complete their life histories. Prior to dams been erected on the Klamath River below Upper Klamath Lake, spring and fall runs of chinook salmon *Oncorhynchus tshawytscha*, steelhead *Oncorhynchus mykiss*, and Pacific lamprey *Lampetra tridentate* (Lane and Lane, 1981). Coho salmon *Oncorhynchus kisutch* may have also used the Sprague River drainage.

Local and regional conditions typified by altered riverine ecosystems, past overfishing, and fish passage barriers (e.g. Klamath River dams and the Sprague River Dam) have severely impacted native sucker and salmonid populations in the Upper Klamath Lake drainage. Despite these impacts, the focus sucker species and Klamath redband trout continue to migrate through the project area to reach upstream spawning springs near Beatty Gap. Recent sucker telemetry studies and larval sucker sampling on the Sprague River determined that suckers spawn upstream of the project area (T. Tyler, USGS, personal communication). It is unlikely that bull trout continue to use these downstream reaches due to degraded water quality and elevated water temperature.

4.0 FUGATT PROPERTY CONDITIONS

The following section presents information on the existing river corridor conditions on the Fugatt property.

4.1 General River Corridor Conditions

Upstream of the Fugatt property, the Sprague River has shortened in channel length since the 1940 air photo (Figure 4-1). The shorter channel has increased the energy gradient through the reach, reduced the availability of complex aquatic habitat, and increased water velocities. An expansive floodplain to the southeast of the current channel location suggests the river has migrated down-valley over time. Floodplain channels upstream and adjacent to the Fugatt property suggest dynamic channel-floodplain interactions during high flows.

The Sprague River through the Fugatt property displays unique characteristics (Figure 4-2). In the upstream portion of the property, the Sprague River channel is narrow and deep. Approaching the primary meander in the reach, a high terrace adjacent to the channel controls the lateral adjustment of the river alignment. Composed of pumice sand and a bedrock outcrop, the terrace limits lateral channel migration across the Sprague River floodplain. A clay hardpan layer also surfaces in the channel, limiting channel depth. Downstream of the terrace, the river again narrows and deepens, reflecting the upstream condition. A review of the 1940 air photo reveals that the channel plan form has remained consistent over time. Bank erosion on the point bar of the meander, loss of riparian shrubs downstream from the terrace, and a floodplain overflow channel are the prominent features differentiating the existing condition from the river corridor condition captured in the 1940 air photo.

Figure 4-1. A three dimensional view of the Sprague River upstream and through the Fugatt property. Floodplain channels and an abandoned meander suggest dynamic channel processes. The Fugatt property project area is highlighted by the red line.

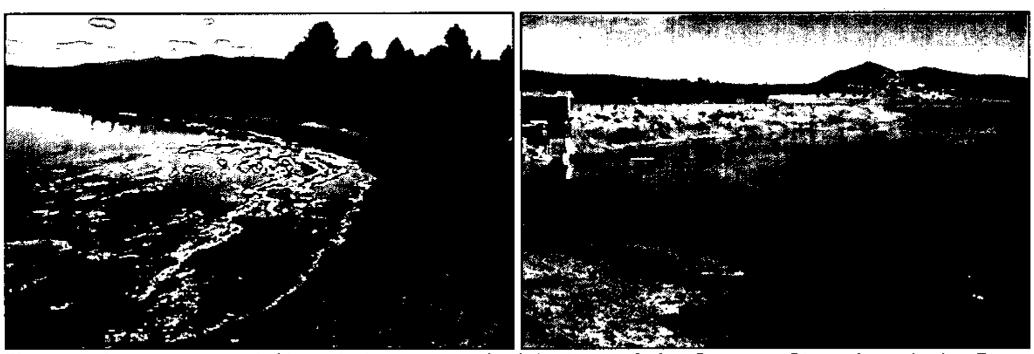

Figure 4-2. Upstream (left) and downstream (right) views of the Sprague River through the Fugatt property. The high terrace bordering the channel and exposed hardpan in the channel, control lateral and vertical channel migration, respectively.

The vegetation in the reach is characterized by a sedge community adjacent to the river with sagebrush on drier terraces. Willows are not found in the reach. The vegetation community reflects the natural conditions of the river corridor as well as the long period of grazing that has occurred on the property. Since purchasing the property, the Fugatts have fenced the property and it is no longer grazed by livestock.

4.2 Channel Conditions

Thirteen cross sections were surveyed through the Fugatt property to characterize the existing channel conditions (Figure 4-3). Cross sections were located to evaluate the channel upstream of the terrace, through the terrace reach, and downstream from the terrace. In plan view, the channel width varies through the reach, especially at the start of the meander. The channel widening is associated with the interaction of the channel with the bedrock outcrop between Cross section 3 and Cross section 4. Table 4-1 displays the bankfull channel dimensions for each of the cross sections presented by subreach.

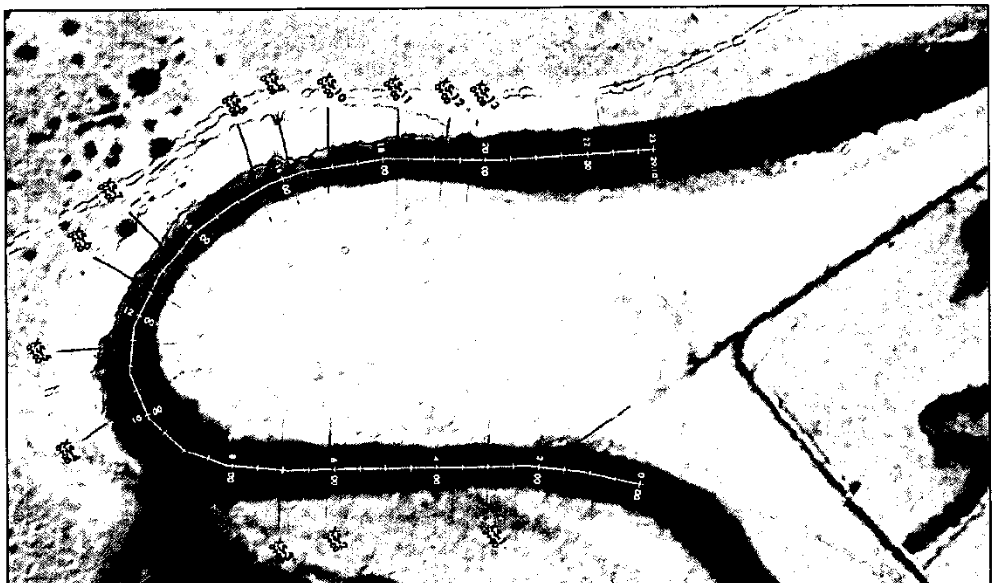

Figure 4-3. Channel cross section locations through the Fugatt reach. Cross sections were situated to evaluate the channel dimensions and how the channel dimensions adjust with the interaction with the clay hardpan from approximately station 11+00 to 18+00.

Typical channel cross sections representing the three sub-reaches are presented in Figure 4-4. Bankfull channel dimensions are presented in Table 4-2. Upstream of the meander, Cross section 1 is characterized by a narrow, deep channel with a vegetated bench below the bankfull elevation. Cross section 8, located downstream from the meander apex, has a wide, shallower morphology. The hardpan is exposed during low flows and does not support vegetation. The smooth surface of the hardpan also results in the efficient transport of bedload through the meander. Gravel in the reach is limited to the margin of the point bar. Cross section 13, located downstream of the terrace and hardpan channel feature, is again narrow and deep, similar to Cross section 1. The channel conditions through the property reflect the presence of the terrace and the hardpan.

Table 4-2. Bankfull channel characteristics for cross sections through the Fugatt property. The channel dimensions in the reach reflect the influence of the bedrock outcrop that controls channel depth.

Cross Section	Subreach	Channel Width (ft)	Channel Area (ft^2)	Mean Depth (ft)	Max Depth (ft)
XS1	Upstream	107.0	602.1	5.6	7.9
XS2	Upstream	133.6	693.5	5.2	7.3
XS3	Upstream	160.0	797.5	5.0	6.8
XS4	Meander	196.3	976.9	5.0	7.2
XS5	Meander	191.9	803.6	4.2	5.2
XS6	Meander	160.7	847.5	5.3	6.6
XS7	Meander	155.4	762.2	4.9	6.2
XS8	Meander	170.6	787.2	4.6	5.7
XS9	Meander	159.0	814.4	5.1	6.2
XS10	Meander	164.0	843.4	5.1	6.3
XS11	Downstream	157.8	738.0	4.7	6.2
XS12	Downstream	148.8	743.3	5.0	7.4
XS13	Downstream	152.8	793.3	5.2	8.0

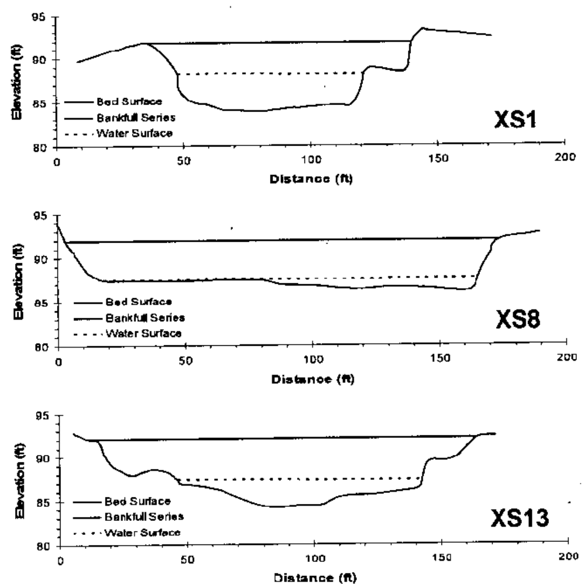

Figure 4-4. Typical channel cross sections through the Fugatt property survey reach.

A longitudinal channel profile was also completed through the reach to evaluate the relation of the channel and bankfull floodplain elevation (Figure 4-5).

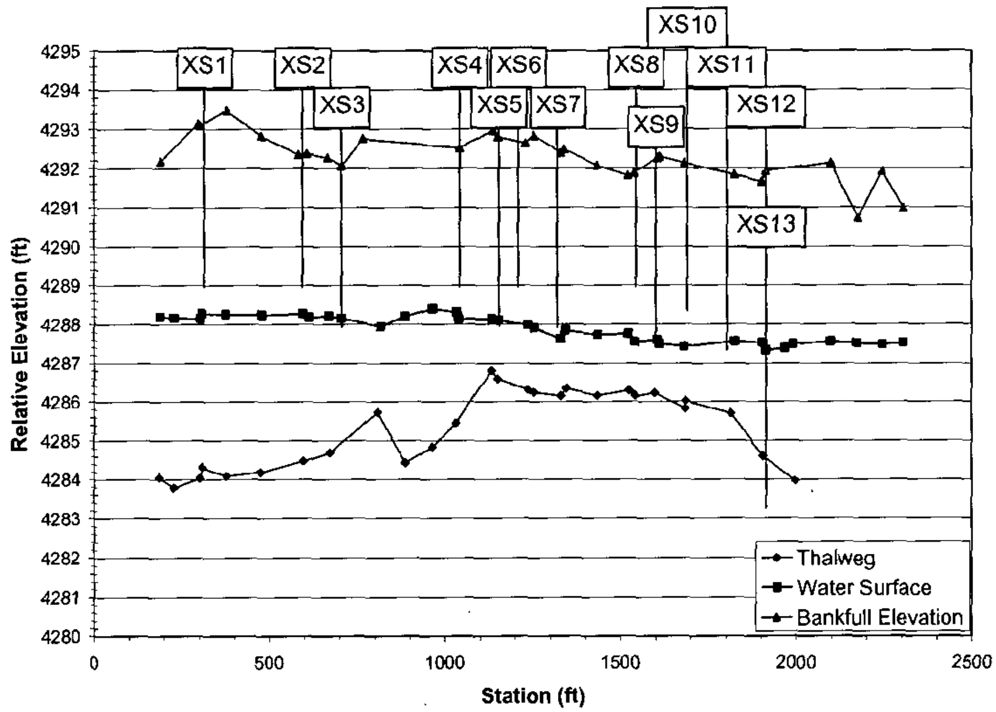

Figure 4-5. The channel profile through the Fugatt reach. The channel cross section locations are denoted by the numbered red boxes. The rise in the channel thalweg from station 11+50 through 18+25 shows where the clay hardpan forms the bed surface of the channel.

The bankfull channel slope is 0.0006 ft/ft. The water surface slope through the reach is 0.0004 ft/ft. The outside of the meander apex is the shallowest portion of the surveyed reach. The hardpan located through this section limits channel scour and pool formation.

A discharge measurement was completed at Cross section 13. The discharge at the time of the survey was 157 cfs. The discharge measured at the U.S. Geological Survey Chiloquin stream flow gage on the Sprague River registered 193 cfs. The U.S. Bureau of Reclamation Beatty stream flow gage on the Sprague River upstream from the Sycan River confluence registered 104 cfs. WinXSPro (Hardy et al., 2005), a one-dimensional hydraulic model, was used to estimate the channel capacity. Data entered into the model included Cross section 13, the measured discharge, the floodplain slope, and the base flow water surface slope. The hydraulic model was calibrated with the base flow discharge data. The model predicted a bankfull discharge of 2000 – 2500 cfs, substantially more than the predicted bankfull discharge of approximately 1,800 cfs at the downstream Sprague River stream flow gaging station near Chiloquin. These results suggest the channel may have extra capacity and the channel may be disconnected from the adjacent floodplain up to the 2-year to 5-year discharge. This would result in an entrenched channel where flows do not access the floodplain as frequently as would be expected based on channel-floodplain connectivity in other portions of the Sprague River.

4.3 Aquatic Habitat Conditions

A range of aquatic habitat conditions are found on the Fugatt property. Upstream and downstream of the primary meander, the Sprague River maintains a narrow and deep channel morphology. Fencing on the Fugatt property has limited livestock access to the river, resulting in an improved vegetation condition. Stable undercut banks provide fish habitat in upstream and downstream portions of the property. The channel morphology through the meander apex is again dominated by the clay hardpan layer. The channel is shallow through this section with limited habitat. Velocities tend to be higher in this section due to the smooth bottom and low channel roughness. Juvenile fish were observed adjacent to the stream bank on the inside of the meander. Juvenile fish used velocity breaks provided by vegetation, stored gravel, and contours in the clay hardpan channel bottom. Vertical banks on the inside of the meander and shallow depths on the outside of the meander provide limited habitat through the meander apex. The smooth channel bed related to the clay hardpan influences gravel storage during high flows when sediment is mobilized through the reach. In the lower third of the meander, rocks and larger pieces of clay hardpan are located in the channel. These materials provide flow refugia for juvenile fish. Numerous fish were observed feeding during the 2005 survey.

4.4 Land Management

The landowner has fenced the property to exclude trespass livestock. The landowner allows several donkeys to graze a small portion of the stream corridor on the left bank downstream from the meander apex. A large pump is also located on the left bank downstream from the meander apex (Figure 4-6). The pump intake relies on water filling an excavated hole in the clay hardpan. Fine sediment typically deposits in the intake hole, reducing pump efficiency. During low water periods, water levels are insufficient for pumping. The landowner is interested in improving the pump's efficiency and increasing the reliability of the pump's water source. In 2005, the landowner with the assistance of the U.S. Fish & Wildlife Service, enhanced an emergent wetland by excavating a floodplain adjacent to the river.

Figure 4-6. *Views of the pump house (left) and pump intake area (right).* A shallow trench has been cut in the clay hardpan to improve water delivery to the pump intake.

4.5 Summary

A bedrock outcrop and clay hardpan layer control the channel morphology through the Fugatt property. Upstream and downstream of the hardpan, the channel is narrow and deep. Aquatic habitat through the hardpan section is limited by a fairly homogenous channel condition characterized by shallow water depths, smooth channel bottom, and simplified channel structure. Vegetation through the reach is characterized by sagebrush on the floodplain and a narrow strip of sedges separating the channel and the floodplain. Vegetation is patchy to absent along the outside bank through the meander apex where the clay hardpan, droughty hillslope, and higher water velocities affect vegetation establishment. Past grazing practices may have suppressed vegetation colonization of the site.

5.0 CONCEPTUAL RESTORATION PLAN

The following sections present conceptual restoration ideas for the Middle Sprague River assessment reach as well as for the Fugatt property. The restoration concepts are generalized and would require additional data collection and analysis prior to implementation.

5.1 Assessment Reach Conceptual Restoration Plan

The Sprague River in the assessment reach has been affected by anthropogenic land uses and natural events. Human activities including levee construction, channel manipulation (e.g. possible dredging and the placement of infrastructure in the channel), and grazing have modified the river corridor making it less resistant to periodic high magnitude flood events. Three abandoned meanders and accelerated bank erosion suggest the river is responding to past and current land use practices.

The following sections present potential restoration activities to improve river stability leading to improved river corridor conditions.

5.1.1 Grazing Management

Grazing has been the predominant land use on the Sprague River floodplain since the late 1800s. Open range grazing is common on this portion of the Sprague River. While appropriately managed grazing does not degrade vegetation conditions, season long grazing or grazing too many livestock on a range has the potential to impair the vegetation community (Figure 5-1). Additionally, suppressed vegetation reduces stream bank resistance to erosion, removes the potential for future woody debris recruitment to the channel, and displaces riparian habitat. Stream bank trampling by livestock results in mechanical bank shear leading to bank failures and sediment delivery to the river.

Grazing management will be a necessary first step in addressing the existing river corridor conditions in the assessment reach. There are several opportunities to improve the river corridor while also meeting the economic needs of the ranching community. First, livestock access to the river must be better managed. Fencing the river channel would allow livestock to continue grazing the floodplain without having free access to the river. Placing water gaps would provide livestock with water access but would confine disturbance to small areas of the river margin. Secondly, grazing could be allowed in the river bottom in the early spring and late fall to capitalize on the forage when the plants are dormant. Livestock would need to be actively managed during these periods to minimize bank disturbance. It is understood that fencing the Sprague River may require periodic maintenance following large flood events and ice floes. However, the long-term benefit of fencing the river channel outweighs the cost of the periodic maintenance. Fencing on the Sprague River upstream of the Town of Sprague River, as well as on the Fugatt property, has successfully excluded livestock from the river channel resulting in the recovery of riparian vegetation.

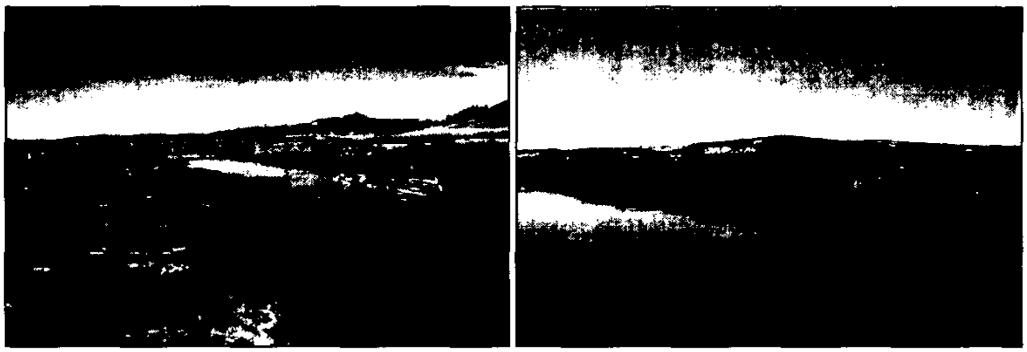

Figure 5-1. *Existing riparian conditions (left) and an example eroding bank (right) related to floodplain grazing.* The photographs were taken in March before the growing season.

5.1.2 Removal of Channel Obstructions

Channel obstructions include remnant dam piers and an irrigation siphon (Figure 5-2). The Sprague River has responded to these in-stream structures by widening or eroding additional channels to increase the channel's cross section area. Channel adjustments have lead to a wider, shallower, and less stable channel.

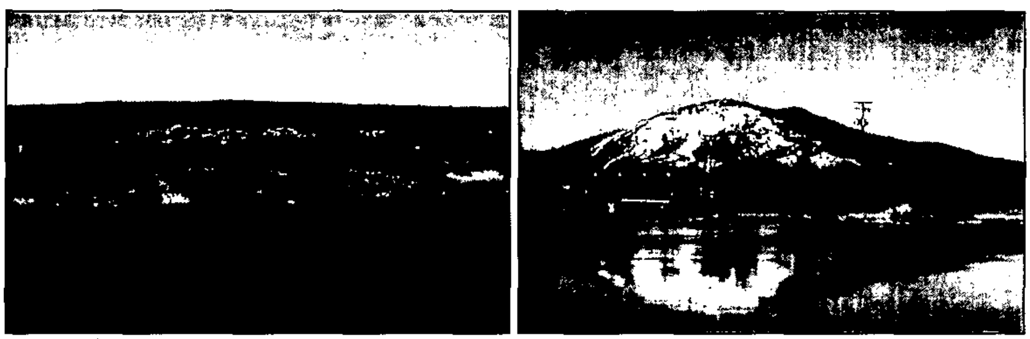

Figure 5-2. Two sites in the assessment reach where in-stream obstructions influence channel stability. The foundation of what is believed to be a former dam at an old manufacturing plant (left) and the remnant piers from an irrigation dam (right) reduce the channel cross section area.

Removing the channel obstructions is recommended to improve the long-term stability of the channel at the affected locations. Removing rock rubble to the channel bottom is advised, though removing the rubble to below the predicted channel scour elevation would be preferable. Channel instability at the affected locations could be treated by sloping and revegetating vertical eroding stream banks with a variety of techniques including vegetated soil lifts.

5.1.3 Floodplain Levee Assessment and Modification

A floodplain levee, constructed after the 1940 air photo, disconnects the river from the adjacent floodplain in the downstream portion of the assessment area. The levee was constructed to improve agriculture and grazing on the Sprague River floodplain by reducing floodplain inundation during spring runoff and periodic rain-on-snow events.

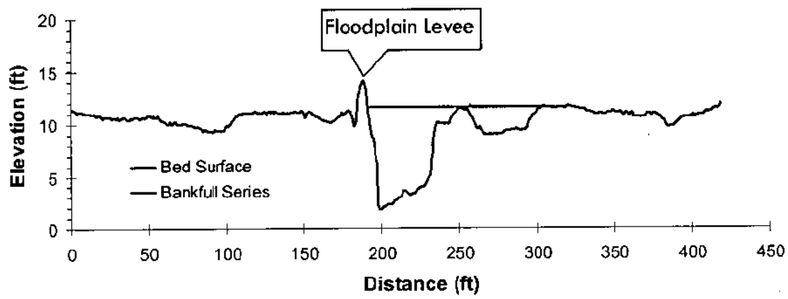

Figure 5-3. Cross section 13 located at the downstream portion of the assessment reach illustrating the channel cross section and the floodplain levee. The levee disconnects the river from more than half of the floodplain. The channel cross section only shows a small portion of the left floodplain. The floodplain climbs in elevation at approximately Station 450 ft and reaches the Sprague River Highway at approximately Station 600 ft. See Figure 3-5 for the cross section location.

The levee has isolated the active channel from the floodplain, disconnected historical channel meanders, and degraded the riparian vegetation community (Figure 5-4). The fill material used to construct the levee is believed to have been excavated from the floodplain and channel. Invasive weeds occupy the levee surface.

Figure 5-4. Vegetation on the levee surface is dominated by noxious weeks and sagebrush (left). The levee disconnects the river from the adjacent floodplain in the downstream portion of the assessment reach.

Addressing the levee will require a more detailed evaluation of the structure and its influence on the river and adjacent properties. Modifying the levee to allow floodwater access to the floodplain behind the levee is recommended. Reconnecting the channel and floodplain would improve habitat diversity, improve floodplain water storage, and likely reduce downstream flood elevations during high water events. Improving floodplain connectivity would also benefit floodplain forage and potentially reduce early season irrigation needs.

5.1.4 River Corridor Habitat

Improving grazing management would be expected to result in a more functional riparian vegetation community. Historically, beaver likely played an important role influencing aquatic habitat. Beaver dams and lodges would have created diverse microhabitats along channel margins. As beaver populations on the Sprague River are now a remnant of the historical condition, the habitat benefits attributed to beavers have also been lost. Reducing grazing on the river bottom is expected to result in the return of willows, a primary food source for beavers. With the eventual return of beavers, fish habitat would likewise improve.

Because the willow regeneration and beaver reintroduction process would likely take a period of time to occur, other measures may be employed to more quickly address the existing simplified aquatic habitat. Placing woody debris jams on channel margins is one method that has been used to increase habitat diversity on the Sprague River. Stable debris jams provide bank integrity and interstitial spaces for juvenile fish rearing. The resistance that debris jams create also promotes vertical channel scour and pool formation. These structures serve as a surrogate for streamside beaver lodges and willow thickets that historically provided aquatic habitat spaces and bank protection. Figure 5-5 shows and example portion of the Sprague River in the assessment reach as well as a woody debris jam constructed on the Sprague River near the Sycan River confluence.

Figure 5-5. An example river corridor condition in the downstream portion of the assessment reach (left). A woody debris jam constructed on the Sprague River provides bank protection and diverse habitat for fish and wildlife (right).

5.1.5 Meander Abandonment (Reactivation and Prevention)

Several opportunities exist to minimize the loss of channel length in the assessment area. Since 1940, channel length in the assessment areas has been reduced by 4,930 ft due to meander abandonment. An additional 3,125 ft of channel is presently at high risk of being disconnected from the primary channel. Several lines of evidence indicate that a combination of land management effects compounded by flooding have accelerated processes associated with meander abandonment on the Sprague River. Although it is not possible to determine how modern channel changes and meander abandonment relates to historical rates, review of the 1940 air photos suggests meander abandonment has accelerated over the past 60 years. Obvious abandoned meanders are not apparent in the 1940 air photos. The processes that have created the current abandoned meanders were set in motion by the 1940s. These processes are believed to be related to land management that included grazing practices that have resulted in the suppression of riparian and upland vegetation.

The objectives of this component of the conceptual restoration plan are two-fold: 1) to reactive abandoned meanders that were disconnected between 1940 and 1998; and 2) to prevent the additional loss of channel length through stabilization of existing floodplain channels. RDG emphasizes that the following concepts will require further evaluation and data collection to determine feasibility. Site stationing corresponds to the channel alignment presented in Appendix B.

Site 1. Meander Reactivation - Station 120+00 to 125+00

Site 1 was identified during the field assessment and occurs at station 120+00 in the project area (Figure 5-6). Based on the air photo analysis, the meander was disconnected from the primary Sprague River alignment between 1940 and 1998. However, by 1940, a majority of the primary flows were likely conveyed through the floodplain avulsion channel rather than the historical primary channel. The historical channel likely conveyed flow during all stages of the hydrograph. However, the historical channel was likely converting from a flowing channel to an abandoned meander. Fine sediment deposition and vegetation encroachment on the channel would have been expected. Meander abandonment by the active channel alignment occurred between 1940 and 1988.

The option to reconnect this section of the Sprague River would be contingent on landowner approval and project feasibility. The project would increase channel length in the middle Sprague River by 3,315 ft from existing conditions. Additional survey work would be required to determine project feasibility. Possible limitations to project success would include the existing vegetation condition, sediment loading to the reach and sediment transport through the re-connected meander, and channel processes that would cause the future re-abandonment of the meander.

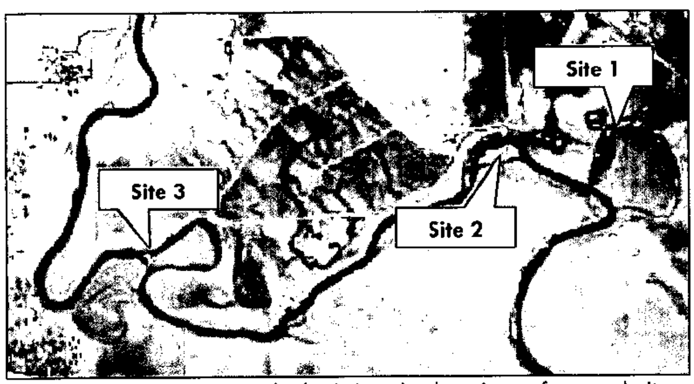

Figure 5-6. A map of the assessment reach depicting the locations of several sites recommended for meander reactivation and meander abandonment prevention.

Site 2. Meander Cutoff Prevention – Station 136+00 to 147+00

Activities specific to Site 2 would focus on preventing meander abandonment. As shown in Figure 5-6, an active floodplain avulsion channel has formed to the south of the primary meander and is conveying a substantial portion of the Sprague River discharge. To prevent a full meander cut-off, engineered log jams coupled with vegetated soil lifts would be constructed at the upstream end of the floodplain avulsion channel. The engineered log jams would act to deflect flows into the primary channel while improving aquatic habitat. The present avulsion channel would remain hydrologically connected to the primary channel alignment as the downstream end would be converted to a backwater wetland. With this alternative, a rigorous revegetation plan would be developed for the floodplain surface to increase floodplain roughness and resistance to scour during flood flows. The remnant dam piers located in the main channel would also be recommended for removal to improve channel capacity.

Site 3. Meander Reactivation – Station 210+00 to 212+00

Site 3 has been identified as a potential site for reactivating approximately 2,600 ft of channel in the assessment area. Similar to Site 1, the channel cutoff was initiated prior to 1998 and was initiated by down-valley meander migration, increasing near-bank stress and streambank erosion potential. In the 1940 air photo, a floodplain surface separated the upstream and downstream extents of the meander. Possibly due to grazing and the reduction in vegetation condition, the narrow floodplain surface separating the upstream and downstream reaches of the Sprague River was compromised, initiating a floodplain avulsion. Presently, the abandoned meander is filling with sediment and transitioning to a wetland. During low flow periods, backwater extends into the oxbow channel providing open water habitat for wetland dependent species.

The option to reconnect this section of the Sprague River would be contingent on landowner approval and project feasibility. The project would increase channel length in the middle Sprague River by 2,600 ft from existing conditions. Additional survey work would be required to determine project feasibility.

Site 4. Meander Cutoff Prevention – Downstream of Cross Section 13 (see Figure 3-5)

Site 4 is characterized by a tortuous meander pattern and well-defined floodplain avulsion channel. The avulsion channel was not present in the 1940 air photo, but was well-defined in the 1998 image of the Sprague River valley bottom. As described for the previous sites, it is anticipated that the existing avulsion channel will capture a greater proportion of the Sprague River flows over time, eventually resulting meander abandonment. Given the relatively early stage of meander cutoff development, a preventative plan is prudent. Restoration activities would be similar to those described for Site 2. Engineered log jams coupled with vegetated soil lifts would be constructed at the upstream end of the floodplain avulsion channel. The woody debris would act to deflect flows into the primary channel while providing for improved aquatic habitat. The present avulsion channel would remain hydrologically connected to the primary channel alignment as the downstream end would be converted to a backwater wetland. With this alternative, a rigorous revegetation plan would be developed for the floodplain surface to increase floodplain roughness and resistance to scour during flood flows.

5.1.6 Summary

Passive and active restoration treatments proposed for the Middle Sprague River assessment area are intended to improve river corridor riparian vegetation conditions, aquatic habitat, and stream bank stability. A long period of grazing and agriculture has modified the Sprague River and its adjacent floodplain. Presented restoration options aim to re-establish the historical processes that created and maintained aquatic habitat, while also benefiting floodplain landowners. Past floodplain levee building and in-stream structure installation have altered river functions. Reconnecting the river to its floodplain and removing in-stream structures would be expected to benefit the river corridor.

5.2 Fugatt Reach Conceptual Restoration Plan

One objective of the Middle Sprague River Assessment was to evaluate the Fugatt property and develop conceptual restoration options with cost estimates. Additionally, the Fugatts are interested in improving the function of their surface water pump located on the west bank of the river.

5.2.1 Fugatt Property Overview

The Fugatts have fenced their property boundary to exclude livestock from the river. The Fugatts also completed a wetland enhancement project in 2005 on the west side of the Sprague River in a narrow portion of the floodplain. The wetland project included excavating an existing shallow wetland to increase the wetland's water holding capacity. Willows are scheduled to be planted in 2006. A surface water pump located on the Fugatt property functions during elevated flows but is less efficient during base flows. Sand deposition fouls the intake area requiring regular maintenance for proper pump function.

5.2.2 Aquatic Habitat Improvement Options

The Sprague River through the Fugatt property is characterized by unique channel morphology. A clay hardpan layer surfaces in the river and controls the channel's morphology and rate of lateral migration. Compared to other portions of the Sprague River in the assessment reach, the river through the Fugatt property appears to have changed little since the 1940 air photo. The riparian fencing the Fugatts have completed is expected to result in an improved riparian vegetation condition due to the livestock exclusion.

Active restoration opportunities on the Fugatt property are limited due to the channel morphology in the reach. Channel excavation for creating more pool habitat in the reach is not warranted due to the unique nature of the clay hardpan layer that dominates the reach. However, placement of stable engineered log jams in the upstream and downstream portions of the property would increase aquatic habitat diversity and potentially attract beavers to the area. An engineered log jam completed on the Sprague River near the Sycan River confluence is being used by a beaver and is providing a protected area for willow growth. Log jams for diversifying aquatic habitat are recommended for upstream and downstream of the primary meander in the reach. Jams would be located where the potential for channel scour and pool formation is greatest. Similarly, locating structures where the channel and floodplain are well connected (e.g. where there is a low bank height relative to the floodplain surface) would reduce the stress on the structure and surrounding banks during flood events.

Engineered log jams would be comprised of rootwads with attached stems as well as tree tops without attached rootwads. Rootwads would average 3 ft to 4 ft in fan diameter and have minimum stem lengths of 25 ft to 30 ft (Figure 5-7). Approximately 10 rootwads would be incorporated in each structure, along with multiple broken stems, logs, and branches to provide additional structure mass and aquatic habitat diversity. Each structure would be anchored with approximately 10 cubic yards of rock. A typical detail for an engineered log jam is presented on Sheet DT-1 in Appendix C.

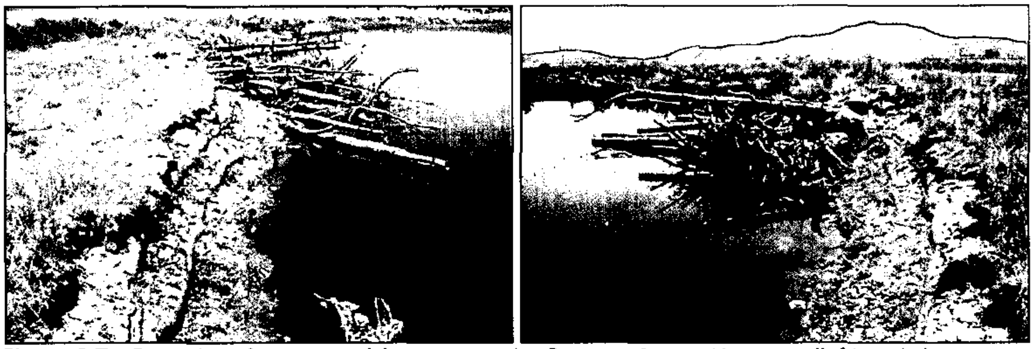

Figure 5-7. Examples of engineered log jams on the Sprague River. Upstream (left) and downstream (right) views of two structures illustrate the bank protection and aquatic habitat creation benefits of the structures. Willow cuttings planted in the soil lifts will provide additional bank stability and riparian habitat in the future.

5.2.3 Riparian Planting

While riparian vegetation condition is expected to improve with the livestock exclusion, riparian plantings are also warranted to speed the vegetation recovery. Willow species found on the Middle Sprague River include *Salix lasiandra* (Pacific willow), *S. lasiolepis* (arroyo willow), *S. geyeriana* (Geyer willow), and *S. bebbiana* (Bebb willow). Planting willow cuttings or containerized plants from locally harvested stock would have the greatest potential for survival. *Ribes aureum* (golden currant) is a plant commonly found on the Sprague River where the river corridor transitions from wetter floodplain areas to the drier sagebrush upland. Planting this species on floodplain benches would increase riparian vegetation diversity on the property. In addition to the proposed plantings, the river corridor through the property should also be monitored to evaluate how willows and other woody species recolonize the site over time.

Although mechanical channel modifications are not recommended through the primary meander on the Fugatt property, bioengineering techniques could be used to stabilize the toe of the terrace and to further improve the riparian condition. Willows at the toe of the slope would trap fine sediment, contribute small woody debris to the channel, and provide riparian habitat for birds and wildlife. Over time as sediment accumulates on the clay hardpan layer, vegetation will establish. An example of an alluvial bar and colonization vegetation from another location on the Sprague River is shown in Figure 5-8. Livestock have been excluded from this site for 5 years.

Figure 5-8. The existing condition on the Fugatt property at the primary meander is characterized by a clay hardpan surface that is nearly devoid of vegetation (left). Planting willows at the toe of the slope will trap fine sediment that could eventually support an herbaceous plant community similar to another reach of the Sprague River that has been fenced to exclude livestock from the channel bottom (right).

5.2.4 Pump Improvement

There are three options for improving the operation of the Fugatt's pump. First, the excavated trench from the baseflow channel of the Sprague River to the pump intake could be expanded. Expanding the trench would require an excavator or backhoe to lower the invert elevation as well as widen the trench. Lowering and expanding the trench would increase the volume of water delivered to the pump intake as well as increase the pumping efficiency longer into the baseflow season. The benefits of this approach include the low cost to execute and the low environmental risk of the action. The downside of this approach would be that the trench would need to be maintained and occasionally cleaned of deposited sediment. Additionally, this approach would require excavating the clay hardpan channel bottom. An additional technique would be to attach a screened or slotted pipe to the pump intake and place the pipe in the trench extending to the low flow channel.

A second option would include placing a check structure downstream of the pump intake to raise the local water surface elevation necessary to provide a deeper pool for the pump intake. A simple approach would be to place rock in the channel to an elevation corresponding to the elevation of the pump intake. The rock would span the outer two-thirds of the channel and would not impede fish passage or recreators on the river. Based on the presence of large rock (approximate dimensions: 2 ft x 1 ft) in the channel in the vicinity of the pump house, it appears as though a similar effort was attempted in the past. The benefits of this approach include the low cost to execute and the low environmental risk of the action. The added substrate would also increase the range of aquatic microhabitats in the reach, benefiting resident fish. The downside of this approach would be the placement of foreign material in the channel and future maintenance. This approach could also affect channel stability as channel adjustments have typically occurred where other channel obstructions are located in the assessment reach, although the other channel obstructions are substantially larger in size than the structure being proposed here.

A third option would include relocating the pump to a deeper portion of the river downstream from the clay hardpan. A recommended approach would be to establish a pumping station with a screened pipe extending into the low flow channel. Depending on the location and elevation of the pumping station, the pump could either be a permanent fixture or could be constructed as a seasonal mounting where the pump could be removed at the end of irrigation season. The benefits of this approach would be a more long term resolution of the pump efficiency problem than the first two options. The downside would be the cost of establishing another pump location and if a seasonal structure was selected, the landowner would be responsible for annually placing and removing the pump from the structure housing. The structure housing would also contribute to the infrastructure located in the floodway. Depending on how far the pump would be moved, the Fugatts could potentially have to file for a new point of diversion.

5.3 Restoration Treatments Summary

Several restoration treatments are proposed for both the assessment reach and the Fugatt property. Presented passive and active restoration treatments aim to improve the Sprague River corridor by improving the riparian vegetation condition and aquatic habitat diversity. Fencing throughout the assessment reach should be completed prior to implementing active restoration treatments. Fencing on the Fugatt property is expected to improve vegetation conditions, bank stability, and riparian habitats. A wetland creation project will be monitored to evaluate juvenile fish, amphibian, and waterfowl use. Increasing the distribution of stable woody debris in the assessment reach as well as on the Fugatt property would be expected to provide more diverse habitat for juvenile fish. Ultimately, reestablishing a beaver population in the assessment reach would provide long term benefits for river function.

6.0 CONCLUSION

The Middle Sprague River Assessment Reach captures a dynamic portion of the Sprague River. Past and contemporary land use activities have modified the river corridor. Channel avulsions have, or are in the process of, disconnecting three substantial meanders. The river has also responded to in-stream obstructions by widening and eroding new channels. A floodplain levee has confined the river in the downstream portion of the assessment reach. Despite these past natural and human-influenced river corridor changes, there is an evolving understanding of the river's association with its floodplain. Re-establishing riparian vegetation and beaver populations in the assessment reach is necessary to restore historical processes that provided a diverse riverine environment.

The Fugatt property offers opportunities to evaluate how vegetation, fish, and wildlife respond to restoration treatments. Livestock have been excluded from the river margins and a floodplain wetland was recently enhanced. Recommended actions for the Fugatt property include planting riparian vegetation, placing stable engineered log jams, and addressing the existing surface water pump.

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