Appendix E

Historical Forms and Processes

Middle Twisp River (RM 7.8 – 18.12)

Contents

1 Historical Channel Form and Processes

Although there is little direct evidence of conditions prior to the mid-1900s, field observations, high resolution LiDAR, General Land Office maps (1902, 1913), underlying geology, and glaciation cycles can provide some theories on historical channel form. During the Pleistocene era, an era defined by a cooler climate and much larger precipitation volumes, the channel form was likely created by large, high volume flooding and sediment inputs. Large boulders and cobbles located on abandoned floodplain surfaces indicate historically the channel moved much larger volumes of water and sediment. This, combined with periodic bursts of glacial meltwater outwash, created a wide, deep channel, fit for transporting large flows and sediment loads. During this time period, the Twisp River's active corridor likely spanned much of the valley floor.

As the Pleistocene epoch came to a close, glaciers in the region retreated. This left behind thick deposits of glacial sediments (glacial terraces) from the upstream extent of the study area down to RM 10. Concurrently, the Twisp climate became much warmer and drier, and the channel no longer had the volumes of water necessary to fill its channel and span the valley floor. Over time, the now 'underfit' Twisp River down-cut into its channel bed, leaving behind abandoned floodplain surfaces and terrace deposits which serve as contemporary controls on lateral channel migration.

Limits on lateral migration processes were also imposed by bedrock outcrops, mass-wasting deposits, and alluvial fan inputs from contributing drainages throughout the study reach. Historically, alluvial fans delivered large amounts of material to the system. This material correlated with the larger discharges of the time, so these drainages were able to transport large cobbles and boulders. As these sediment inputs aggregated, they spanned across the valley floor. This process, as well as occasional mass-wasting events, would divert the boundaries of the channel, moving it towards the opposite slope. The channel would remain in its new course until larger flows would move this material through the system, allowing the channel to migrate into a new course.

Variations in confinement would have been a major driver of channel-scale geomorphic processes. These variations can be classified into three relative scales of confinement: confined, moderately confined, and unconfined. Throughout the confined reaches (e.g. Reach 2), lateral migration of the channel would have been highly limited by valley wall encroachment and narrow glacial terraces on either side. High confinement and high stream power would have limited habitat complexity principally to boulders. These boulders would have created hydraulic variability, scour pools, and temporary locations for the accumulation of large woody material. Within the moderately confined reaches (e.g. Reach 4), glacial terraces and alluvial fan deposits would have allowed for slightly more channel migration. Here, slightly lower stream power would have made habitat features less transient, with sediment deposition and sorting, wood accumulations, and occasional off and side-channel habitat. Lastly, the unconfined reaches (e.g. Reach 5) would have displayed the highest level of habitat complexity throughout the study area. The processes of channel avulsion, lateral migration, sediment deposition, channel braiding, floodplain scouring, and accumulation of large wood would have created complex habitat features.

2 Historical Hydrologic Regime

The headwaters of the Twisp River originate on the eastern slope of the Cascade Mountains. Historically, following the last period of glaciation, there were likely more active tributaries than contemporary conditions, and these tributaries would have input much larger discharges than today. Similar to contemporary conditions, the natural hydrologic regime within the study area was dominated by the seasonal dynamics of a snowmelt runoff system. The flow pattern would have exhibited increasing flow through the spring with an annual peak in June and a rapid decline to baseflow conditions by August. Due to the coarse alluvial and glaciofluvial sediments characteristic of the watershed, ground and surface water interactions likely had an impact on both discharge and stream temperature (Konrad 2002). Historical streamflows for the Twisp are unknown, as irrigation diversions occurred prior to installation of the first stream gage.

3 Historical Habitat Conditions

There is no information specifically describing the pre-disturbance habitat conditions of the Twisp River within the study area. Land-use development and disturbance had advanced quickly preceding the time of the first reports on conditions in the watershed. Despite a lack of pre-disturbance habitat observations, reasonable reconstruction of historical habitat can be accomplished based on observations of existing conditions, knowledge of first-order controls on channel processes (geology), and the typical results of early documented land-use activities (logging and grazing). Pre-disturbance conditions in the study area can be broken into three categories based on their confinement: confined, moderately confined, and unconfined.

The confined reaches (Reaches 1 and 2) would have had high lateral and vertical stability. These reaches are likely closer to their pre-disturbance condition where major habitat elements in the channel are large boulders, log jams, and plunge pool or dam pools. Off-channel habitat is naturally limited in these reaches, and a reduction in such habitat would not be expected via human disturbance. Log jams would have likely played a very transitory role in providing habitat, with only very large pieces being persistent, as high energy during floods would be capable of moving most large woody material (LWM) through these reaches.

Within moderately confined reaches (Reaches 3 and 4) there would have been an increase in channel complexity and associated habitat elements. Large floods would have created side channel habitat in select locations and large wood would have provided some gravel recruitment and sorting. In areas where glacial terraces and fan deposits created constriction points, habitat would have been less complex.

Within unconfined reaches (Reaches 5 and 6), a higher concentration of gravels, greater sinuosity, side-channels, and wider riparian areas would have combined to create complex habitat. Large wood would have provided cover and complexity, as well as serving as a geomorphic driver of channel form. Off-channel habitat would have been mainly composed of side-channels with some floodplain wetlands.

The earliest available habitat survey was performed in 1935. This habitat survey described a stream capable of supporting runs of several thousand salmon and steelhead with “an adequate number of large resting pools and sufficient shallow riffles to accommodate large runs of salmon and steelhead.” Streambed substrate was documented as 65% medium and small rubble, a large portion of which was described as suitable for spawning.

4 Historical Large Wood Dynamics

Historically, large wood would have been an important driver of geomorphic form and process, and would have had a strong influence on instream habitat availability and complexity. The following section outlines large wood dynamics, including sources of instream large wood (sources), how wood is made available to the stream (recruitment), and how wood is retained within the stream where it provides habitat functions (retention).

4.1 SOURCES

In a pre-disturbance condition, there were two primary sources for large wood material on the Twisp River (1) additions from the active river corridor (floodplain, terrace slopes, and riparian areas), and (2) wood contributed from the upper basin that entered the system through periodic landslides. Through the study reach, riparian and upslope areas historically included pine and fir (GLO 1913).

The species and size of wood sourced from the contributing watershed would have varied depending upon time since the last disturbance (e.g. floods and fires). Although trees aged between 200 and 500 years of age were found in the watershed, if a disturbance was relatively recent, smaller hardwoods would have likely been predominant (USBR 2008). Conversely, if a disturbance had not occurred recently larger, coniferous trees likely were predominant. Compared to existing conditions, there would have been a greater source of large old-growth trees that would have been periodically recruited to the system. Early General Land Office (GLO) surveys note pines up to forty inches in diameter.

4.2 RECRUITMENT

Historically, large wood would have entered the Twisp from both chronic (i.e. single-tree) mortality and episodic disturbance-related events. Disturbance-related contributions would have included fire, floods, windstorms, avalanches, diseases, and landslides. The unconfined reaches would have recruited wood via lateral and transverse scrolling of the channel, whereas recruitment in the more confined reaches would have occurred primarily through single-tree mortality.

4.3 RETENTION

Retention of large wood is related to characteristics of the wood itself and also characteristics of the stream channel (Gurnell 2003). In general, the larger the wood piece (diameter and length) with respect to channel size (width and depth), the more likely it is that wood will be retained (Bilby and Ward 1989, Brauderick and Grant 2000, Bocchiola et al. 2008). In large rivers, wood is frequently retained in the channel in the form of log jams. Large, stable pieces that initiate log jam formation are often referred to as “key pieces” (WFPB 1997). Key pieces, which typically have attached rootwads, are retained in the channel first and serve as foundation pieces for capturing and racking additional wood from upstream. In the pre-disturbance Twisp River, the greater availability of these larger key piece sized pieces, as discussed previously, would have supported a greater degree of log jam formation. Furthermore, these log jams would have been retained much longer.

Another important factor affecting wood retention is the degree of channel complexity. A complex channel with numerous obstructions to flow (e.g. bank protrusions, islands, gravel deposits, boulders, wood pieces) will retain wood more readily than simplified uniform channels (Fetherston et al. 1995, Haga et al. 2002, Bocchiola et al. 2008). A historically more complex channel, prior to human alteration, would have retained more wood than contemporary conditions. These wood accumulations would have promoted both geomorphic and habitat functions including creation of pools, sediment retention (trapping) and sorting, increased channel complexity and cover for fish. Through the less confined reaches, these jams would have driven the creation of numerous point- and mid-channel bars and the creation of side channels. Within more confined reaches, large wood jams likely would have been created between large boulders. Wood would have accumulated behind these channel-spanning key pieces until a large enough flood would remobilize the wood and displace the jam.

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