3.3 Geology, Fluvial Geomorphology, and Soils

This section addresses geologic, fluvial geomorphic, and soils issues related to implementation of the Proposed Action and alternatives. The following evaluation is based on review of existing literature and data, along with information obtained from the wetland delineation, reconnaissance-level assessment of the local geologic and geomorphic conditions, and detailed geomorphic mapping provided by the TRRP.

3.3.1 Affected Environment/Environmental Setting

Regional Geology

The Trinity River basin occupies portions of two parallel but distinct geologic provinces: the Coast Ranges Province and the inland Klamath Mountains Province. The presence of both provinces can be attributed to processes associated with plate tectonics, the interaction of mobile plates of the Earth's crust. In both cases, convergent motion of crustal (lithospheric) plates, where a relatively thin, dense oceanic plate collided with the thicker, more buoyant continental crust, has accreted material to the western edge of North America, uplifting and deforming it to produce the landscapes seen today.

The Coast Ranges Province, which consists chiefly of the well-known Franciscan Assemblage and its associated basal unit, the South Fork Mountain Schist, is composed of highly disrupted and generally unstable rocks of sedimentary and volcanic origin. It occupies a limited area (approximately 56,000 acres, or less than 3 percent of the basin) at the northwestern extremity of the watershed downriver from any proposed TRRP projects. The Coast Ranges of northern California represent recent and contemporary accretion and uplift of geologic materials associated with the development of the Cascadia Subduction Zone, which is also responsible for the formation of the Cascade Range volcanoes to the north and east of the Trinity River basin, including Mt. Shasta and Mt. Lassen.

East of the Coast Ranges, the Klamath Mountains were assembled from older metamorphic and igneous intrusive or *plutonic* rocks. The majority of the Trinity River basin lies within the Klamath Mountain Province. This province is divided into the Eastern Klamath, Central Metamorphic, Western Paleozoic and Triassic, and Western Jurassic sub-provinces or *terranes*. These terranes were successively accreted against the western margin of North America over an approximately 300-million-year period of convergent motion of lithospheric plates and are generally younger from east to west. The Klamath Mountains represent one of the most complete records of the westward growth of the North American continent.

Plutonic intrusions into metamorphic rocks are distributed across the watershed. These are often informally termed *granitic* rocks or granite. Some of the larger intrusions include the Shasta Bally Batholith at the headwaters of Grass Valley Creek, and numerous plutons that form the granitic core of the Salmon-Trinity Alps. Granitic rocks are highly erodible; they weather into individual sand-size grains and are a chronic source of fine sediment to streams and rivers. Grass Valley Creek is a classic example of a tributary source of fine sediment to the Trinity River downstream of the TRD.

Several distinct sedimentary units occur within the watershed. The Weaverville Formation, a series of non-marine deposits, is exposed in fault-bounded valleys across the southeastern portion of the watershed. Younger terraces and floodplains occur in the largest river valleys in the watershed, and some older alluvial deposits are located in higher topographic positions where uplift has occurred since their deposition. These deposits were the focus of large-scale placer gold mines that re-shaped the alluvial landscapes of Trinity County during the Gold Rush era. Glacially eroded materials, largely of granitic origin, add to the sediment input to the Trinity River system, particularly from streams such as Rush and Weaver creeks that emanate from the Salmon-Trinity Alps.

Local Geology

Surficial deposits blanket the project area and consist of recent and modern alluvial floodplain and terrace deposits and historic hydraulic and dredge tailings. The project will take place almost entirely in Quaternary alluvium that overlies the older terranes of the Klamath Mountains.

Several regional formations from the Klamath Mountain terranes dominate the local geology. The Trinity River channel is bounded in several areas by bedrock as it flows through the project area. The geology of the southern edge of the project area is the dominated by the Shasta Bally batholith and its associated emplacement. The portion of the batholith in the project area consists of quartz diorite. The batholith is markedly elongate, trending roughly northwest. This batholith intruded the older Copley greenstone and the Bragdon formations and caused regional contact metamorphism. Copley greenstone is a metamorphosed volcanic sequence that consists mostly of intermediate and mafic volcanic rocks. The Bragdon formation is a metamorphosed sedimentary formation that locally has been converted to gneiss and amphibolite. The northern edge of the project area shares the same geologic formations as the southern edge, but the Shasta Bally batholith is less prominent. The Copely greenstone and contact metamorphosed Bragdon formation are found on the north side of the river, north of Lewiston. The Dark Gulch site is bounded by the Shasta Bally batholith to the north and south.

Mines and Mineral Resources

The geologic properties of many of the terranes are related to their origins as oceanic crust and/or their intrusion by plutonic bodies; these properties have resulted in mineralization that is widely distributed across the watershed. Many minerals of economic importance are present, including gold, copper, zinc, chromite, manganese, platinum, silver, and mercury. These minerals have been mined by a variety of methods from the advent of European settlement to the present.

Historically, the principal mineral of economic importance was gold; the Trinity River watershed had the greatest concentration of gold mines in California outside of the Sierra Nevada. Both lode (hardrock) mines and placer (alluvial gravel) mines are present in the watershed, with activity from 1848 to the present. The tailing deposits associated with large-scale placer mining provide a substantial source of aggregate required in various construction projects. Recent and ancient alluvial deposits were mined until the 1940s using a variety of techniques. The hydraulic mining operations used high water pressure to erode and mobilize large quantities of unconsolidated overburden from gold-bearing areas. Evidence of this activity can be seen from the banks of the Trinity River within the site boundaries. Large-scale bucket-line dredge operations were also common between 1930 and 1950. These activities left behind tailing deposits that continue to influence the form and function of the Trinity River, particularly at the FG and DG activity areas.

Since World War II, mineral extraction activities have focused on aggregate resources, although some gold mining activity continues, primarily using suction dredging. Over time, aggregate mining of alluvial deposits and reworking of hydraulic tailings have resulted in additional channel modifications and changes in sediment supply.

Active Mining Claims

The General Mining Law of 1872 is one of the major statutes that direct the federal government's land management policy. The law grants free access to individuals and corporations to prospect for minerals in public domain lands and allows them, upon making a discovery, to stake (or "locate") a claim on that deposit. Those sections of the Trinity River that are under federal jurisdiction are therefore open to prospecting.

A number of placer mining claims exist along the Trinity River. Placer claims are established with the intent to sort unconsolidated alluvial materials for precious metals (i.e., gold, platinum). Suction dredging is the principal mining method used for these claims, typically during low-flow periods when alluvial features are exposed or accessible. The closest placer mining claim to the rehabilitation sites occurs in Lewiston, downstream of the FG activity area. There has been no mining activity associated with this claim for several years (Hitt, pers. comm. 2006). Proposed rehabilitation activities are not likely to disturb materials at this claim or disrupt any ongoing mining developments and activities within the boundary of either site.

Regional Fluvial Geomorphology

Fluvial geomorphology was fundamental in the evaluation and selection of the preferred alternative for the FEIS/EIR. Addressing the relationships between flow, sediment, and vegetation formed the basis for the Implementation Plan (Appendix C of the FEIS/EIR). This plan identified a number of actions concerning flow and sediment that would be implemented. These actions included:

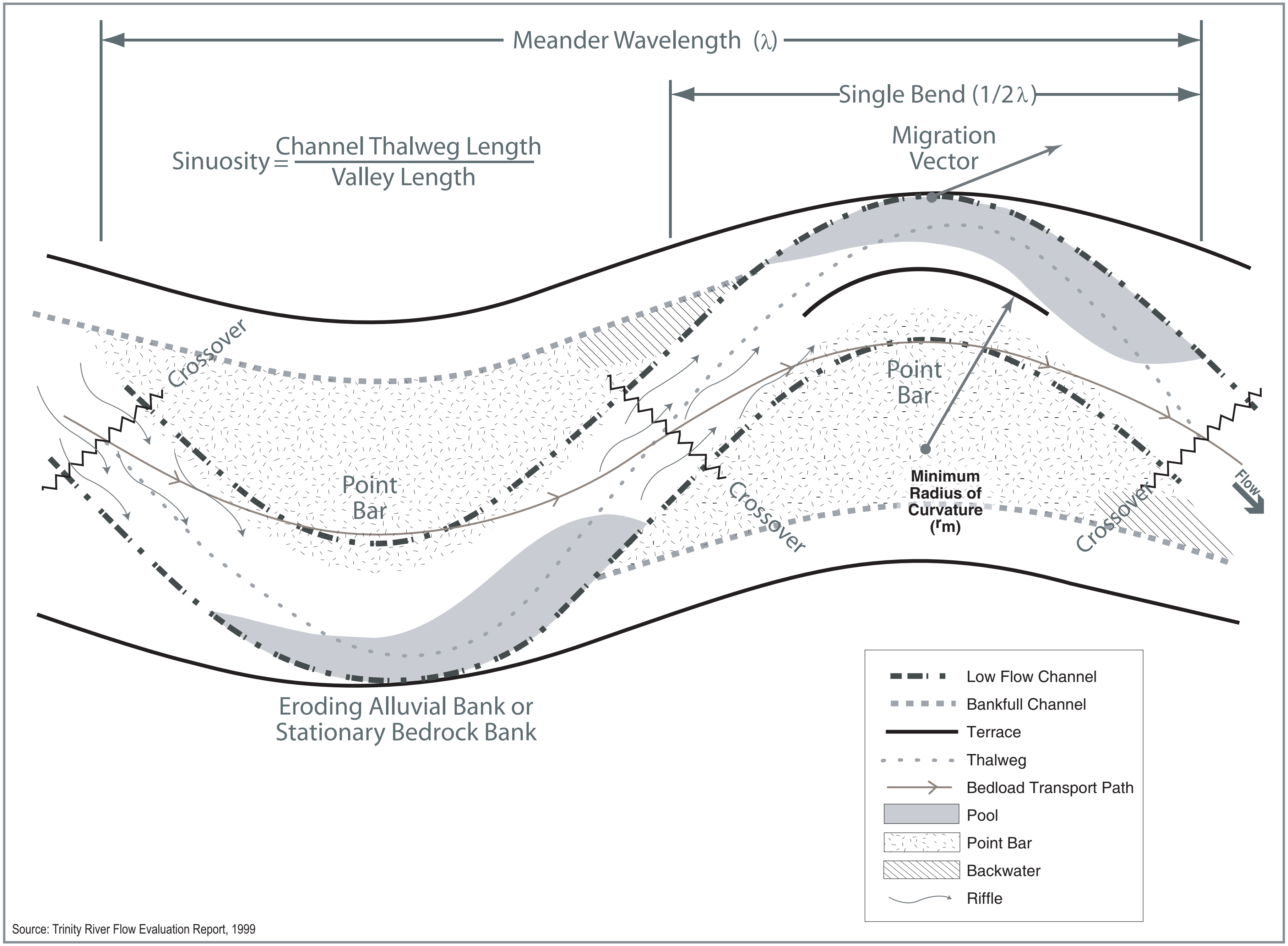
- instream release volumes to the Trinity River (dam releases, storage, timing)
- mechanical rehabilitation (high flow and channel projects)
- coarse and fine sediment management program (coarse augmentation, fine control)
- infrastructure modifications (bridges, structure relocations)
- watershed protection program
- adaptive environmental assessment and management

River channels are formed and maintained by the dynamic interaction of three primary components: sediment of various size classes, varying quantities and ages of vegetation, and varying amounts of water. Complex interactions between these three components define the geomorphic environment and provide a diversity of physical structures, such as point bars and riffle-pool sequences, that perform a variety of environmental functions. The resulting geomorphic environment typically supports a unique ecosystem that depends on geomorphic processes to maintain its fundamental structure. A change in one or more of these components would change the geomorphic environment (U.S. Fish and Wildlife Service et al. 2000b).

Generally, a highly variable flow regime in an alluvial river system results in a physically complex river that provides substantial ecological benefits. This complexity provides a variety of riverine and riparian habitats that can be used by different species under a range of flows. Varying flows impart varying amounts of energy throughout a river channel and elicit varying responses in the river channel. Flows can mobilize and deposit a wide range of sediment particle sizes, ranging from fine material to large boulders during peak events. This movement and deposition of sediment particles in turn scour and shape the river channel, creating river bars, pools, and riffles, and can force the main channel to shift its position in the floodplain (Figure 3.3-1). Within the scour zone, vegetation on gravel bars is inhibited by the depth and duration of flow.

The construction of the TRD replaced the Trinity River's pre-dam hydrology with a greatly reduced, near-constant flow schedule (Figure 3.3-2) from 1960 to 2004. This reduction in water and associated energy has directly affected the character of the channel (Figure 3.3-3). The lower flows allowed woody riparian vegetation (e.g., willows, alders) along the channel to become established and to mature, and sediment berms developed along the channel margins. These berms further anchored the sides of the channel and resulted in the loss of many broad, gently sloping point bars, thereby converting the pool-riffle-run sequences created by alternate bar sequences to a largely monotypic run habitat. The loss of these bars has substantially reduced the complexity and diversity of riparian and riverine habitats (McBain and Trush 1997). These changes in geomorphic processes and channel geomorphology have decreased the quantity and quality of these habitats.

Ten attributes were identified in the Trinity River Flow Evaluation Report (U.S. Fish and Wildlife Service et al. 1999) and used in the FEIS/EIR to describe the geomorphic environment and processes of a healthy alluvial river. These attributes were developed specifically for the Trinity River based on an in-depth historical and literature search (McBain and Trush 1997) and a comparison of pre- and post-dam conditions in the watershed. The comparison was largely based on aerial photographs taken before and after dam construction. The "healthy river" attributes provide a foundation for understanding the dynamic equilibrium of the river, and were used to develop recommendations to meet rehabilitation objectives. The healthy river attributes described in the FEIS/EIR provide a benchmark for evaluating potential strategies for improving the fishery within the mainstem Trinity River. The methodology used in the FEIS/EIR assumed that if all 10 of these attributes were present, the Trinity River would have the physical characteristics necessary to support a healthy alluvial river ecosystem.



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Source: Trinity River Flow Evaluation Report, 1999

Figure 3.3-1

Alternate Bar Formation

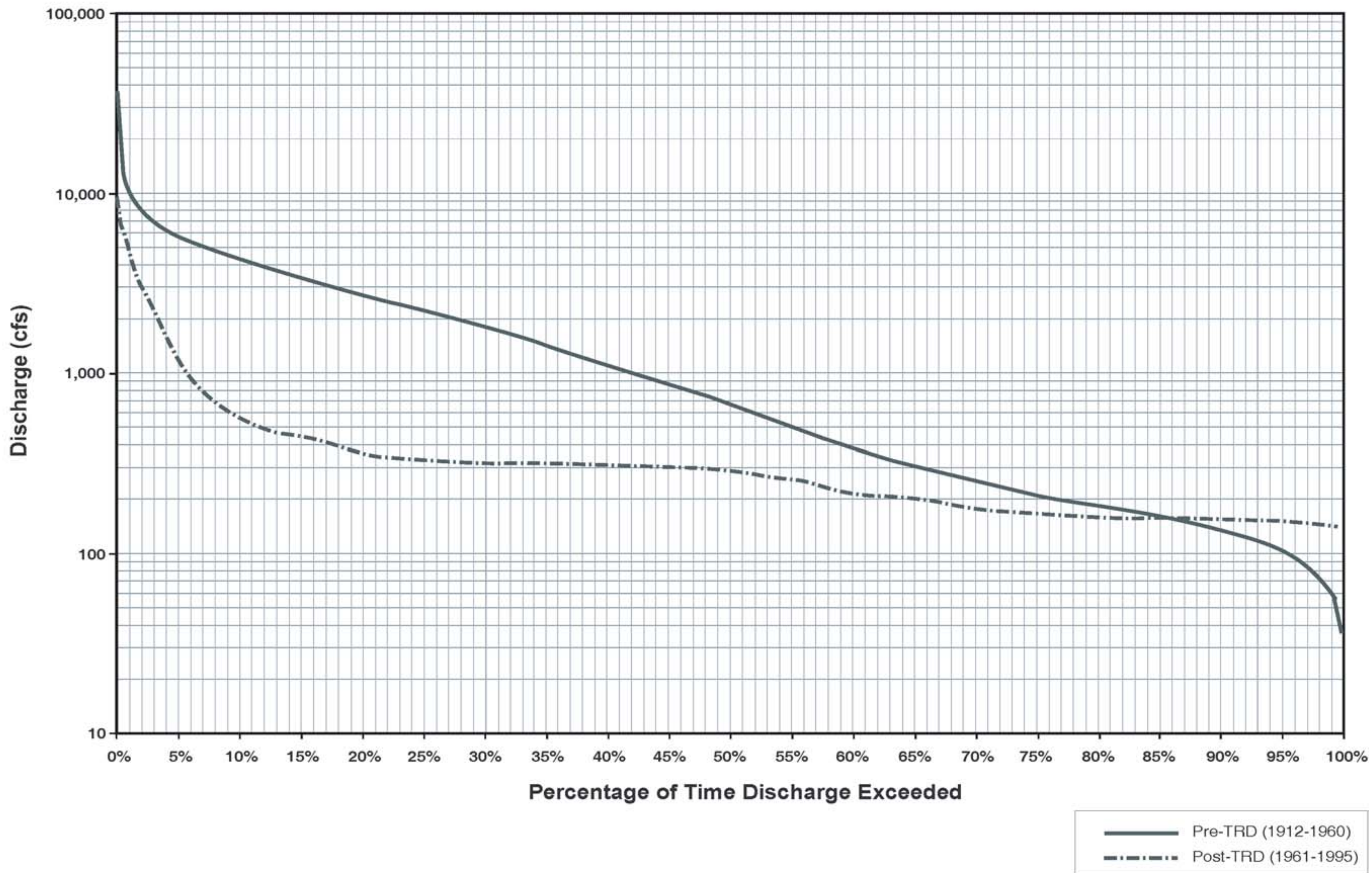
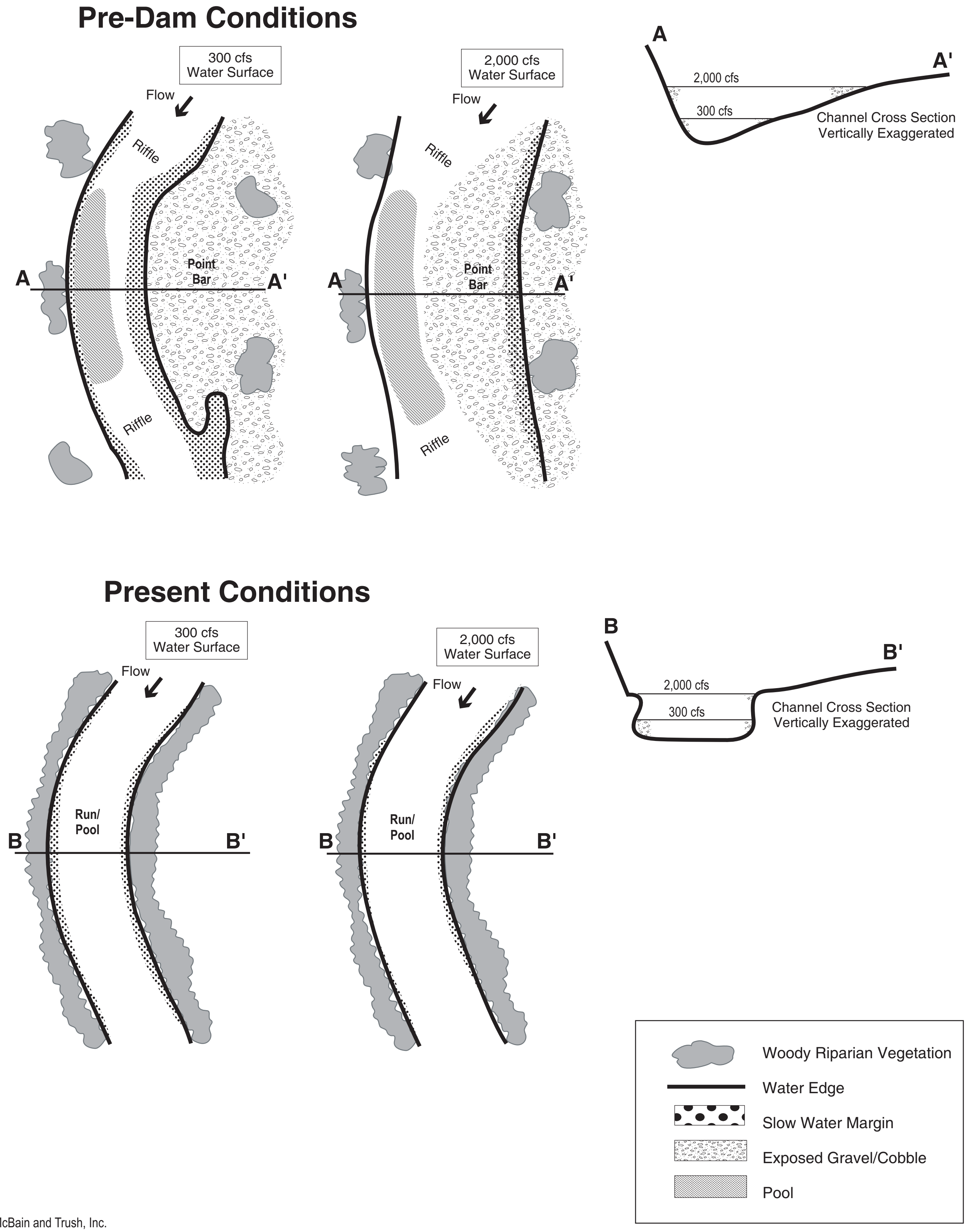


Figure 3.3-2
Pre- and Post-Dam Hydrology



Source: McBain and Trush, Inc.

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Figure 3.3-3
Simplified Geomorphology

The healthy river attributes identified in the FEIS/EIR are:

- Attribute 1: Spatially complex channel geomorphology
- Attribute 2: Flows and water quality are predictably unpredictable
- Attribute 3: Frequently mobilized channel bed surface
- Attribute 4: Periodic channel bed scour and fill
- Attribute 5: Balanced fine and coarse sediment budgets
- Attribute 6: Periodic channel migration
- Attribute 7: A functional floodplain
- Attribute 8: Infrequent channel resetting floods
- Attribute 9: Self-sustaining diverse riparian plant community
- Attribute 10: Naturally fluctuating groundwater table

Local Fluvial Geomorphology

The geomorphic environment is directly affected by the hydrology, channel bed composition and sediment regimes, and riparian vegetation within the site boundaries. The sites contain a number of distinct morphological features (i.e., weir, berms, deltas, pointbars, floodplains). These features support habitat components that depend on a variety of physical processes to maintain their fundamental structure. Modification of the channel and floodplain configurations at the sites has altered and simplified the natural diversity of geomorphic processes and energy regimes available for maintenance of a variety of channel forms, habitats, and vegetation structures.

Figure 3.3-3 illustrates the generalized geomorphic setting of a typical channel segment similar to that of the Proposed Action. Figures 3.3-4a, 3.3-4b, and 3.3-4c characterize the geomorphic features at the rehabilitation sites. Extensive modification of channel forms and other alluvial landforms is evident based on the distribution of natural and human-caused features observed (i.e., point bars, bridges, and tailings piles). The construction and operation of the TRD caused formation of riparian berms along the channel margins in response to the establishment of persistent stands of riparian vegetation due to the elimination of scour by high seasonal flows. These berms have effectively reduced the sinuosity of the channel and inhibited the development and migration of alternate point bars. While floodplain features persist, the simplified channel and development of riparian berms have reduced access to the floodplain for the most frequently recurring floods and diminished the river’s ability to regulate overbank flows during higher flow events.

Geologic Hazards

Seismicity and Seismic Hazards

Seismicity refers to the geographic and historical distribution of earthquakes, while seismic hazards refers to the risk of loss from damaging earthquakes. According to Reclamation’s Dataweb (http://www.usbr.gov/dataweb/dams/ca10196.htm), the infrastructure of the TRD (e.g., dams, tunnels, powerhouses) is located in a region of low historical seismicity and few known Quaternary faults. The region, however, may be subject to low to moderate levels of ground shaking from nearby or distant earthquakes.

The most recent (2003) Probabilistic Seismic Hazards Assessment Model for California (California Geological Survey/USGS, http://www.consrv.ca.gov/cgs/rghm/pshamap/pshamain.html) describes the peak ground acceleration (Pga) with an exceedance probability of 10 percent in 50 years as falling at approximately 0.18 Pga on firm rock, approximately 0.2 Pga on soft rock, and approximately 0.24 Pga on alluvium for the project sites as well as for upstream areas that include the TRD facilities.

Seismic hazard ratings increase markedly west of the rehabilitation sites due to the presence of numerous active seismic structures in the north coastal region of California. Peak accelerations of 0.3-0.4 Pga are forecast under the seismic hazards model of the Trinity River watershed downstream of Helena, California. A de-aggregated seismic hazard map of California (Peterson et al. 1996) can be found at http://www.consrv.ca.gov/cgs/rghm/psha/ofr9608/index.htm. This reference indicates that west-central Trinity County falls within the categories of furthest or second-furthest distance from earthquakes causing the dominant hazard for peak ground acceleration (50-200 km), with the strongest earthquake (8.5 [MW] or greater) necessary to create that hazard. These identified hazard ratings are related to the possibility of seismicity on the northern portion of the San Andreas fault zone and related fault splays in the northern Coast Ranges, and, more importantly, along the Cascadia Subduction Zone along the western Humboldt and Del Norte County coast.

No local Quaternary faults have been identified, although little detailed mapping of Quaternary geologic features has been conducted in the area. Historic earthquake activity in the area has been very low. No areas of Trinity County are described or mapped as Fault-Rupture Hazard Zones under the Alquist-Priolo Earthquake Fault Zoning Act (California Department of Conservation Division of Mines and Geology 1999).

Maximum credible earthquakes (MCEs) were determined for potentially significant faults, including Likely, Hat Creek, Freshwater, Mendocino, and San Andreas. These MCEs have projected surface wave magnitudes that range from 7 to 8.5. A maximum Modified Mercalli Level of VI to VII was also estimated for local seismicity (Trinity County 2001). The Modified Mercalli scale describes the intensity of an earthquake's effects at a given locality. The Mercalli level described above generally equates to a widely felt, often frightening, but minimally to moderately damaging earthquake.

Liquefaction

Liquefaction is a process whereby water-saturated granular soils are transformed to a liquid state during ground shaking. Loose to medium dense sands, gravels, and silts occurring below the water table are prone to liquefaction. The soils bordering the Trinity River in immediate proximity to the rehabilitation sites are predominantly alluvial in nature. These soils have potential to experience liquefaction; however, no detailed analysis was conducted because the type of activities described in Chapter 2 of the EA/Draft EIR would not affect the potential for liquefaction or be affected by liquefaction were it to occur.

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North State Resources, Inc.

Lewiston-Dark Gulch Rehabilitation Project: Trinity River Mile 105.4-111.7

Figure 3.3-4a
Lewiston - Geomorphology