Memorandum

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SUBJECT: Geomorphology and Flood Hydraulics Technical Memorandum

Geomorphologic and Sedimentation Analysis

The U.S. Army Corps of Engineers (USACE) completed geomorphological (Water Engineering and Technology, 1990) and sedimentation studies (Hall and Thomas, 1993) as part of the ongoing flood control planning and design studies of the Truckee River. These studies included collection and analysis of bed and bank material samples, identification of sediment discharge measurements, analysis of existing and historical channel conditions, geomorphic channel response and evolution, and numerical modeling of sediment discharge and channel adjustment. The reports focused on the sedimentation and geomorphic conditions of the Truckee River from Ambrose Park to the Vista Gage, encompassing the river for several miles upstream and downstream of the Glendale Diversion.

Based on water rights records, some form of diversion has been present at the Glendale Diversion site since the late 1800's. Aerial photographs of the Truckee River at Glendale are available from 1939 to present. Figures 1A-1D are aerial photographs of the Glendale reach from 1939, 1957, 1981, and 2001. The planform of the river has been unchanged in the 62 years covered in the photographs. The return flow from Eastman Ditch has moved upstream, but the diversion location has been constant throughout the period covered in the photographs.

Very little survey data about the channel geometry or planform exists for the time period prior to the 1940's. The bed elevation profile from the Corps of Engineers existing condition Truckee River HEC-RAS model was compared with bed profiles surveyed in 1959, 1975, and 1989. The channel invert elevations for the Glendale project reach are shown on Figure 2. The 1959 survey provides bed elevations immediately upstream and downstream of the Glendale Diversion, but does not provide any information of the diversion crest elevation. The 1975, 1989, and existing condition surveys indicate that the bed elevation profile upstream of Glendale Diversion has been relatively constant for nearly three decades. Bed elevation profiles appear to be nearly constant since 1959 in the reach bounded by Highway 395 and Kietzke Lane bridges. The bed elevation profiles indicate relatively significant channel aggradation downstream of the Glendale Diversion since 1959. The geomorphic study of the Truckee River attributed this response to channel widening projects completed prior to 1959 (Water Engineering and Technology, 1990). The results of the Corps of Engineers sedimentation modeling studies agree with this observation,

indicating that sediment deposition and channel aggradation is most pronounced on the Truckee River downstream of the Glendale Diversion (Hall and Thomas, 1993).

Bed material samples were collected upstream and downstream of the Glendale Diversion (Water Engineering and Technology, 1990). The size distribution of Truckee River bed materials was evaluated by completing "Wolman pebble counts" at active gravel riffles, and the bed material size distribution is summarized on Figure 3. The D84, D50, and D16 size classes represent size for which 84, 50, and 16 percent of the bed material is finer. For reference, the Glendale Diversion is located at approximately River Mile 50. The sediment samples show that the bed material sizes are approximately equal in the immediate vicinity of the Glendale Diversion, indicating no preferential sorting or trapping of bed material by the existing diversion. The bed material grain size becomes finer in response to the flatter channel slope in the lower Truckee Meadows area, located several miles downstream of the diversion. Similarly, bed material size increases several miles upstream of the diversion, reflecting the steeper river gradient through downtown Reno and points upstream.

Flood Profile Analysis

Flood profiles for the Glendale Diversion reach were computed based on the Corps of Engineers HEC-RAS model of the Truckee River. The geometry and peak flows in the Corps' model were used to compute flood elevation profiles for existing and several diversion alternatives. The peak flows used in the analysis are identical to those used by the Corps of Engineers, and are provided below in Table 1.

Table 1. *Peak flows, Truckee River at Glendale Avenue*

	Return Interval				
	5-year	10-year	20-year	50-year	100-year
Flowrate, cfs	5,949	7,540	9,150	13,721	20,732

Initial model runs indicated that the 100-year flood profile was above the upstream soffit of the Glendale Avenue bridge. Thus, a cross-section was added to the Corps' model at the upstream face of the bridge in an effort to more accurately model the flow conditions through the bridge and tailwater conditions of the diversion weir. The existing diversion weir is located approximately 100 feet upstream of the Glendale Avenue bridge. The HEC-RAS cross section layout is shown on Figure 4.

Existing Condition Flood Profiles

The 100-year flood is contained in the channel at the U.S. 395 highway bridge, located approximately 2500 feet upstream of the Glendale Diversion. Immediately downstream of U.S. 395, water surface elevations exceed the right bank elevation and flows break out of the channel upstream of Glendale Avenue. The model results indicate that 100-year flood flows return to the channel immediately upstream of Glendale Avenue and are contained within the channel through the bridge. Overbank flooding upstream of Glendale Avenue extends approximately 800 feet away from the top of bank for the 100-year flood. Existing condition model results indicate that extensive overbank and breakout flows occur downstream of the Glendale Diversion, however these hydraulic conditions are unaffected by the configuration of the Glendale Diversion.

Alternative Diversion Configurations and Locations

Four new model geometries were evaluated with the Truckee River HEC-RAS model to identify the effects of alternative weir locations on flood elevations and sedimentation.

Alternative 1: Existing Weir Removed

The effect of removing the existing weir on flood profiles was evaluated. Under this condition the existing weir structure was removed from the HEC-RAS geometry, however no dredging or excavation of the bed material upstream of the weir was specified. The modification results in a steep bed slope in the immediate vicinity of the weir. Removing the weir would also preclude any surface water diversion at this location to the TMWA treatment facility. The 100-year flow elevation profiles for this condition are provided on Figure 5. The flood profiles indicate a reduction in flood elevation of approximately 1 foot in the immediate vicinity and upstream of the weir. Flood elevation profiles increase approximately 600 feet upstream of the weir due to frictional losses associated with the increase in channel velocity resulting from the weir removal. Flood elevation profiles become coincident in the vicinity of the Highway 395 bridge. Flood elevation reduction can only be obtained by removal of the existing weir and extensive excavation of channel bed materials.

Removing the existing weir has significant effects on shear stress in the vicinity of the diversion (Figure 6). The localized increase in shear stress and steep bed slope would result in an upstream traveling head-cut, mobilizing large quantities of sediment that would be transported into the reach downstream of Glendale Avenue. Downstream from the existing weir, shear stress is equivalent for existing and removed weir conditions. The increased sediment load would result in sediment deposition and channel aggradation downstream of the diversion. This deposition would result in increased flood elevations, filling of pools, and deposition of sediment on spawning riffles. To negate these adverse effects, project alternatives that involve moving the surface water diversion to points upstream and excavation of the channel bed materials are presented below.

Alternative 2: New weir in existing location

The bed profile for this alternative is the same as the existing bed profile as shown in Figure 7. The conceptual design includes a more gradual downstream face to enhance fish and boat passage over the structure. The stage-discharge relationship for the proposed weir is hydraulically more efficient than the existing diversion structure, resulting in a reduction of the 100-year flood water surface elevation in the vicinity of the weir. The 100-year flood profile, shown in Figure 7, indicates that 100-year flood elevations are reduced approximately 1 to 2 feet in the vicinity of the weir. Channel control results in coincident flood profiles upstream of the weir for both conditions.

Channel control occurs when the water surface elevation and the slope of the flood profile are primarily affected by the shape and slope of the channel rather than by the weir downstream. Thus, minor changes in weir length or height have little effect on the flood elevations upstream of the weir. Significant changes in weir length or height could cause the flood elevations in the channel upstream to be controlled by the weir.

Channel shear stress is an indication of bed material mobility. The computed shear stress for existing and Alternative 2 conditions is shown on Figure 8. The shear stress profiles indicate a small increase in shear stress upstream of the weir for Alternative 2. The increase in shear stress indicates that sediment passage over the new weir would be enhanced compared to existing conditions and that construction of the new weir would result in a reduced level of sediment trapping upstream of the diversion.

Alternative 3: New weir 700 ft upstream of existing location

The impacts on flood elevations arising from the construction of a new weir structure located approximately 700 feet upstream of the existing weir and excavation of channel bed materials

was determined by modifying the existing condition HEC-RAS model. The new weir crest elevation was determined by evaluating the hydraulic head required to feed the treatment facility by gravity flow through a new surface water diversion. Approximately 4,400 cubic yards of sediment would be excavated between the new weir and the existing weir to provide a bed slope of approximately 1.5% between these two locations. This alternative results in a reduction in 100-year flood profile elevation downstream of the new weir, and a slightly higher flood profile elevation upstream of the weir. The existing and Alternative 3 channel invert and 100-year flood profile are shown on Figure 9.

The computed shear stress upstream of the new weir is slightly lower that computed for existing conditions, indicating that the new weir may trap sediment upstream of the structure (Figure 10). Increased shear stress and reduced water surface profiles downstream of the new weir indicate a propensity for bed and bank scour. Bank erosion protection measures may be required downstream of the new weir.

Alternative 4: New weir 2100 ft upstream of existing location

The impacts on flood elevations arising from the construction of a new weir structure located approximately 2,100 feet upstream of the existing weir and excavation of channel bed materials was determined by modifying the existing condition HEC-RAS model. The new weir would be located upstream of the Highway 395 bridge. The new weir crest elevation was determined by evaluating the hydraulic head required to feed the treatment facility by gravity flow through a new surface water diversion. Approximately 18,500 cubic yards of sediment would be excavated between the new weir and the existing weir. This alternative results in a reduction in 100-year flood profile elevation downstream of the new weir, and a slightly higher flood profile elevation upstream of the weir. The existing and Alternative 4 channel invert and 100-year flood profile are shown on Figure 11.

The computed shear stress upstream of the new weir is higher than that computed for existing conditions, indicating that the new weir would not adversely trap sediment upstream of the structure (Figure 12). Increased shear stress and reduced water surface profiles downstream of the new weir indicate a propensity for bed and bank scour. Bank erosion protection measures may be required downstream of the new weir.

References

Hall, Brad R. and William A. Thomas, 1993. *Truckee River Sedimentation Study*, US Army Corps of Engineers, Waterways Experiment Station, Technical Report HL-93-13, September 1993, Vicksburg, Mississippi.

Water Engineering and Technology, Inc., 1990. *Geomorphic Analysis of the Truckee River from RM 56 to RM 43*, US Army Corps of Engineers, Sacramento District, Contract DACW05-88-D-0044, Delivery Order #10, Sacramento, California.