
# Memorandum

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DATE: 23 September 2004 PROJECT: Glendale Diversion Weir – Hydraulic Design

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SUBJECT: Technical Memorandum, Hydraulic Design for Public Safety

Improving public safety is one of the primary goals in replacing the Glendale diversion weir. The public for this project consists of several user groups. They are visitors at the city park on the left bank, users of the recreation trail, fishermen, rafters, kayakers, and swimmers and inner-tubers.

The existing Glendale diversion weir is a rubble pile consisting of rocks and pieces of concrete (Figure 1). Many of the concrete pieces have steel reinforcement protruding from them. There is a breach at the left (east) end of the dam resulting in a steep, dangerous chute. There are two islands with trees on the downstream face of the weir. The trees, concrete, and steel reinforcement present entrapment dangers to anyone in the river, including fishermen, rafters and kayakers, and swimmers and inner-tubers. Dangerous hydraulic conditions, such as plunging, recirculating flow and sharp rocks and concrete, are also present in the chute downstream of the breach. Currently, the Truckee River in the vicinity of Glendale overtops the left bank onto the recreation trail, approximate elevation 4439 ft NAVD88, every 2-5 years at flows above 4300 cfs. The park on the left bank is at an elevation of about 4444 ft NAVD88, and is not flooded during the 100-year event.

The following are some guidelines for improving public safety at the Glendale Diversion Weir. The design should decrease flood-overtopping frequency in areas of public use. The new diversion should minimize entrapment dangers for anyone in the river. Finally, the diversion must avoid creating unacceptably dangerous hydraulic conditions that may result in drowning.

The improved Glendale diversion weir will be designed according to the public safety guidelines described above. A plan view of a proposed design for the Glendale diversion weir is shown in Figure 2. The weir consists of an arc shaped rest that is recessed at the center of the crest. A chute that provides for both passage of boats (rafts, kayaks, canoes, and inner tubes) and upstream and downstream migration of salmonids is a key feature of the improved weir. Figure 3

compares the rating curve of the existing weir structure to the rating curve of the proposed diversion weir. The new design of the Glendale diversion weir lowers flood levels for all flows greater than about 2200 cfs. Flooding of the recreation trail will occur at flows exceeding 6200 cfs, whereas flooding of the trail for existing conditions commences at flows exceeding approximately 4300 cfs. The trees and concrete rubble with protruding steel reinforcement will be removed, thereby minimizing the entrapment potential present at the existing structure. Dangerous hydraulic conditions that cause drowning will be eliminated with the longer, milder sloped weir face and properly design energy dissipation pool. The asymmetrical, roughened rock face of the weir is designed to minimize the development of dangerous hydraulic conditions on and downstream from the weir face. Physical modeling of the structure at a range of conditions from low summer flows to high flood discharges will be completed to confirm the absence of dangerous hydraulic conditions at all flows.

The existing diversion at Glendale is unsafe for recreational boaters on the Truckee River. At typical spring and summer flows in the Truckee River, there is no clear path for boat passage over the weir without encountering obstacles such as rocks, concrete and reinforcing steel, or trees. There is a steep chute with plunging flows on the east end of the dam that may appear passable to boaters unfamiliar with the weir and river safety. Eastman Ditch runs along the right bank at a milder slope but has been blocked off with boulders to maintain sufficient pool depth for delivering flow to the water treatment plant.

The new diversion weir at Glendale must address the safety of boaters on the Truckee River. No formal guidelines for boat passage safety and design exist. The following are general guidelines developed from design team member's experience and knowledge of whitewater boating and research completed at the University of Illinois on recreational boat passage characteristics of hydraulic jumps (Caisley, ____). A boat passage at the new weir must be at least 15 feet wide to accommodate rafts. Additionally, the depth of water must be at least 6 inches deep so that rafts won't run aground. Any hydraulic jumps created in the passage must not keep a boat for any length of time. Thus, jumps created by steep, plunging flow, as commonly seen at Ogee shaped spillways and over rock ledges in natural streams, must be avoided.

The Truckee River is used by recreational rafters, kayakers, and inner-tubers, so a specially designed channel will be constructed on the weir face to allow for safe passage of boaters. This channel has the additional benefit of providing upstream and downstream passage of salmonid fish species present in the river. The boat passage will be located in the center of the new diversion weir as shown in Figure 3. The design for the boat passage at the new Glendale diversion weir consists of 4 sloped drop reaches with 3 pools separating the drops. Figure 4 shows a profile of the boat passage chute channel. The drops have a 10% slope and are 15 feet long and 25 feet wide. Along the face of the drops, boulders will be placed to concentrate the flow towards the center of the drop to aid in aligning boats in the downstream direction. The boulders will be placed such that they are at least 15 feet apart from one another. The pools are 24 feet long and 25 feet wide. The total length of the boat passage is 176 feet long with a total drop in elevation of 10 feet and an overall slope of 5.7%.

A hydraulic model of the boat passage was developed using HEC-RAS. Additional detailed evaluation of the boat passage will be completed in a physical model, after completion of the concept design. The boat passage was modeled with HEC-RAS for flows ranging from 250 cfs to

3000 cfs. At 250 cfs, the minimum flow depth in the boat passage was 1.23 feet, satisfying the guideline that the depth of water must be at least 6 inches deep for raft passage. The minimum depth of water for 3000 cfs was 2.65 feet. Water surface profiles in the boat passage are shown in Figure 5. Flow velocities in the boat passage are shown in Figure 6. Velocities are generally slower in the pools of the boat passage allowing the boater some recovery time before entering the next drop. There are a number of locations in the boat passage where Froude numbers are greater than one, indicating that hydraulic jumps are likely downstream of these locations. However, Froude numbers in the boat passage never exceed 1.7, the upper limit for the formation of undular jumps (Chow, 1959). As flows increase in the Truckee River, the boat passage has the potential for receiving additional side inflows from the weir face. The effects of side inflows can not be determined using computer models, and will be investigated using the physical model. Any unsafe boating conditions in the passage will be identified in the physical model and eliminated.

Public safety is a primary goal in the design of the replacement of the diversion weir at Glendale. The proposed design of the diversion weir lowers flood levels, increasing the safety of people on the banks of the river in the park or on the recreation trail. Design features, such as the boat passage and the mild sloped roughened rock face, improve the hydraulics for minimizing drowning risks to people in the river. Also, the removal of dangerous objects, such as trees in the main flow and concrete with protruding steel reinforcement, will add to public safety.

## References

Caisley, Marjorie E. 2000. *Hydraulic Model Study of a Canoe Chute for Illinois Streams*, MS Thesis, University of Illinois at Urbana Champaign, Illinois.

Chow, V.T. 1959. *Open Channel Hydraulics*, McGraw Hill, Inc., New York, New York.