Research Update

S&T Program Project ID 1799

Bulletin 2017-15

Bottom Line

A literature review was conducted to identity types of hydraulic structures that may cause dangerous hydraulic conditions and how these structures could be modified to enhance safety.

Better, Faster, Cheaper

Reclamation and other entities with low-head hydraulic structures will benefit from a better understanding of how low-head hydraulic structures affect public safety.

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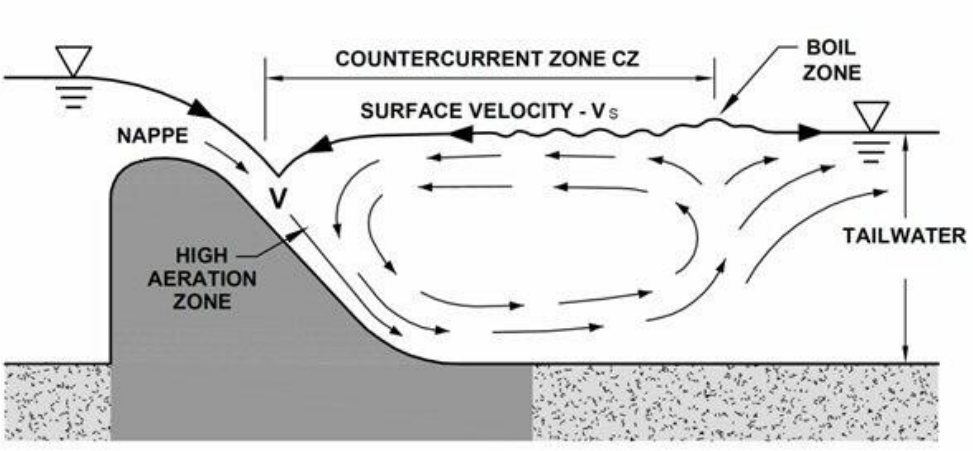
Public Safety of Low-Head Hydraulic Structures

Understanding public safety risks associated with submerged hydraulic jumps

Problem

Low-head hydraulic structures may create dangerous currents, hydraulic forces, and other hazardous conditions to someone trapped downstream of the structure because of localized hydraulic conditions. Over the last 50 years, dam failure fatalities have decreased while the number of low-head dam fatalities has increased (Tschantz 2014). There is momentum in the engineering community to examine public safety at low-head dams including new research and laboratory studies, professional articles, and technical committees within professional societies.



A submerged hydraulic jump produces strong rotational currents toward the dam face. The calm appearance of submerged hydraulic jumps at the water surface makes the low-head dam deceptively dangerous to river recreationalists (reprinted from Tschantz and Wright 2011).

Reclamation manages both an Operation and Maintenance (O&M) program and a Safety of Dams Program. Submerged hydraulic jumps that can be generated by low-head hydraulic structures generally fall outside of the responsibilities of both O&M and Safety of Dams programs. Properly operating structures can create dangerous hydraulic conditions that are not necessarily identified or addressed under current programs.

Solution

A literature review was conducted to find technical documents, guidelines, research studies, and articles relating to public safety at low-head dams and other hydraulic structures. The literature review showed that potentially dangerous low-head hydraulic structures typically have the following characteristics:

1. Continuous overflow from bank-to-bank
2. Not designed for storage, often for flow diversion
3. Generally without hydraulic structures such as gates, pipes, penstocks

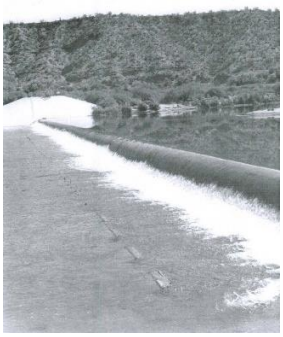
Solution *(continued)*

4. Typically less than 15 ft high
5. Located on natural river systems where recreationalists are found

Hydraulic structures that meet the above criteria include, but may not be limited to: low-head run-of-river dams (ogee-crest or flat-top weirs), low-head diversion structures, channel-wide vertical drop structures and check structures, fish barriers, grade control structures, and low-head dams with fully-open floodgates.

Structural remediation options for existing structures include installation of baffled chute spillways, stepped spillways, large concrete steps, staggered flow deflectors, or protruding platforms on the downstream face of the dam, installation of upstream-facing ramps, placement of large rocks/boulders or grout bags immediately downstream of the dam face, or installation of boat chutes, moveable crest dams, or nature-like rock ramp fishways.

Two examples of low-head hydraulic structures remediated by Reclamation to enhance public safety were identified during the literature review: Power Canal Diversion Dam on the Salt River (modified 1989) and Huntley Diversion Dam on the Yellowstone River (modified 1997).



Left: Original ogee-shaped weir design of Reclamation's Power Canal Diversion Dam upstream of Roosevelt Dam.

Right: Safer design of Reclamation's Power Canal Diversion Dam, retrofitted in 1989 with steps on the downstream dam face.

In experimental model runs all three improvement categories independently demonstrated an increased ability to accurately represent the capabilities of hydropower facilities in power system models relative to the status quo.
Notably, a power system/watershed model was developed for 10 large reservoirs on the Columbia River that demonstrated significant improvements in the modeling of actual hydropower flexibility versus a power system only model. This flexibility allowed the system to reduce the curtailment of hydropower generation by shifting it to times with fewer variable generation resources and resulted in total production costs savings of $4 million (or 2%), and a $2-3/MWh reduction in marginal electricity prices, averaged across the simulation period.

Future Plans

Research gaps relating to public safety at low-head hydraulic structures were identified and potential technical and non-technical paths forward were provided in the report. Researchers will present results of this study to several offices within Reclamation to discuss findings and potential future actions.

References:
Tschantz, Bruce A. and Kenneth R. Wright. 2011. "Hidden Dangers and Public Safety at Low-Head Dams". Association of State Dam Safety Officials. The Journal of Dam Safety, Volume 9, Issue 1.

Tschantz, Bruce A. 2014. "What We Know (and Don't Know) About Low-head Dams". Association of State Dam Safety Officials. The Journal of Dam Safety, Volume 12, Issue 4.

"Many approaches can be used to minimize risk to the public at low-head hydraulic structures. Engineering solutions for safe design of new structures and structural modifications to existing structures can significantly reduce risk over a broad range of flow conditions."

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More Information
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