CAPAY DIVERSION DAM MODERNIZATION FOR SUSTAINED IRRIGATION DEMAND

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ABSTRACT

The Yolo County Flood Control & Water Conservation District (District) releases about 250,000 acre-feet per year from two water supply reservoirs in the Cache Creek watershed for the irrigation of about 60,000 acres of farmland in Yolo County, California. That water is diverted into the Winters Canal and the West Adams Canal at Capay Diversion Dam on Cache Creek. The continued operation of Capay Dam is vital to the sustained future of irrigated agriculture of the District.

Urbanization and infrastructure construction in California resulted in extensive sand and gravel extraction from Cache Creek downstream of Capay Dam. Although that mineral extraction ceased many years ago, the streambed of Cache Creek has degraded. Presently the streambed elevation at the toe of Capay Dam is as much as 15 feet below the elevation of the apron of the dam and the dam is at risk due to downstream channel bed degradation and local scour during floods.

Capay Dam is a concrete diversion that was constructed in 1915. The main portion of the dam is an overflow section about 475 feet long with low-level sluice gates and service spillways at both abutments. The abutments also contain the headworks for the irrigation canals. Due to streambed degradation, local scour at the toe of the apron and the more than 90-year service life of the structure, the District embarked on a program of dam inspection, including the use of non destructive testing of the concrete, and rehabilitating the dam and headworks so as to continue to provide a sustainable irrigation supply of surface water from Cache Creek. The dam inspection and rehabilitation and betterment program for Capay Diversion Dam is presented. This includes the issues of environmental permitting, stream morphology, sediment transport and historic data collection.

INTRODUCTION

Agriculture plays a key role in Yolo County, California's heritage and economy. Almost 99 percent (more than 600,000 acres) of its unincorporated land is designated for agricultural use. The Yolo County Flood Control & Water Conservation District (District) provides irrigation water to about 60,000 acres. Depending on water supply in its two upstream water supply reservoirs (Clear Lake and Indian Valley Reservoir), the

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District releases about 250,000 acre-feet of water during the irrigation season. That water is diverted from Cache Creek into two main canals, the Winters Canal and West Adams Canal, at the Capay Diversion Dam. From Capay Dam, water from Cache Creek is delivered via nearly 175 miles of canals and laterals. The continued and reliable operation of Capay Dam is vital to the sustained future of irrigated agriculture in Yolo County. An aerial photo of the District showing the location of Capay Diversion Dam is provided in Figure 1.

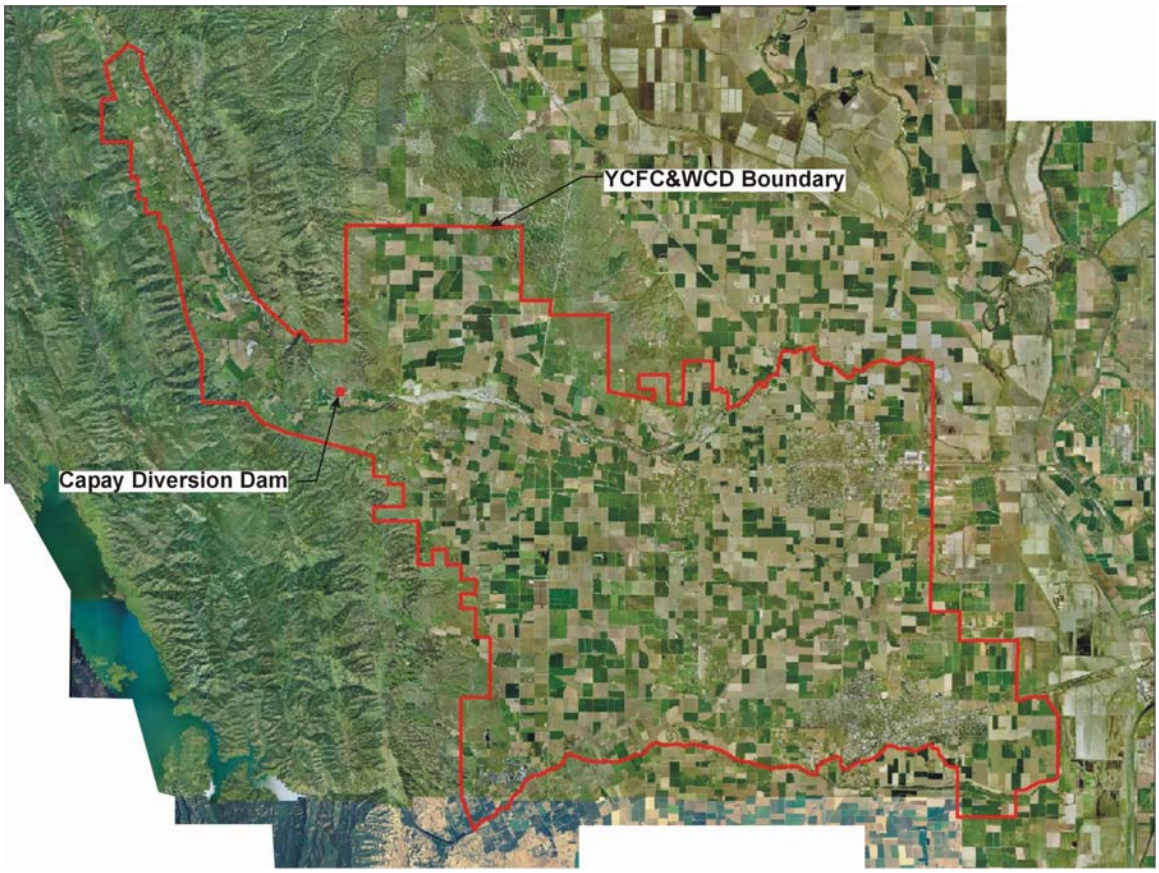

Figure 1. Yolo County Flood Control & Water Conservation District Boundary and Location of Capay Diversion Dam

Cache Creek is a valuable economic resource to Yolo County. Irrigation diversions began prior to 1850. Near the turn of the century, extensive canals and laterals were constructed to serve the agricultural demand. Besides water, Cache Creek is a major regional source of sand and gravel for the construction industry. Extensive rock product extraction from the creek accelerated in the 1950s. Cache Creek experienced streambed degradation from the mineral extraction which was exacerbated by other anthropogenic influences to Cache Creek. The geomorphic changes to Cache Creek resulted in streambed degradation at Capay Dam of more than 15 feet since the dam was constructed. In the 1990s, concern for Cache Creek resulted in a regional resource management plan.

Capay Diversion Dam

Capay Dam (Figures 2 and 3) is a concrete overflow diversion with headgates at each abutment. The Winters Canal headworks is in the right (looking downstream) abutment and the West Adams Canal headworks is in the left abutment. The dam was constructed in 1915. The overflow section is 475 feet long with low-level sluice gates and service spillways near each abutment. A short concrete apron extends downstream of the overflow section. The concrete overflow section is 10 feet high. The dam was originally fitted with timber flashboards that were repaired or replaced prior to each irrigation season. In 1993, a 5-foot high inflatable bladder was added to the crest of the dam so as to improve the efficiency of irrigation diversions while maintaining the dams' historic flood discharge capacity.

Figure 2. Aerial Photo of Capay Diversion Dam

Figure 3. Photo of Capay Diversion Dam showing Cache Creek streambed degradation and local scour at end of apron

In 2003, a section of the apron failed (Figure 4) resulting in an emergency repair. The cause of the partial apron failure was not confirmed but was probably due to the combined effect of streambed degradation, scour at the end of the apron, and concrete erosion of the apron due to sediment impact.

Capay Dam Inspection

In 2006, Capay Dam was subjected to a combination of review of design and operation records, and physical site inspection. This involved review of hydrologic records and analyses, hydraulic analyses including scour calculations, geologic and geotechnical investigations, concrete testing and structural analyses. In 2008, additional inspections, concrete testing and structural analysis were performed on the abutment walls. Major results of the inspections are:

1. The greatest threat to the dam is due to streambed degradation and local scour at the end of the apron. A new, longer apron and cutoff wall is needed.
2. The dam is unstable against overturning.
3. The emergency repair of the apron is in jeopardy of failing.
4. Sediment induced concrete erosion has occurred and may have contributed to the apron failure. Concrete erosion has damaged the piers that support the inflatable bladder deck.

5. The abutment walls are structurally distressed due to design and construction factors. Those walls do not have adequate factors of safety and need to be structurally reinforced.
6. There is seepage through cracks and construction joints in the dam. The upstream face of the dam needs to be inspected. That inspection is scheduled for 2009.
7. The headworks of both canals need repairs to the concrete and gates.

Apron Replacement

Alternatives for apron replacement were evaluated and the preferred alternative was selected. Apron replacement will be by use of roller compacted concrete (RCC). The apron will be lengthened to contain the energy of the hydraulic jump and a deeper cutoff wall will be employed to protect against local scour, (see Figure 5). The apron replacement will incorporate structural reinforcement of the abutment walls. A grade control structure will be constructed in Cache Creek a short distance downstream of the dam. That structure will provide protection of the dam against continued streambed degradation. Construction of the apron replacement is scheduled for fall 2009 at the end of the irrigation season. A major factor in the selection of RCC as the construction material is the short construction window between the end of the irrigation season and the start of the uncontrolled winter runoff in Cache Creek.

Figure 4. Partial failure of apron of Capay Diversion Dam in 2003

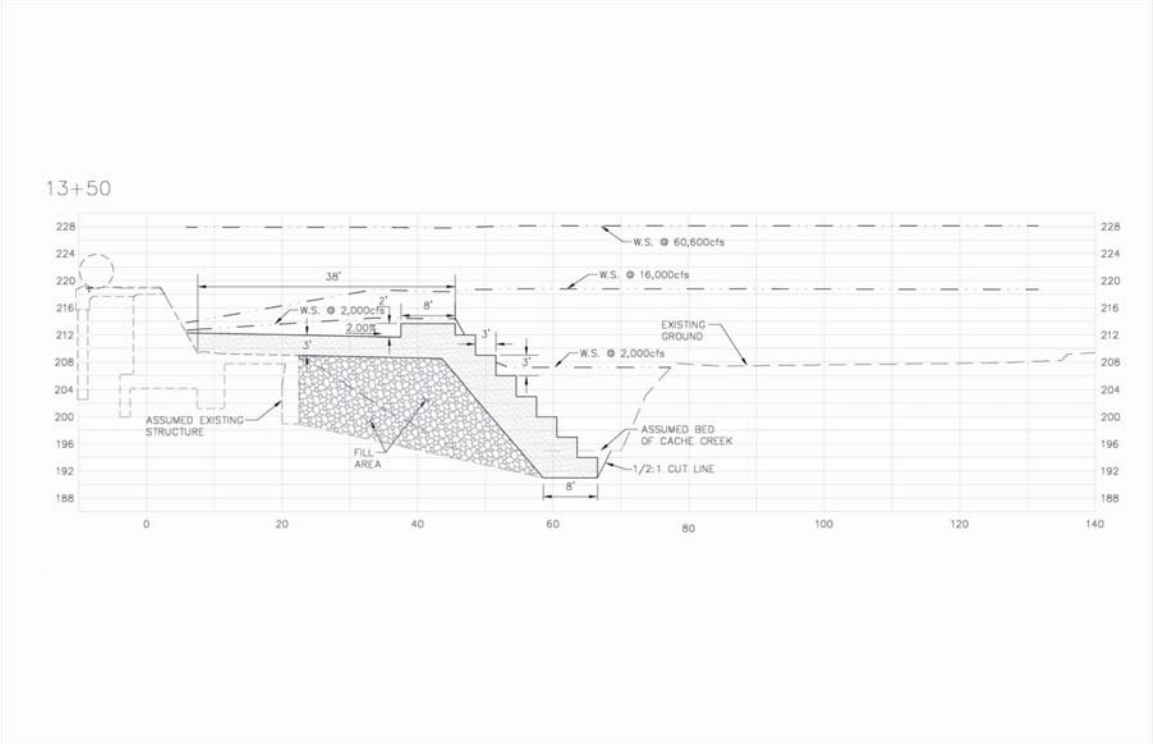

Figure 5. Illustration of replacement apron for Capay Diversion Dam

Conclusions

1. Watershed practices such as sand and gravel mining and other anthropogenic influences can adversely impact structures such as diversion dams in watercourses.
2. Conditions, such as streambed degradation, can develop over time that jeopardize diversion dams and headworks.
3. Hydraulic design practices of old irrigation structures may not provide adequate factors of safety against failure.
4. Construction, material specifications and quality control practices of old structures can lead to structural degradation.
5. Irrigation structures, such as diversion dams, need preventative maintenance and periodic inspection.
6. Modern material testing methods are cost effective in assessing the integrity of irrigation structures.
7. Sediment induced erosion of concrete can result or contribute to failures.