ROUTING FLOOD WATER THROUGH AN IRRIGATION DELIVERY SYSTEM

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ABSTRACT

The Turlock Irrigation District, located in the Central Valley of California, supplies irrigation water to 150,000 acres and electricity to over 60,000 customers. The District's irrigation service area is highly developed, and most natural drainage channels have been eliminated. The irrigation delivery system, consisting of 250 miles of canals and laterals, is used by farmers and cities to route storm drainage during the wet season. There are two small intermittent streams, Sand Creek and Mustang Creek, that enter the canal system. During normal storm events, runoff is small and the canals can readily handle the flows from the two creeks, and storm water from Turlock, other communities, and farms.

On February 12, 1992 an intense storm in the area resulted in rainfall accumulations of 2.5 inches to 3.5 inches in a 24-hour period. Rainfall of these intensities occurs less frequently than once every 100 years. By early afternoon it was obvious that large flows from the two streams would reach the canal system by evening. A command post was established and crews were organized to patrol the canals and to route flows to laterals with capacity available. In the early evening the Highline Canal had broken in five locations. Crews were immediately dispatched to begin repairs, and additional help was secured from local contractors and farmers.

During the same period, the Turlock Main Canal was flowing at peak capacity, with flows being routed to several laterals. The City of Turlock had to discontinue pumping for almost 24 hours. By carefully routing the storm water and keeping the canals and laterals free of debris, additional major damage was avoided. As a result of this emergency, the Turlock Irrigation District is preparing a flood control manual for use in future flood events.

INTRODUCTION

The Turlock Irrigation District is located in central California between Sacramento and Fresno and provides irrigation water to 150,000 acres of

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agricultural land that produces milk, poultry, beef cattle, almonds, grapes, melons and other crops (Fig. 1). Most of the District's water is stored in Don Pedro Reservoir on the Tuolumne River. The Modesto Irrigation District and the City and County of San Francisco also get their water supplies from the Tuolumne River. The Turlock Irrigation District was formed in 1887 and as the oldest irrigation district in California, it is one of only three that also provide electricity to retail customers. There are over 60,000 electric customers in a 425-square mile area. The District operates a 203-MW hydroelectric plant at Don Pedro Dam, several other smaller hydroelectric plants, and a gas turbine plant that provide up to 45% of the District's power needs in normal water years. The area has just experience its sixth consecutive drought year as shown in Table 1.

Table 1. Rainfall and Runoff for Tuolumne River Watershed

Water Years	1986 1987	1987 1988	1988 1989	1989 1990	1990 1991	1991 1992
% of normal precipitation	53.6	63.9	74.4	76.1	71.2	71.0
% of normal runoff	34.8	43.6	69.7	44.9	58.4	44.6

Normal precipitation is 36.05 inches, normal runoff is 1,882,000 acre feet.

While the drought continued in the watershed, precipitation in the Turlock area was 11.39 inches in 1991-1992, exceeding the normal precipitation of 10.79 inches. The storm of February 12, 1992, which caused considerable local flooding, therefore did little to break the six-year drought.

GENERAL FLOOD OPERATIONS

The Turlock Irrigation District operates and maintains about 250 miles of main canals and laterals throughout its service area (Fig. 2). The land is very flat, land systems have been graded to minimize tailwater, and natural drainage channels in the area have been eliminated. The canals and laterals serve as the storm drainage systems, with cities special districts, counties, and farms discharging flood water into the system. There are two small streams entering from the east. Sand Creek has a drainage area of 18.4 square miles and enters the Turlock Main Canal. There is no storage except for ponding above the siphon where it flows under the Highline Canal. Mustang Creek has a drainage area of 22.7 square miles and enters the Highline Canal. There are two small flood control basins on Mustang

Fig. 1 General Location Map

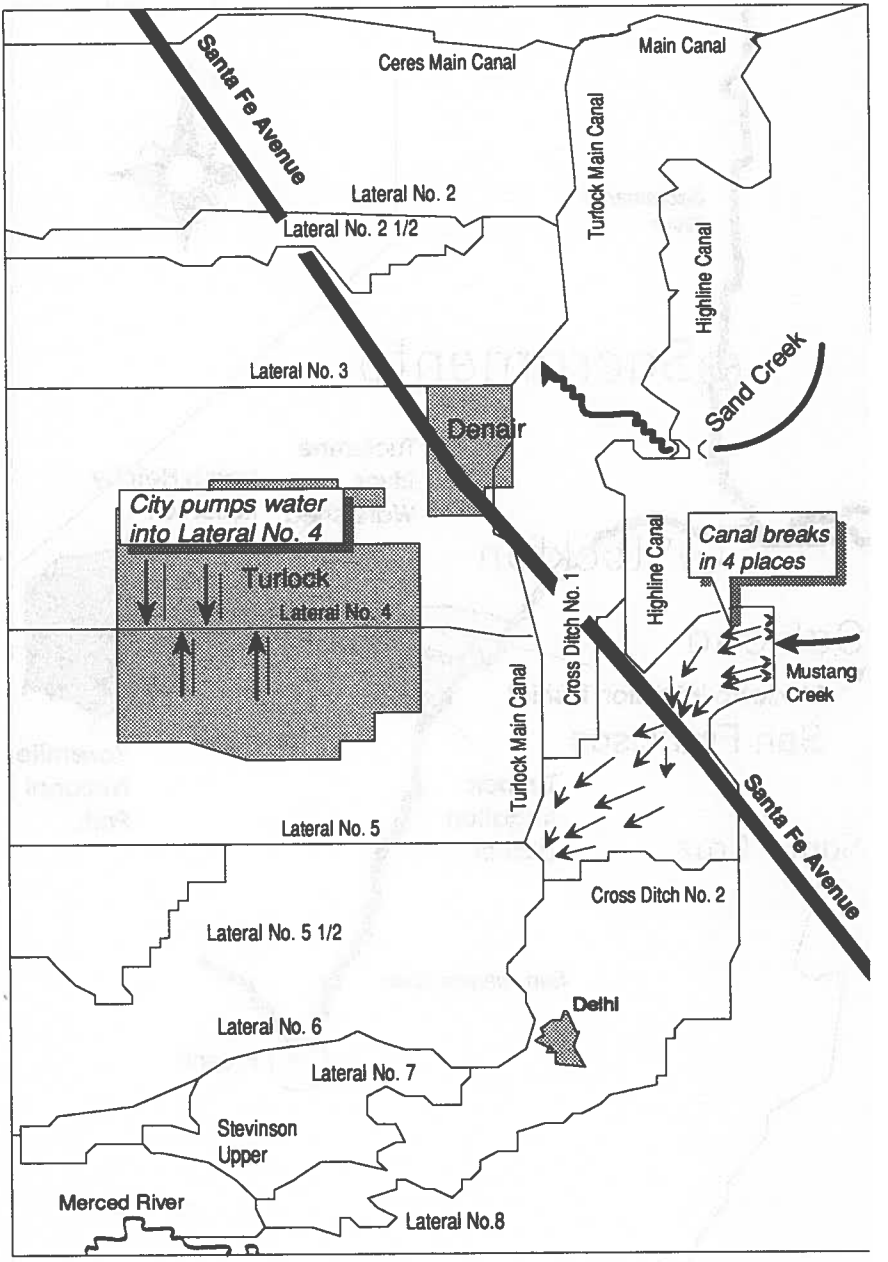

Fig. 2 Turlock Irrigation District Flood Area

Creek, with a combined storage of about 600 acre-feet. Capacities of the anals range from 30 to 2200 cubic feet per second (cfs), and the District ias storm water pumping agreements with the cities and others who lischarge into the system. These agreements take into consideration the apacity of the system and other flows which must be accommodated. The anal system is designed to deliver irrigation water and not to pass flood lows, with canal capacities decreasing as they go downstream. In some ases storm water can be discharged from the canals into community and rivate ditches, and directly onto farm land. Each fall after the irrigation eason has ended, canal structures are cleaned, repaired, and set to route torm water through the system. Major repairs and system improvements ire scheduled to least interfere with flood operations. When major storms ccur, the system is patrolled as needed to keep structures and grates clean f debris, to monitor flow, and to route flood water through the system.

FEBRUARY 12, 1992 STORM

The storm of February 12, 1992 brought from 2.5 inches to 3.5 inches of ain to the District in a 24 hour period. The Sand Creek and Mustang Creek drainage areas to the east of the District received the most rain, with ip to 3.8 inches for the day and 5.25 inches for the week being reported. The 50 year, 24 hour storm for the area is 2.50 inches, the 100 year, 24 iour storm is 2.74 inches. Further to the east, in the Sierra-Nevada oothills, rainfall was much less, and the mountain areas received only a noderate amount of snow. The storm caused flooding and damage hroughout Stanislaus and Merced Counties, and flooding also occurred in Southern California during the same time period.

DISTRICT RESPONSE

During the morning of February 12, 1992 there was localized urban looding throughout Turlock, including the District's Corporation Yard. It oon became apparent that a major storm event had occurred, and that preparations were needed to route significant flood flows through the District's canal and lateral system. A command post was established and ield crews were organized and scheduled to patrol the system throughout he afternoon and night. Technicians were also dispatched to obtain flow lata on the streams entering the system and at key points on the canals nd laterals.

Highline Canal Breaks

About 7:00 p.m., a two-man crew was working its way up the Highline Canal, cleaning debris from drop structures and grates. The canal had been running at near capacity, 600 cfs in this area, when the crew noticed a significant decrease in flow. They continued to drive upstream and came to two breaks in the canal above Santa Fe Avenue and below the point where Mustang Creek enters the canal. At about the same time another crew was working its way down the Highline Canal and discovered two other breaks in the canal above Mustang Creek. Both crews reported the breaks to the command post about 7:30 p.m. By 8:00 p.m. two additional managers had come in to assist at the command post, and one immediately left for the Highline Canal to observe the breaks and make plans for repairs. District employees were called to form a repair crew, and arrangements were made with nearby farmers to excavate and haul earth from their land to repair the breaks. Contractors were also called during the night and were on the job by early morning to haul earth and rock. The major breaks were closed by the afternoon of February 13, and other repairs were completed by the next day.

Canal capacity is 500 cfs above Mustang Creek and 600 cfs below Mustang Creek. Peak Flows which caused the breaks were estimated at 630 cfs in the Canal above Mustang Creek, with an additional 300 cfs entering the Canal from Mustang Creek.

Turlock Main Canal Operations

The Turlock Main Canal takes storm water primarily from Sand Creek (Figure 2), and the water is routed to Laterals 3, 4, 5, 5½, 6 and 7 where it is then discharged to the San Joaquin River. Some farms also can pump into the system, and the City of Turlock pumps into Lateral. By the evening of February 12 the Turlock Main Canal and the laterals were flowing at near their peak capacity of 585 cfs, and by 9:00 p.m. we required the City of Turlock to discontinue pumping. By noon on February 13 the flows had begin to recede and by 6:00 p.m. we were able to stop diverting flows to Lateral 4, and the City was able to resume pumping to drain flood basins and city streets.

The crews that patrolled the system were able to turn off many of the pumps draining farm land, and in other cases found farmers who were willing to flood their land with storm water from the canals and laterals.

n area of particular concern was the head of Lateral 6, where flood water om the Highline Canal breaks would reenter the system. Due to the pography of the area, this water did not reach Lateral 6 until about 8 m. on February 13, well after the peak flows on the Turlock Main system ad passed. The rate of flow reentering the system was only about 20 cfs.

nother area of concern was where Lateral 5 crosses Highway 99. The rate at that location plugged repeatedly with tumbleweeds and other ebris, and a crew had to be stationed there continuously during the peak ow period.

ctions After the Flood

nce the peak flows had past and no new major storms were predicted, urlock Irrigation District managers, engineers, technicians and key field eople met several times to assess the storm event, the resulting flooding, nd the District's response. Actions from those meetings included the llowing:

1. Gathering and organizing of all available rainfall and flow data.

2. Debriefing of all field personnel and others who responded to the flood.

3. Development of a plan for continued minor repair of the system, and improvements to markings of floodgates and flow measurement stations.

4. Development of long range plans to line additional reaches of the Highline Canal.

5. The cost of the flood to the District was estimated at $37,000 for overtime and for materials and contracts for repairs.

6. Plans to write a flood control manual to ensure that our response to future flood situations is timely and appropriate. The major items to be included in the manual are:

    a. End of season setup for the canals and laterals.

b. Emergency response planning, to include crew-call out lists, rental equipment lists, repair material locations, emergency puchase order procedures, and command post arrangements.

c. Storm water routing planning, to include canal capacity maps, storm weather watch, routing of storm water, command post activation, and canal system monitoring

d. Damage assessment and debriefing.

CONCLUSION

In conclusion, an extraordinarily intense local storm took place in the Turlock, California area on February 12, 1992, in the middle of a string of severe winter storms. These storms caused flooding and damage in several areas of Stanislaus and Merced Counties. Water flowed from the hills to the east of the Turlock Irrigation District down into the Highline and Turlock Main Canals from a storm which deluged the area with several inches of rain in a short period of time.

The storm water caused breaches in the Highline Canal in many places both by breaks and by topping over. Much of the District's canal system filled to capacity because of the unusual storm. Without the canals and the storm water storage system on Mustang Creek the flooding probably would have been much worse and more widespread. The canal system and District crews functioned very appropriately and only the large amount of water in a relatively short period of time could account for the flooding that took place.