Mitigation of the Sept 10\textsuperscript{th} and Sept 15\textsuperscript{th} 2011 Flood Peaks by Pima County Regional Detention Basins

Pima County Regional Flood Control District
January 2012
BACKGROUND:

The City of Tucson and Pima County experienced two large rainfall events in September, 2012 but regional detention basins, constructed and operated by the Pima County Regional Flood Control District, prevented these large rainfall events from becoming large flood events. This report describes the rainfall and how the detention basins functioned to prevent flooding.

On Saturday Sept 10th, 2011, Pima County ALERT rain gauges recorded rainfall depths in the range of 1.14 to 2.05 inches from a localized thunderstorm over central Tucson, with much of the total rainfall recorded within a two hour period between 6 – 8pm.

On Thursday, September 15, 2011, rainfall depths were recorded that ranged from 1.22 in up to 2.76 on ALERT and National Weather Service (NWS) gauges, with the NWS recording 2.67 inches falling within 3 hours (between approximately 1:00 PM and 4:00 PM).

Radar data from those storms shows that the most intense rainfall for the Sept 10th and Sept 15th storms occurred over central Tucson, (Figures 1 and 2, Radar data courtesy of NOAA/NOS nowCOAST).

Pima County ALERT rain gauges in the vicinity of the Sept. 10th and 15th storms show that some recorded rainfall depths were near a 10-yr recurrence interval for the 2-hours when most of the rainfall occurred (Figures 4, 5, 6).

Even though these were rare and large rainfall events, with the potential to cause flooding, virtually no flood damage occurred. Our analysis shows that the September 10th and 15th, 2011 flood peaks were mitigated within Pima County and the City of Tucson by regional detention basins (Figure 3). The mitigation of the flood peaks by the Earp wash basin, Rodeo wash basin, and the Kino Environmental Restoration Project are evaluated in this report.

METHODS:

Determining Flood Peak Mitigation by the Earp Wash Basin

According to the radar-estimated rainfall depths, the Earp wash watershed was in the area where the largest rainfall depths occurred, similar to the nearby Tucson airport (the dark purple color on Figure 2). The Earp wash is near the Tucson Airport, where 2.84 inches of
Figure 1. Sept 10th, 2011 NEXRAD radar estimated rainfall depths over Pima County and Tucson.
Figure 2. Sept. 15th, 2011 radar estimated rainfall depths over Pima County and Tucson.
Figure 3. Pima County Regional Detention Basins.
Figure 4. Pima County ALERT rain gauges and a NWS rain gauge near the center of the Sept. 15th, 2011 storm.
Figure 5. Two-hour rainfall depths recorded by Pima County ALERT and a NWS gauge for the Sept 10th and Sept 15th storms compared to 2-yr, 10-yr, and 100-yr two-hour rainfall depths.
rainfall was observed. The District input this rainfall data into the rainfall-runoff model used to design the detention basin for the Earp Wash (DJA Engineering Corp., 1999) in order to model the flood peak for the Sept 15, 2011 storm event.

Flood detention basins work by routing floods, which typically have flash-flood characteristics, into a large basin where the water will spread out. The flows are then metered out more slowly using a specially-designed outlet. Based on the storage characteristics of the Earp wash regional basin (Figure 6), it is possible to understand how it mitigated the impact of the Sept. 15, 2011 storm event.

Rodeo Wash Basin
The Rodeo wash detention basin drains a 4.4 square mile watershed and was designed assuming the watershed would become fully developed (Johnson-Brittan, 1983). As anticipated, the watershed has seen considerable development since the basin was designed. On September 15, 2011, the detention basin was in the center of the storm and received rainfall depths similar to those seen at the airport based on the radar data in Figure 2. Once again, the Sept 15th storm was modeled using the rainfall from the airport and applying it to the rainfall-runoff model used to design the Rodeo Wash basin.

The outflow rates were used to estimate flood depths downstream of both the Earp and Rodeo basins and compared with estimated flow depths if no detention basin had been built.

Kino Environmental Restoration Project

While flows into the Earp and Rodeo basins had to be estimated using rainfall-runoff models, the inflow to the Kino Environmental Restoration Project (KERP) is measured (ALERT Gauge 6233 at the inlet of KERP). As with the other basins, the flow out depends on the storage characteristics of the basin, and the outlet structure. Because KERP actually stores (retains) stormwater for future use, it provides both flood retention and detention benefits. However, the KERP ponds were essentially full from the September 10th storm event, it did not provide flood retention benefits for the September 15 event. Even so, the flood detention benefits are substantial. The estimated outflow from the Sept 15th event was compared to the inflow to assess the benefit in flood reduction provided by KERP.
Figure 6. The Earp wash and Rodeo wash regional detention basins.
Figure 7. The Kino Environmental Restoration Project (KERP).
RESULTS:

**Flood Peak Mitigation by the Earp Wash Detention Basin**

The Earp Wash peak discharge for the Sept. 15, 2011 event was estimated to be 65 cfs leaving the detention basin, however if the basin had not been constructed it is estimated the peak discharge would have been 292 cfs (Figure 6), which indicates that the Earp Wash basin provides substantial flood control benefit to downstream properties (a reduction in peak discharge of 78% for the Sept 15th storm). Following the Sept. 15th, 2011 storm event, the high water mark indicates that the Earp wash basin function as designed (Figure 7). The modeled flow depths of the Earp Wash immediately downstream were 1.6 ft for the existing condition (with the detention basin) and 3.2 ft deep if the basin had not been constructed (Table 1.) Because 3.2 feet of flooding would have had impacted many properties downstream of the basin, the detention basin provided a substantial benefit to property owners living downstream of the basin.

![Figure 6. Modeled inflow and outflow to the Earp wash basin for the Sept 15, 2011 storm. The “without basin” condition is represented by the inflow hydrograph.](image-url)
Figure 7. The observed high water mark at the Earp Wash basin following the Sept 15th, 2011 storm event. All flow appears to have exited through the orifice and no flow appears to have overtopped the spillway.

Flood Peak Mitigation by the Rodeo Wash Detention Basin

The PC-Hydro model results for the Sept 15, 2011 storm estimated an inflow peak discharge of 2744 cfs and runoff volume of 573 ac-ft to the Rodeo wash detention basin. The modeled peak outflow downstream of the basin was 410 cfs which indicates that the Rodeo basin also provides substantial flood protection to downstream properties (a reduction of 85% in this case). The Rodeo Wash peak flow depth in the constructed channel immediately downstream of Alvernon Rd. was modeled as 5.0 ft with the existing detention basin and 11.4 ft without the basin, which would result in overtopping the constructed channel to the north towards Valencia Rd. In fact, the flows on September 15 remained in the constructed channel, indicating that the detention basin prevented downstream flooding.
Figure 8. The Rodeo Wash basin modeled inflow and outflow hydrographs for the Sept 15, 2011 event. The “without basin” condition is represented by the inflow hydrograph.

Flood Peak Mitigation by the Kino Environmental Restoration Project

The Sept 15th peak inflow at KERP was 2175 cfs, according to the gauge data and the outflow peak discharge is estimated as 1370 cfs (Figure 9). A reduction in peak discharge of 37% was observed even though the flood retention benefits of KERP did not come into play because the ponds were filled during the September 10th event. The inflow hydrograph represents the “without basin” condition if KERP and the Ajo Detention basin had not been constructed.
Summary of Flood Peak Reductions

The evaluation of the inflow and outflow of the Earp wash basin, Rodeo wash basin, and the Kino Environmental Restoration Project indicates that the detention basins functioned as designed by mitigating flood peaks and minimizing downstream impacts. The detention basins provided substantial reduction in the Sept. 15th, 2011 flood peaks (Table 1, Figure 10) despite receiving significant rainfall days earlier on Sept 10th, 2011. In addition, a greater percent reduction in flood peak at KERP can be expected when the retention basins are not at capacity from antecedent rainfall.
Table 1. The reduction in peak discharge and flow depth due to the detention basins for the Sept 15, 2011 storm.

<table>
<thead>
<tr>
<th>Detention Basin</th>
<th>Without Detention Basins</th>
<th>With Detention Basins (Existing)</th>
<th>Reduction in Flood Peak due to Detention Basin</th>
</tr>
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<tr>
<td></td>
<td>Peak Discharge (cfs)</td>
<td>Flow Depth (ft)</td>
<td>Reduction in Flood Peak (cfs)</td>
</tr>
<tr>
<td>Earp Wash</td>
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<tr>
<td>Rodeo Wash</td>
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<td>KERP</td>
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</table>

Figure 10. Reduction in Sept 15th, 2011 flood peaks due to regional detention basins following the Sept 10th event.