Bexar County Flood Warning System

Curtis Beitel, PE, CFM, Anthony Henry
and Wayne Tschirhart, PE, PMP
Software Overview

FloodWorks

- 2 Processes
  - Hydrometric DB
  - Event Manager

- Automatic
  - Low = Every 6 hours
  - High = Every 15 minutes
  - 24/7

- Runs
  - InfoWorks RS
  - InfoWorks CS
  - InfoWorks SD

System Overview

NEXRAD
15 min from NWS

Rain Gages

Level Gages

Hydrometric Database

FloodWorks Server at SARA office

Western Configuration

Central Configuration

Eastern Configuration

XML

Website

Website Parser

SARA Web Server

Bexar County Flood Warning System

May 2014
Warning Locations

- Selected by SAOEM based on historic operations
- Upper San Antonio River
  - 46 locations
- Leon Creek
  - 30 locations
- Medina River
  - 20 locations
- Cibolo Creek
  - 13 locations
- Salado Creek update
  - 14 pilot + 19 new locations
- Total of 142 locations

Bexar County Flood Warning System

Upper San Antonio River Scoping Map
Warning Locations

- RS model available (at 74 locations)
  - Elevation / Depth
  - Flow
  - Velocity
  - Location Map
  - Inundation Map

- No RS Model (at 68 locations)
  - Flow only
  - Location Map
Hydrology

• 2 Processes
  – Probability Distributed Model
  – Simplified Runoff Model

• Probability Distributed Model
  – Estimates soil moisture from gaging station

• Simplified Runoff Model
  – Uses soil moisture to generate runoff hydrographs at ungaged locations
Hydrology - PDM Calibration

• Developed by CEH Wallingford
  – Requires real time gaging station
  – Estimates soil moisture

[Diagram showing flowchart of hydrological processes including Rainfall, Evaporation, Probability Distributed Soil Moisture Storage, Direct Runoff, Surface Storage, Groundwater Storage, Surface Runoff, Recharge, Baseflow, and Total Stream Flow.]

Upper San Antonio River Gages
Hydrology – PDM Calibration

USGS Discharge Data

- SAR Lower 08178565
- SAR Upper 08178050
- Olmos 08177700

Calibration Event

Daily Mean Discharge (cfs)

SAR Lower 08178565
SAR Upper 08178050
Olmos 08177700

Date

Bexar County Flood Warning System

May 2014
## Hydrology – PDM Calibration

![Graph showing observed flow, computed flow, and rainfall rate over time for Olmos Creek at Dresden Drive - September 2010 Event.](image)

<table>
<thead>
<tr>
<th>Date / Time</th>
<th>Observed Flow (cfs)</th>
<th>Computed Flow (cfs)</th>
<th>Rainfall Rate (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/4/10 9:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/4/10 18:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/5/10 12:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/5/10 21:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/6/10 6:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/7/10 0:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/7/10 8:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/8/10 18:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/8/10 21:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/9/10 0:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/10/10 9:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/10/10 18:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/11/10 3:00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hydrology – PDM Calibration

San Antonio River at Mitchell Street - September 2010 Event
Hydrology – PDM Calibration

San Antonio River at Loop 410 - September 2010 Event

Bexar County Flood Warning System
Hydrology - Simplified Runoff Model

- Generates runoff hydrographs for each basin
- Basin average rainfall
- Effective rainfall
  - Based on soil moisture deficit
- Converts to runoff \( Q \)
- \( Q \) input into InfoWorks RS
  - At a point
  - Distributed over reach
Hydraulics - Overview

• Upper San Antonio River
  – 72 miles
• Leon Creek
  – 66 miles
• Medina River
  – 19 miles
• Cibolo Creek
  – 0 miles
• Salado Creek
  – 24 miles
• Total = 181 miles
Hydraulics – Development

- DFIRM RAS models
  - As detailed as possible
  - Steady peak flow rate
  - Focused on 100-year
  - 1D flow
  - Hydrologic routing
  - English units

- InfoWorks RS models
  - Match RAS within 0.5 feet
  - Unsteady, Full range of flows
  - Balanced focus (low & high)
  - 1D with multiple flow paths
  - Dynamic channel routing
  - Metric units
Hydraulics - Development

- Simplified RS models
  - Run within 15 minute window
- Starts with DFIRM RAS
  - Review / refinement
  - Delete unnecessary sections
- Import into RS
- Steady RS (low flows)
- Unsteady RS (HMS hydrographs)
- Add structures 1 at a time
- Compare RAS vs. RS
- Optimization
Hydraulics - Capabilities

- Complex split flow areas
  - Martinez Creek
Hydraulics - Capabilities

- Apache Creek
  - Undersized storm drains
  - 10-year flow in storm drain
  - Rest of 100-year overland
Hydraulics - Capabilities

- Concepcion Creek
  - 100-year flow is completely contained in a large box culvert system
Hydraulics - Capabilities

- Flow through neighborhoods
  - Apache Creek
  - Concepcion Creek
- Series of storage areas in InfoWorks RS
Hydraulics - Capabilities

- Flood Control Tunnel Operations
  - San Pedro Creek Tunnel
  - San Antonio River Tunnel
Warning Thresholds

- Established for each location
- At least 1.0 foot between threshold elevations
- Stage-discharge rating curve at locations without RS models

<table>
<thead>
<tr>
<th>Roadway Flooding</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Elevation of: Lowest Bank or 3 feet below Roadway Elevation</td>
<td>Watch</td>
</tr>
<tr>
<td>Lower Elevation of: Roadway Overtopping or First Habitable Structure Flooded</td>
<td>Minor</td>
</tr>
<tr>
<td>Higher Elevation of: Roadway Overtopping or First Habitable Structure Flooded</td>
<td>Major</td>
</tr>
</tbody>
</table>
### Warning Thresholds - Elevations

- At locations with RS model
- Used DFIRM RAS models at each location
- Depth = Elevation – Datum (flowline)
- Detailed spreadsheets to document

---

#### Upper San Antonio River: Threshold Inundation Elevation Determination by Point of Interest

<table>
<thead>
<tr>
<th>Location Number</th>
<th>Location Name</th>
<th>Floodworks Node</th>
<th>Infoworks RS Section</th>
<th>US HEC-RAS Section ID*</th>
<th>Bank Elevation</th>
<th>Low Deck Road Elev</th>
<th>Low Habitable Structure FF**</th>
<th>High Habitable Structure FF**</th>
<th>Threshold Elevation</th>
<th>Threshold Depth</th>
<th>Threshold Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAN001</td>
<td>Camino Coahuiteca &amp; Willamain Rd</td>
<td>SAR1</td>
<td>SAR_170487</td>
<td>170757</td>
<td>512.6</td>
<td>514.6</td>
<td>513.6</td>
<td>513.5</td>
<td>513.5</td>
<td>26.4</td>
<td>29.1</td>
</tr>
<tr>
<td>SAN002</td>
<td>Symphony Ln &amp; E Pyron Ave</td>
<td>SAR2</td>
<td>SAR_388605</td>
<td>188605</td>
<td>547.3</td>
<td>548.7</td>
<td>547.6</td>
<td>547.3</td>
<td>547.1</td>
<td>15.1</td>
<td>15.4</td>
</tr>
<tr>
<td>SAN003</td>
<td>E White Ave &amp; Riverside Dr</td>
<td>SAR3</td>
<td>SAR_24143</td>
<td>194225</td>
<td>570.7</td>
<td>587.7</td>
<td>570.7</td>
<td>570.7</td>
<td>570.7</td>
<td>25.9</td>
<td>26.3</td>
</tr>
<tr>
<td>SAN004</td>
<td>Avenue J &amp; 12th St</td>
<td>SAR4</td>
<td>SAR_229999</td>
<td>201839</td>
<td>648.9</td>
<td>650.8</td>
<td>649.8</td>
<td>650.8</td>
<td>650.8</td>
<td>18.9</td>
<td>19.5</td>
</tr>
<tr>
<td>SAN005</td>
<td>E Magnolia Ave &amp; River Rd</td>
<td>SAR5</td>
<td>SAR_236995</td>
<td>206955</td>
<td>608.4</td>
<td>608.8</td>
<td>608.4</td>
<td>608.4</td>
<td>608.4</td>
<td>4.0</td>
<td>5.5</td>
</tr>
<tr>
<td>SAN006</td>
<td>Avenida De &amp; Hillje St</td>
<td>State_HOS</td>
<td>Hydrology Link</td>
<td>8375</td>
<td>596.0</td>
<td>596.0</td>
<td>596.0</td>
<td>596.0</td>
<td>596.0</td>
<td>3.5</td>
<td>5.0</td>
</tr>
<tr>
<td>SAN007</td>
<td>School St &amp; Monroe St</td>
<td>Rockwood</td>
<td>Hydrology Link</td>
<td>5278</td>
<td>597.3</td>
<td>598.0</td>
<td>597.5</td>
<td>598.0</td>
<td>598.0</td>
<td>4.0</td>
<td>5.5</td>
</tr>
<tr>
<td>SAN008</td>
<td>Broadway St &amp; Fairland Pl</td>
<td>Catalpa</td>
<td>CAT_PFS_2</td>
<td>240840</td>
<td>665.3</td>
<td>667.3</td>
<td>665.3</td>
<td>665.3</td>
<td>665.3</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>SAN009</td>
<td>Borillo Pl &amp; Broadway St</td>
<td>BW1</td>
<td>Hydrology Link</td>
<td>3230</td>
<td>702.0</td>
<td>702.0</td>
<td>702.0</td>
<td>702.0</td>
<td>702.0</td>
<td>1.0</td>
<td>1.9</td>
</tr>
<tr>
<td>SAN010</td>
<td>Rosemary Ave &amp; N New Braunfels Ave</td>
<td>BW2</td>
<td>Hydrology Link</td>
<td>9031</td>
<td>575.0</td>
<td>575.0</td>
<td>575.0</td>
<td>575.0</td>
<td>575.0</td>
<td>1.4</td>
<td>2.2</td>
</tr>
<tr>
<td>SAN011</td>
<td>N McCullough Ave &amp; Jackson Keller Rd</td>
<td>Olmos1</td>
<td>Olmos_storage</td>
<td>12166</td>
<td>715.0</td>
<td>714.8</td>
<td>714.8</td>
<td>714.8</td>
<td>715.0</td>
<td>6.8</td>
<td>9.8</td>
</tr>
<tr>
<td>SAN012</td>
<td>D/S of N McCullough Ave &amp; Barbara Dr</td>
<td>OlmosAP1</td>
<td>Hydrology Link</td>
<td>3264</td>
<td>734.0</td>
<td>734.1</td>
<td>734.0</td>
<td>734.0</td>
<td>734.0</td>
<td>8.5</td>
<td>11.5</td>
</tr>
<tr>
<td>SAN013</td>
<td>Cornwall Dr &amp; Thames Dr</td>
<td>OlmosAP2</td>
<td>Hydrology Link</td>
<td>11367</td>
<td>792.0</td>
<td>792.0</td>
<td>792.0</td>
<td>792.0</td>
<td>792.0</td>
<td>3.0</td>
<td>4.8</td>
</tr>
<tr>
<td>SAN014</td>
<td>West Ave &amp; Jackson-Keller Rd</td>
<td>Olmos2</td>
<td>Hydrology Link</td>
<td>28403</td>
<td>766.6</td>
<td>768.6</td>
<td>766.6</td>
<td>766.6</td>
<td>766.6</td>
<td>6.0</td>
<td>8.4</td>
</tr>
</tbody>
</table>

---

**Legend:**

- **Watch:**
- **Minor:**
- **Major:**
- **Left:**
- **Right:**
- **Lowest:**
- **Bank Elev:**
- **Road Elev:**
- **Structure FF:**
- **Elevation:**
- **Datum:**

---

Bexar County Flood Warning System

May 2014 22
**Warning Thresholds - Flows**

- Only flows at locations without RS models
- Stage-discharge rating curve to relate flow and elevation
- Detailed analysis for San Antonio and Leon Creek watersheds

### Upper San Antonio River: 100 year - Routing

<table>
<thead>
<tr>
<th>Location Number</th>
<th>Location Name</th>
<th>HEC-RAS MODEL</th>
<th>Threshold Elevation</th>
<th>Threshold Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAN012</td>
<td>D/S of N McCullough Ave &amp; Barbara Dr</td>
<td>Tributary A to Airport Tributary</td>
<td>732.0</td>
<td>735.0</td>
</tr>
<tr>
<td>SAN044</td>
<td>Babcock Rd &amp; Northill Dr</td>
<td>Alazan Unamed Tributary</td>
<td>771.0</td>
<td>774.0</td>
</tr>
<tr>
<td>SAN011</td>
<td>N McCullough Ave &amp; Jackson Keller Rd</td>
<td>Olmos Creek Lower</td>
<td>766.6</td>
<td>769.0</td>
</tr>
<tr>
<td>SAN006</td>
<td>Avondale Ave &amp; Hillje St</td>
<td>State Hospital Creek</td>
<td>596.0</td>
<td>597.5</td>
</tr>
<tr>
<td>SAN015</td>
<td>West Ave &amp; Jackson-Keller Rd</td>
<td>Olmos Creek Lower</td>
<td>766.6</td>
<td>769.0</td>
</tr>
<tr>
<td>SAN039</td>
<td>Senisa Dr &amp; Seeling Blvd</td>
<td>Alazan Unamed Tributary</td>
<td>706.8</td>
<td>708.9</td>
</tr>
<tr>
<td>SAN043</td>
<td>Overdale Pl &amp; Laddie Pl</td>
<td>East Woodlawn Ditch</td>
<td>740.0</td>
<td>742.0</td>
</tr>
<tr>
<td>SAN007</td>
<td>School St &amp; Monroe St</td>
<td>Rockwood_Creek_LimDetail082306</td>
<td>597.5</td>
<td>598.5</td>
</tr>
<tr>
<td>SAN014</td>
<td>Cornwall Dr &amp; Thames Dr</td>
<td>Tributary A to Airport Tributary</td>
<td>791.0</td>
<td>792.8</td>
</tr>
<tr>
<td>SAN010</td>
<td>Rosemary Ave &amp; N New Braunfels Ave</td>
<td>BroadwayDrain_Detailed</td>
<td>755.9</td>
<td>756.7</td>
</tr>
<tr>
<td>SAN009</td>
<td>Barilla Pl &amp; Broadway St</td>
<td>BroadwayDrain_Detailed</td>
<td>700.7</td>
<td>701.6</td>
</tr>
</tbody>
</table>
Warning Thresholds – Dam Safety

- Value added for dam safety in Martinez-B watershed
  - Discharge thresholds
  - Based on SARA design rating curves for pool elevations

<table>
<thead>
<tr>
<th></th>
<th>Q Outflow at Aux Spillway</th>
<th>Q Outflow at 3 feet &lt; Top of Dam</th>
<th>Q Outflow at Top of Dam</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Watch</strong></td>
<td><strong>Minor</strong></td>
<td><strong>Major</strong></td>
<td></td>
</tr>
<tr>
<td>Martinez 1</td>
<td>65</td>
<td>2,066</td>
<td>8,985</td>
</tr>
<tr>
<td></td>
<td>675.70</td>
<td>677.80</td>
<td>680.80</td>
</tr>
<tr>
<td>Martinez 2</td>
<td>60</td>
<td>248</td>
<td>4,245</td>
</tr>
<tr>
<td></td>
<td>657.70</td>
<td>658.30</td>
<td>661.30</td>
</tr>
<tr>
<td>Martinez 3</td>
<td>104</td>
<td>972</td>
<td>8,313</td>
</tr>
<tr>
<td></td>
<td>636.00</td>
<td>637.10</td>
<td>640.10</td>
</tr>
<tr>
<td>Martinez 4</td>
<td>338</td>
<td>4,359</td>
<td>10,592</td>
</tr>
<tr>
<td></td>
<td>738.50</td>
<td>742.60</td>
<td>745.60</td>
</tr>
<tr>
<td>Martinez 5</td>
<td>258</td>
<td>6,624</td>
<td>14,822</td>
</tr>
<tr>
<td></td>
<td>791.90</td>
<td>796.50</td>
<td>799.50</td>
</tr>
<tr>
<td>Martinez 6a Rehab</td>
<td>380</td>
<td>25,181</td>
<td>51,179</td>
</tr>
<tr>
<td></td>
<td>625.80</td>
<td>631.20</td>
<td>634.20</td>
</tr>
</tbody>
</table>
Future Rainfall

- Quantitative Precipitation Forecasts
  - 1 hour to 5 days
  - GIS-based spatial/volume input

- Forecast information from
  - NWS/NOAA
  - Private sector

- Wanted to use NWS QPF product
  - 2” total for May 25, 2013 event
  - Actual total = 10” on San Pedro Creek

- Established flexible procedure with NWS
  - Utilizes NWS WFO’s judgment
  - Applied USGS SIR 2004-5075

http://www.nssl.noaa.gov/projects/q2/q2.php
Future Rainfall

- SAOEM call with NWS WFO in New Braunfels
- NWS meteorologist discusses storm type, total rainfall and timing
- SAOEM requests SARA to add
- Library of profiles in FloodWorks from USGS SIR 2004-5075
Future Rainfall - General

- Widespread
- 6, 12 and 24 hour profiles


Bexar County Flood Warning System

May 2014 27
Future Rainfall - Convective

- Thunderstorm
- Most in 1st quarter
- 3, 6, 12 and 24 hour profiles

Future Rainfall - Tropical

- Landfalling tropical systems
- Wide variety of historic profiles
- 1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd} and 4\textsuperscript{th} quartile 24 hour profiles

Future Rainfall - Tropical

- Landfalling tropical systems
- Wide variety of historic profiles
- 1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd} and 4\textsuperscript{th} quartile 24 hour profiles


Bexar County Flood Warning System
Interactive Website at EOC

Bexar County Flood Warning System

May 2014

31
Details at Warning Location

- Local web design firm
  - Updated SAOEM site
- Current and concise data
- SAOEM EOC
- SAFD Dispatch
- Swift Water Rescue
- SAPD/Sheriff evacuations
Real Time Inundation Mapping

- Available at RS locations
- Maximum inundation in 48 hour window
- Road closures
- Evacuation limits
Bexar County Flood Warning System

System Summary

- NEXRAD 15 min from NWS
- Rain Gages
- Level Gages
- Hydrometric Database
- FloodWorks Server at SARA office
- Western Configuration
- Central Configuration
- Eastern Configuration
- Future Rainfall

SAOEM EOC
NWS

Website
Website Parser
SARA Web Server

XML
BCFWS Operations

- Rainfall event is forecast
- SARA switches FloodWorks from 6 hours to 15 minutes
- SAOEM call with NWS WFO in New Braunfels
- NWS discusses type, total rainfall and timing
- SAOEM requests SARA to add for Western, Central, Eastern
- SARA adds from library of profiles in FloodWorks
- Provides 1 to 5 hours of lead time (NWS call & travel timing)