Presentation Overview

• Study purpose
• Case study location
• Methodology
• Evacuation modeling elements
• Assessment results
• Future applications
Study Purpose / Background

• Undertake a pilot flood evacuation study
• The goal of the study is to develop a decision support tool for emergency managers
• The tool considers the time-varying hazard resulting from the propagation of a flood during an evacuation
• This dynamic consideration of the hazard definition is a new addition to the science of Emergency Management planning for flooding
Pilot Study Location – Natomas Basin

- Development in deep floodplain
- Well-defined physical boundaries
- 100,000 residents
- Critical infrastructure
- Increased risk from future development
Methodology

- High-resolution 2D hydraulic flood modeling
- Vehicular evacuation modeling
- Both models currently exist independent of one another
- Wood Rodgers has developed a methodology to link both types of models
- Linked modeling enables the dynamic assessment of an evacuating population, accounting for the progression of a flood hazard during an event
Evacuation Process During Flood Propagation
2D Hydraulic Modeling Purpose in CVFED Program

• Determine maximum depth and extent of flooding
• Develop a level of detail in the 2D models suitable for planning and for legislative requirements
• Develop models that are acceptable to FEMA and USACE
Hydraulic Model Requirements for Emergency Response

- High resolution is necessary to adequately characterize flood propagation in the floodplain
- Temporal variations in inundation extent, depth and velocity
Hydraulic Modeling

• TUFLOW is recommended for high-resolution two-dimensional flood hazard modeling
  • Inputs can be easily migrated from existing FLO-2D model datasets
  • Simulations are up to ten (10) times faster than FLO-2D

• TUFLOW estimates the time of flood arrival earlier than FLO-2D does.
  • More conservative assessment
  • TUFLOW results are consistent with other industry standard 2D hydraulic models (MIKE 21, XP-2D)
Hydraulic Modeling

TUFLOW Result Summary:

- Flood propagation \( \approx 0.4 \text{ mile/hour} \)
- Peak flow velocities at flood wave front \( \approx 3 \text{ to } 6 \text{ft/s} \)
- Rate of rise \( \approx 1 \text{ft in 10 minutes} \)
Evacuation Modeling

• An effective evacuation model will need the following criteria:
  • The capacity of the road network is considered
  • The traffic model is integrated to simulate traffic congestion
• ArcCASPER (Capacity-Aware Shortest Path Evacuation Route) meets both criteria
• ArcCASPER solves for routes with the shortest evacuation time
Pilot Study Assessment Results

- Pilot study population = 22,612 vehicles (portion of Natomas)
- Time required to evacuate population = 54 minutes
- 1,216 vehicles flooded (before and during evacuation)
- 8 vehicles stranded (though not flooded)
- 21,388 vehicles safely evacuate
Pilot Study Assessment Results
Pilot Study Assessment Results

• Evacuation center (safe zone) results
Future Applications (General)

- Useful tool for planning studies
- Assessment significantly increases certainty in evacuation time predictions
- This information be used to improve planning associated with all elements of the evacuation planning process to achieve a successful evacuation
  - Hazard prediction time (P)
  - Resource mobilization time (M)
  - Evacuation warning time (W)
  - Community acceptance / risk education (Wf)
  - Vehicle movement during an event (Vt)
Timeline – Failed Evacuation

- **Time = 0**
- **Prediction Calculation** $P$
- **t₀** First sign of flood
- **tp** Estimate of flood severity
- **Start response** $tr$
- **Decide Strategy & Mobilize Resources** $M$
- **Start warning** $tw$
- **Start evacuation traffic/movement** $te$
- **Time Needed to Warn All Dwellings** $W$
- **Community Acceptance Response Factor** $Wf$
- **Actual Available Time** $Ea$
- **Total Time Needed for Evacuation** $En$
- **Time Needed for Vehicle Movement** $Vt$
- **Low point in route cut by floodwater**
- **Time Lost** $L$
- **Evacuation interrupted before completion** $ti$
- **Rescue Phase** $R$
Timeline – Successful Evacuation

- **Time = 0**
- **Prediction Calculation (P)**
  - **t₀**: First sign of flood
  - **tᵖ**: Estimate of flood severity
- **Start response (tr)**
- **Decide Strategy & Mobilize Resources (M)**
- **Community Acceptance Response Factor (Wf)**
- **Time Needed to Warn All Dwellings (W)**
- **Start evacuation traffic/movement (te)**
- **Total Time Needed for Evacuation (En)**
- **Time Needed for Vehicle Movement (Vt)**
- **Safety Factor if Available (S)**
- **Raised route cut by floodwater (ts)**

**Equation Breakdown**

1. **En** = **Vt** + **Wf**
2. **Vt** = **Wf**
3. **Wf** = **P**
4. **P** = **t₀** + **tᵖ**
5. **t₀** = **P**
6. **W** = **tw** + **te**
7. **tw** = **tr** + **M**
8. **te** = **W** + **M**
9. **M** = **Wf**
Future Application (Jurisdiction Examples)

• Useful for emergency response personnel to plan and guide large-scale evacuations
• Helpful for local authorities to decide when to call for a mandatory evacuation to save life and property
• Can be used by DWR Flood Operations Center staff to advise local authorities of probable risks
• Evacuation results can be used as a community education tool, enhancing the DWR Flood Risk Notification Program
Questions?

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