Leveraging Flood Warning Systems for Multiple Purpose Decision-Making

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Introduction

- **Steve Malers**
  - 2015 founded TriLynx Systems
  - 2013 founded nonprofit Open Water Foundation – open source software tools for water resources (openwaterfoundation.org)
  - Since 2011 have served on the Fort Collins Water Board, as Chairperson 2013-2015 (water, wastewater, stormwater)
  - Over 25 years developing software systems for water resources data management, hydrologic modeling and forecasting applied at different scales
  - Colorado State University BS and MS in Civil Engineering

- Presentation is a perspective on integration of data for multiple purposes
Why Multi-Purpose Decisions?

- **Land use complexities**
  - Proximity and overlap of different land uses
  - Changing land use such as conversion of agricultural lands to urban
  - Public/private land

- **Jurisdictional complexities**
  - Overlapping service areas
  - Interconnected infrastructure

- **Different time frames of decisions and impacts**

- **Triple Bottom Line, master plans, integrated resource plans**

- **Budgets and staff constraints – need to collaborate**

- **Water can have multiple impacts, multiple uses, multiple benefits**
Overlapping Jurisdictions and Mission

- Municipal **stormwater** planning and infrastructure for flood safety.
- **Water quality** best management practices driven by regulatory compliance.
- **Recreational interests** such as trails.
- Natural areas interested in preserving and enhancing the **environment**.
- Ditch companies operating for **water supply**, with opportunistic use of excess storm-generated water supply.

Photo credit: Steve Malers, view from TriLynx office.
Nonstationarity

- Climate change?
- Storage?
- Development?

Real-time data is used for monitoring within historical context
Basic Flood Warning System

- Focus is on preventing loss of life and minimizing damage
- Data
  - Precipitation
  - Stream stage and flow
- Data visualization
- Potentially coupled with hydrologic/hydraulic model as forecasting tool
- Connection to emergency management community
  - Alarms and notifications
  - Emergency response
- Although pre-planned, immediate decisions are reactive to storm events
- Risk is considered based on analysis of historical short-timeframe events
Water Supply Questions

- How much of a contribution did the last storm provide to water supply?
- What are reservoir levels?
- What are soil moisture conditions?
- How will storm events impact operations related to water supply?
- Can the additional data from flood warning systems augment information about consumptive use, such as outdoor irrigation?
- Extensive planning occurs, and decisions play out over seasons and years.
- Risk is considered based on analysis of historical hydrology and highly variable current hydrology (demand can generally be quantified with some certainty)
Historical Drought

Baseline with significant on-channel storage
Historical Drought

Yampa-White Basin SWSI History

Basin with little on-channel storage
Historical Drought

HUC 10190007 (Cache La Poudre) Surface Water Supply

HUC 10190007 (Cache La Poudre) SWSI
Water Quality Questions

- What is the local impact of rain events on wildfire burn areas?
- What is the impact of runoff on water quality, including sediment load and contaminants?
- What are long-term trends in water quality?
- What are water temperatures?
- Will data from flood warning systems help with regulatory compliance?
- Decisions are driven by regulatory compliance
- Risk is considered by evaluating the impacts of non-compliance
Environmental Flow Questions

- Can the real-time data from flood warning systems be used to monitor environmental flows?
- How is the drought impacting environmental flows?
- Can flood warning systems augment flow data at critical intermediate locations (for example where water supply gages are not available)?
- Because environmental flow is for the most part non-consummptive, can flood warning system data help make better decisions with short-term management of flood waters that allows better longer-term decisions related to water supply? Flood/hydrologic forecasting helps with both.
- Decisions may be driven by species recovery or protection programs
- Risk is considered as consequences of failure to meet species protection programs and potential negative impact of environmental damage
Environmental Flow Questions

South Platte Basin, Colorado

Dots represent confluence points
Environmental Flow Questions
Decisions are often made with imperfect or insufficient data – can use available data to explain decisions

It is important to understand the differences between and use of data
- flood warning decisions
- water supply decisions
- regulatory compliance
- real-time monitoring compared to planning

Decisions are made at locations within an interconnected system
- infrastructure
- jurisdictions, natural systems

Decisions are ultimately made by people who have a job description, at organizations that have a mission, within a larger community, state, and federal government

Decision-making failures can be highly publicized and lead to finger-pointing (Flint Michigan)
Decision-Making Data Considerations

- Who has access to the data, and how?
- Data security concerns
- Do people REALLY understand data limitations?
  - Definition of data
  - Measurement accuracy
  - Quality control protocols and use of flags
- Is flood warning system data quality good enough for other types of decisions? Is provisional data good enough for all uses?
- Is flood warning system data a primary data source or a cross-check?
- Are historical data available for analysis (trends, etc.)?
Policy and Operational Considerations

- Do single-purpose entities such as special districts have an obligation to share data for decisions and is this obligation self-imposed or by statute?
- Should organizations implement an open data policy and open data portal?
- Should data products be created to facilitate use by other decision-making entities?
- Is it a zero-sum game (you help me, I help you)?
- How are data attributed?
### Results matching category of Water

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<th>Name</th>
<th>Popularity</th>
<th>Type</th>
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Showing 10 of 150
There are known data quality issues due to sensor, communication, and decoding errors, with ALERT2 providing improvements.

Data are suitable for emergency management decisions but may not be suitable for engineering/modeling decisions.

Other data sources also have data quality issues.
# Streamflow Measurement

## Free-Flow Discharge Table for Parshall Flumes

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Public Perception

- Are flood warning systems “invisible” until there is an event?
- Or are the issues related to water ongoing and require as many resources as possible to address?
Predictions

- The “Internet of Things” (IoT) will become more pervasive with additional sources of data
  - consumer-level data from devices
  - could have data overload
  - could have appreciation of data

- Data-driven decision-making will increase
  - IT department dependency
  - cloud-hosted services increase

- Flood warning systems will increasingly be leveraged to provide data for a broader set of decisions

- But… flood warning systems are only are part of the solution
Questions?

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http://trilynxsystems

Photo credit: Steve Malers, Poudre River channel near Environmental Learning Center, Fort Collins.