Creating an Extensible Data Exchange and Analytics Sandbox for Smart Water infrastructures

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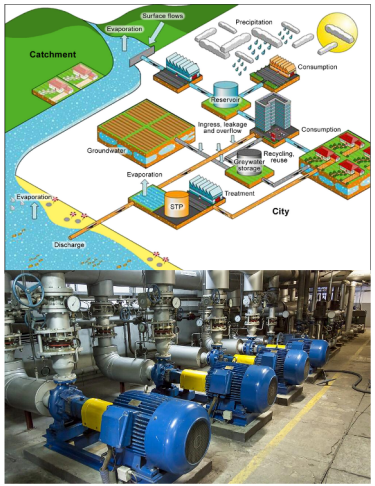
SWADE Technology Partners & Community Advisory CAB

SWADE: Project Motivation

Water infrastructure is aging and becoming increasingly complex

- Multiple Infrastructures, and dedicated regulatory and compliance agencies

Drinking water



Wastewater

Stormwater

- Data and structural information siloed within agencies and systems
- Decision-makers (agencies, policy-makers) need tools to interpret data, identify problems and take actions

SWADE: Project Overview

Key Premise

Water cycle data (historical and live) and its dependencies, a bulk of which resides within community agencies, if combined and enhanced with other geo-distributed data sources can enable new levels of efficiency and resilience

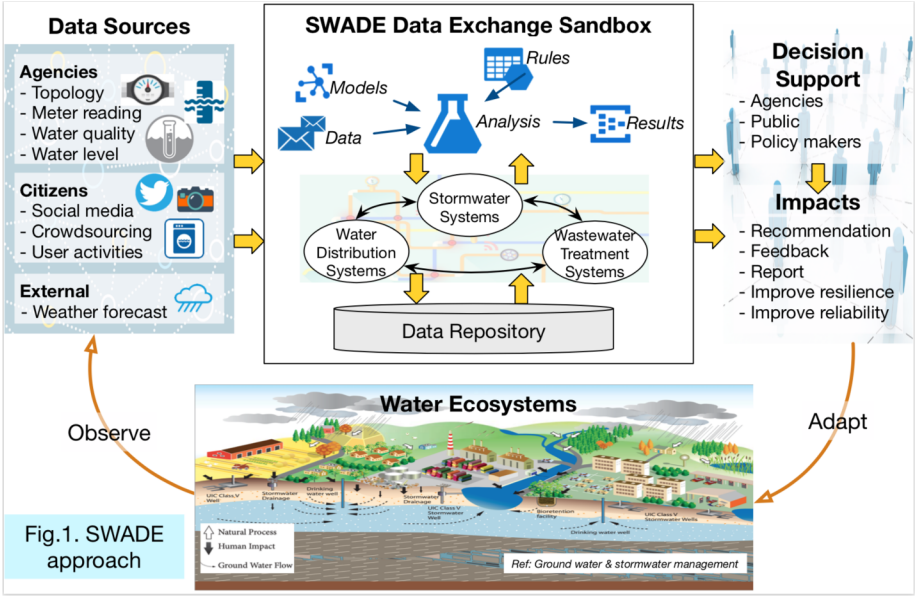
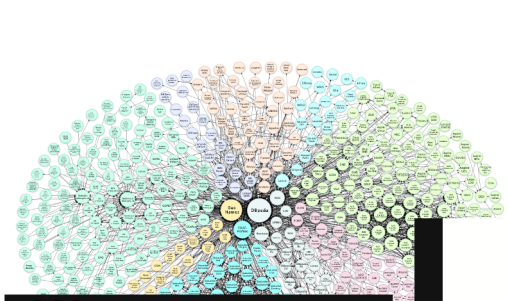
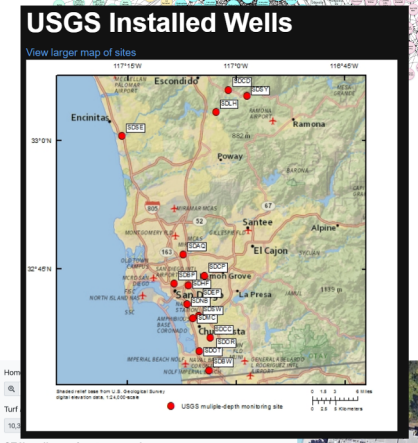


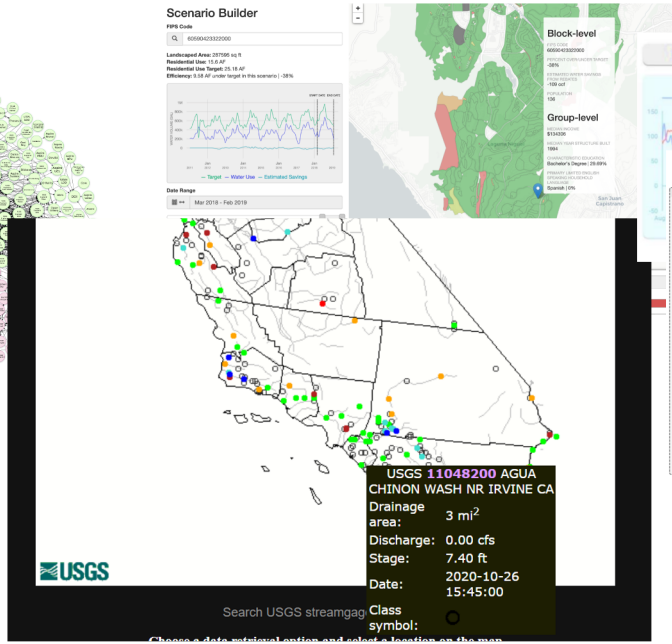
Fig.1. SWADE approach

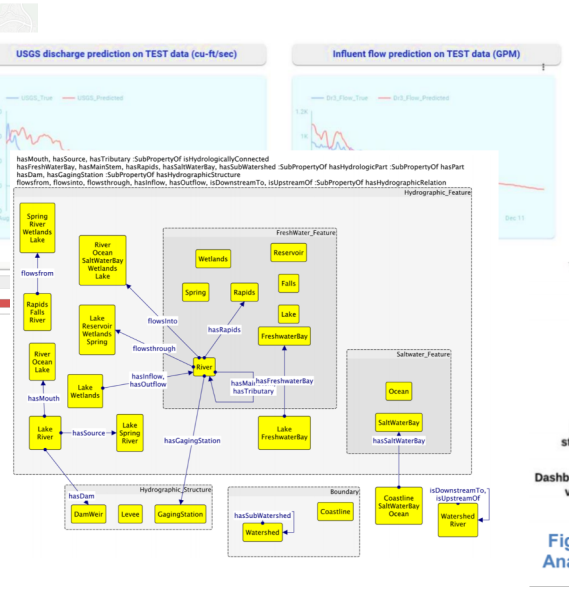
- **Model** the **different water infrastructures** and interconnections under normal operation or extreme events
- Determine barriers (societal, policy/regulatory) on gathering, sharing and usage of data.
- Identify challenges in translating (restricted) data to meaningful information for timely decision making, especially under large disruptions
- Current approaches: (1) requires significant effort to acquire and understand data; (2) information processing delays; (3) high levels of data redundancy; (4) lack of infrastructure for data exchange

SWADE: Project Evolution









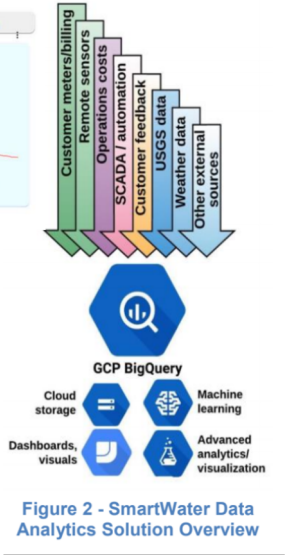


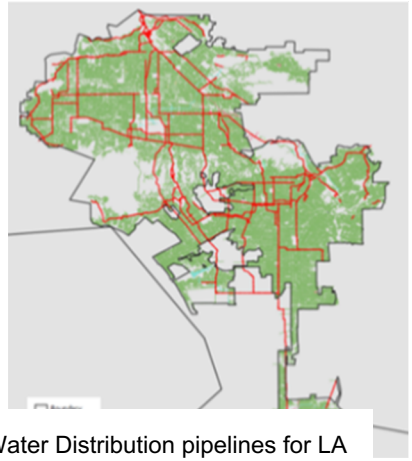
Figure 2 - SmartWater Data Analytics Solution Overview

- Many diverse, scattered sources of information
- Strategy:
  - Work with community partners to identify focus problems
  - capture and represent relevant concepts and data in a data architecture.

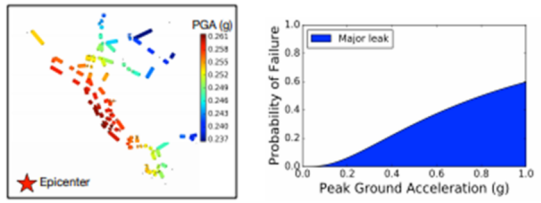
SWADE: Drinking Water Systems

Focus Problem :
Infrastructure Resilience to Extreme Events

- Exploit robust simulations to identify seismic event scenarios with significant impact on water distribution networks
- Enable additional instrumentation and retrofit to provide rapid predictions for community safety



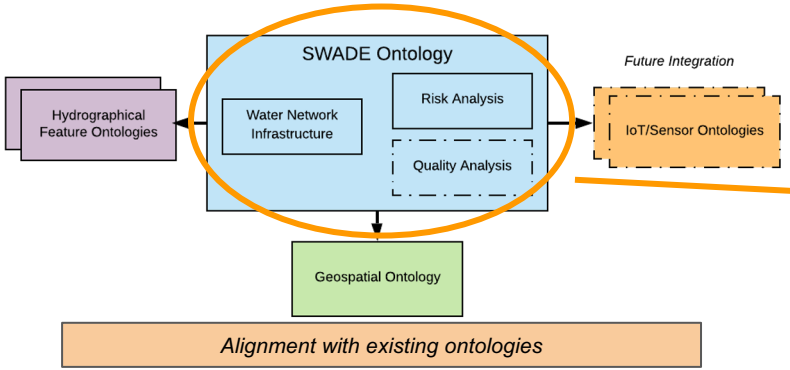
Water Distribution pipelines for LA

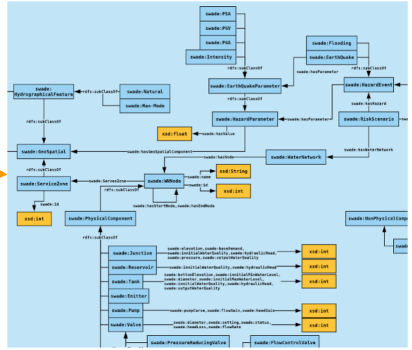


(a) Peak Ground Acceleration (b) Fragility Curve

Fig. 7: (a) PGA of pipelines for a magnitude of 5.5 earthquake. (b) Fragility curve for pipe damage.

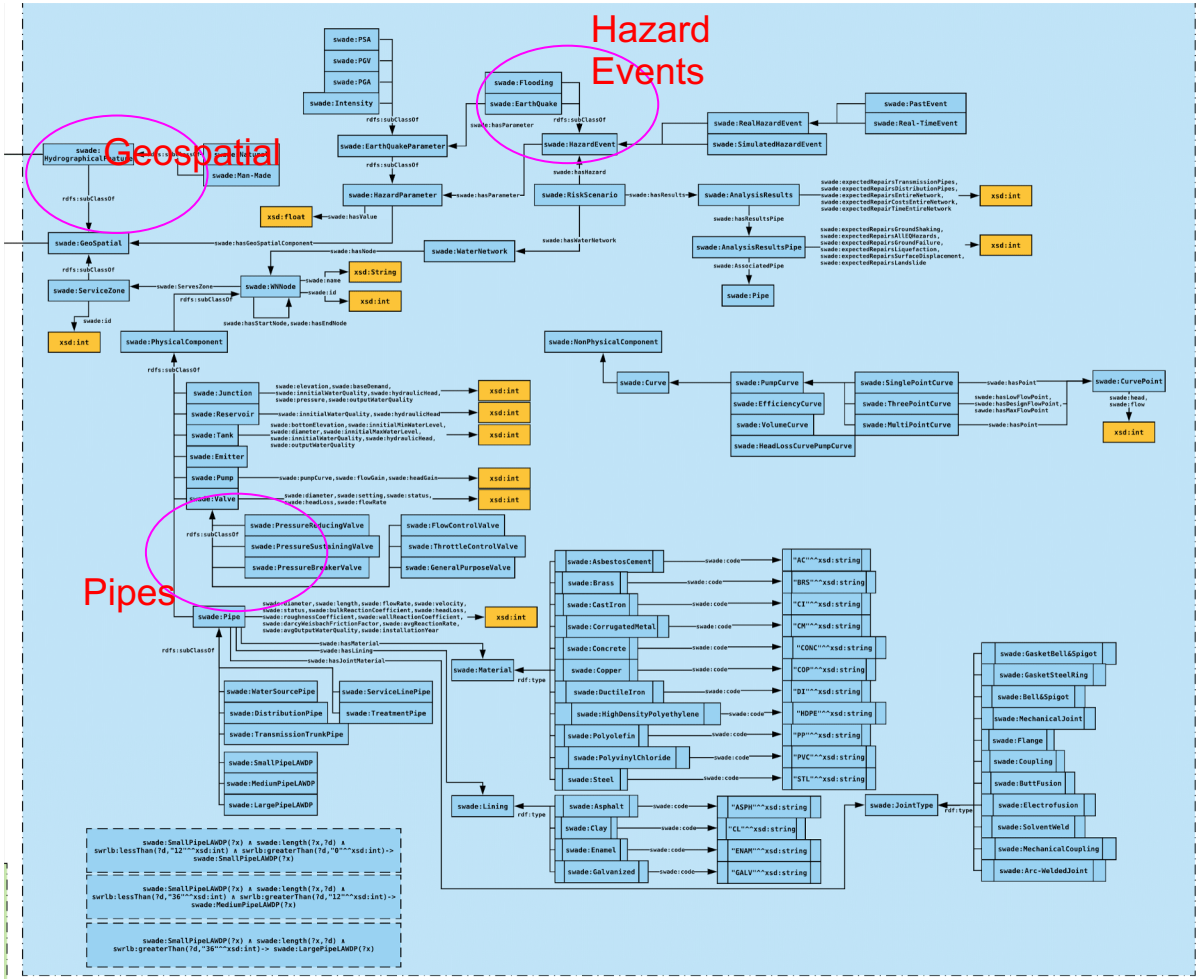
SWADE Ontology: Vocabulary to enable interoperability of water organizations





- **Current version**: Definition of water networks and components, geographical elements, hazards, and risk analysis results.

SWADE: Ontology



SWADE - Wastewater Systems

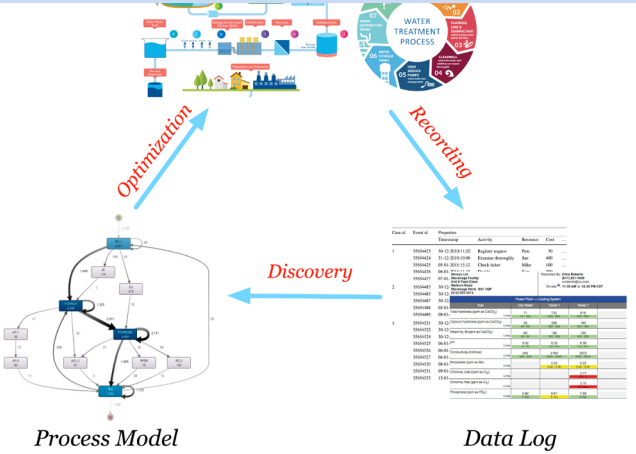
Focus Problem :
Process Mining for Wastewater Treatment Plants

Mining Implicit or Hidden Knowledge

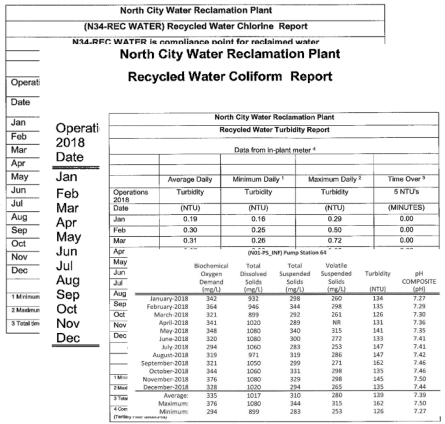
- Extract implicit knowledge and experience from historical treatment event logs
- Discover knowledge or structural properties (timing constraints, interdependent flows)
- Use to improve practical wastewater treatment workflow

Improving operational efficiency with soft-sensors

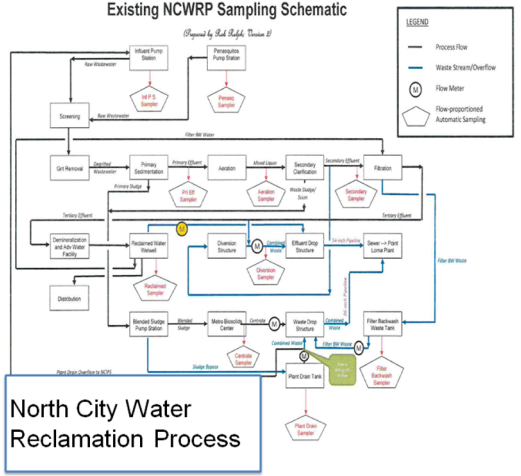
- Reduce energy demands caused by excess aeration without sacrifice in effluent quality.
- Combine data from physical sensors with regression methods.



Wastewater Treatment Event Logs



Existing NCWRP Sampling Schematic



SWADE - Stormwater Networks

Focus Problem :
Source Identification for Dry weather monitoring

Sensor Placement

- Tradeoff - Budget vs. Quality of monitoring
- Need to quickly detect high impact events

Resource-efficient monitoring

- High deployment & operational costs - underwater installation, human grab sampling.
- Coarse-grained monitoring (efficient, less accurate) vs. fine-grained monitoring (expensive, high accuracy)

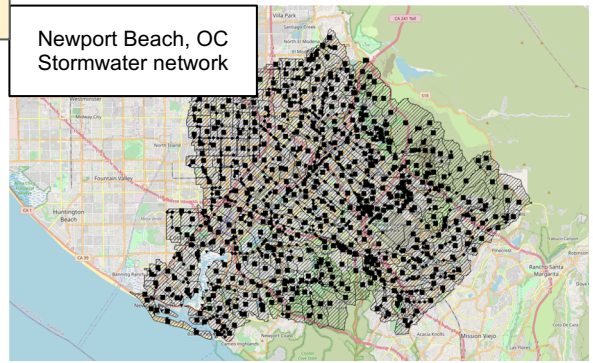
Network Structure and Time Series Analysis

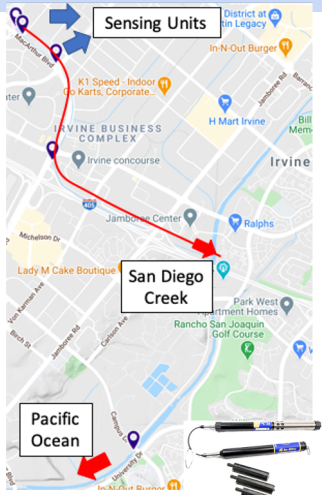
- Detect contamination events and sources rapidly
- Understand role of network structure and its relationship to data generated using time-series analytics

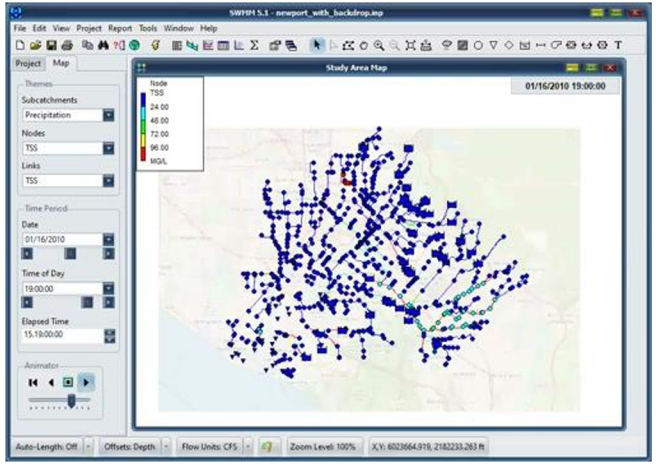
Generalizable Data Analytics

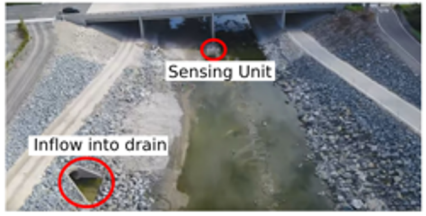
- Allow other agencies/communities to reuse successful models
- Train ML models that are robust to location-specific data biases

OC Public Works









Community Engagement

- **Stakeholder workshops and data challenge events**
  - Workshop to survey stakeholders (agencies, policy makers, academics, industry groups, etc.)
  - What tools will be valuable to them?
  - What are their concerns (privacy, data sharing, accessibility)?
  - What tools can be build to facilitate cooperation?

- **Engagement for platform creation and community data instantiation**
  - Engagement from SWADE stakeholders to help design and develop platform
  - Leverage currently used tools, datasets, and data formats.

- **Validation studies with Community Water Networks**
  - Scenario creation with partner agencies
  - Deployment of SWADE tools for analytics

- **SWADE Internships**
  - Embedding students as interns at various agencies.
  - Undergraduate and High-school research opportunities

SWADE: Ongoing work

- System-specific milestones
  - Drinking Water: Create vocabulary to represent drinking water systems and water quality analysis
  - Wastewater: Examine data representation needs for operational efficiency
  - Stormwater: Integrate time-series analytics with network structure analysis, explore generalization methods to improve robustness of ML techniques
- Identify relationships and interdependencies between different water infrastructure systems
- Expand data representation and ontology to capture multiple relationships