

Prediction of Nonlinear Climate Variations Impacts on Eutrophication and Ecosystem Processes and Evaluation of Adaptation Measures in Urban and Urbanizing Watersheds

presented to

Utah Lake Modeling Group Meeting

Dr. Michael Barber

October 4, 2016

Presentation Outline

- Introduction of Research Team
- Study Goal and Objectives
- Background & Research Hypotheses
- Research Approach and Activities
- Expected Results, Outputs, & Outcomes

Research Team

1. Michael Barber (CvEEN)
2. Steven Burian (CvEEN)
3. Ramesh Goel (CvEEN)
4. Sarah Hinnners (City & Metro Planning)
5. Brett Clark (Sociology)



Roles and Responsibilities

Investigator	Primary Responsibilities	Secondary Responsibilities
Barber, M.	Project Management Water Quantity and Quality Modeling	BMP/LID Practices Field Work
Burian, S.	Integrated Urban Water Modeling Stormwater Management and LID Practices Climate Impacts	Field Work Public Outreach and Education
Goel, R.	Field and Laboratory Studies of Water Chemistry for SOD/DO	Education Agency Coordination
Hinners, S.	Land Use Planning with ET+ Scenario Development	Public Outreach and Education
Clark, B.	Societal Values Public Outreach and Education	Scenario Development

Goal

...to develop an improved system-wide quality and quantity model of the Jordan River watershed that can be used by stakeholders to improve planning related to water supply and demand forecasting, TMDL planning and implementation, policy decisions related to urban growth and water projects, and public education and outreach.

Objectives

1. Develop a dynamic water quantity/quality model of Jordan River watershed using SWMM, DHSVM, EFDC, and WASP
2. Link the process-based model of the Jordan River watershed to a system dynamics model of the integrated urban water system for the Salt Lake City metropolitan area
3. Integrate each of the four AR5 climate projections into prediction of 2050 water quantity and quality baseline scenarios
4. Conduct field and laboratory analysis to parameterize kinetic coefficients and determine non-linear responses under climate scenarios

Objectives (continued)

5. Examine land use planning implications including scale-related phenomenon related to headwater versus downstream economic, social, and ecosystem constraints
6. Hold participatory stakeholder workshops to develop future scenarios related to conservation, reuse, land use changes due to population, BMP/LID implementation, wildfire disturbances, and water management
7. Use models to examine impacts of scenarios and levels of investment needed to achieve a sustainable environment for economic and ecosystem protection

Objectives (continued)

8. Create a framework for maximizing value of BMP placement through off-site investment to achieve water quantity and quality goals
9. Incorporate findings into classroom instruction to help prepare the future workforce in thinking holistically to solve tomorrow's challenges.

Background

Watershed Characteristics

- * 3,850 mi² drainage
- * 52-mi long Jordan River
 ≈ 800 mi² watershed
- * flows through 15 cities
- * ~ 7,000 feet elevation Δ
- * 15 municipalities
- * 4 WWTP

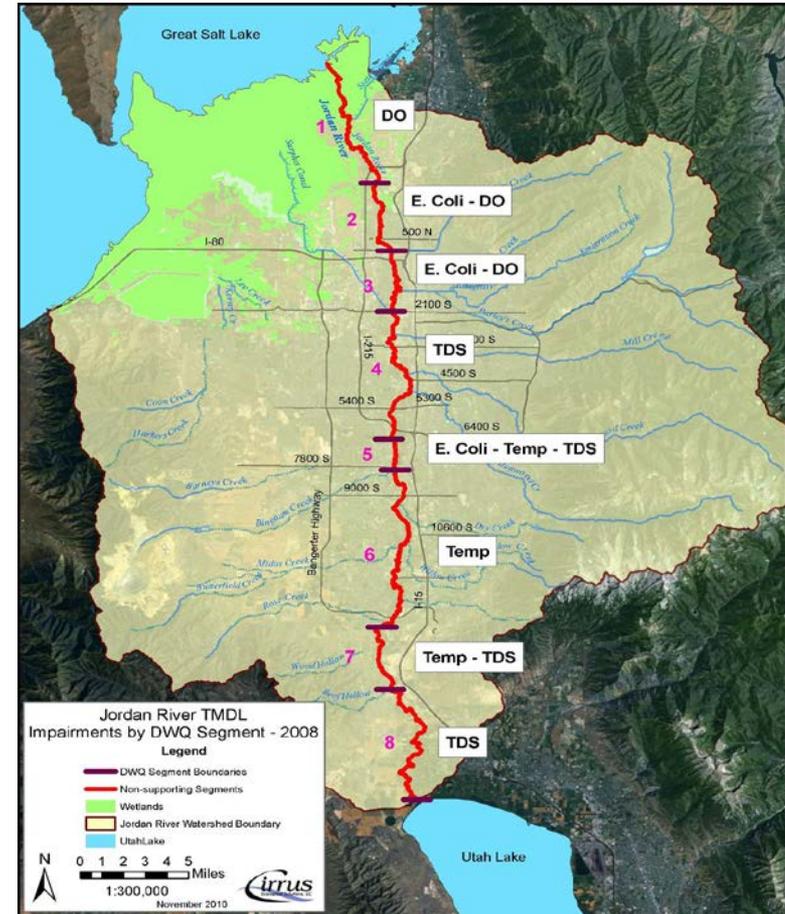
- * Utah DWQ has an existing TMDL for the Jordan River



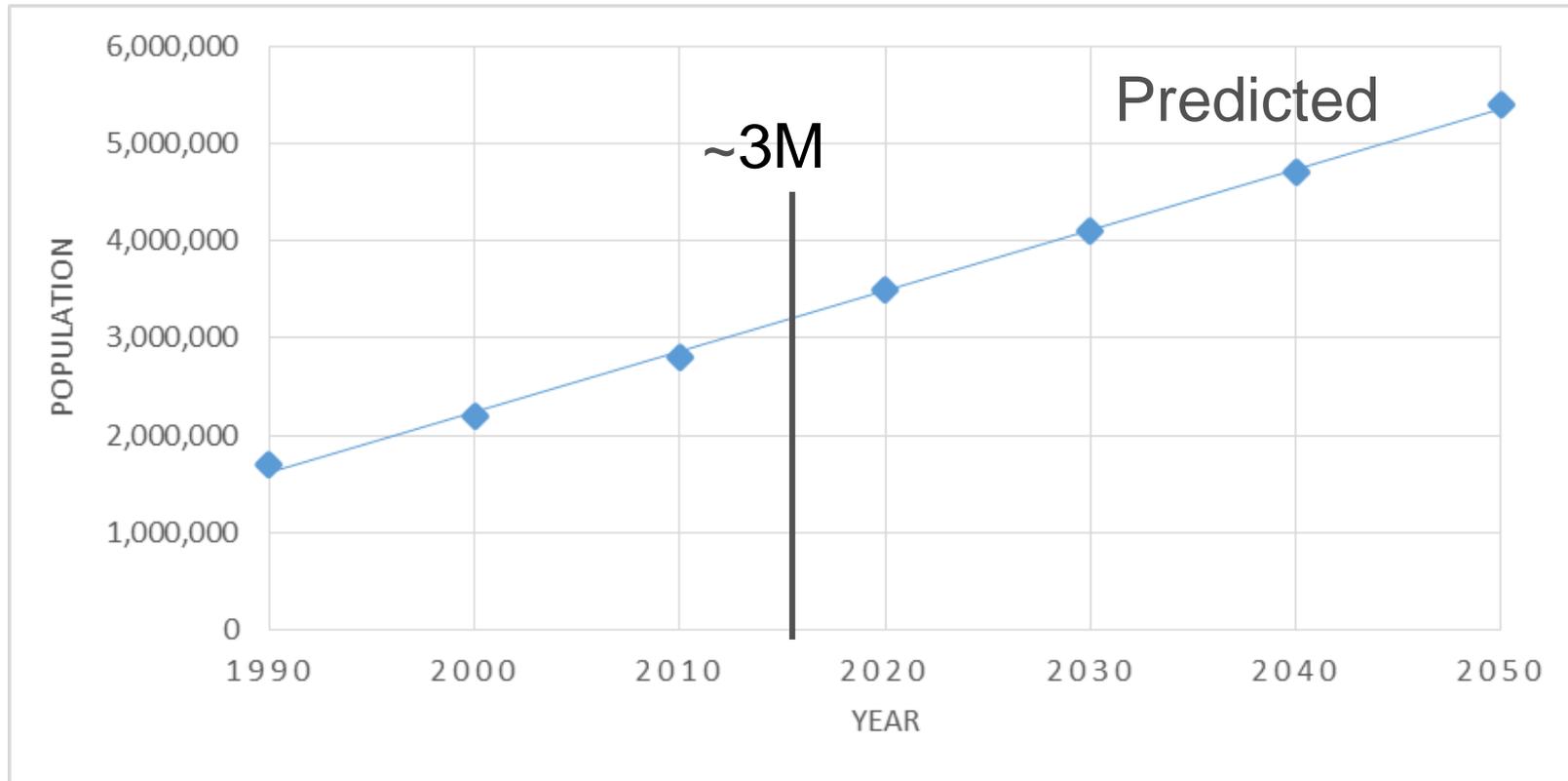
TMDL/303(d) Concerns

Reach Dependent

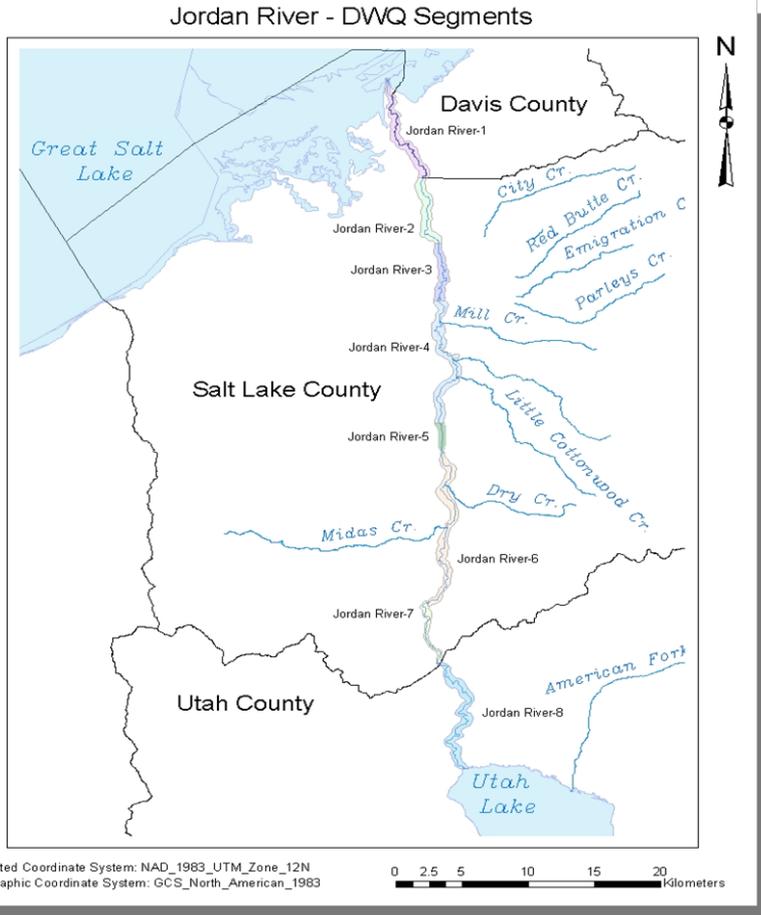
- Temperature
- Phosphorus
- E. Coli
- Dissolved Oxygen
- TDS
- Metals



Economic and Population Growth

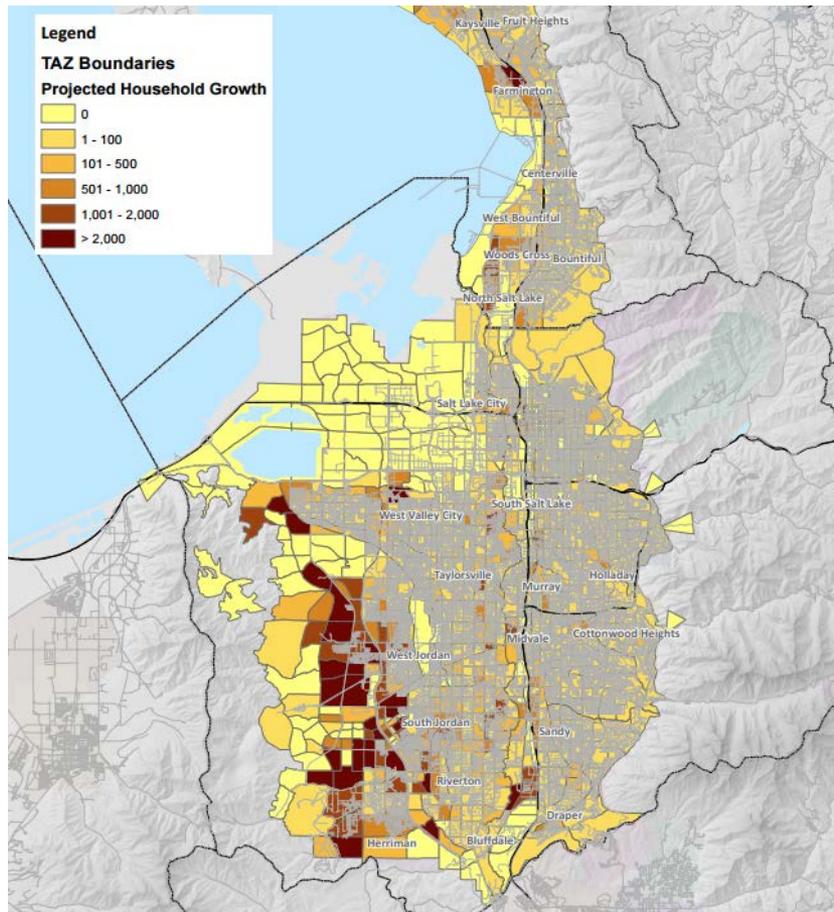


Concentrated Growth



Utah Lake/Jordan River watershed population will increase 72% by 2050 resulting in an additional 1,100,000 people.

2040 Projected Household Growth



Our population is growing, but what does that translate to on the landscape and water quality?

Wasatch Front Regional Council

Research Hypotheses

- H₀ 1: Climate change impacts to water quality and quantity in urban areas will require adaptation measures beyond traditional historic time series data-related design practices due to extreme wet and dry periods.
- H₀ 2: There remains sufficient resilience in the Jordan River system to accommodate a major urban area and maintain a clean and safe water supply through careful, cooperative, and innovative community planning, engineering, and design.

Research Hypotheses (continued)

- H₀ 3: Regional stakeholder-driven solutions to water quality issues will prove more cost effective and more beneficial to the environment than individual projects.
- H₀ 4: Effective planning and adaptive management for extreme events will help alleviate the adverse economic and ecosystem impacts of wildfires, droughts, and floods.
- H₀ 5: Education and outreach can be used to develop innovative solutions that are embraced by stakeholders throughout the watershed and thus implemented on a broader basis.

Research Approach

- ***Water Quality Kinetics***. Produce new understanding of water quality kinetics and reactions under temperature scenarios representative of climate change.
- ***Process Modeling Framework***. Integrate existing models to study climate modified stormwater runoff and receiving water responses. The methodology demonstrated will provide a framework for others to follow with existing models in their area.
- ***Planning Scenario Informed Analysis***. Use ET+ to demonstrate the use of planning and policy decision making to guide scenario development for use in process and system modeling of climate impacts.
- ***Coupled Process-Systems Modeling***. Couple the process models with a systems model to provide the power to analyze the interconnections and feedbacks of system level changes on explicit receiving water response.
- ***New Resiliency and Vulnerability Metrics***. Resiliency and vulnerability metrics for stormwater management and improved water quality systems.

Approach: Models and Linkages

- Distributed Hydrology Soil Vegetation Model (DHSVM)
- Storm Water Management Model (SWMM)
- Envision Tomorrow Plus (ET+)
- Environment Fluid Dynamics Code (EFDC)
- Water Quality Analysis Simulation Program (WASP)
- GoldSim

Comprehensive Modeling Framework

Climate Dependent Water Quality Predictions

DHSVM: To generate hydrograph and stream temperatures for the mountainous tributaries feeding Jordan River and Utah Lake

SWMM: Used to predict the impact of climate change on urban storm water runoff

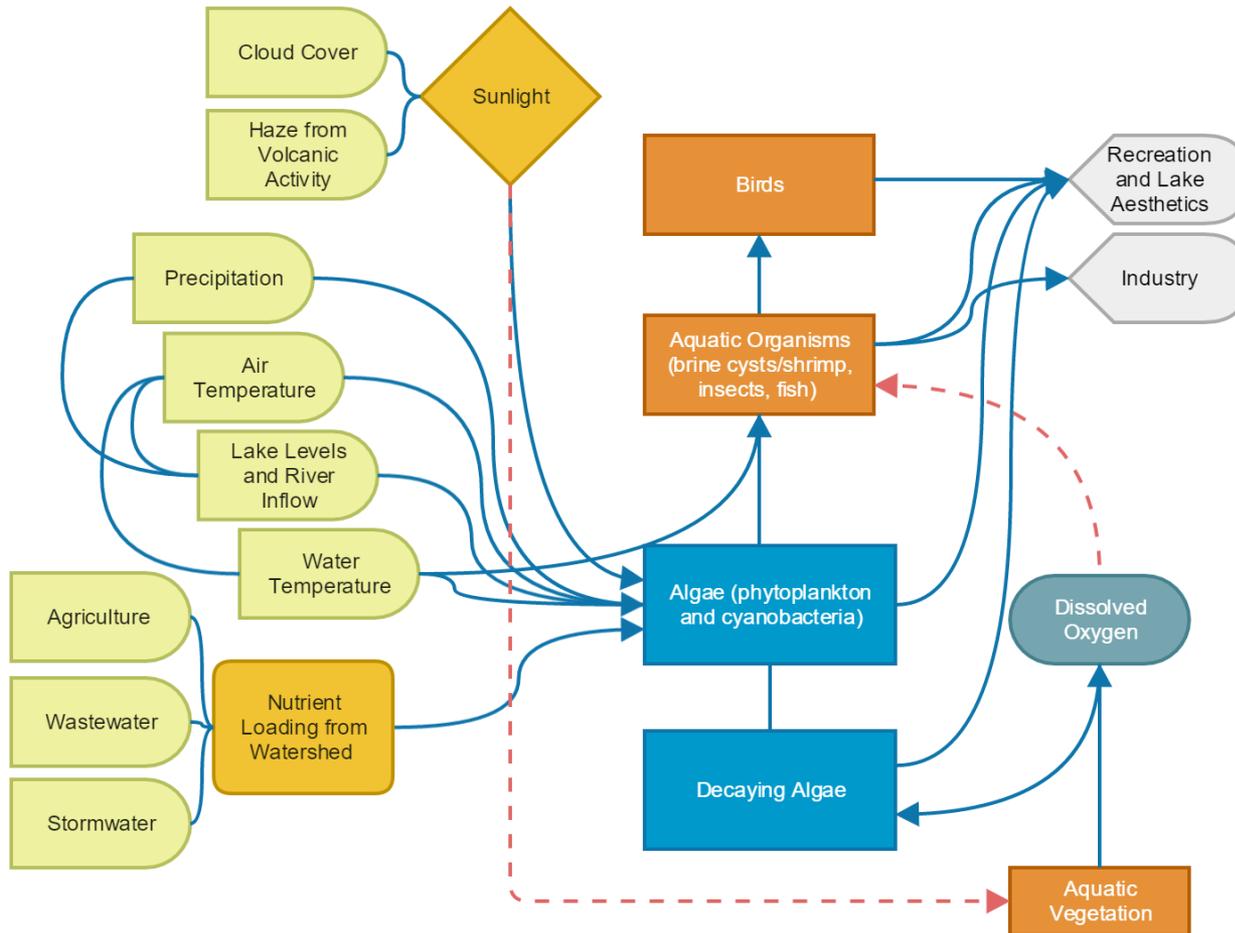
ET+: Provides outputs concerning the impacts of policies, development decisions, and current growth trajectories

EFDC Hydro: Will provide hydrodynamic inputs to WASP

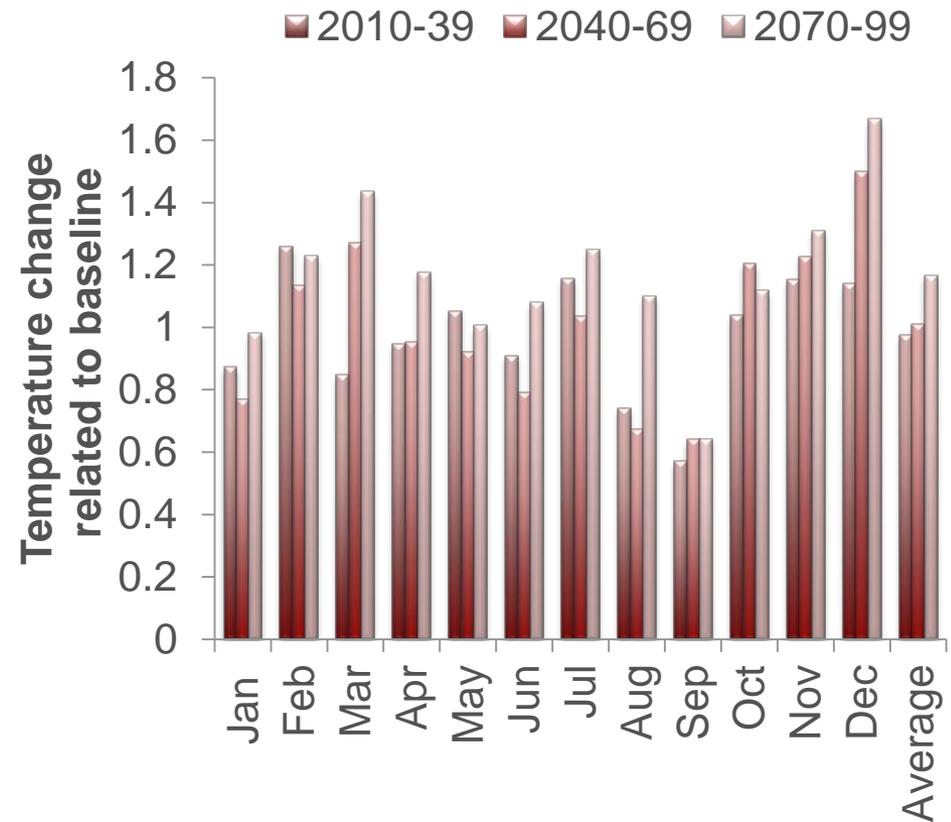
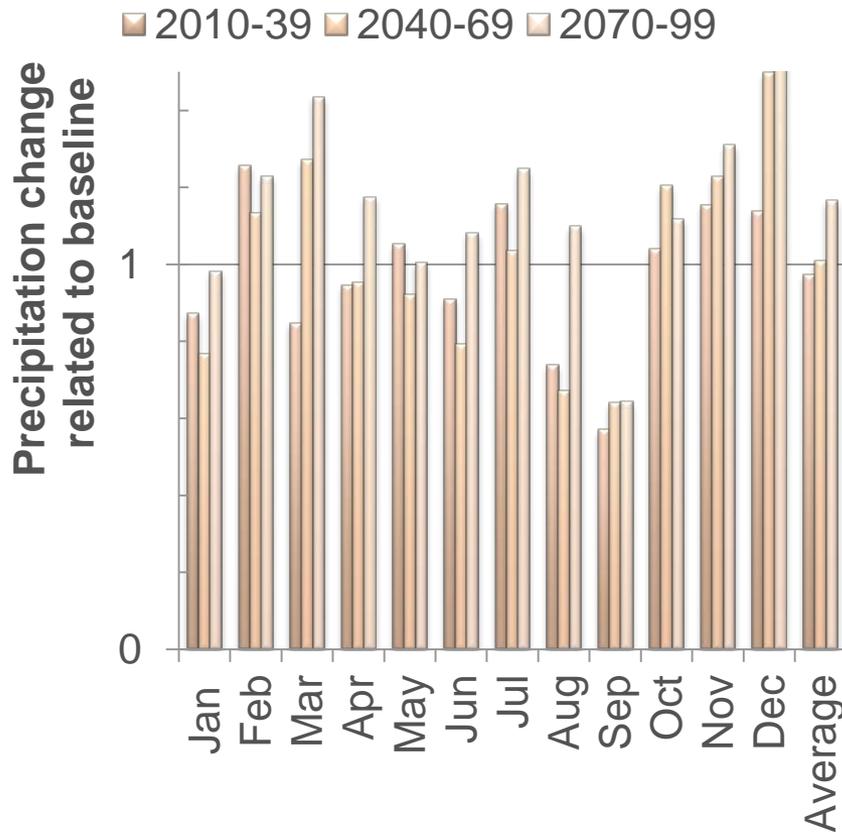
WASP: To simulate surface water quality as a result of climate, hydrology, land use, point & non-point loadings, and the impacts of potential policies

GoldSim: Integrated platform based on Monte Carlo simulations

Algae in Lake Ecosystems



Normalized Precip and Temp



Critical Questions

- How does drought (seasonal and prolonged), exacerbated by extreme weather and climate change, affect water quality and availability of surface water and groundwater? (Incorporate climate models)
- How do subsequent drought related events, such as changes in surface runoff and wildfire, lead to additional changes in water quality and availability? (Incorporate watershed models)

Critical Questions (continued)

- How can changes in water quality driven by other variations in the hydrological cycle related to drought, such as changes in the timing and intensity of spring snowmelt and runoff, affect water quality? (Incorporate hydrologic models)
- What adaptive management strategies and innovative, cost-effective technologies provide communities and ecosystems with protection and resilience against direct and secondary drought related impacts exacerbated by climate change? (Incorporate socio-economic aspects)

Critical Questions (continued)

- How can the proposed management strategies and technologies be demonstrated in different communities to facilitate adoption of sustainable water management?

Expected Outcomes

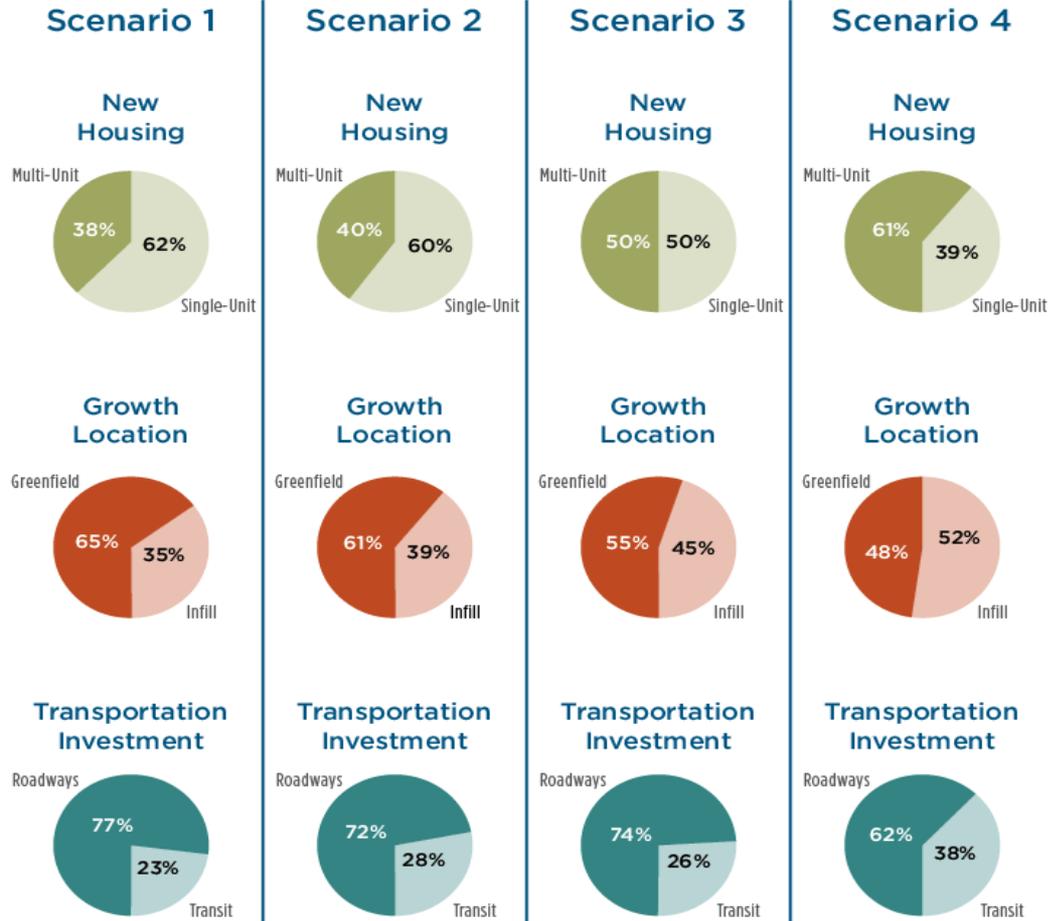
1. A dynamic tool capable of accurately predicting the appropriate numeric nutrient criteria for the Jordan River and Utah Lake necessary to prevent eutrophication under existing and future climate conditions.
2. An integrated process-systems model capable of coupling detailed watershed-water quality dynamics (the process model) with planning, policy, people, and interconnected systems such as water supply and water demand (the systems model).

Expected Outcomes (continued)

3. At least three peer-reviewed journal papers in engineering, ecology, planning, and sociology related venues.
4. Two public workshops to Jordan River stakeholders and other public outreach activities such as community seminars and K-12 education.
5. Revised curriculum contents integrating interdisciplinary research approaches and findings into case studies designed to expand the envelope of creative thinking.

Initial Research Activities

With MUCH stakeholder feedback, **Preferred Scenarios** have been proposed

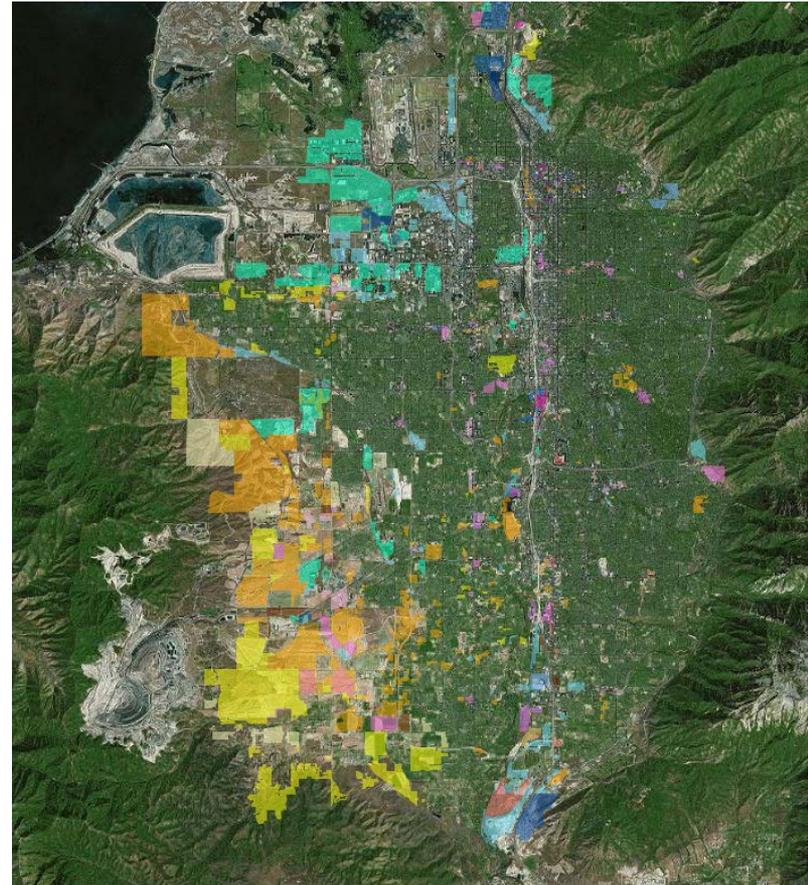


“Preferred” 2040 Development Plan



Development Type May 2015

- | | | | |
|--|--------------------------|---|---------------------------|
|  | Big Box Commercial |  | Open Space |
|  | Boulevard Community |  | Single Family Subdivision |
|  | Compact Neighborhood |  | Station Community |
|  | Downtown Neighborhood |  | Strip Commercial |
|  | Flex Employment Space |  | Suburban Office District |
|  | Heavy Industrial |  | Town Center |
|  | Large Lot SF Utah County |  | Town Neighborhood |
|  | Large Lot Single Family |  | Urban Center |
|  | Light Industrial |  | Urban Neighborhood |
|  | Main Street Commercial |  | Urban Office District |
|  | Main Street Community | | |
|  | Metropolitan Center | | |



Initial Outreach Activities

- Informal Discussions with Utah DWQ
- Radio Interview on local KUER NPR
- Presentation at last falls' SLC Watershed Symposium
 - “Uncertainty in Future Water Quality and Quantity in the Jordan River”

Questions and Discussion



Thank You!



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