Influence of climate change on regional hydrology and public health

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Decision Making Activities

- States need a low cost, quick method for estimating water quality.
  - A number of states are unable to quickly test for harmful bacteria in coastal waters
  - States are unable to warn their citizens of harmful water quality.
- Accurate long term predictions of water capacity for wastewater treatment plants are necessary.
- All states are faced with rising costs for wastewater treatment plants
- Construction of these plants is extremely costly and resisted by municipalities
- Inadequate facilities result in degraded water quality

Hypotheses

1. Coastal water quality is driven by precipitation, land use, and discharge from watersheds.

   A regression model can be used to predict water quality.

2. Projected climate and land use changes will lead to robust increases in precipitation and river discharge.
3. Increased discharge will lead to decreased water quality in the coastal environment.

   Output from NASA climate models will allow for accurate predictions of discharge and water quality.

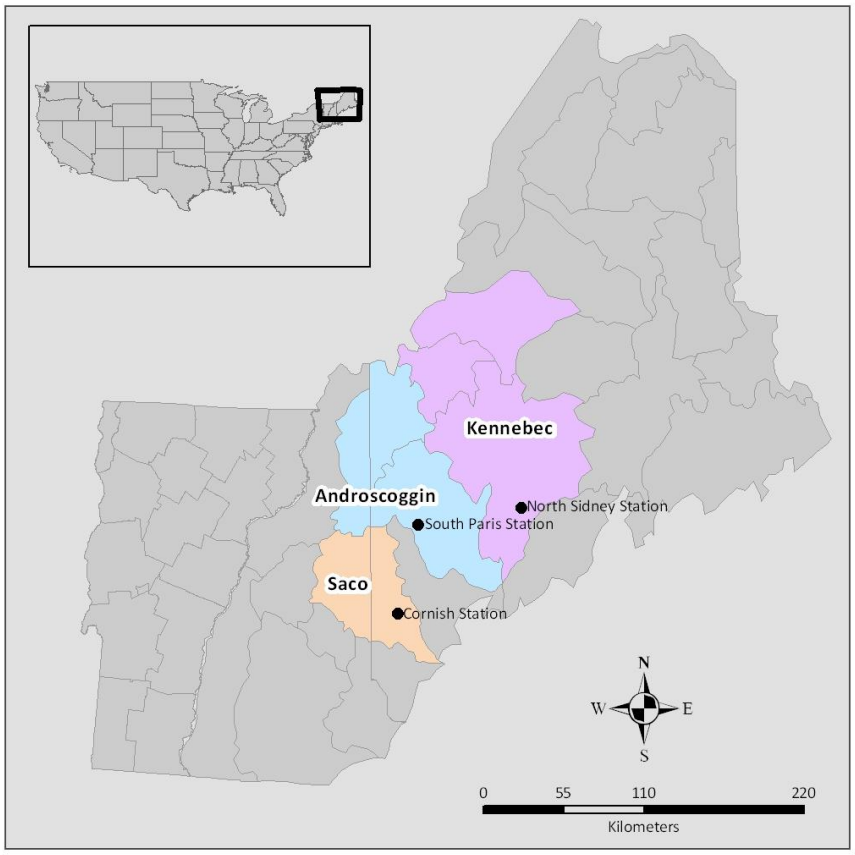
Research Objectives

- Accurately predict for three Maine watersheds :
  - River discharge
  - Water quality in coastal waters
- Examine effects of climate change scenarios on :
  - River discharge
  - Water quality in coastal waters
- Forecast wastewater treatment needs over a 10-20 year time period.
- Adapt method to large scale forecasts for US East Coast

Test Case: Three watersheds in Maine

Maine watersheds were chosen due to:

- PIs proximity to decision makers
- Maine's present tools are unable to predict water quality
- Measurements of environmental variables and water quality are readily available.



Earth Science Research Results

- Land cover data
  - Landsat Multi-Spectral Scanner (MSS), Thematic Mapper (TM), and Enhanced Thematic Mapper Plus (ETM+)
  - Time Range: 1972-Present
  - Spatial Resolution: 30 - 240 m
- Precipitation Data
  - Tropical Rainfall Measurement Mission Microwave Imager (TMI)
  - Time Range: 1998-Present
  - Spatial Resolution: 0.25° x 0.25°
- Climate Model Output
  - NASA/GISS 4x3 Atmosphere-Ocean Model
  - Spatial Resolution: 4° x 3°

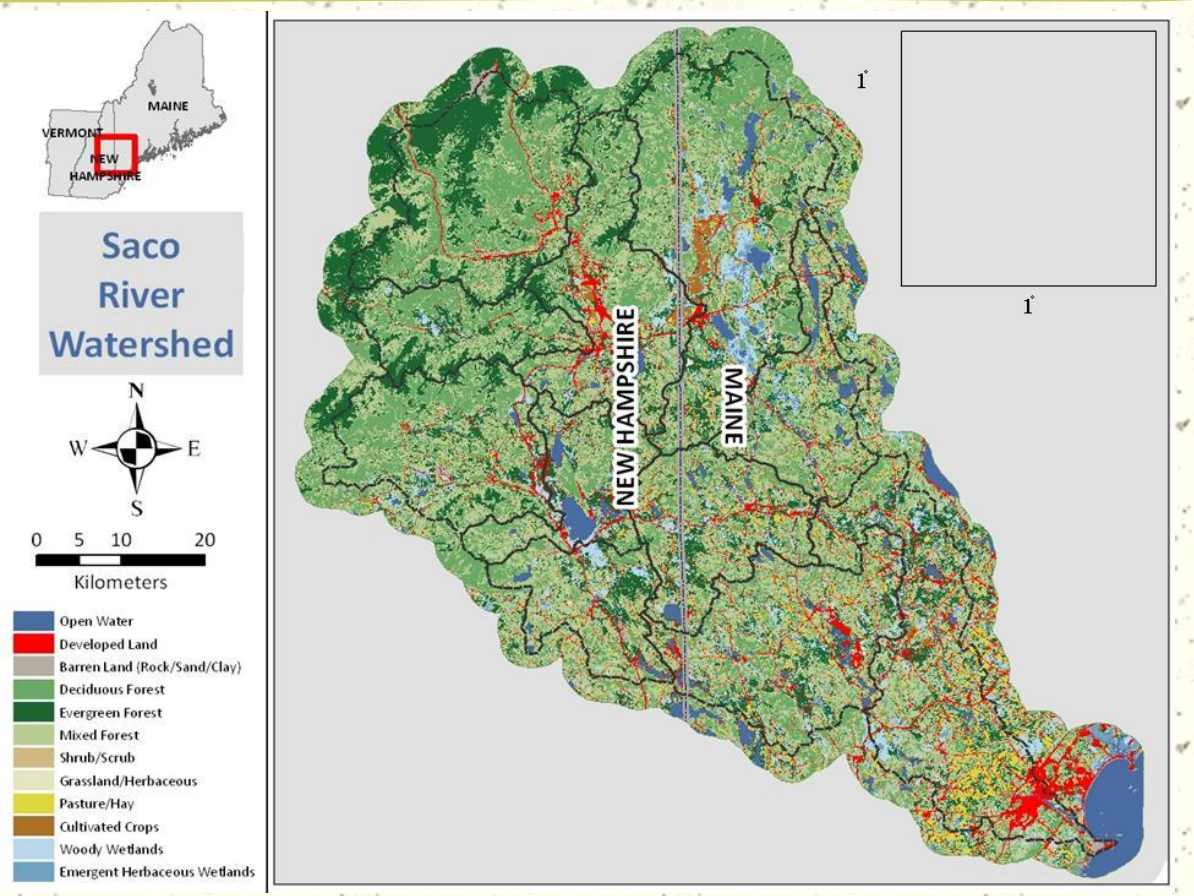
Additional Data

- Additional Precipitation Data
  - National Climatic Data Center
  - Spatial Resolution: variable
  - Time Range: 1965-Present
- River Discharge Data
  - United States Geological Survey
  - Time Range: 1905-Present
- Water Quality Data
  - Standard indicator bacteria
    - *E. coli*
    - Fecal and total coliforms
  - Time Range: 1998-Present

Data Partners

- Maine State Planning Office
  - Sample water quality at Maine beaches
  - Recommend beach closings
  - Make projections of waste water needs
- Casco Bay Estuary Partnership:
  - Monitor water quality in Casco Bay estuary
  - Examine links between water quality and coastal development
  - Recommend clam flat closings
- Saco River Corridor Commission
  - Monitor water quality data in Saco River

Task 1: Determine land use characteristics

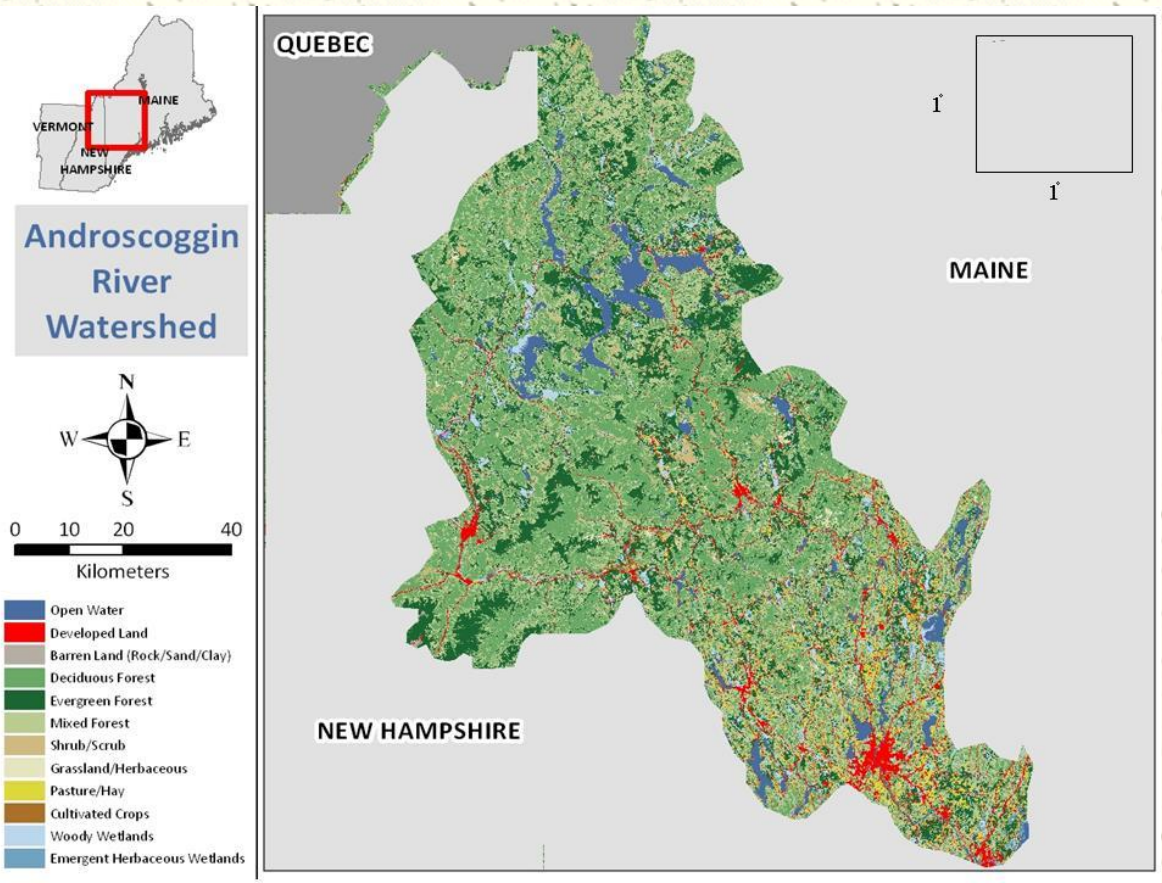


LandSat –
MSS, TM, ETM+
1972- Present

4,410 km^2 area

mean discharge = 90 m^3/s

Task 1: Determine land use characteristics

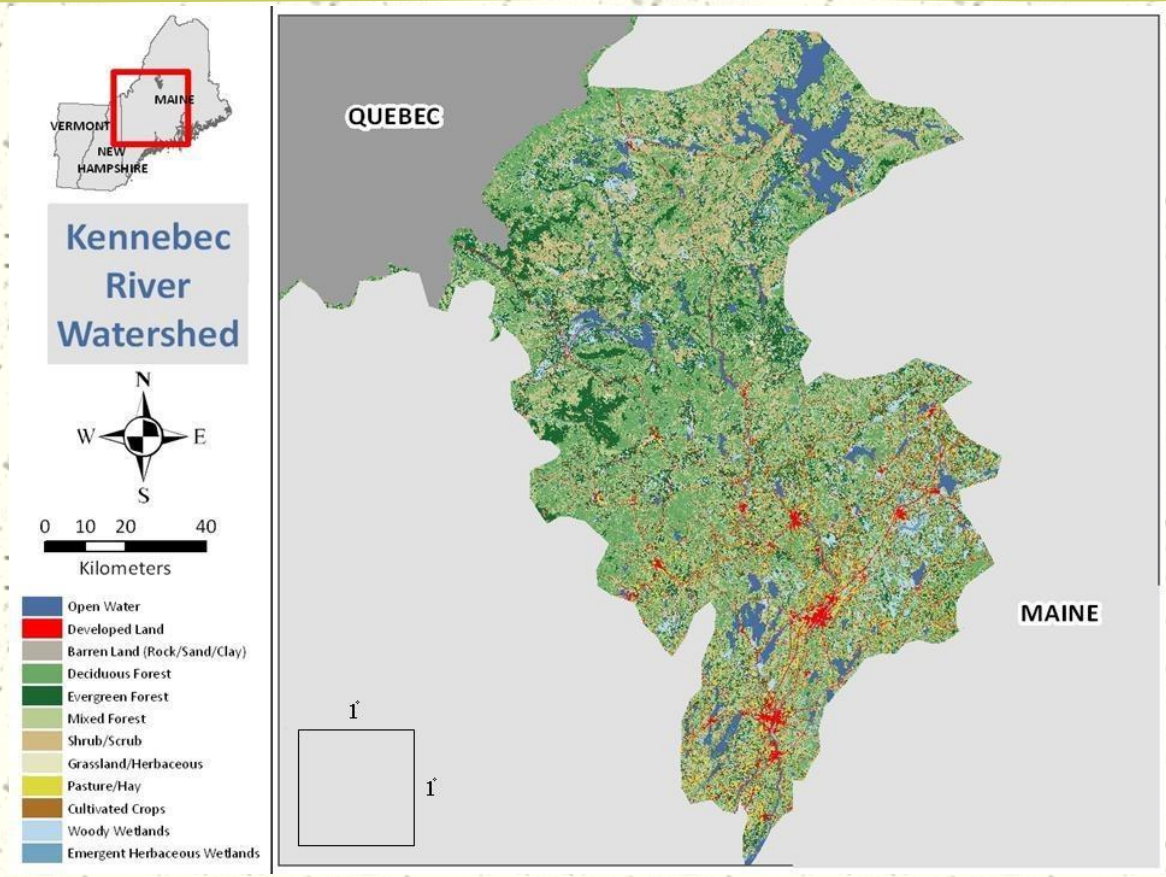


LandSat –
MSS, TM, ETM+
1972- Present

9,100 km^2 area

mean discharge = 175 m^3/s

Task 1: Determine land use characteristics

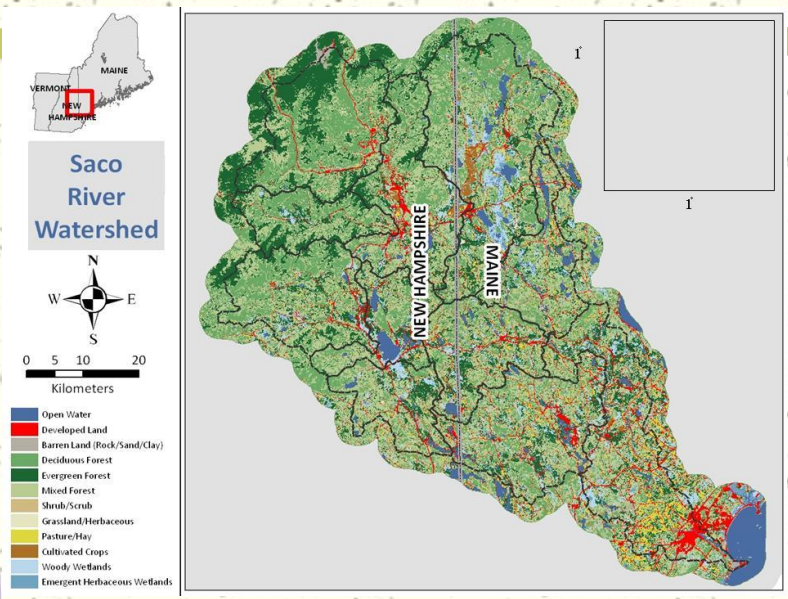


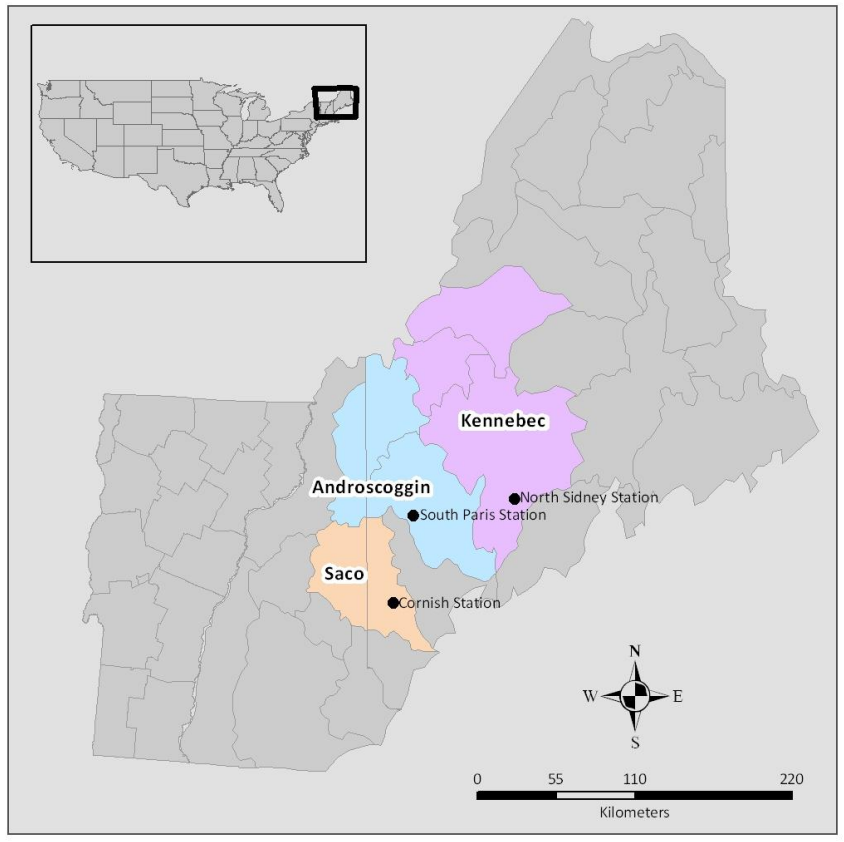
LandSat –
MSS, TM, ETM+
1972- Present

15,200 km^2 area

mean discharge = 258 m^3/s

Task 2: Determine river discharge and precipitation



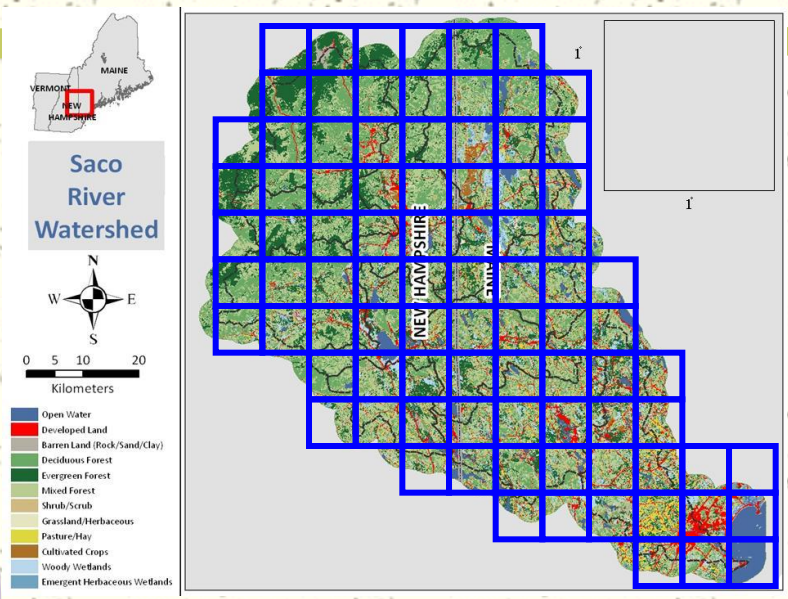


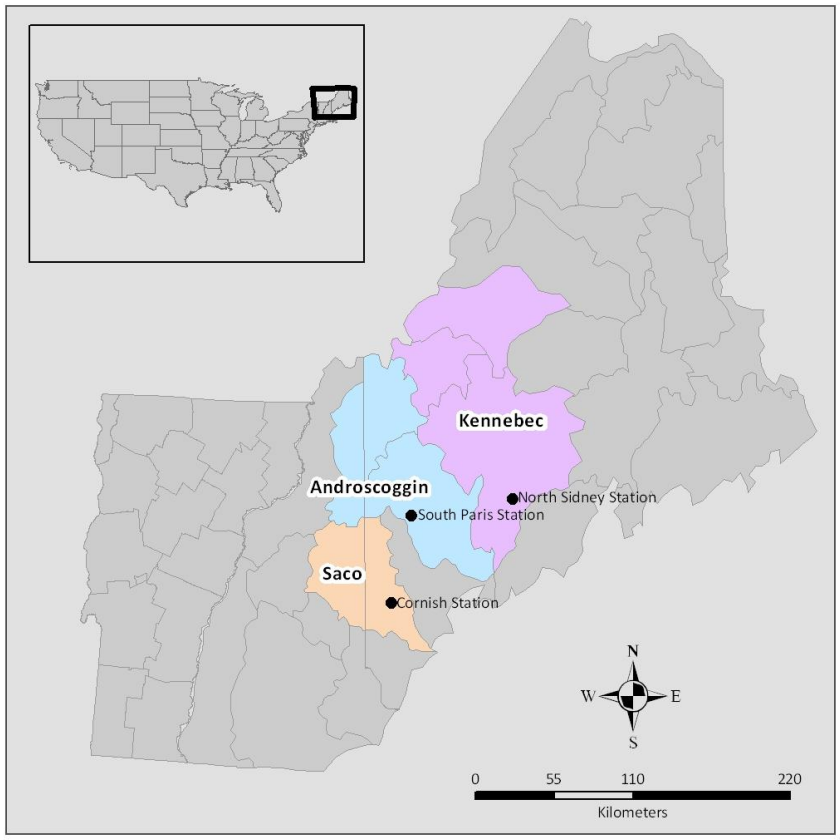
TRMM Data - 1998-Present

Station Data - 1965-Present

Discharge Data - 1905-Present

Task 2: Determine river discharge and precipitation





TRMM Data - 1998-Present

Station Data - 1965-Present

Discharge Data - 1905-Present

Task 3: Use regression analysis to estimate discharge

$$D(t) = \sum_{j=1}^{M} a_j L_j (t - \zeta_L) P_j (t - \zeta_P)$$

D = discharge

L = land use characterization

P = precipitation

a = weighting function

ζ = time lag

j = environmental spatial coordinate

Task 4: Obtain water quality measurements

- Data Partners
  - Maine State Planning Office
  - Casco Bay Estuary Partnership
  - Saco River Corridor Commission
- Water Quality Data
  - Standard indicator bacteria
    - *E. coli*
    - Fecal and total coliforms
  - 1998-Present

Tasks 5 & 6: Use regression analysis to predict coastal water quality in 2007-2008

Tasks 7 & 8: Use regression analysis on gridded observations to predict water quality in 2007-2008

$$W_{ik}(t) = \sum_{j=1}^{M} b_{ijk} L_j(t - \zeta_L) P_j(t - \zeta_P)$$

W_i = water quality of ith component
L = land use characterization
P = precipitation
b = weighting function
ζ = time lag
j = environmental spatial coordinate
k = water quality spatial coordinate

Anticipated Results

We anticipate that this study will demonstrate that our method is able to:

- Accurately predict for three Maine watersheds:
  - River discharge
  - Water quality in coastal waters
- Examine effects of climate change scenarios on:
  - River discharge
  - Water quality in coastal waters
- Forecast wastewater treatment needs over a 10-20 year time period.
- Adapt to large scale forecasts of US East Coast

Project Timeline

	2009				2010											
Task	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Task 1. Determine land use characteristics																
Task 2. Determine river discharge and precipitation																
Task 3. Predict river discharge and validate with observations.																
Task 4. Obtain water quality measurements.																
Task 5. Construct regression model to estimate water quality.																
Task 6. Predict water quality and compare with actual observations.																
Task 7. Interpolate available measurements of precipitation to grid resolution of NASA/GISS 4x3 Model.																
Task 8. Downscale the gridded observations and use the regression model to hindcast water quality.																
Prepare final report to NASA																
Deliver model to NASA																

Alignment with NASA Research Priorities – NASA's *Science Plan*

- ***Science Mission Directorate 2007-2016.***
  - Objectives related to **Earth Science**:
    - How is the global Earth system changing?
    - How does the Earth system respond to natural and human-induced changes?
    - What are the consequences for human civilization?
    - How will the Earth system change in the future?