Climate Change

What We Know and What We Are Learning

Water & Wastewater Plants Generate A Lot Of Greenhouse Gases

- Use about 75 billion KWh of energy per year
- Responsible for about 3% of total US consumption of electricity
- Energy Use equivalent to entire residential electricity demand of California.
- Contribute about 7% of nationwide green house gas emissions

Source: EPA

Water and Wastewater Systems Will Be Affected

- New York – Impact of Intense Storms on Turbidity, Safe Yield, Sewer Capacity
- Miami, Dade County – Salt water intrusion into Biscane Aquifer due to sea level rise and increased tropical storm activity.
- Denver – 12% reduction in Safe Yield for a 2 degree Fahrenheit rise in temperature due to loss of snowmelt. Increase in demand 6%. Pine beetle epidemic in watersheds due to loss of cold snaps.

Water and Wastewater Systems Will Be Affected.

- Southern California, MDC - earlier melting of Sierra Nevada snow pack; sea level rise, source water quality, shifting/increasing demand patterns.
- Calgary – Have an integrated water, sewer and storm water system. Reduction of snow melt is a major concern.

Changing Climate Impacts MWRA In the Following Areas:

- Energy Use
- Sea Level Rise
- Sewer System Capacity and CSO Activations
- Evaluation of Supply and Demand
- Viability of Community Local Sources
- Water Quality

MWRA's Emission Reduction Strategy Recognized By State

Renewable Energy And Sustainability

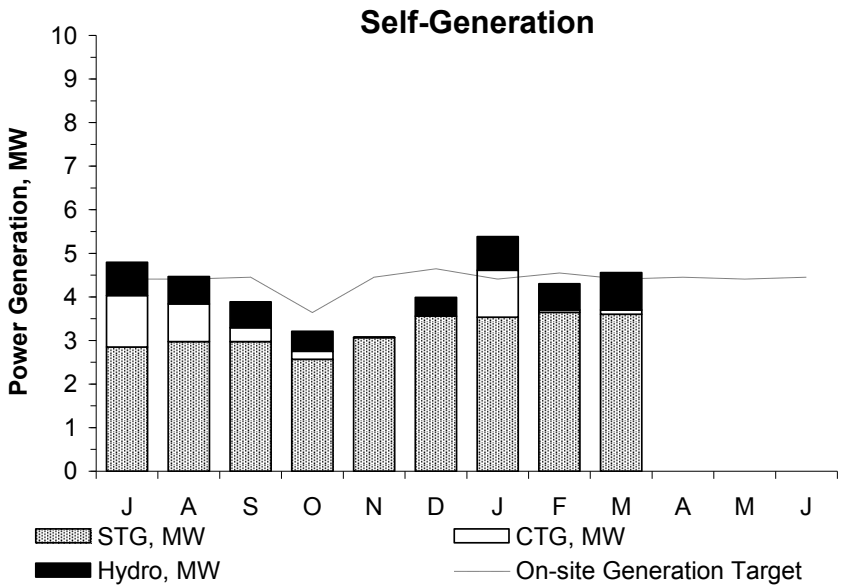
- Awarded $870,000 in grants and no-interest loans for solar panels at Deer Island
- Awarded contract to study 12 sites, as well as Deer Island, for wind turbines
- Cosgrove and Oakdale hydroelectric facilities generated almost $1 million in FY2007
- Efficiencies at Deer Island

Energy Audits

- An energy audit of the Carroll Water Treatment Plant is underway.
- A lighting audit at CWTP has already been completed; staff to begin implementing recommendations soon.
- A lighting audit is also underway at the Deer Island Treatment Plant.
- An energy audit is also being developed for the Chelsea Facility.

Deer Island Energy

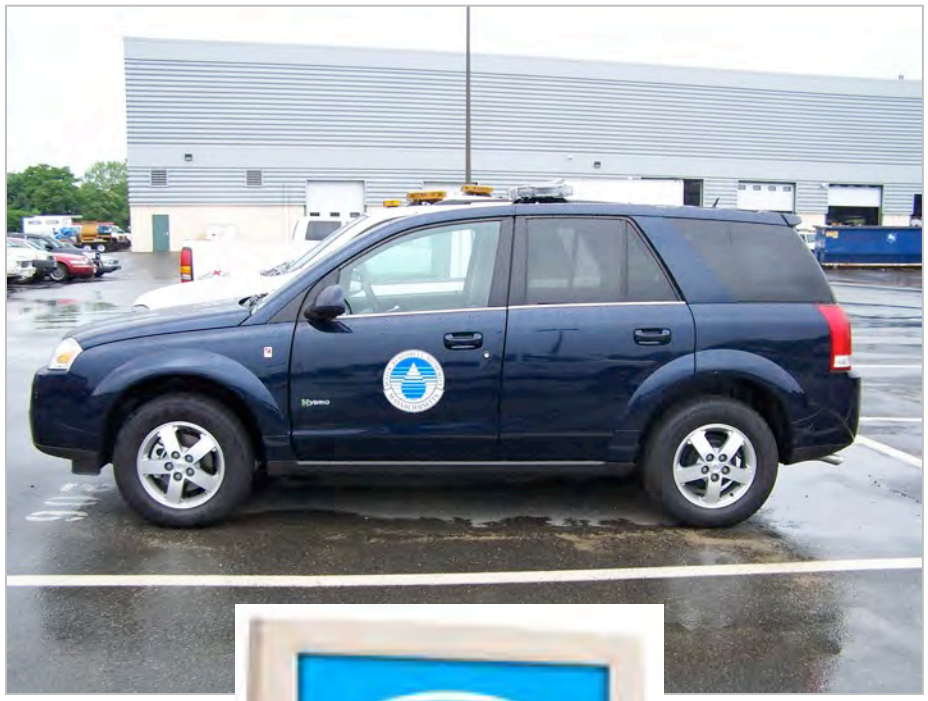
- Deer Island's annual electricity budget is nearly $14 million
- Self-generation target for FY2008 is 23%



Renewable Energy And Sustainability

- Fleet optimization
  - 23 Hybrid
  - 15 CNG
  - 6 Propane
  - 18 Ethanol
  - 188 Biodiesel
  - Retrofit 65 large diesel-powered units with catalytic converters

- Replaced 500 computer monitors with energy-star rated LCDs



Impact Evaluation

- A few concrete examples.
- MWRA's partnered approach.

Impact of Global Warming: 100 Year Storm and Sea Level Rise In Year 2100.

Data sources: Flooded area IPCC , ground elevations determined by LIDAR.

More like Venice in 1966!

The worst acqua alta in memory, the one that truly woke Venetians up to how bad things could get, occurred on November 3, 1966. The high tide that swept into all corners of the city that night lasted an astonishing 22 hours (typical high tides last six).

100 Yr Storm – Today's Situation

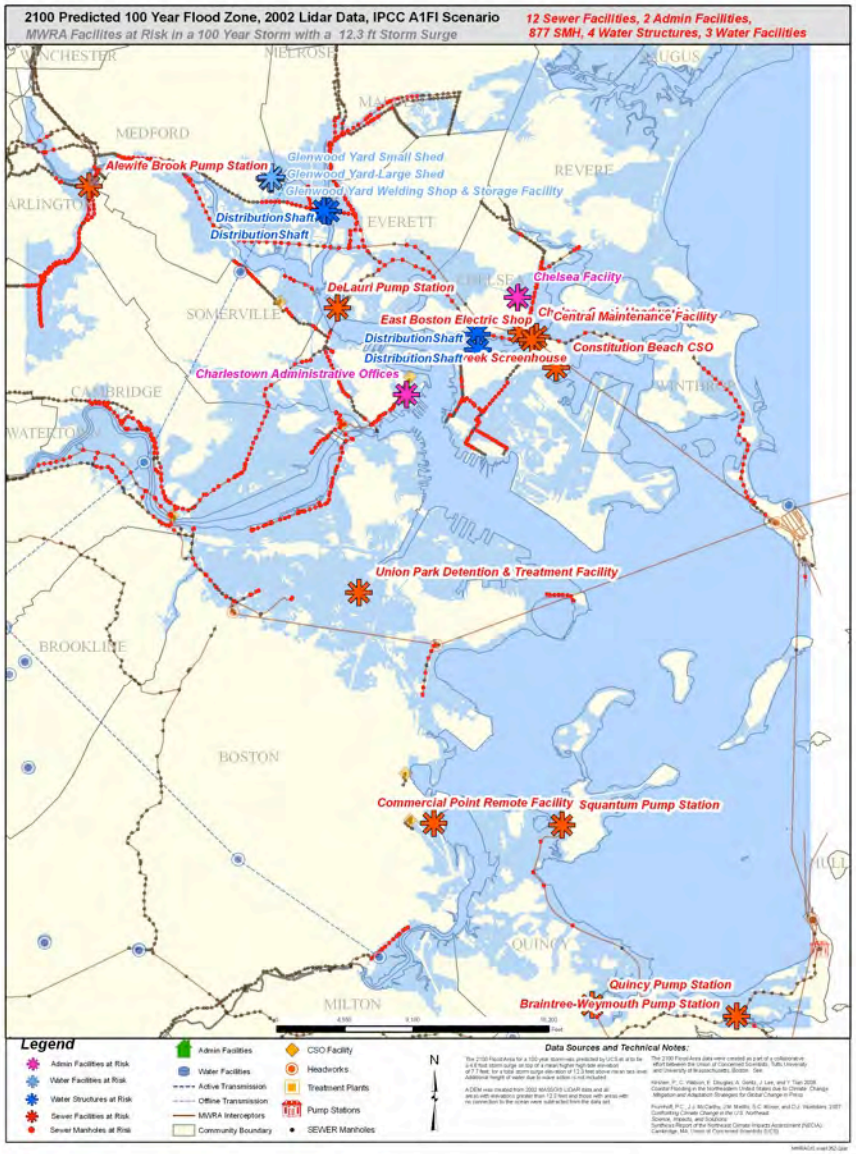
Data Sources:

Ground elevation from 2002 LIDAR data.

Impact of Global Warming: Year 2100

Extent of probable MWRA Impact

- **12 Sewer Facilities**
- **2 Administrative building facilities**
- **877 Sewer Manholes**
- **3 Water facilities**



Data Sources:

Flood Zone, IPCC A1F1 Scenatio.

Elevations: 2002 LIDAR data.

Cambridge's Fresh Pond In Harm's Way?

Water Supplies Affected by International Panel on Climate Change (IPCC) Predicted Storm Surge - Fresh Pond

Watershed Protection Zones, and IPCC A1FI Mid Scenario Sea Storm Surge Shown

Adaptation For Sea Level Rise In The Design of Deer Island

A Rising Sea Impacts The Hydraulics Of The Outfall Tunnel ….
But we've accounted for this in a 1989 design of Deer Island.

Design assumed maximum sea-level rise of
1.9 ft by Year 2050

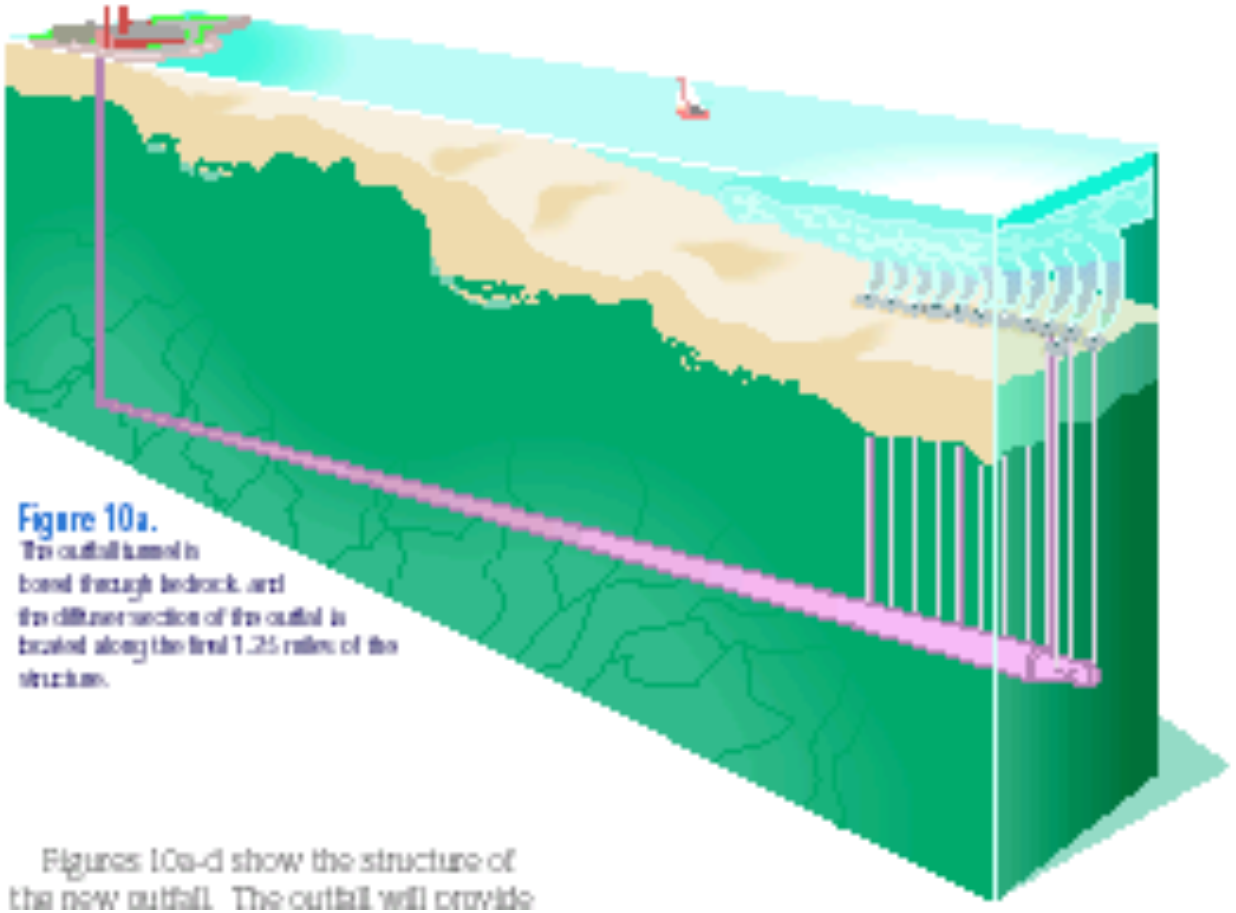


Figure 10a.
The outfall tunnel is bored through bedrock, and the diffuser section of the outfall is located along the final 1.25 miles of the structure.

Figures 10a-d show the structure of the new outfall. The outfall will provide

Sewer System – Climate Change May Need to be Incorporated in Design Criteria.

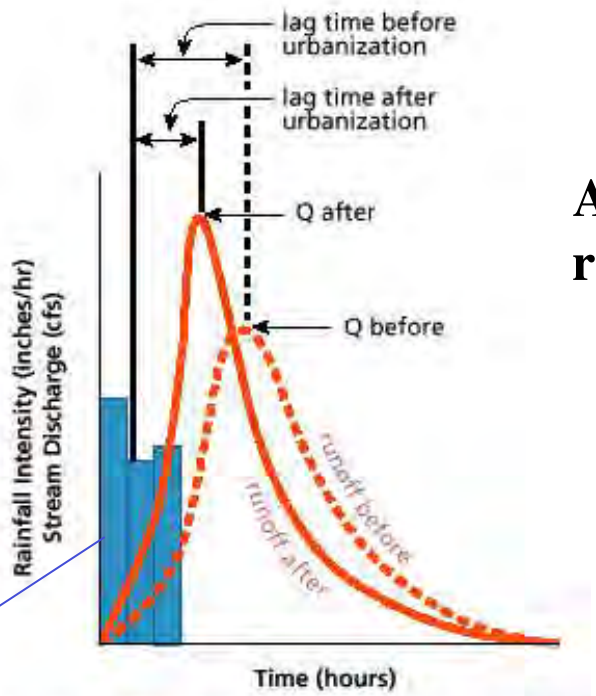


Figure 1: Effects of urbanization on timing and quantity of peak storm flows. (Source: Stream Corridor Restoration, EPA 1998)

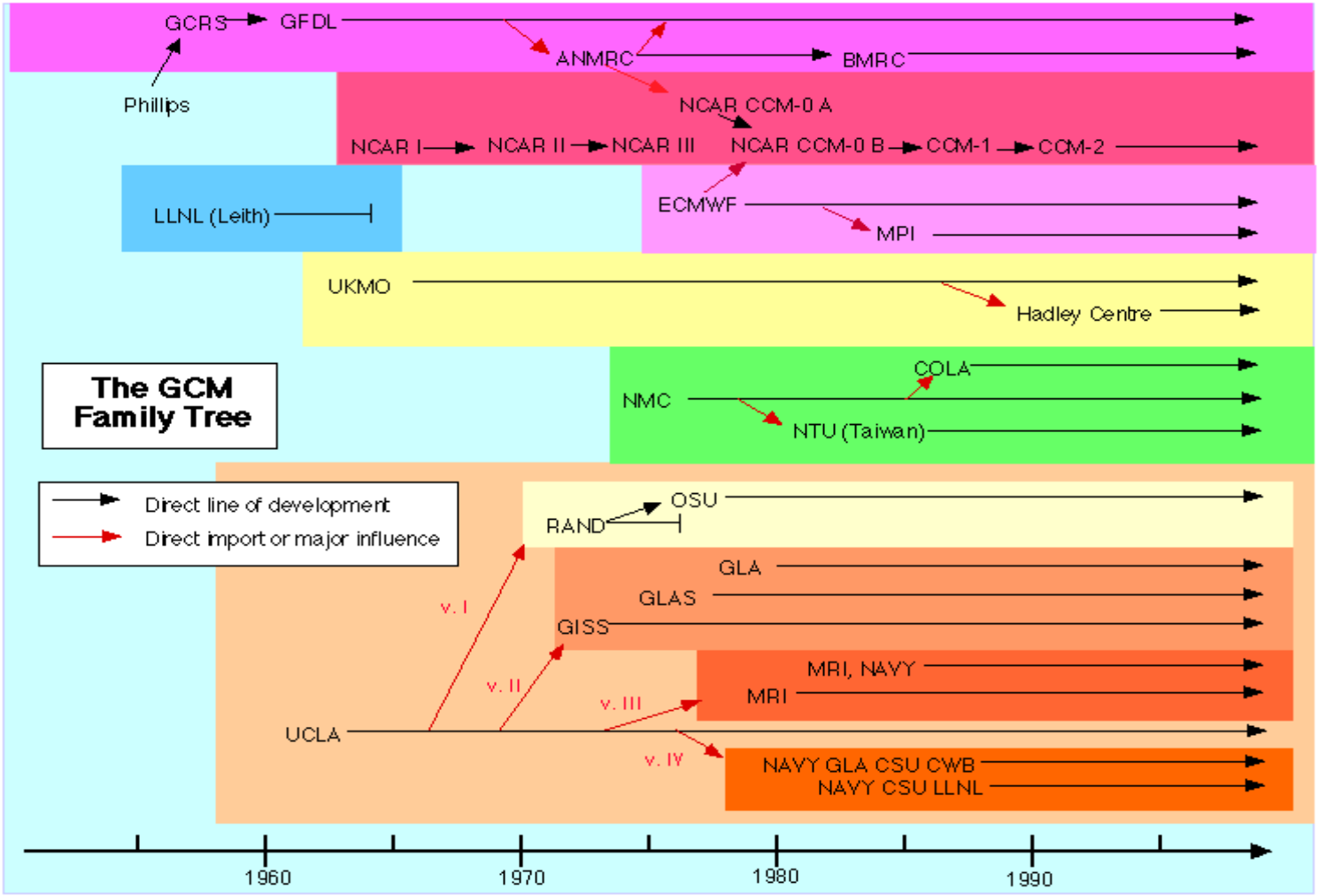
Climate Change may alter the shape of the design and typical storms used to design new interceptors and evaluate CSOs

All Systems will need to review their design criteria.

EPA's Draft CSO Study Exemplifies A Scenario Approach

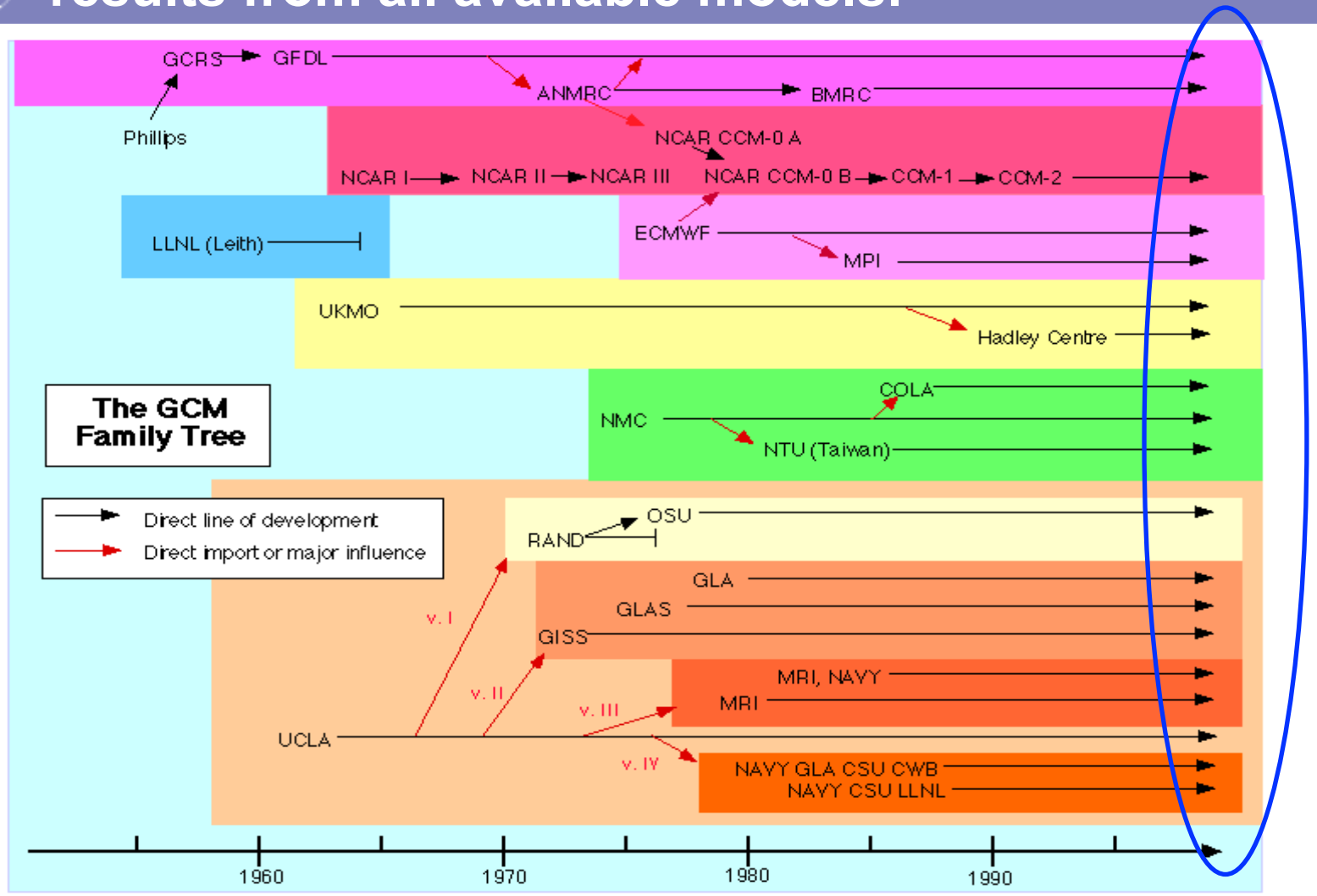
- Using Hadley model, 12% *increase* in frequency of discharges predicted
- Using Canadian model, 17% *decrease* in annual frequency of CSO discharges predicted.
- Example of a scenario analysis.
- NCAR is advocating using theory of decision making under uncertainty.
- This will rely more on applying probability theory and more intensive modeling.

Climate Models Have Evolved Over Time With Many Participants.



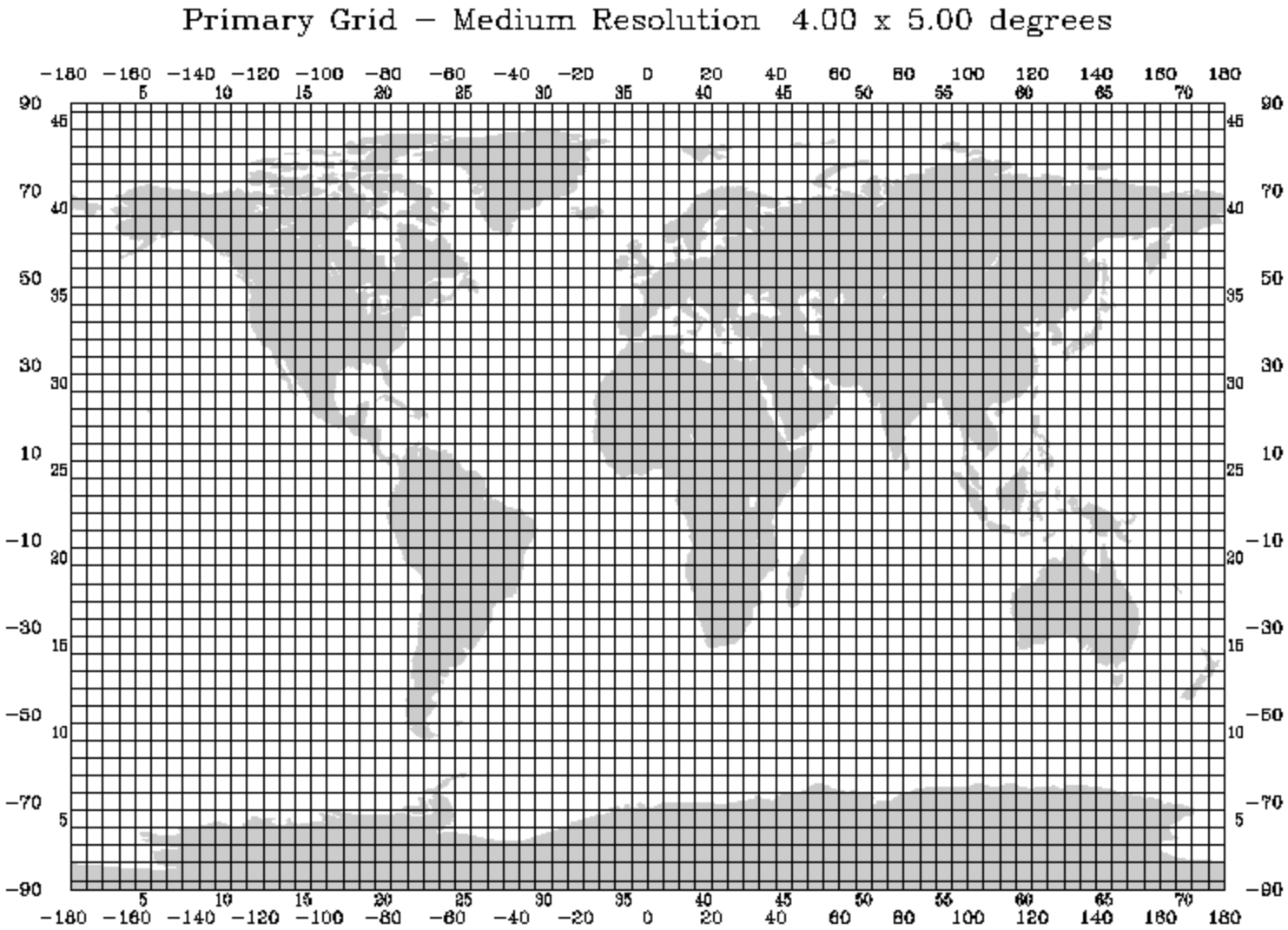
Source: http://www.aip.org/history/climate/GCM.htm

MWRA/NCAR/AWWaRF Study: Using latest results from all available models.



Source: http://www.aip.org/history/climate/GCM.htm

Over time, model resolution has become finer



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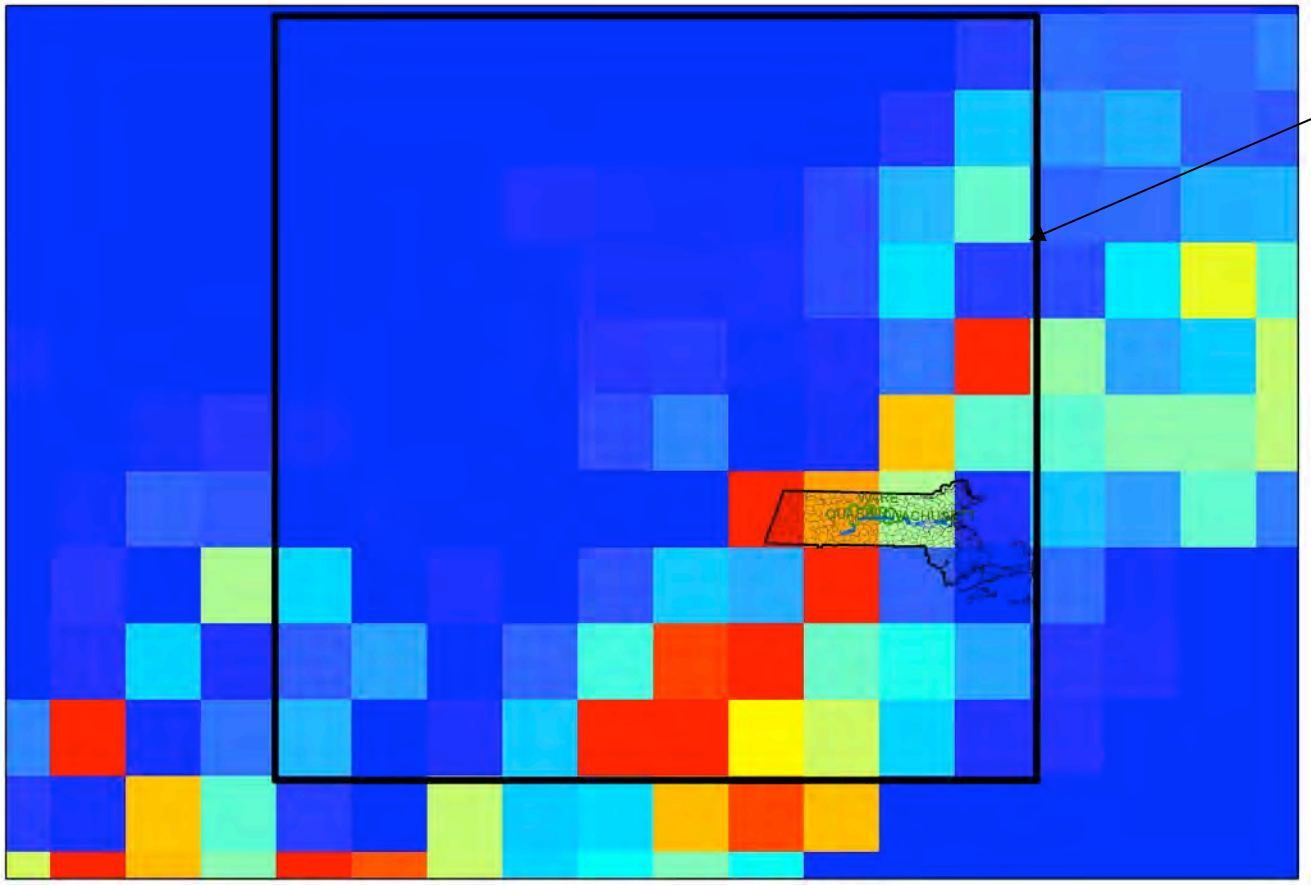
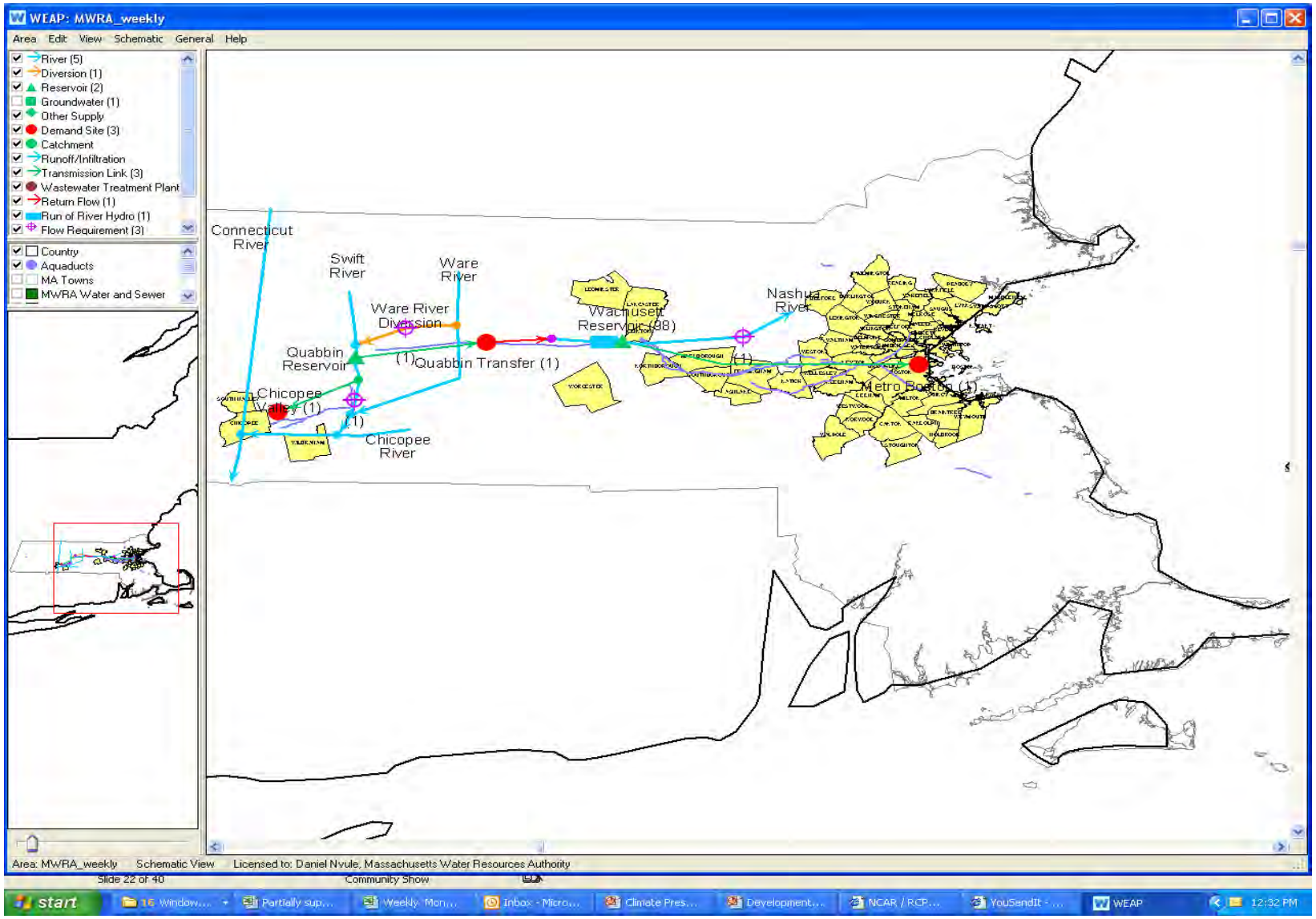


GCM computational cells color coded by predicted precipitation:

Source: NCAR

Through AwwaRF, MWRA Now Has A State-Of-The-Art Supply System Modeling Environment.

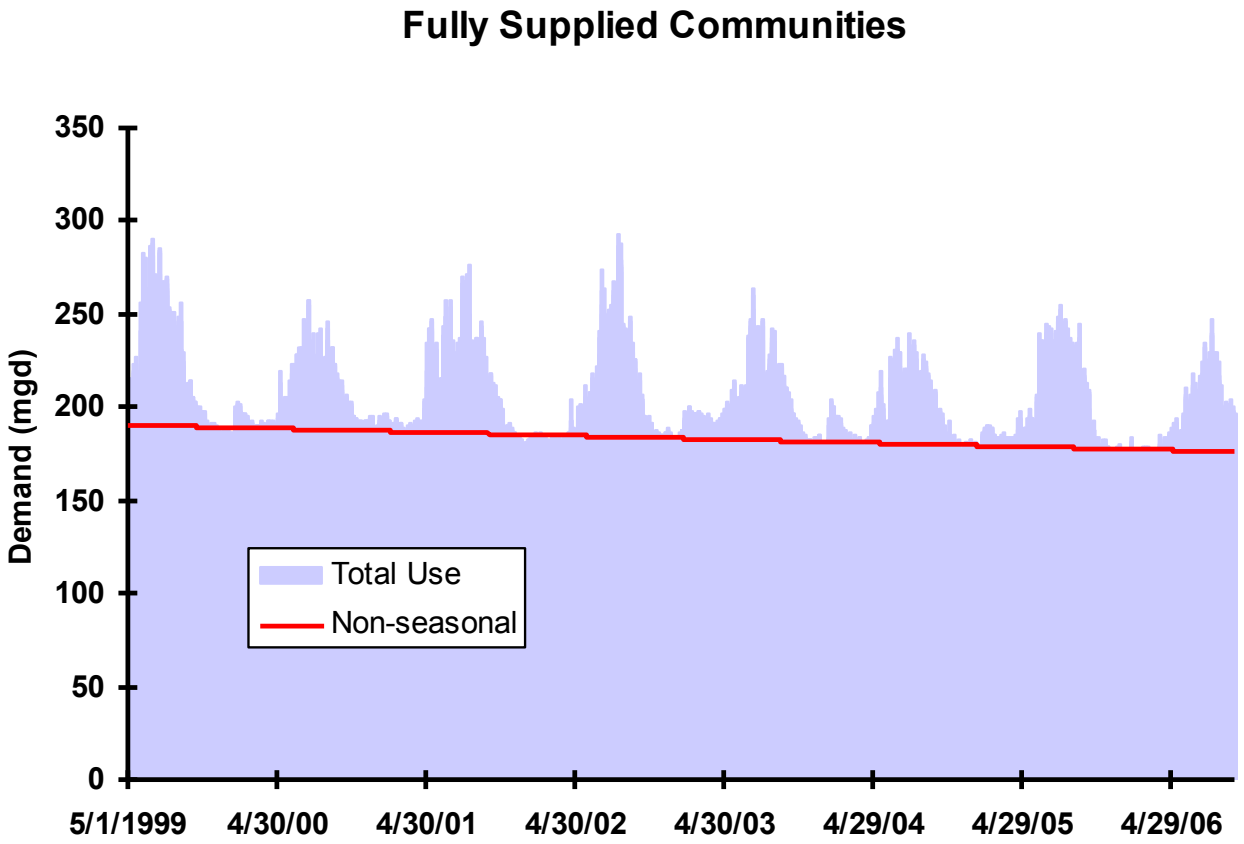


Components of MWRA Demand

- Non-seasonal (Indoor)
- Seasonal (Outdoor)

- Reduction of yield of local sources

Non-seasonal Use has been declining



Indoor use has been declining at a rate of about 2 mgd/ year mainly due to efficiency gains & increased rates.

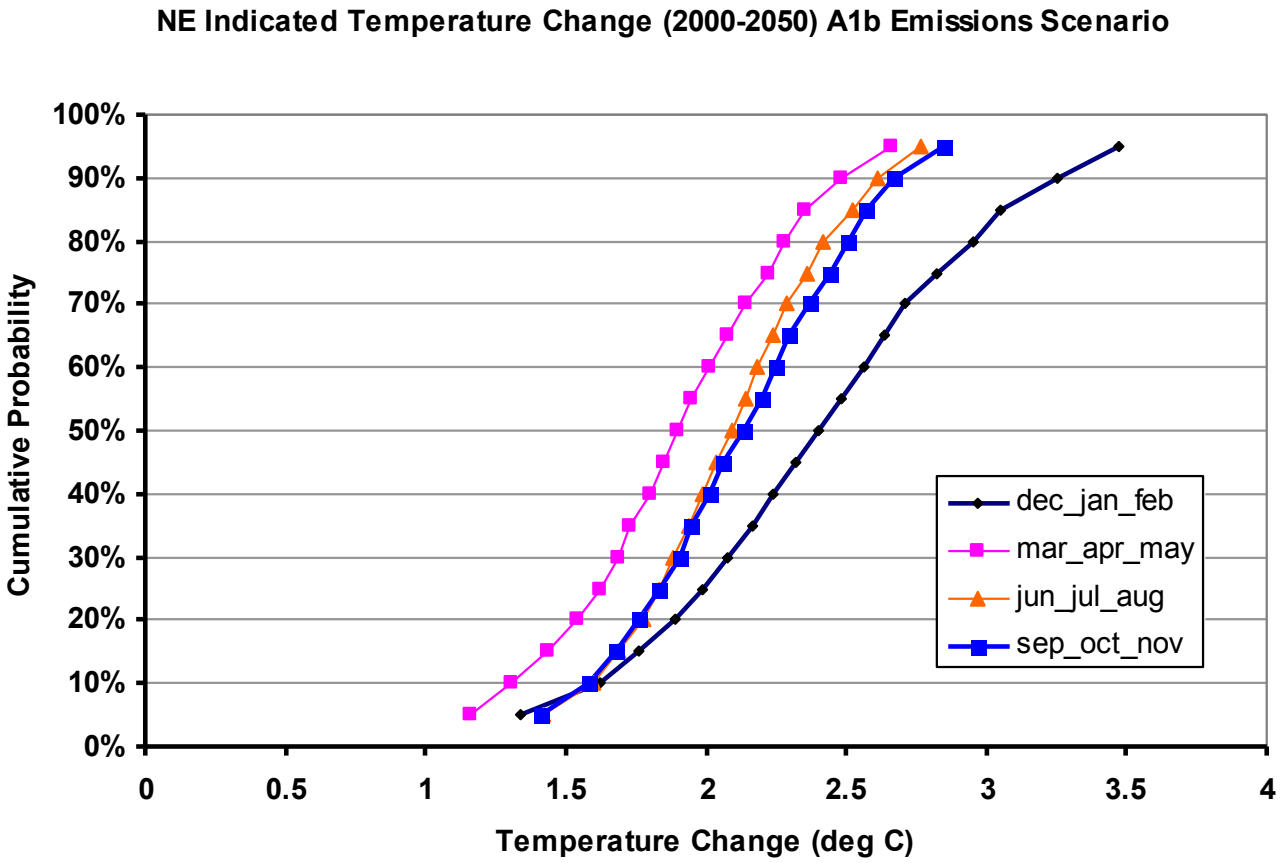
Seasonal Use Likely To Be Impacted By Climate Change

Indoor use not likely to change much

Seasonal use influenced by:

- Maximum air temperature;
- Growing season precipitation;
- Length of growing season;

How Are Future Temperatures Likely To Change?



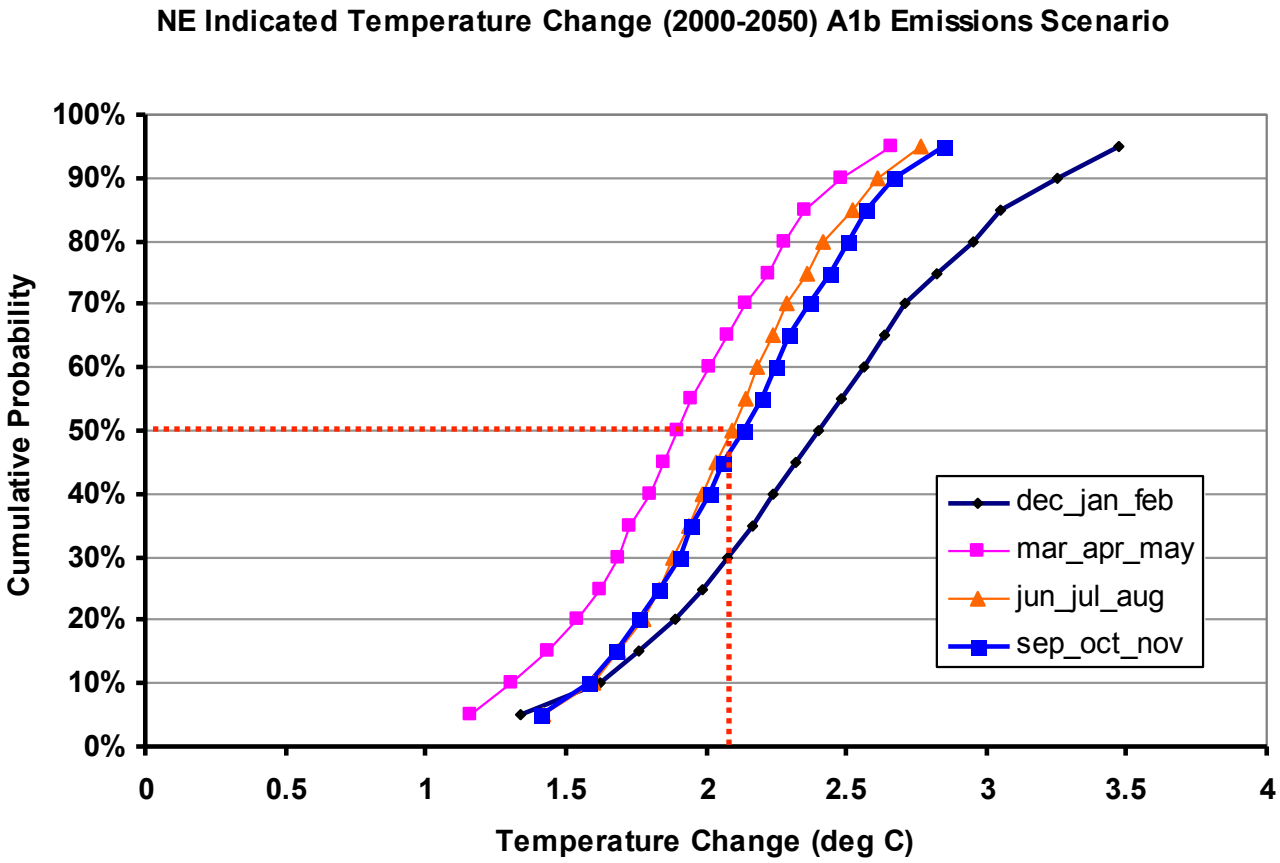
Source:

NCAR

Scenario Approach: Use a single point, e.g. summer median of 2.1 deg C

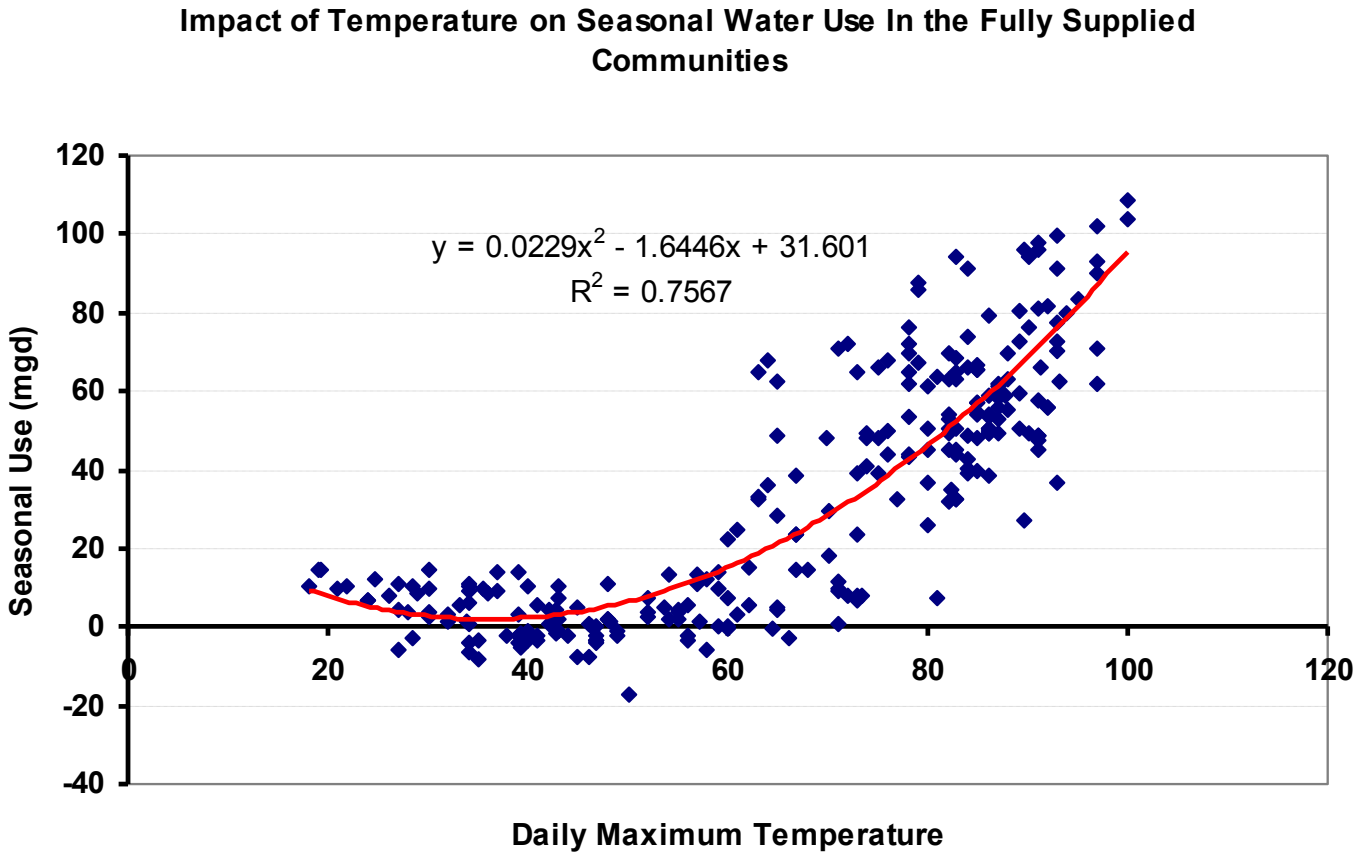
New approach: Use an ensemble of climate predictions each with an underlying probability distribution derived from all models

Scenario approach uses one model



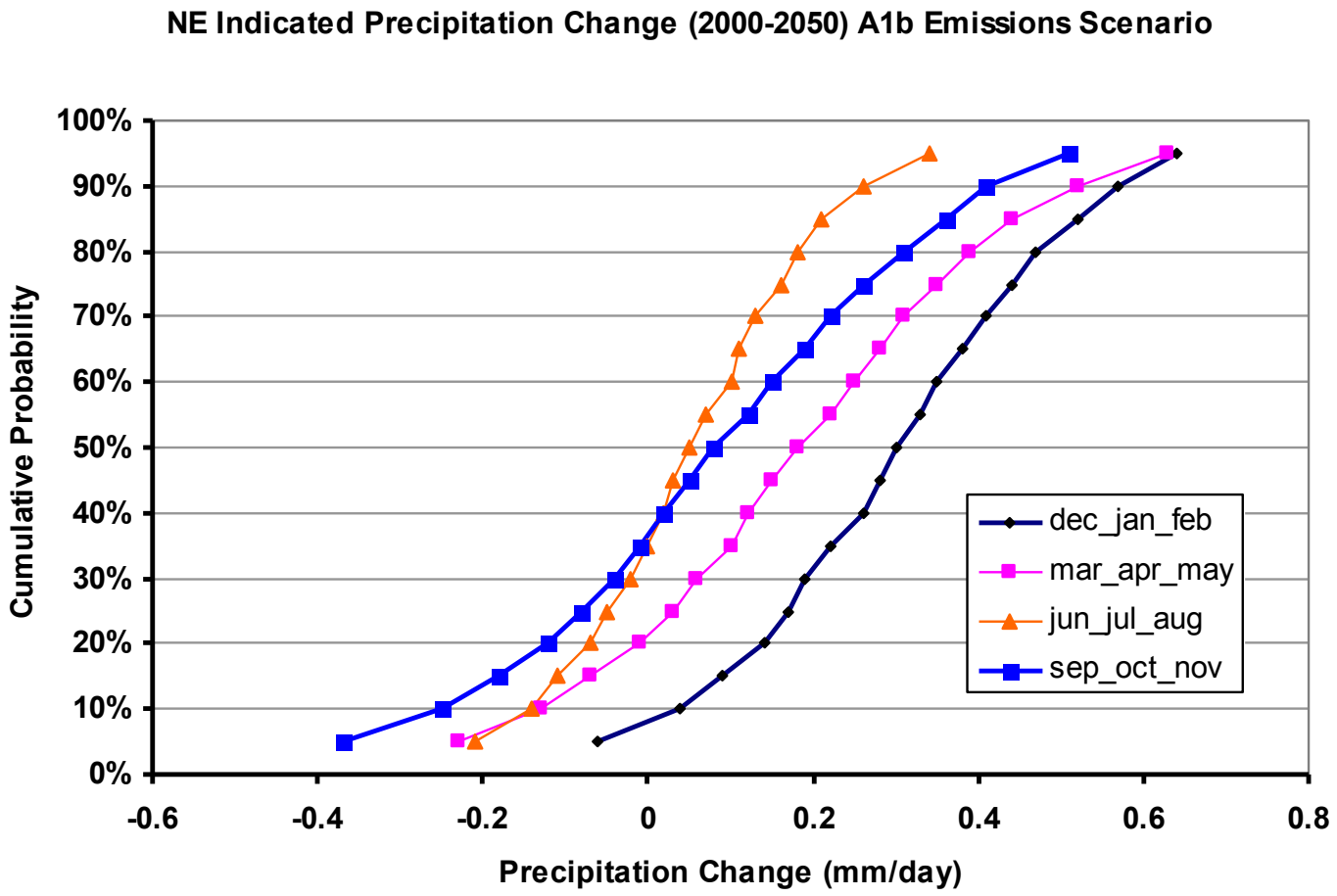
What Then Is The Impact On Seasonal Use?

A warming of 2 deg Celsius could mean an 8 mgd increase in demand in August



Most Models Predict Increase in Precipitation

Impact on demand is much smaller. Potential increase in system yield

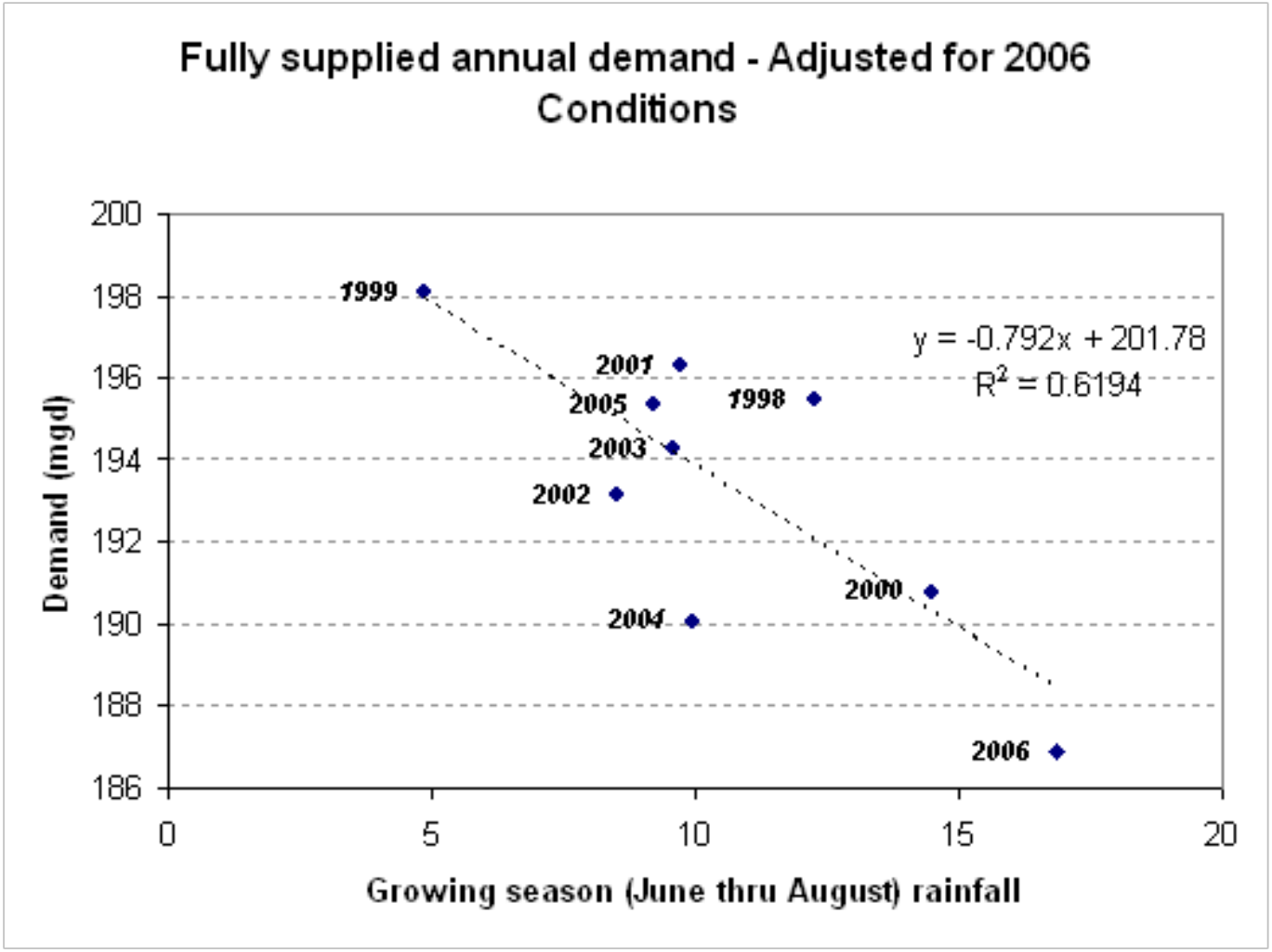


Source: NCAR

How Is the Future Precipitation Likely to Change?

- Most of the *increase* in precipitation is for Winter Period (middle 50% range is 0.65" to 1.5")
- Half of the models indicate an *increase* of about 0.05mm/day (4.6mm or 0.18 inches) for the June thru August Period
- The most extreme prediction for the same period is about 0.3 mm/day (Total of 28 mm or 1.1")
- 30% of the models predict a *decrease* of up to 1.4" for the September to November period.

Precipitation Could Raise or Lower Demand Slightly.



Change in precipitation likely to result in -0.9 mgd to 0.6 mgd change in annual demand

Overall Impact Is Likely to Be Relatively Small

- Likely to see an overall increase in seasonal demand
  - air temperature likely to be up
  - small increase in growing season rainfall
- Not likely to be a major impact on total annual demand.
- What happens in the partially supplied communities may be key.

Most models expect increase in climate variability

Extreme weather events likely to be more intense – wetter wets and dryer drys:

- Hotter summer days;
- More Intense Storms;
- Steeper, longer Droughts

Exactly the type of conditions which could affect local sources.

Partially Supplied Communities

- More vulnerable to a changing climate due to lack of storage.
- MWRA will most likely pick up the deficits.
- Already shown by CLIMB study.
- A key piece of the technical analysis is to evaluate partial users' additional demand.
- New opportunity for MWRA to help adjacent communities,

We may need to evaluate distribution system

As with sewer design criteria, long term MWRA may need to re-evaluate pipe design criteria

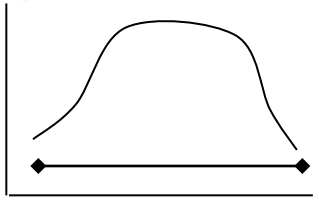
A warmer climate may increase peak demands leading to a need to evaluate pipe and distribution reservoir capacities over longer term.

MWRA's Evaluation Strategy

- Partnered with National Center for Atmospheric Research (NCAR) and Stockholm Environmental Institute to update analytical tools.
- NCAR is developing ensembles of future climate that have been scaled locally for use in the analysis.
- Watershed yields for modeling will be derived using watershed models already developed with the help of Tufts University.
- Conclusions will be based on a statistical analysis of a multitude of computer runs.

MWRA's Approach Similar to What's Used Elsewhere.

- Ranges of regional temperature and precipitation trends from GCMs → **(Tebaldi et al.)**



- Method for developing weather sequences reflective of local conditions and GCM trends → ***K-nn*** **(Yates et al.)**
- Water management model that projects supply, demand, and reliability under wide range of weather and management conditions → WEAP Water Evaluation And Planning System
- Analytic engine and methodology to evaluate many scenarios and guide policy formation → **Robust Decision Making**

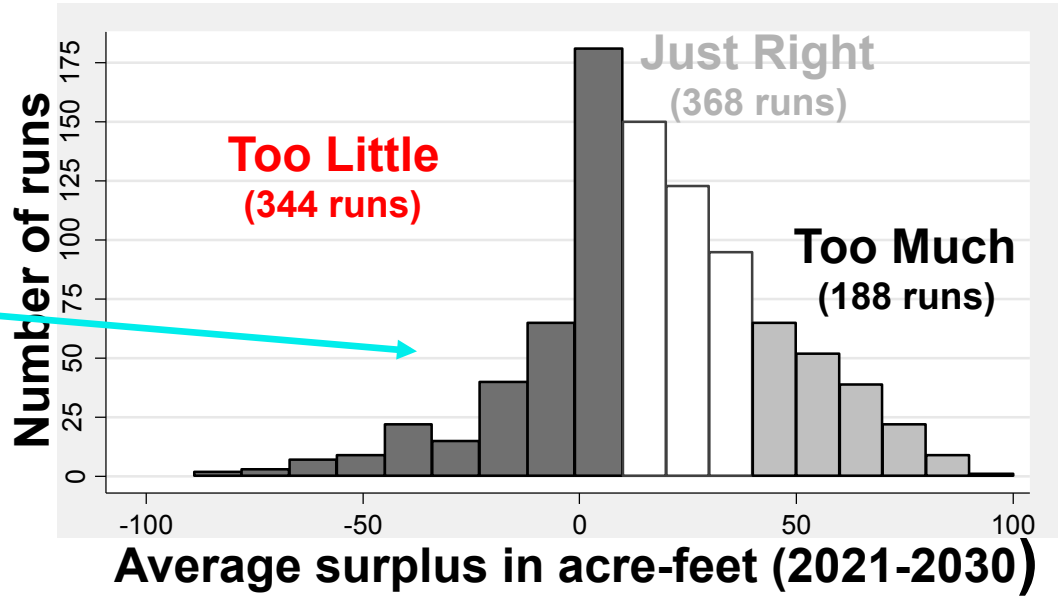
Example of What The Results Might Look Like

RAND corporation performed the following tasks for a case study in California:

- Ran the model 1000 times under different combinations of uncertain factors (e.g. temperature and precipitation trends and others).

1. Used statistical search algorithms to identify conditions that lead to management plans to perform poorly .
2. Identified key factors that drive “policy relevant” scenarios.

Statistical analysis suggested factors that contribute most to these undesirable outcomes



Some of the research questions:

- What will be the impact on Safe Yield?
- Are we likely to see an increased demand on our system?

- How will sewer capacity change?
- Are our facilities protected from sea level rise?
- What happens to the activation frequency of CSOs?
- Will it effect our non-filtered status?