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Water Utilities and Climate Change: A Research Workshop on Effective System Adaptation

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Water Utilities and Climate Change: A Research Workshop on Effective System Adaptation

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LIST OF ACRONYMS

CCSR	Center for Climate Systems Research
CES	Florida Center for Environmental Studies
FAU	Florida Atlantic University
FDOT	Florida Department of Transportation
FSU	Florida State University
GHG	Greenhouse Gas
GPCD	Gallons Per Capita Per Day
GW	Ground Water
HUD	U.S. Dept. of Housing and Urban Development
IPCC	Intergovernmental Panel on Climate Change
MGD	Million Gallons Per Day
MIT	Massachusetts Institute of Technology
NOAA	National Oceanic and Atmospheric Administration
NYCDEP	New York City Department of Environmental Protection
SLR	Sea Level Rise
UF	University of Florida
USACE	U.S. Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WaterRF	Water Research Foundation

ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

The workshop brought together forty-one utility professionals, academics, and others to review the current role of climate change in utility planning and to make recommendations for the future. A review of the increased interest in climate change adaptation in what is a very vulnerable area was followed by detailed presentations by four water utilities (Palm Beach County, Broward County, Miami-Dade County, and Tampa Bay Water). The workshop also included presentations by the research team on current climate change science and climate scenarios for Southeast Florida, adaptation planning, the variety of adaptations available, and the evaluation of proposed adaptations. The workshop concluded with a panel discussion on Identifying Barriers and Opportunities and a presentation of next steps, including an outline of the final report. A comprehensive list of findings and recommendations has been developed from the workshop that includes recommendations for water and sewer utilities, state and local agencies and universities, and the Foundation.

Key findings and recommendations include:

- The most important climate change issues for Florida utilities are sea level rise, saltwater intrusion and salinization of the aquifers, and changing patterns of precipitation. It is expected that there will be both substantial drought periods and more intense rainfall periods.

- Generally, integration of climate adaptation measures into the rehabilitation and capital replacement cycles is important and will reduce overall costs.

- Any further development of utilities must take sea level rise and salinization issues into account

- Coastal utilities should take a detailed inventory of infrastructure that is at risk to sea level rise, storm surge, and coastal flooding.

- Incorporate the concept of flexible adaptation pathways in plan development and prioritization – avoiding an inflexible commitment of significant resources, and staging and timing adaptations to conform with actual climate change.

- Cooperation on climate change adaptation should continue to be expanded by state and local agencies and universities

- State and local agencies and universities should, to the extent possible, consider the impact of land use planning decisions on water and sewage utilities.

- The Foundation should consider sponsoring detailed case studies of climate change adaptation for water and sewage utilities to be used as guidelines for other utilities.

- The Foundation should consider sponsoring a workshop to develop estimates of the total cost of climate change adaptation for water and sewer utilities for the Gulf and East Coasts of the United States based on vulnerabilities and impact studies.

Chapter 1: Introduction

This Final Report for the Water Research Foundation's (WaterRF) Project 4228, "Water Utilities and Climate Change: A Research Workshop on Effective System Adaptation", provides an overview of the project and presents key elements of the workshop. It also gives a series of findings and recommendations for needed research and applications to assist water utilities in mainstreaming climate change adaptation into their operations and maintenance activities, infrastructure, and policies. The research team for the project was drawn primarily from the Columbia University Earth Institute's Center for Climate Systems Research (CCSR) and the Florida Center for Environmental Studies (CES). The project workshop was held successfully on June 10, 2011 at the headquarters of the Palm Beach County Water Utilities District in West Palm Beach, Florida. The workshop followed the original plan as foreseen in the project proposal, but with changes to take into account the impressive steps for dealing with climate change over the past several years in Florida. As Maurice Tobon, representing the Palm Beach County Water Utilities District, said in welcoming remarks, the workshop was timely both because of the current water crisis in Southeast Florida, and because it is the right time for a partnership to be developed among Florida's utilities.

The project, a collaboration sponsored by the Palm Beach County Water Utilities District in conjunction with the Foundation, was conceived originally as a result of an earlier Foundation workshop held in Edinburgh, UK in September, 2007. The 2007 workshop was co-sponsored by UK Water Industry Research. Researchers and utility representatives traded ideas and the proposal followed. Originally, the project was designed to transfer and adapt methods and procedures then under development elsewhere to Florida, where relatively little had been done on climate change at the time. A notable exception was the work of Miami-Dade County. Outside of Florida, earlier work included the New York City studies leading to New York City Department of Environmental Protection (2008), and New York City Panel on Climate Change (2010), and other studies such as University of Washington Climate Impacts Group and Washington Department of Ecology (2008). However, the proposal was several years in gestation and approval, and during that time, there was a very substantial increase in climate change-related activities in Florida, including initiatives by state and local governments, such as the Florida Oceans and Coastal Council (2010) from the office of Governor Charlie Christ, and the Southeast Florida Regional Climate Change Compact (http://www.broward.org/NaturalResources/ClimateChange/Documents/CompactFinal.pdf). There has also been extensive work by CES, other Florida universities, and utilities. As a result of these activities, the final workshop became an enriched version of the original proposal, dealing both with the earlier work elsewhere and the work that has been accomplished in Florida. Funding for the project came from the Foundation and from the Palm Beach County Water Utilities District, with additional in-kind contributions from Columbia University, CES, and the Palm Beach County Water Utilities District.

In addition to this introduction the Report has the following chapters: Chapters 2 and 3 describe the workshop, key elements of the presentations, and follow-on activities.

Chapter 4 discusses the relevance of the workshop to utilities in Florida and other areas. It includes planning, adaptation, and organization; climate scenarios; and adaptation assessment steps. Chapter 5, Going Forward, presents extensive findings and recommendations for water and sewage utilities, state and local agencies and universities, and the Foundation.

The workshop included, in addition to introductory remarks, a review of climate change activity in Florida, presentations by four utilities on problems and opportunities facing them, and presentations by the research team on current climate change science and climate scenarios for Southeast Florida, adaptation planning, the variety of adaptations available, and the evaluation of proposed adaptations. The workshop concluded with a panel discussion on Identifying Barriers and Opportunities and a presentation of next steps, including an outline of the final report. The workshop agenda is shown as Appendix A.

The workshop was attended by a diverse group of 41 registered participants, including those from the Foundation, the Foundation's Project Advisory Committee, the research team and, the largest group, representatives of a dozen water utilities and environmental agencies. The participants were invited primarily on recommendations from the Foundation, the sponsoring utility, and the research team. The participant list is shown as Appendix B.

Among the materials distributed at the workshop were printed and digital reports from the Foundation and participating utilities and a List of References and Resources compiled by the research team, shown as Appendix C.

There were several follow-up activities to the workshop. One was the establishment of a website for the presentations at the workshop (http://www.ces.fau.edu/climate_change/wrf_2011), and a second was responses by utilities to questions asked at the workshop which could not be answered during the day because of time limitations. The responses to these questions are reported in Appendix D to this report. Additional follow-up activities included discussions with utilities relating both to the workshop and the final report.

1.1. The Florida Context (Dr. Berry)

Discussions at the University level on the impacts of climate change in Florida began to intensify in 2006 and in the last five years there has been a steady growth in the scope and in-depth analysis of a whole range of issues in many different agencies. A selection of key developments was presented: as a group they provide the immediate context both for the workshop and for the operations and planning of Florida's water utilities. In May 2007, CES organized the first state-wide conference on climate change involving academics, agencies, and the public sector. The Southeast Florida Regional Climate Change Compact, commonly known as the Four County Compact, was formed between Miami-Dade, Monroe, Broward, and Palm Beach Counties in 2009. Agreement on this group was a major accomplishment; crossing county lines for these purposes for the

first time, making climate change a key issue. People have moved from the idea of climate change impacts as an issue for 2100 to realizing that it is a matter of concern now and that it must be dealt with now.

The Climate Compact Counties recognized the critical need to unify the existing local sea level rise (SLR) projections to create a single regional SLR projection. Key participants developing the existing projections and other local scientists specializing in the areas of SLR and climate change were invited to participate as the Regional Climate Change Compact Technical Ad Hoc Work Group (Work Group). Through a series of facilitated discussions, the Work Group reviewed the existing projections and the current scientific literature related to SLR and accelerating ice melt. The Work Group recommended that the SLR projections to be used for planning purposes in the SE FL region be based on the U.S. Army Corps of Engineers (USACE) July 2009 Guidance Document until more definitive information on future SLR is available. Two key planning horizons are highlighted: 2030 when SLR is projected to be 3-7 inches and 2060 when SLR is projected to be 9-24 inches. Other projections may be developed as information becomes available. New data shows that the previous estimates of SLR are on the low end and that the higher-end projections are more accurate. National Oceanic and Atmospheric Administration (NOAA), the United States Geological Survey (USGS), and the U.S. Army Corps of Engineers (USACE) are changing their internal planning processes to include climate change adaptation guidelines. In addition to higher SLR, there may also be increases in droughts.

Other key initiatives include:

- The South Florida Regional Planning Council (2011) received a major grant from the HUD to focus on sustainable communities and climate change resilience. This project will have implications for climate decisions on a short time frame.

- A USGS/Florida Sea Grant/FAU Sea Level Rise (March 2011) workshop reviewed the conceptual ecological models being used for the Everglades Restoration program in three important ecosystems in South Florida and proposed guidelines for incorporating current and potential sea level rise (SLR) into the models.

- Water Utilities Working Groups - The University of Florida's Water Institute, The Florida Climate Institute (UF and FSU), and Tampa Bay Water convened a workshop in 2010 to bring representatives from public water supply utilities, water management districts, and academia together to explore the development of a "Public Water Utilities Climate Impacts Working Group" focused on increasing the relevance and usability of climate change and variability data and tools to the specific needs of public water supply utilities in Florida.

- MIT- MUSIC Project- "Addressing the Challenges of Climate Change in the Greater Everglades Landscape" is a research initiative funded by the United States Fish and Wildlife Service (USFWS) and the United States Geological

Survey (USGS) and carried out by researchers at the Department of Urban Studies and Planning of the Massachusetts Institute of Technology (MIT) in cooperation with CES. The overarching goal is to develop and test new methods for regional planning under climate change. This requires a comprehensive approach, because climate change is occurring in addition to changes in other factors, and the potential interactions are both serious and complex. In addition to biophysical stressors like sea level rise, the project team jointly considers changes in land use planning, development practices, and human settlement patterns.

- The purpose of a Florida Department of Transportation (FDOT)/FAU study "Development of a Methodology for the Assessment and Mitigation of Sea Level Rise Impacts on Florida's Transportation Modes and Infrastructure" is to provide a methodology for assessing and mitigating the impacts of SLR on Florida transportation modes and infrastructure for planning purposes. The final report includes a summary of potential impacts of SLR on transportation physical infrastructure along Florida's coastline and low-lying terrain, and currently available tools for protection of transportation infrastructure and tools needed for adaptation and planning of transportation networks and systems (Berry et al.).

- Florida Atlantic University's (FAU) focus on climate change is embodied in the focus project, "Integrated Collaborative on Climate and Energy", which has been selected as one of three University-wide Research Priorities, and is now currently funded and underway. New projects under this Research Priority include Ocean Acidification, Carbon Sequestration, and Salinity Monitoring (ICCE 2009).

- Various climate change workshops and conferences include a State University System (SUS) Project, focused on identifying current State University climate change expertise, research and curricula, enhancing cooperation with State and Federal agencies to bring science into climate change-related decision making, and developing a climate change information system and portal that will connect SUS assets with these agencies and other groups to facilitate communication and collaboration (Jones et al. 2012).

- There is a new South Florida Water Management District paper titled "Past and Projected Trends in Climate and Sea Level for South Florida" (Obeysekera et al., 2011).

Chapter 2: Workshop Presentations I: Problems and Opportunities for Florida Water Utilities

2.1 Maurice Tobon, PE, Director, Engineering, Palm Beach County Water Utilities
The immediate focus is on addressing a rapid increase in population. This includes a future northern regional water treatment plant for which the site plan is already approved. Palm Beach County is preparing to address the increase in Infiltration/Inflow into the sewer systems caused by higher ground water (GW) levels and more intense rainfall (Figure 1). In some areas up to 50 percent of the wastewater flow is caused by infiltration/inflow. As GW levels and storm intensity increase this will worsen.

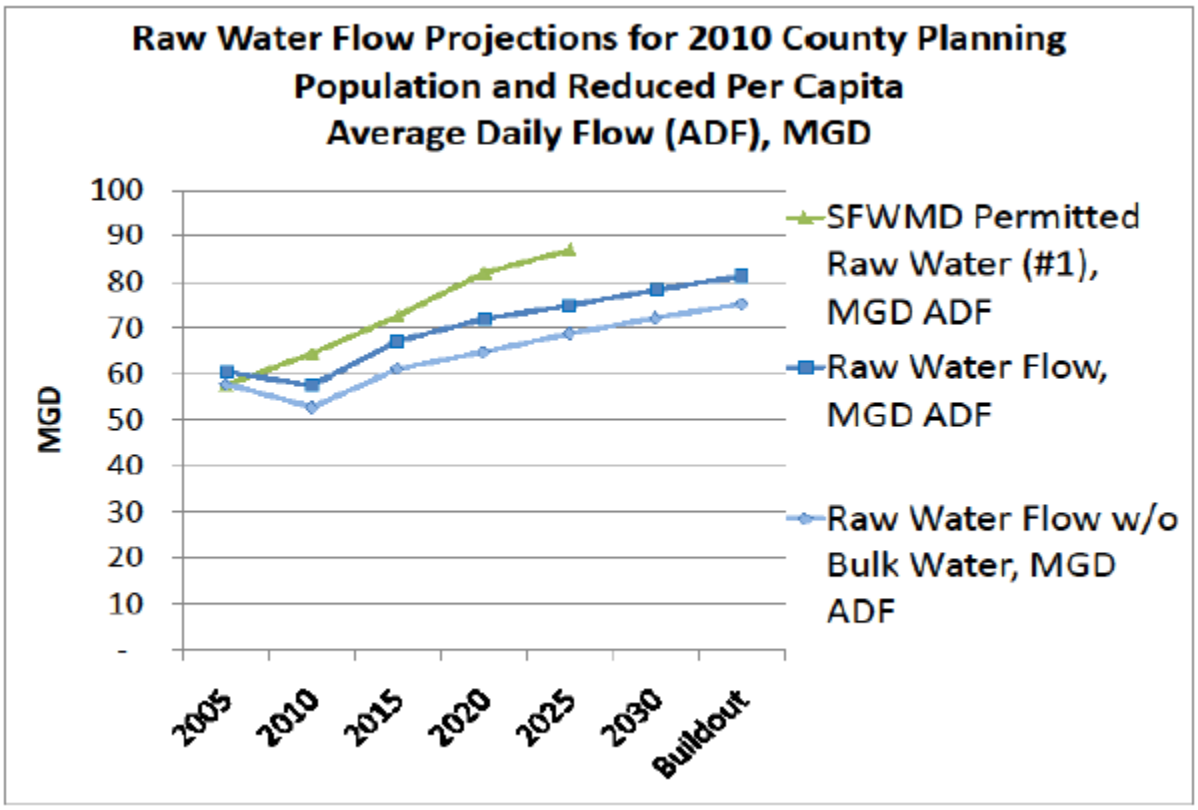


Figure 1: Water Flow Projections for Palm Beach County, 2010.

2.2 Jennifer Jurado, PhD, Director, Broward County Environmental Services
Broward County has made substantial investments in assessments, because climate change adaptation has become an obvious need in the last two to five years. We are on the horizon of making large-scale investments as we identify the cost and energy implications associated with these investments.

Major current climate change implications for Broward County include:

- Increased tidal flooding
- Inland flooding and extreme rain events

The issues are compounded by:

- Delicate balance between recharge and flood control systems and connection between surface and ground water
- Influence of infiltration and inflow on wastewater collection systems and water quality
- Need to comply with Regional Water Availability Rule
- Obligations to 2008 Ocean Outfall Legislation

Table 1: Broward County Water Supply Planning Strategy

An integrated approach that considers combined needs and influences relating to:	Priorities:	Current efforts include:
o Potable Water o Wastewater o Stormwater	o Succeed in Water Conservation Initiatives o Preserve Existing System Capacity o Diversify Water Supplies o Gain Efficiencies through Regional Coordination	o Launching of a county-wide water conservation and incentives program in collaboration with 16 water utility and municipal partners o Local amendments to building codes relating to cooling towers, condensate recovery, and indoor plumbing fixtures o Regional Coordination • Convene Built Environment, Transportation, Land, and Natural Systems Workgroups • Focus on areas where efficiency and effectiveness can be gained through regional strategy and coordination • Water resources • Adaptation action areas • Land use and building codes • Energy use and production • Outreach

2.3 Douglas Yoder, Deputy Director Miami-Dade Water and Sewer System:

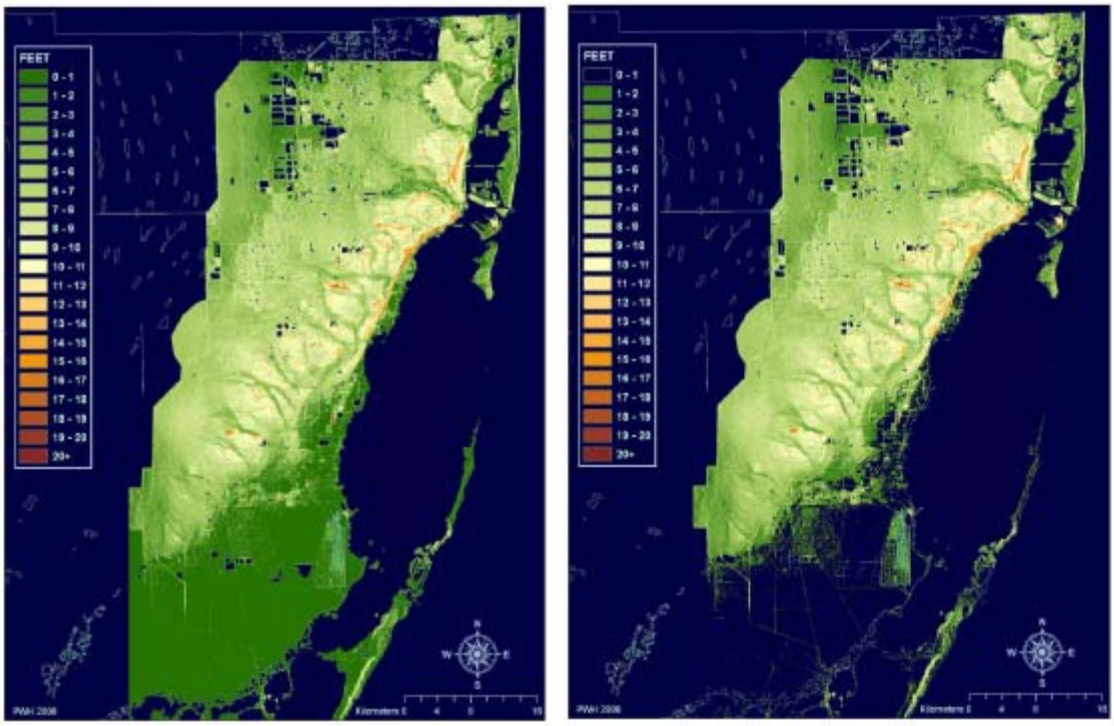
- Serving more than 2.2 million residents
- 3 large regional (lime softening) and 5 small water treatment plants
- Supplying 313.5 million gallons per day (MGD)
- 90% of the County's public water supply
- Per capita water use 140 gpcd
- 417,969 retail customers
- 14 wholesale customers
- 100 water supply wells
- 7,559 miles of pipes
- 38,955 fire hydrants
- Nationally Recognized Leak Detection Program
- Extensive Water Conservation Program

Potential Problems:

- Drainage/Flooding
- Water Supply/Salt Intrusion
- More Frequent Drought/Intense Rain
- Tropical Storm Activity/Storm Surge Impacts
- Habitable Space, Economic Viability, Future Demands
- Natural System Changes/A Different Everglades

What is Miami-Dade doing?

- Sustainability Plan (Mitigation of GHG Emissions)
- Ground Water/Surface Water Model
- Large Scale Alternative Water Supply Plan
- Climate Change Adaptation Plan
- Energy Efficient Operations and Buildings
- Regional Responses
    - Scenario Planning With Adaptation Strategies Associated With Increments of Sea Level Rise
    - Regional Monitoring Program to Track the Extent and Rate of Sea Level Rise (Figure 2)
    - Careful Analysis, Optimization, and Appropriate Retrofits to Flood Control System
    - Alternative Water Supply Development With Flexibility to Respond to Changing Conditions
    - Infrastructure Analysis to Establish Vulnerability (building elevations, drainfields, sewer lines)



(a) Present Conditions (b) One Foot Sea Level Rise

Figure 2: Miami-Dade County (a) present and (b) one foot projected sea level rise.

2.4 Alison Adams, PE, PhD, Tampa Bay Water

Tampa Bay Water is Florida's largest wholesale public water provider. Together we cover 6 local governments (3 counties and 3 cities). Over the past 12 years, Tampa Bay Water has developed additional water supplies and today we have diverse sources of supply. Over half of our water supplies are surface water with an increased vulnerability to changes in climate. Changes in climate may increase annual streamflow variability. As mean annual rainfall rises and falls, streamflows in the Hillsborough River and Alafia Rivers go up and down. High stream flow can be followed by one or more years of very low stream flow.

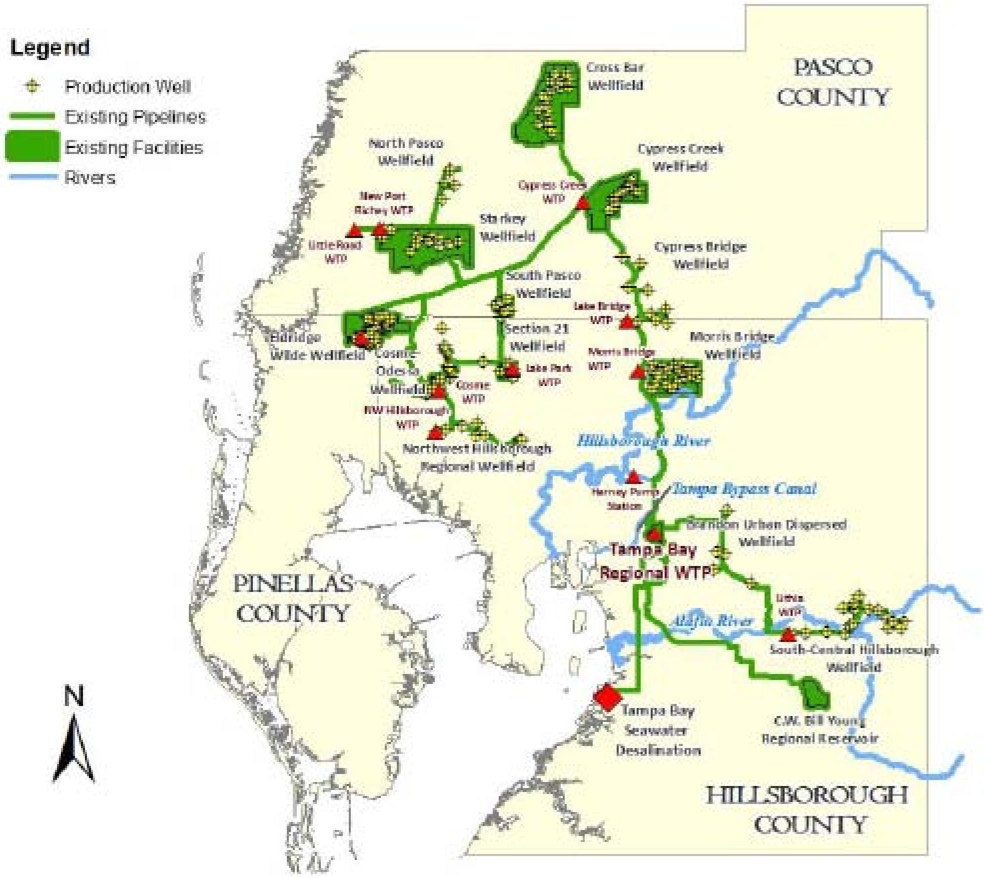


Figure 3: Tampa Bay Water's Diverse and Integrated System.

Changes in the climate may alter a water supply that is already difficult to plan for. Tampa Bay Water's diverse water supply system is shown in Figure 3. Its sources include: 13 groundwater wellfields, 3 surface water sources, a 15.5 billion gallon off-stream storage reservoir, and a seawater desalination plant.

Tampa Bay Water provides potable water to serve nearly 2.4 million people with average daily demands between 220 and 250 mgd (Figure 4). Our diverse water supplies are integrated into one regional supply and delivery system including 1 surface water treatment plant, 8 pumping stations, 6 groundwater treatment plants, 2 hydrogen sulfide removal plants, 2 alkalinity adjustment facilities, and over 250 miles of transmission mains. Having a diversified supply system allows the agency to use adaptive management strategies to handle climate change.

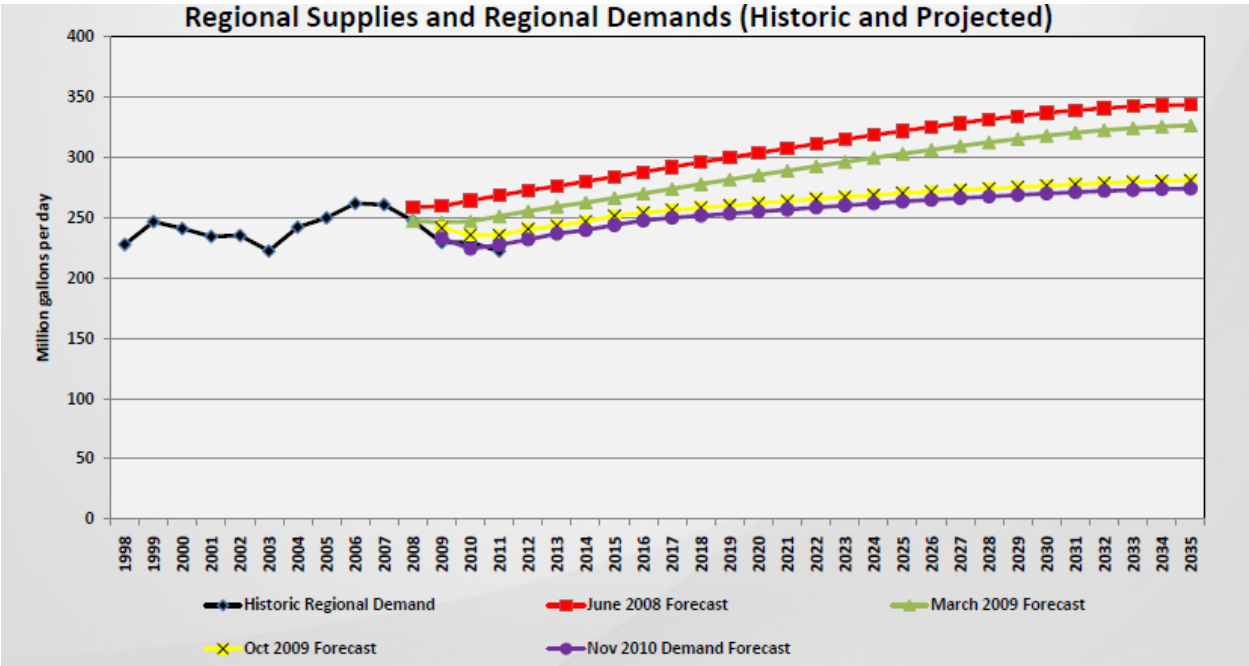


Figure 4: Tampa Bay Water's Highly Variable Demands and Uncertain Projections.

2.5 Discussion Session

The panel discussion (held in the afternoon, following the presentations described in Chapter 3) on these issues included: Alison Adams, Tampa Bay Water Source Rotation and Environmental Protection Manager; Jennifer Jurado, Director, Broward County Natural Resources Planning and Management Division; Maurice Tobon, Director of Engineering for Palm Beach County; and Douglas Yoder, Deputy Director, Miami-Dade Water and Sewer Department. The panel was chaired by Dr. Leonard Berry. In this section, a selection of questions that were raised by participants at the workshop and answered during the session is given. These indicate both the interest of the participants in the workshop topic and their concern with detailed issues of climate change adaptation. Other questions, which could not be answered during the session, were responded to in writing; these are in Appendix D.

Q:
"Have any of you actually spent money on changes to your water systems specifically and solely for the purpose of preparing for or adapting to climate change effects? If not, what do you see being the main driver for these decisions in the future?"

A:
Leonard Berry and Doug Yoder – "It is very difficult for elected officials to make decisions now about which improvements not to make in areas that may be abandoned. It's likely that the big migrations will be due to storm surges and extreme events. The insurance industry will also provide a forcing factor.

"It is likely that there will be an incremental approach, instead of a blanket determination that we will not service an area. Planning and land management decisions will be

integrated, guiding new development within a 20-30 year time frame. So infrastructure will be designed for short-term use. This all may happen in a more strategic way. The Port of Miami expansion project is designed to accommodate post-Panamax cargo ships. The Florida Department of Transportation will loan the Port of Miami $77 million for the deep dredging project. Along with the Port of Miami Tunnel Project and the U.S. Department of Transportation's $22.7 million grant to restore rail service between the Port and the Florida East Coast Rail Yard, total costs are perhaps $100 million. This type of long-term investment may be an example of a project that should incorporate sea level rise projections into the planning process.

"Projections will change, and that is why we should take a flexible adaptation approach. 10 years from now we will have a more solid perspective-- a better picture. By that time our models will be better, possibly 95% confidence. There are other indicators that should be incorporated, i.e. methane, CO_2 increases due to energy for water treatment, micro fauna, etc. IPCC reports show a progressive increase in confidence. The Utilities Working Group formed for this purpose can serve as a continuing vehicle for assessing projection impacts and adaptation needs."

Q:
"Case studies, if you had to pick a case study, what would be helpful".

A:
Leonard Berry – "Let's look at how business schools write case studies. We are kind of early in the process to demonstrate concrete examples related to climate change".

Doug Yoder –"This is the idea of these workshops, utilities managers need to identify these aspects and how to move forward, i.e. Australian drought and flood, how do you plan and adapt to change?"

Jennifer Jurado – "The City of Fort Lauderdale is investing in drainage infrastructure to deal with extreme high tides. We will see how this works in the future. We expect to do a refined analysis to give us more information that we can use in decision making and planning, but also will provide methodology of how to approach these issues in other places that have similar issues".

Maurice Tobon – "At the moment Palm Beach County is more focused on diversification. Climate change issues for Palm Beach County are not as immediate as Broward, Monroe or Miami-Dade".

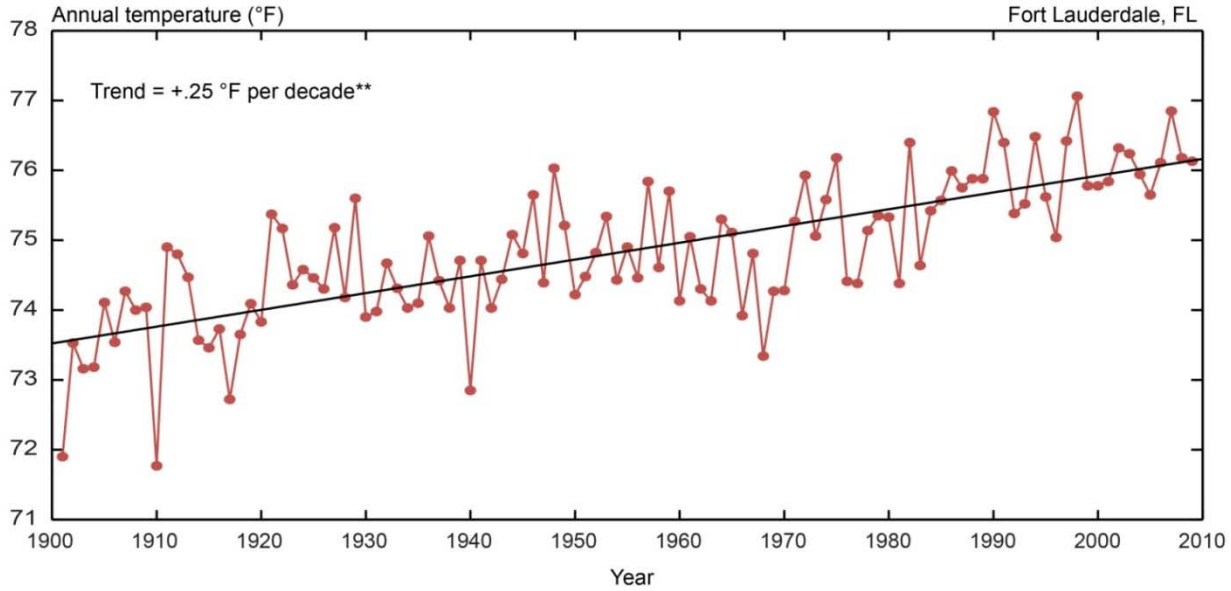
David Major – "There is a comprehensive report from NYCDEP (2008) on climate change, and there is a study either underway or about to start to find out what the effects of sea level rise will be on the sewer and wastewater treatment systems. One thing I'd like to see done is for somebody to make an estimate of the total future cost of dealing with the impacts of climate change, especially sea level rise and storm surge, on sewer systems and wastewater treatment plants along the East and Gulf Coasts. I would guess $10's of billions."

Leonard Berry – “USACE, they’ve agreed on projections and that they should be considered, but they have established a group to determine what “consider” really means. We need to include things in our planning process in very clear ways”.

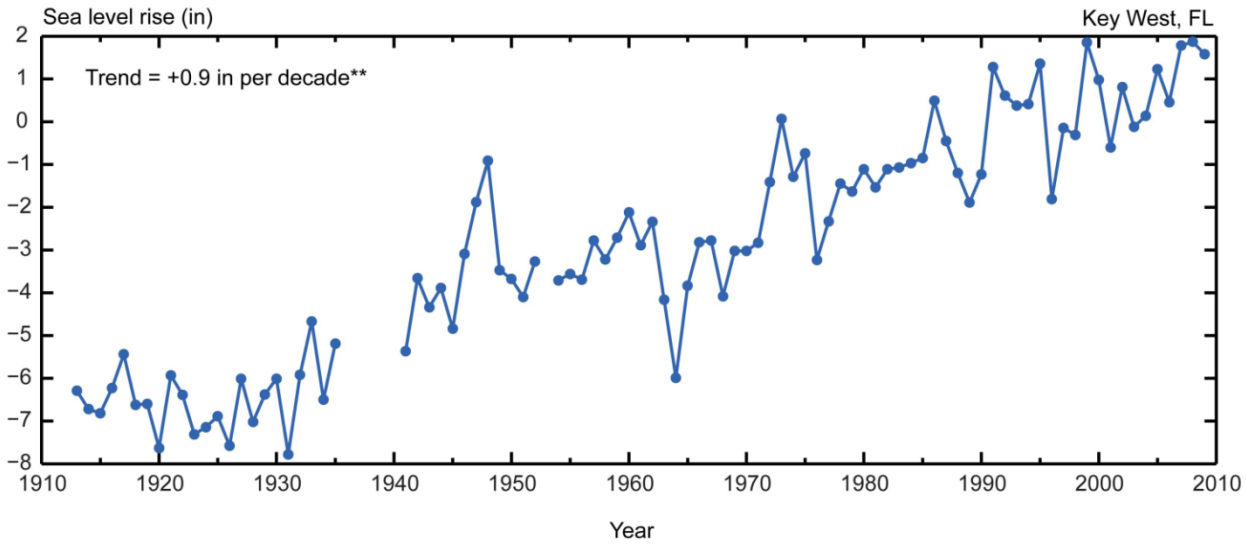
Chapter 3: Workshop Presentations II: Climate Science and Planning Presentations

3.1 Current Climate Science and Climate Scenarios for Florida (Mr. Bader and Dr. Gornitz)

This session presented the current state of climate science, including references to both international efforts and studies focused on Florida. The current climate of Florida was described, including its teleconnections to larger climate processes such as the El Niño Southern Oscillation (ENSO). Observed long-term trends for Southeast Florida, shown in Figure 5, indicate that both temperature and sea level have been on an upward trajectory consistent with global climate change science. The process of developing regional climate scenarios from GCM scenarios was described, and the scenarios for southeast Florida were explained. The sea level rise scenarios (Figure 6) that are described more fully in Chapter 4, and others that are available, indicate both that the range of sea level rise that could occur in southeast Florida is wide and that there is a possibility of quite substantial sea level rise—perhaps by a meter or more--by the end of the 21st century. Extreme event scenarios were also presented, including the possibility that days with maximum temperatures of 90° F or greater will increase from a baseline of 60 annually to 130 to 174 per year in the 2080s. As utilities prepare to confront these significant changes, and the impacts that they will have on water utility infrastructure and operations, it will be essential for them to keep up with new data on sea level and scientific advances in the development of scenarios. The most important upcoming scientific evaluation of climate change and its impacts will be the IPCC's 5th Assessment Report, due in 2013.



(a) annual temperature trends, Fort Lauderdale, Florida



(b) annual sea level rise trends, Key West, Florida

Figure 5: Observed Climate Trends in South Florida (a) temperature and (b) sea level rise - Temperature data from NOAA NCDC. Sea level data from NOAA Tides and Currents. Source: Columbia University Center for Climate Systems Research

	Baseline	**2020s**	**2050s**	**2080s**
IPCC-based	**NA**	**+ 2 to 4 in**	**+ 6 to 9 in**	**+ 10 to 19 in**
Rapid ice-melt scenario	**NA**	**~ 4 to 6 in**	**~ 18 to 21 in**	**~ 39 to 48 in**

Figure 6: Sea Level Rise Projections for Southeast Florida. Source: CCSR

3.2 Adaptation Assessment and Planning (Dr. Major)

An important element of climate change adaptation for water utilities is the use of an overall adaptation assessment framework to insure that activities take place in a consistent and integrated way. This session presented one well-known approach to the challenge, an eight-step process developed originally in the context of water utility planning for the New York City Department of Environmental Protection (NYCDEP) (Major and O'Grady 2010). The approach relates to all of the risk management, maintenance and operations, and capital planning processes of water utilities (or other

agencies and organizations that manage and operate critical infrastructure). The eight steps are described in detail in Chapter 4. During the session, examples of several steps were discussed. One was the use of a risk theory concept embodying estimates of: climate hazard probabilities; likelihood of impact occurrences; and the magnitude of consequences if an impact occurs. This 3-dimensional approach provides a convenient method for prioritizing adaptation strategies for water utilities (Figure 7). A second important topic is the continued interaction between theory and practical application; examples were given of how theoretical concepts in planning might be modified in practice. Further, the importance of integrating climate adaptation measures into the rehabilitation and capital replacement cycles was stressed—this may allow for very substantial economic savings as compared to add-on adaptations. Other topics discussed were perspectives on plan formulation and the importance of monitoring.

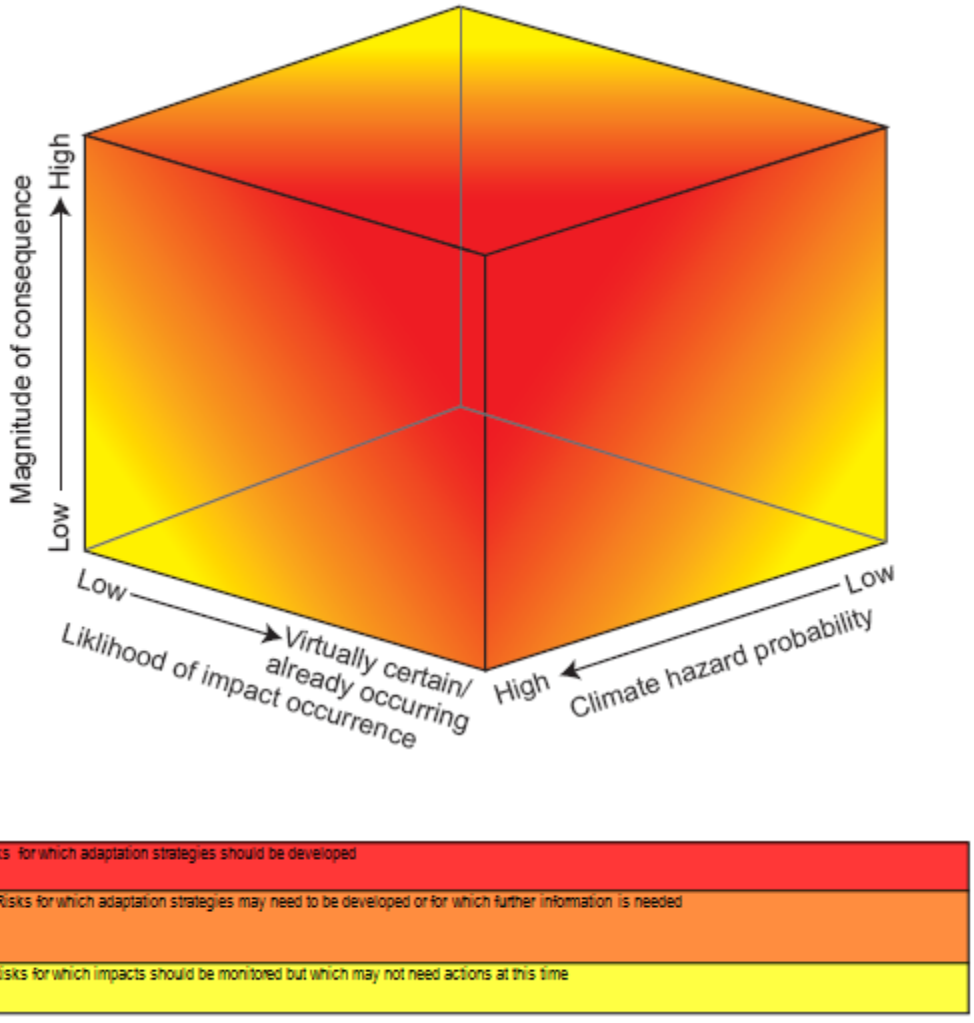


Figure 7: Theory - Characterize Risk. Source: Major and O'Grady, 2010, p. 254.

3.3 Adaptations for Operations, Infrastructure and Policy (Dr. Major)
This session presented a wide range of perspectives on, and examples of, climate adaptations for water utilities. Adaptation to climate change is unified by the framework

of adaptation assessment and the need for long-term adaptation plans. It is, however, also segmented in practice, for example by type--maintenance and operation, infrastructure, policy; by time period--short-, medium- and long-term; and by cost--easily funded, extremely capital-intensive. Various examples were presented in the session. An operations research study of relatively low cost that can be undertaken in the short term is the use of climate scenarios in reservoir operation models to begin to plan for quantity and quality challenges resulting from climate change. There are also "soft" infrastructure measures of moderate cost that can be phased in over time, such as reconstructed wetlands to buffer storms. High-cost, long-term infrastructure projects are also being studied in many areas, including surge barriers. Policy measures are available such as interagency cooperation in adaptation including physical linkages between systems that vary in cost and appropriate timing.

The many types of adaptations available provide for a menu of choices in planning and emphasize the importance of techniques to choose among adaptations (such as benefit-cost analysis and environmental impact assessment) and to prioritize among worthwhile possibilities. Prioritization can be usefully done using spreadsheets with a range of characteristics (such as cost, environmental impact, timeliness, and others) and a ranking function. Simple matrices are also helpful, such as a timeliness/funding matrix developed for practical applications (Figure 8). An important perspective in plan development and prioritization is the concept of flexible adaptation pathways: avoiding inflexible commitment of significant resources when flexible, staged approaches are possible that may track climate change more successfully. The importance of developing more case studies of adaptation to help in sharing progress in the field was stressed.

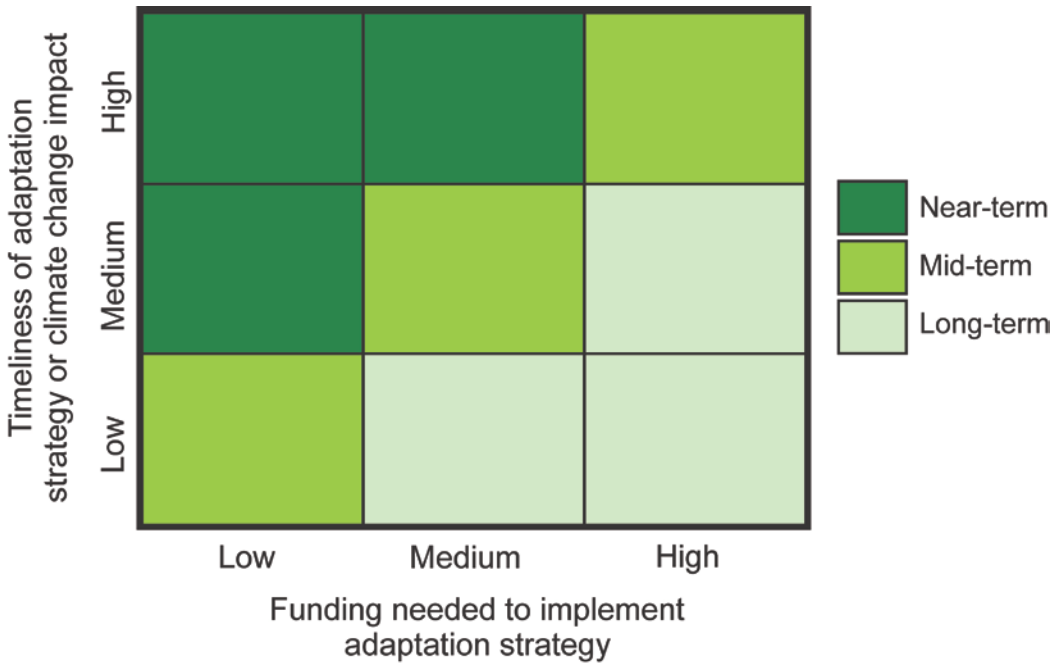


Figure 8: Method for Prioritizing Adaptation Strategies for Water Utilities. Source: Major and O'Grady 2010, p. 257.

3.4 Evaluation of Adaptations (Dr. Bloetscher)

Utilities and Climate Change (relevant to Florida utilities and utilities in other areas)
Utilities in low lying areas that depend on water precipitation and storage that is seasonal should address the risk associated with changes in current climatic patterns. This includes the development and prioritization of infrastructure to improve resiliency to climatic changes. Current patterns for utility operations may change substantially when climate patterns change; including the realization that all water is one water and that different patterns of use and disposal may be required in the future. For example, excess stormwater may need to be captured to provide raw water supplies, and that targeted aquifer recharge with highly treated wastewater will be viewed as a more effective solutions that irrigation or other options.
Critical Issues

- Three critical issues regarding climate change:
  - How increasing hydrologic variability may affect water supply and demand and wastewater collection and treatment,
  - How energy usage to treat and deliver potable water and to treat and dispose of wastewater may contribute to climate change or variability, and
  - How sea level rise may impact road, water, sewer and stormwater infrastructure.

Impacts on utilities over the next century:

- Inundation of certain low-elevation areas with salt water in the eastern coastal cities
- Contamination of groundwater from sea water inundation and storm surge
- Higher water table means less capacity to store rainfall, which means less potential for irrigation with reclaimed water or other sources, esp. west
- Septic tanks fail to operate
- Increased manhole leakage/inflow (from saltwater intrusion and surface flooding)
- An associated increase in chlorides in raw wastewater and hence added treatment required for reclaimed water
- Saltwater migration toward raw water wellfields.

Chapter 4: The Relevance of the Workshop Discussions to Water Utilities in Florida and Beyond

The material presented in the workshop and the discussions held during the meeting were focused primarily on climate change adaptation in southeast Florida. However, a significant portion of the material presented and discussed is relevant to many other coastal water utilities. In particular, two elements of the presentations, climate scenario methods and an adaptation assessment framework are widely applicable.

4.1 Planning, Adaptation, and Organization

Much of the East and Gulf Coasts of the United States have gently sloping beaches that are subject to severe storms. Many adaptations relevant to Southeast Florida are more broadly applicable. These include solutions to gravity drainage of canals, sewer systems, and wastewater treatment plants as sea level rises, hardening or removal of infrastructure as flooded areas increase, movement of wells as salt water intrusion increases, and more backup facilities against the potentially more severe storms that may accompany global warming. Of course there will be physical differences among superficially similar sites that must be taken into account in adaptation planning.

The planning methods discussed are more broadly applicable to coastal water utilities whether or not they are physically similar to landscapes in southeast Florida. The eight-step Adaptation Assessment guidelines are designed to be general enough to be useful for a range of jurisdictions and infrastructure sectors, including coastal water utilities, yet specific enough to serve as the template for developing and implementing any given utility's adaptation efforts. The steps can be modified with region-specific adjustments related to climate risk information, critical infrastructure, and protection levels. The climate scenarios discussed during the workshop can be generated for all coastal areas.

Similarly, the range of available adaptation options discussed, and the ways in which they can be evaluated and prioritized, are generally applicable. As noted earlier, adaptations vary by type: maintenance and operation, infrastructure, policy; by time period--short-, medium- and long-term; and by cost--easily funded, extremely capital-intensive; and they must be evaluated, prioritized and scheduled, with checkpoints to review planning as more climate information becomes available. The tools of prioritization, for example, are widely applicable, such as a spreadsheet that can be used as an initial screening device (Figure 9). This lists desirable strategy traits with rankings for different adaptation strategies and a simple weighting system.

Adaptation Strategy	Strategy Cost (1 = low to 3 = high)	Strategy Feasibility (1 = high to 3 = low)	Timing of implementation (1 = high to 3 = low)	Efficacy (1 = high to 3 = low)	Resiliency rating (1 = high to 3 = low)	Co-benefits (1 = high to 3 = low)	Average*	Notes & institutional considerations
Strategy 1	1	1	1	2	2	2	1.8	
Strategy 2	3	2	2	1	3	2	2.2	

*1 = high priority strategy, 2 = medium priority strategy, 3 = low priority strategy
Rankings are illustrative only

Figure 9: An Example of Generalized Strategy Prioritization Framework. Source: Major & O'Grady, 2010, p. 259.

Finally, organizational methods can be widely applied. This is an area in which southeast Florida water utilities have taken the lead, as for example with the Four County Compact. Coordinating adaptations with other utilities, especially neighboring utilities, will become more and more important as adaptations become increasingly necessary to cope with sea level rise, storms, and greater flooding. Coordination can relate to compatibility in infrastructure design (for example, sea walls), physical interconnections of delivery systems, and emergency planning.

4.2 Climate Scenario Methods

Climate scenarios can be developed in a variety of ways using different assumptions and models. Temperature and precipitation scenarios for Southeast Florida through the 2080s, based on downscaling from 16 GCMs and 3 greenhouse gas emissions scenarios, are shown in Figure 10.

	Baseline	**2020s**	**2050s**	**2080s**
Air Temperature	76 ˚F	1.0 to 2.0 ˚F	2.0 to 3.5 ˚F	3.0 to 5.5 ˚F
Precipitation	56 in	-5 to 5 %	-10 to 5 %	-10 to 5 %

Figure 10: Temperature and Precipitation Scenarios for Southeast Florida (central ranges: middle 67%). Source: CCSR

The results of sea level rise scenarios developed for Southeast Florida using the IPCC methodology for the 7 IPCC GCMs for which sufficient data are available to calculate

sea level rise, and for the same 3 emissions scenarios used for temperature and precipitation, are shown in Figure 6. The IPCC methodology incorporates two global factors, thermal expansion and ice melt, and two local factors—local ocean water density changes and local uplift or subsidence. This approach yields estimates of sea level rise in Southeast Florida for the 2080s of + 10 to 19 in.

Modified scenarios were also developed assuming a more rapid ice melt, using paleoclimatic analogs. This was undertaken because the IPCC GCMs for the Fourth Assessment Report (IPCC 2007) were not set up to model dynamic ice sheet changes that could result in increased ice melt; such an increase is now thought to be a real possibility. This approach gives a range of sea level rise in Southeast Florida of ~ 39 to 48 in for the 2080s.

The methods used to generate the scenarios generated by the project team and presented at the workshop are described in detail in Horton and Rosenzweig (2010).

A further set of sea level rise scenarios, currently used by Southeast Florida water utilities, is found in U.S. Army Corps of Engineers (2009). These are based on updated 1987 National Research Council scenarios, and give 9 and 24 inches of sea level rise for 2060, and 19 and 57 inches for 2100. A comparison of the approaches is shown in Figure 11. The range of possibilities suggests that water utility projects and programs will have to be designed for a wider range of variation than they are today.

Year	Relative Sea Level Rise, inches				
	Historic	Modified NRC Curve I	Modified NRC Curve II	IPCC-based	Rapid ice-melt
2010	0	0	0	-2 to 4	-2 to 4
2030	2	3	7	1 to 6	5 to 10
2060	4	9	24	4 to 13	19 to 28
2100	8	19	57	10 to 29	49 to 70
2110	9	23	67	NA	NA

Figure 11: Comparison of Sea Level Rise Scenarios Discussed in the Text.

Note: Modified NRC Curves I and II refer to the U. S. Army Corps of Engineers (2009) scenarios; IPCC-based and Rapid Ice-Melt scenarios are those developed for Southeast Florida by the project team. Source: CCSR

4.3 Adaptation Assessment Framework

As noted, one of the most important elements of climate change adaptation for water utilities is the use of an overall adaptation assessment framework within which activities can take place in a consistent and integrated way. Major and O'Grady (2010) identified an eight-step process (Figure 12), developed originally in the context of water utility planning for the New York City Department of Environmental Protection (NYCDEP), to help stakeholders identify at-risk infrastructure and develop adaptation strategies to address those risks (see also Rosenzweig and Solecki, 2001; Rosenzweig et al., 2007; Metropolitan Transportation Authority, 2007; NYCDEP 2008; Major et al., 2011).

These Adaptation Assessment steps are designed to be incorporated into the risk management, maintenance and operations, and capital planning processes of water utilities (or other agencies and organizations that manage and operate critical infrastructure). The set of steps is general enough to be useful for a range of jurisdictions and infrastructure sectors, yet specific enough to serve as the template for developing and implementing any given utility's adaptation efforts. The steps can be modified with region-specific adjustments related to climate risk information, critical infrastructure, and protection levels. A 2009 National Research Council report includes a discussion of the New York City climate change planning procedures as an appendix (NRC 2009, Appendix A). Other sets of broadly similar steps have been proposed, including a set for developing countries (Lim and Spanger-Siegfried, 2005).

The eight Adaptation Assessment Steps are:

1. Identify current and future climate hazards
2. Conduct an inventory of infrastructure and assets
3. Characterize risk of climate change on infrastructure
4. Develop initial adaptation strategies
5. Identify opportunities for coordination
6. Link strategies to capital and rehabilitation cycles
7. Prepare and implement adaptation plans
8. Monitor and reassess

The eight steps reflect the fundamental nature of adaptation planning which is, in principle, a highly complex, multidimensional optimization problem. They are designed to enable stakeholders to adapt to climate change in practice, while at the same time, staying within a suitable conceptual framework. The extent to which each of the steps will be implemented will vary with the extent to which planning has been undertaken for various utilities; generally the steps would be followed in order, with substantial review and reconsideration throughout. Among the most interesting applications of adaptation planning within this assessment approach to date are the use of a risk management framework (Yohe and Leichenko, 2010), flexible adaptation pathways (Major and O'Grady, 2010, p. 243), a 3-dimensional climate change risk assessment approach (Figure 7, above), and a generalized adaptation prioritization matrix (Figure 9, above).

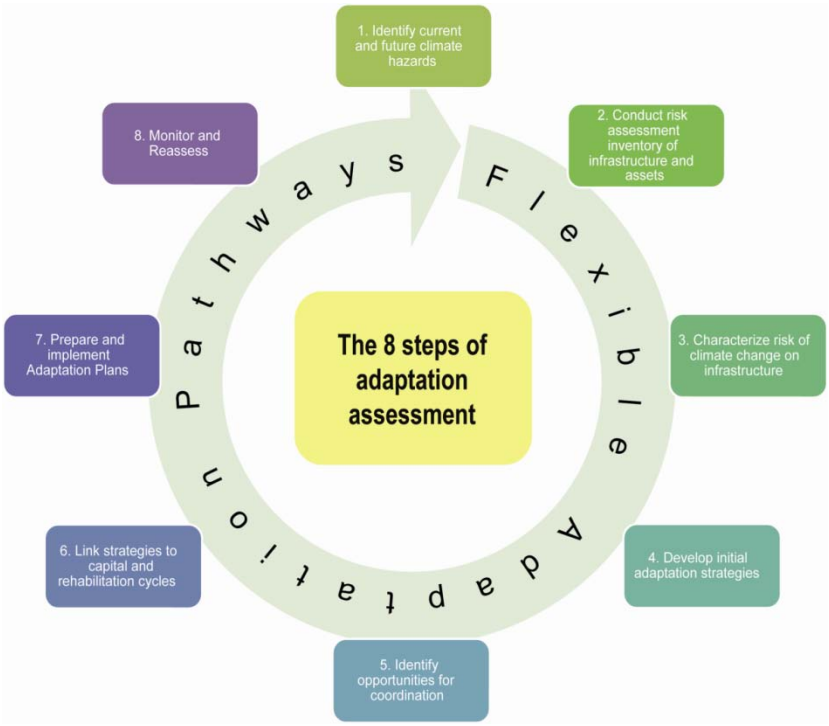


Figure 12: Steps in the Adaptation Process. Source: Major and O'Grady, 2010, p. 240.

Among the most important activities within this framework are to:

a. Provide (for coastal utilities) a detailed inventory of as-built infrastructure within 10 to 20 feet (3 to 6 m) of current sea level, calibrated to the current geodetic datum, NAV88 (Step 2). These can also be developed for current and future defined flood zones. Inventories for utilities not on the coast will also be required as a basis for adaptation planning relating to temperature and precipitation changes, including possible increases in inland flooding.
b. Review all large-scale infrastructure projects currently in the planning stage to make appropriate adjustments for adaptation to climate change (all Steps).
c. Prepare a set of plans for adaptation, using flexible adaptation pathways for the short, medium, and long terms (Steps 4-7). These will need to be reviewed on a regular basis as new information on sea level rise, storm surge, and temperature and precipitation changes accumulates (Step 8).
d. Develop detailed benefit-cost estimates for different available adaptation options to assist in the development of a climate adaptation plan for various time periods (Steps 4-7).
e. Continue to utilize the latest climate change inputs as a central element in planning for climate adaptation (Step 1). These will be particularly important in monitoring and reassessment (Step 8).

Chapter 5: Going Forward

Utilities in Florida have many climate-related challenges to face at every stage of their existence from planning and construction to operation and maintenance. To meet these challenges several processes need to be in place:

1. A process of information sharing on the latest scientific assessments of the impacts of climate change in Florida. This can be achieved through the work of the universities and utilities and through ongoing workshops/conferences already in the planning stages. These include the Florida conferences on adaptation to sea level rise, June 2012, and workshops on the urban environment fall 2012.
2. A process of ongoing research on specific utility issues such as:
    a. Modeling of the salinity interface with sea level rise
    b. Innovative solutions to water storage
    c. Reuse systems for water

These can be achieved by joint university/utilities collaborations.

Findings

1. Many utilities in Florida have in the past few years built climate change issues into their planning processes. Others are just beginning this process.

2. The most important climate change issues for Florida utilities are sea level rise, saltwater intrusion and salinization of the aquifers and changing patterns of precipitation, with substantial drought periods followed by intense rainfall periods.

3. These issues currently have an impact which is expected to grow in the future.

4. The potential impact of sea level rise on drainage and flooding can have a significant secondary impact on utility demand forecasting, which is now largely a function of demographic forecasts provided by State and County agencies.

5. Land use decisions taken today may be problematic in the future because of drainage problems caused by sea level rise.

6. Desalinization is currently an expensive energy-intensive option, but in the Tampa Bay region of Florida it is an important part of the established water supply.

7. Agencies in South Florida have agreed to use the USACE sea level rise projections as a consistent guideline for the region; it is recognized that current information suggests that the higher part of these projections is possible. These are planned to be reviewed when the 2013 IPCC report is available.

8. Regional planning agencies, particularly in South Florida, have developed additional scenarios and some have detailed studies of the impact of sea level rise and critical areas for adaptation measures.

9. Local Florida agencies and universities have made great progress in assessing the vulnerabilities to and impacts of climate change in Florida.

10. Many of the observations and conclusions are relevant to utilities outside of Florida.

11. There is a significant range of research activities that can be undertaken.

12. Utilities in Florida are in regular cooperative discussions about these.

Recommendations to water and sewage utilities

1. Water and sewage utilities need to actively engage with state and local land use planning agencies. Regional cooperation through agreements such as those used in South Florida should be considered as a model. Smaller utilities that are not often involved in these discussions should be included regularly.

2. Utilities should be regularly involved in monitoring climate change and science and how it relates to the opportunities and challenges of Florida utilities.

3. Any further development of utilities must take sea level rise and salinization issues into account, focusing particularly on coastal utilities. This may require engagement with State and County agencies that provide population scenarios that may not incorporate the impacts of climate change on drainage and flooding patterns.

4. A combination of centralized and decentralized patterns of water use are likely in the future and utilities should adapt to these possibilities now, using the adaptation process of Major and O'Grady (2010).

5. Utilities should organize their climate change adaption in a consistent framework such as that discussed in the workshop.

6. Coastal utilities should take a detailed inventory of their infrastructure at risk to sea level rise, storm surge, and coastal flooding.

7. Utilities should incorporate the concept of flexible adaptation pathways in plan development and prioritization – avoiding an inflexible commitment of significant resources, and staging and timingadaptations to conform with actual climate change.

Recommendations to state and local agencies and universities

1. State and local agencies and universities should continue to expand their efforts to provide a framework to adapt to climate change. The Florida-wide utilities working group is a good model for other states.

2. Cooperation on climate change adaptation should continue to be expanded by state and local agencies and universities.

3. Conferences and workshops of the kind outlined in this report should occur on a regular basis as our information base grows. Workshops should be at least on a bi-annual basis.

4. State and local agencies and universities should be prepared to work with scientific groups in other states and countries to advance climate change adaptation.

5. State and local agencies and universities should, to the extent possible, consider the impact of land-use planning decisions on water and sewage utilities.

Recommendations to the WaterRF

1. Consider sponsoring detailed case studies of climate change adaptation for water and sewage utilities to be used as guidelines for other utilities.

2. Consider sponsoring research to develop standard steps for climate change assessment and adaptation.

3. Consider sponsoring additional workshops of this type in other vulnerable coastal cities in Florida and beyond. This would help to disseminate the important progress made in Florida and New York and other leading centers of climate change adaptation.

4. Consider sponsoring special workshops for small utilities in Florida and beyond that do not have the resources themselves to engage in climate change adaptation.

5. Consider sponsoring a workshop to develop estimates of the total cost of climate change adaptation for water and sewer utilities for the Gulf and East coasts of the United States based on vulnerabilities and impact studies. Consider distributing the results of this workshop beyond the membership of the Foundation.

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Appendix A: Workshop Agenda

Water Utilities and Climate Change Workshop **Friday, June 10, 2011** **Palm Beach County Water Utilities Department** **8100 Forest Hill Blvd. (Okeeheelee Park South)** **Central Regional Operations Center – O&M Conference Room 55** **West Palm Beach, Florida 33413**	
9:00 – 9:15 AM	Welcome – *Bevin Beaudet, PE, Director of Palm Beach County Water Utilities and Kenan Ozekin, PhD, Water Research Foundation*
9:15 – 9:30 AM	Workshop Overview and Status of Climate Change Adaptation in Florida (Information on Four County Compact, South Florida Regional Planning Council, etc.) *Dr. Leonard Berry, Florida Atlantic University*
9:30 – 10:10 AM	Current Climate Science and Climate Scenarios for Florida *Dr. Vivien Gornitz and Dan Bader, Columbia University*
10:10 – 10:25 AM	Break
10:25 – 11:30 AM	Utility presentations - Problems and Opportunities *Maurice Tobon, PE, Director Engineering Palm Beach County Water Utilities* *Jennifer Jurado, PhD, Director Broward County Environmental Services* *Douglas Yoder, Deputy Director Miami-Dade Water and Sewer* *Alison Adams, PE, PhD, Tampa Bay Water*
11:30 – 12:00	Adaptation Assessment and Planning *Dr. David Major, Columbia University*
12:00 – 1:00 PM	Lunch
1:00 – 1:45 PM	Adaptations for Operations, Infrastructure and Policy *Dr. David Major, Columbia University*
1:45 – 2:15 PM	Evaluation of Adaptations *Dr. Fred Bloetscher, Florida Atlantic University*
2:15 – 2:30 PM	Break
2:30 – 3:30 PM	Identifying Barriers and Opportunities Panel Reflections and Discussion (Palm Beach County, Broward County, Miami-Dade, Tampa Bay) *Moderated by Dr. Leonard Berry, Florida Atlantic University*
3:30 – 3:45	Next Steps, WaterRF Report Outline and Adjourn *Dr. David Major, Columbia University*

Appendix B: Participant List

Water Utilities and Climate Change Workshop
West Palm Beach, Florida - June 10, 2011

Alison Adams
Water Research Foundation Advisory Committee and Tampa Bay Water

Louis Aurigemma
City of Riviera Beach

Daniel Bader
Columbia University

Rick Bailes
City of West Palm Beach

Leonard Berry
Florida Atlantic University
Center for Environmental Studies

Frederick Bloetscher
Florida Atlantic University

Jerry Brown
Water Research Foundation Advisory Committee and Contra Costa Water

Tom Conboy
Palm Beach County Environmental Resources Management

Mark Elsner
South Florida Water Management District

Bonnie Finneran
Palm Beach County Environmental Resources Management

Larry Johnson

Jo Ann Jolley
Florida Atlantic University
Center for Environmental Studies

Jennifer Jurado
Broward County

Poonam Kalkat
City of West Palm Beach

Mario Loaiza
City of Riviera Beach

David Major
Columbia University

Josh Nichols
City of West Palm Beach

Ron Nunes
Southeast Florida Utilities Council
Parkland Utilities, Inc.

Kenan Ozekin
Water Research Foundation

Penni Redford
City of West Palm Beach

Diana Rivera
Palm Beach County Water Utilities District

Thomas Romah
Florida Atlantic University

Shane Forsythe
Florida Atlantic University
Center for Environmental Studies

Frank Fusiek
City of West Palm Beach

Patrick Gleason

Bertha Goldenberg
Miami-Dade Water and Sewer Department

Vivien Gornitz
Columbia University

Wendy Graham
University of Florida, Water Institute

Nicole Hammer
Florida Atlantic University
Center for Environmental Studies

Francis Henderson
Broward County

Patrick Painter
City of West Palm Beach

Timothy Perkins
Ft. Pierce Utilities Authority

Dean Powell
South Florida Water Management District

Barbara Powell
South Florida Water Management District

Oscar Rubio

Brian Shields
Palm Beach County Water Utilities District

Patricia Springer
Florida Atlantic University
Center for Environmental Studies

Charlotte St John
Broward County

Maurice Tobon
Palm Beach County Water Utilities District

Ken Todd
Palm Beach County Administration

Doug Yoder
Miami-Dade Water and Sewer Department

Appendix C: Climate Adaptation Resources

Climate Adaptation Resources

GENERAL CLIMATE ADAPTATION RESOURCES

- Climate Change Vulnerability Assessments: Four Case Studies of Water Utility Practices

  EPA - prepared by the National Center for Environmental Assessment's Global Climate Research Staff in the Office of Research and Development
  http://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=233808#Download

- Climate Change Adaptation in New York City: Building a Risk Management Response

  New York City Panel on Climate Change (NPCC). (2010). Climate change adaptation in New York City: building a risk management response, C. Rosenzweig and W. Solecki (eds.), New York Academy of Sciences, New York, NY.
  Appendix A has the methodology for the climate scenarios, and Appendix B is the Adaptation Assessment Guidebook.
  http://www.nyas.org/Publications/Annals/Detail.aspx?cid=ab9d0f9f-1cb1-4f21-b0c8-7607daa5dfclimate change

- List of State and Local Adaptation Plans

  The Georgetown Climate Center provides states and local governments with best-practice models, legal analysis, policy work and legislative tracking, and seeks to maximize the federal, state, regional, and local collaborations that are needed to implement new approaches to adaptation.
  http://www.georgetownclimate.org/adaptation/index.php

- A Survey of Climate Change Adaptation Planning

  The H. John Heinz lll Center for Science, Economics and the Environment
  http://www.heinzctr.org/publications/PDF/Adaptation_Report_October_10_2007.pdf

- Shaping Climate-Resilient Development: A Framework for Decision-making

  Climate Works Foundation, Global Environmental Facility, European Commission, McKinsey & Company, The Rockefeller Foundation, Standard Chartered Bank and Swiss Re
  http://ec.europa.eu/development/icenter/repository/ECA_Shaping_Climate_Resilient_Development.pdf

- Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change

  http://www.dnr.state.md.us/climatechange/climatechange_phase2_adaptation_strategy.pdf

- Climate Ready Water Utilities Toolbox

  http://www.epa.gov/safewater/watersecurity/climate/toolbox.html

- Adapting to the Impacts of Climate Change

  National Academy of Sciences
  http://dels.nas.edu/Report/Adapting-Impacts-Climate/12783

FLORIDA-SPECIFIC CLIMATE ADAPTATION RESOURCES

- Lee County Climate Change Vulnerability Assessment

  Southwest Florida Regional Planning Council
  http://www.lee-county.com/gov/dept/sustainability/Documents/Lee%20County%20Climate%20Change%20Vulnerability%20Assessment%20Final%20201.pdf

- Southeast Florida Regional Climate Change Compact

  Four-county agreement
  http://www.broward.org/NaturalResources/ClimateChange/Documents/CompactFinal.pdf

- List of Resources for Planning for Adaptation

  http://www.broward.org/NaturalResources/ClimateChange/Pages/Adaptation.aspx

- Adaptive Response Planning to Sea Level Rise in Florida and Implications for Comprehensive and Public-Facilities Planning

  http://www.dca.state.fl.us/fdcp/DCP/publications/Files/AdaptiveResponsePlanningSeaLevelRise.pdf

- Local Strategies for Addressing Climate Change

  NOAA Coastal Services Center
  http://www.broward.org/NaturalResources/ClimateChange/Documents/climatechangestrategies.pdf

- First Annual Report, February 2011 - Southeast Florida Regional Climate Change Compact

  Look under “Highlights” on
  http://www.ces.fau.edu/climate_change

- A Unified Sea Level Rise Projection for Southeast Florida

  Southeast Florida Regional Climate Change Compact
  Look under “Highlights” on
  http://www.ces.fau.edu/climate_change

- Analysis of the Vulnerability of Southeast Florida to Sea Level Rise

  Southeast Florida Regional Climate change Compact
  Look under “Highlights” on
  http://www.ces.fau.edu/climate_change

- Southeast Florida’s Resilient Water Resources: Adaptation to Sea Level Rise and Other Impacts of Climate Change

  Look under “Publications” on
  http://www.ces.fau.edu/climate_change

- Post Disaster Redevelopment Planning: A Guide for Florida Communities

  http://www.dca.state.fl.us/fdcp/dcp/PDRP/Files/PDRPGuide.pdf

- 2006 Countywide Post Disaster Redevelopment Plan, Palm Beach County, Florida

  http://www.pbcgov.com/publicsafety/emergencymanagement/resources/pdf/pdr...

- Virtual Climate Adaptation Library

  Florida Institute of Technology
  http://research.fit.edu/sealevelriselibrary/

- Sea Level Rise Planning

  City of Satellite Beach
  http://satellitebeachfl.org/cpabsealevelrise.aspx

- Public Water Supply Utilities Climate Impacts Working Group

  University of Florida Water Institute
  http://waterinstitute.ufl.edu/workshops_panels/PWSU-CIWG.html

Appendix D: Written Discussion Panel Responses to Additional Questions Submitted in Writing on June 10, 2011

Question: "Is the County Climate Compact group lobbying for State/Fed funding aimed at assisting communities to deal with issues? If not, why not?"

Response #1: "In response the question about Compact group lobbying for funding, the response is yes. One of the commitments detailed in the 4-County Compact is to partner in the development and advocacy of climate-related policies and legislation at the state and federal levels. In FY '11 the Compact Counties developed a regional legislative package which was formally adopted by each of the county commissions. It was a result of this joint policy position and advocacy that we were able to gain during this last legislative session integration into state law the designation of "Adaptation Action Areas." Representatives from each of the Counties have also partnered in joint lobbying efforts in D.C. on at least 3 different occasions. Just this last week, 2 of the 4 counties were able to send representative to the Clean Energy Summit hosted by Climate Communities. During these trips, county officials and staff meet with Congressional leaders and agency heads. Most recently, promotion of the Compact, the issues confronting SE Florida, the designation of "Adaption Action Areas" in WRDA, and funding for adaptation and mitigation strategies were all part of the shared agenda".

Response #2: "In addition to Jennifer's thorough response, it is worth noting that the South Florida Regional Planning Council has spearheaded a successful effort to bring 7 counties together in an effort to address regional sustainability planning with a multi-million dollar federal grant. This will necessarily involve attention to climate change as a variety of services are addressed over the long term. Part of all of these efforts is to standardize an approach to incorporating climate change into all aspects of land use, facility, and service planning at all levels of government. In that way the resources normally applied to these activities will take into consideration the climate change questions, one hopes in a consistent way".

Question: To Tampa Bay Water "What is the difference in energy use for desalinization vs. groundwater/surface water treatment (per MGD)?"

Response: "For Tampa Bay Water's desal plant the energy use/mgd varies depending on the amount of water produced. For a production rate of 19 mgd the unit usage is 13,907KW/mgd and at a production rate of 11.5 mgd the unit usage is 15,274 KW/mgd. For the SWTP, the unit usage is 432.4 KW/mgd. We have several GW treatment plants. At our largest GW WTP facility the usage is 619 KW/mgd".

Question: "How do you perform weekly projections for water use? What are the largest factors?"

Response #1: "At Tampa Bay Water we have developed autoregressive with exogenous variable models that incorporate rainfall, number of rainy days in a week,

and number of consecutive rainy days and temperature, using the period of record daily delivery data for each point of connection. These models project weekly water demands and are our points of connection base with rainfall projections. Using various rainfall predictions a range of demands can be forecasted. We currently are using the expected value. The forecast is updated each week. Consecutive rainy days and number of rainy days are the largest factors".

Response #2: "This is not something that we routinely do, in part because we are not making decisions as to how we can optimize service delivery by choosing among various supply options (as is more directly the case for Tampa Bay Water, for example). We have enough flexibility in our distribution system that we can move the boundaries of our service areas to some extent in terms of which of our water treatment plants are being used to a greater or lesser extent (which we may do to accommodate maintenance work, line breaks, or ground water elevation conditions)".

Question: "Can you speak a little bit more on using treated wastewater to recharge the surficial and Floridan aquifers?" "How far along is this solution in design or consideration?"

Response #1: "With respect to treatment of wastewater to recharge the surficial and Floridan aquifers, the technologies are well established and have been employed in areas such as California for several years. In California the regulatory process requires treatment with membrane bioreactors followed by reverse osmosis followed by 1). UV disinfection coupled with advanced oxidation or 2). ozone treatment. A similar course of treatment would be required in order to meet groundwater standards in Broward County. Similar treatment technologies and treatment trains have been piloted by a number of utilities in Miami-Dade and Broward Counties. The City of Pembroke Pines currently has plans to recharge the Biscayne Aquifer following advanced wastewater treatment and is piloting a treatment process. As far as I am aware, there are no local projects in the permitting phase as of yet, but several utilities have projects of this type included in their 10-year Water Supply Facility Workplans. More recent has been discussion about providing recharge to the Floridan Aquifer since state regulations may not require the same level of advanced treatment prior to discharge to this brackish aquifer. Local regulations may required additional treatment, however.

"Modeling conducted by Broward County indicates that regional withdrawals to be produced as a result of projects identified by water utilities as part of their 10-year water supply facility workplans will produce changes in chloride concentrations in the source wells as a result of wellfield drawdown equivalent to several hundred feet. Most of these changes were predicted to produce an increase in chloride concentration ranging from several hundred to several thousand mg/l (in a few instances there is actually a predicted freshening of water, but still very much brackish). There are at least two utilities in the region that have realized chloride concentrations in Floridan withdrawals that exceeded expectations. In Palm Beach County, one water utility has already begun to realize increases in chloride concentrations that were not predicted for several years. Since no regional scale modeling of the planned Floridan withdrawals had been

conducted prior to the project undertaken by Broward County as part of an Integrated Water Resources Management Master Plan (IWRMMP), we are not really able to assess whether the modeled increases are apt to occur more quickly than once anticipated. However, it has generally been suggested that the Floridan would be able to sustain all proposed projects with no stated water quality concerns. The results of the Broward IWRMMP indicate that assumption is not valid, consist with the experience of at least 2 individual water utilities".

Response #2: "On recharging the surficial (Biscayne) and Floridan aquifers with reclaimed water: Jennifer described this very well. Higher levels of treatment are currently required for recharging the Biscayne aquifer, in part because of the fact that this water interacts with surface waters (canals and lakes) as well as Biscayne Bay, an Outstanding Florida Water and part of Biscayne National Park. The "best available technology" approach is also pertinent to the Biscayne aquifer's "sole source aquifer" designation (although the number of Floridan aquifer systems now in operation could be used to challenge the "sole source" designation). The fact that reverse osmosis is a standard treatment required to remove the salt from the Floridan water to make it potable also argues in favor of a somewhat less stringent reclamation standard for replenishment of the Floridan, thereby making a strategy that relies more on the Floridan for both replenishment and water supply a potentially more cost effective approach than using the Biscayne for this purpose. Another advantage of replenishing the Floridan is that it will not contribute to drainage/flooding problems as will be the case with replenishing the Biscayne and thereby potentially intruding upon the unsaturated zone that is used for storage of stormwater. Storage and drainage capacity is a very key issue in the consideration of the consequences of sea level rise in south Florida, so a reuse strategy that contributes to that problem is not such a good idea. Miami-Dade County has completed the 90% design of a reclamation plant similar to the plant operating in Orange County, California, that was to be used to replenish the Biscayne aquifer so that a new water treatment plant could be built in the southern portion of the County. After considering the total cost of both the reclamation facility and the water treatment plant, we have concluded that it is much more cost-effective to use the Floridan aquifer as the main supply for the water plant (as discussed in my presentation to the group). These technologies are extremely expensive both in terms of capital cost and operating cost, so this ultimately has to be factored into the equation".

Question: "Has your research shown that the Floridan aquifer is being drawn down at a faster rate than initially assumed? By how much?"

Response: "Regarding drawdowns in the Floridan aquifer: We will be getting into the Floridan supply in the next year or so when the plant we are jointly funding with Hialeah is finished, so we do not have direct operating experience yet. Certainly more work needs to be done to better understand the sustainable yield and sub-regional yields of the Floridan in the south Florida area. The South Florida Water Management District is doing some of this work, and the monitoring of operational impacts at the various plants now operating should be useful in better understanding the consequences of long term pumpage. By the same token, we don't really understand at this point how

replenishment of the Floridan is likely to integrate with the native water and how the hydrological connections may work to disperse the reclaimed water in one direction of another. It could turn out that replenishment will become a kind of Aquifer Storage and Recovery process with respect to water supply needs, pushing the practice more in the direction of Direct Potable Reuse rather than Indirect Potable Reuse normally associated with ground water replenishment".

Also see Response #1 to the previous question

Question: "With respect to the WEAP model- has there been an additional module to assess the cost/benefits of future projects?"

Response: "No formal cost/benefit module in WEAP, but multiple project can be entered into the model and comparison of the cost between them can be made, if a benefit can be quantified that data can be entered and analyzed".