

Project title:
**Flood and drought risk management under climate change:
methods for strategy evaluation and cost optimization**



Performance Progress Report

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Table of Contents

- I. Preliminary materials..... 1
 - A. Research project objectives: 1
 - B. Stakeholders and decisions makers..... 1
 - C. Approach..... 1
 - D. Matching funds/ activities..... 2
 - E. Partners..... 2
- II. Accomplishments 3
 - A. Project timeline and tasks accomplished 3
 - B. Application of your findings to inform decision making..... 4
 - C. Planned methods to transfer information and lessons learned 4
 - D. Significant deviations from proposed work plan 5
 - E. Completed publications, white papers, or reports..... 5
- III. Graphics 5
- IV. Website address..... 5
- Appendix 1: System robustness for drought risk management in Miami Dade County 6
- Appendix 2: Economic optimization method for optimal timing and level of investment in risk reduction/ adaptation 12
- Appendix 3: Kick-off meeting program 23-26 March, 2015 16
- Appendix 4: Working Meeting report 18
- Appendix 5: Stakeholder workshop report..... 20

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I. Preliminary materials

A. Research project objectives:

With this project we aim to reach the following objectives:

- Extend the analysis of the climate change impacts on the occurrence of floods and droughts in the South Florida Water Management District;
- Gain more insight into the intended and unintended effects of flood and drought risk reduction measures;
- Develop and apply a method to evaluate system robustness to drought events, and use the outcomes in the assessment of comprehensive adaptation strategies aimed at flood and drought risk reduction under climate change;
- Apply an economic optimization method for determining the optimal investment in flood risk reduction. With this application, we document the process of moving the method from The Netherlands to Florida, and we will identify what is required to apply the optimization method to other regions;
- Assess and communicate the usefulness of applying this optimization method for decision making in water resource management;
- Publish the general outcomes on the methods and the specific outcomes for the case study area, through two stakeholder and expert workshops and scientific journal publications.

B. Stakeholders and decisions makers

The project has attracted great interest from stakeholders during the start and first year. This is clear from the stakeholder workshop that was organized in March 2015, and was well attended (see report and attendee list).

Also, the following public organizations have committed their time and collaboration:

- South Florida Water Management District (our main stakeholder and project partner);
- Miami Dade County (through e.g. the office of Nichole Hefty).

C. Approach

Development of economically efficient and sustainable water management strategies hinges on the assessment of the costs of weather extremes, in particular damages due to floods and droughts and their mitigation, as well as the framework in which the costs for adaptation and the benefits of damage reduction are weighted. The primary challenge is to properly assess and value flood and drought risks (both probabilities and consequences) that may become more costly in the future. Long-term planning horizons require that estimations of potential climate change impacts are included in the assessment. We will base our approach on earlier work for developing robust flood and drought risk management strategies and on the award-winning method for cost-benefit analysis for the Delta Program in The Netherlands (Franz Edelman Award 2013).

The robustness analysis method helps to understand the sensitivity of the water management system to drought under changes in climate and climate variability, and can improve decisions on investment in risk reduction and environmental restoration. A risk-based cost-benefit method will be developed for a portfolio of potential measures brought together in adaptation strategies,

focusing on flood and drought impacts in the South Florida region. The optimization method will be applied for the case study area, and optimal levels of measures for flood protection will be derived on the basis of cost estimates of flood risk (e.g. expected damages) and cost of these risk reduction measures.

The methods will be applied to flood and drought risks in south Florida specifically in the city of Miami. The proposed work would support better decisions for managing water resources in this area, thereby potentially reducing damage and investment costs. The South Florida Water Management District (SFWMD), the regional water management agency responsible for the development and implementation of water resource management strategies in South Florida is a project partner and key stakeholder. Its role is critical for the provision of information, data, models and expert advice on the analysis. Both methods will be applicable beyond just the Everglades, and if successful will be beneficial to other complex systems such as the California Bay-Delta system and the Mississippi River Basin. In addition, through applying and extending the optimization method to this particular location, we will develop more experience in applying the method to the integrated management of flooding.

This proposal is targeted at the competition: NOAA-OAR-CPO-2014-2003692: Climate and Societal Interactions Program (CSI), Sectoral Applications Research Program (SARP), “Climate extreme event preparedness, planning, and adaptation”. The proposed work will contribute to understanding methods for evaluating strategies to increase climate change resilience. The project will broaden a proven method for decisions regarding flood protection and will additionally focus on drought risk management. The methods will be tailored to the US and especially to the local case study, while learning about broader application of the method during the transfer from the Dutch situation where the method was developed, to Florida. The proposed project addresses the societal challenges identified in NOAA’s Next Generation Strategic Plan (NGSP), namely by analyzing potential future climate change impacts on water resources, and possible adaptation strategies for flood and drought risk management. We also address NOAA’s NGSP long-term climate goal, in particular Goal 2: “Assessments of current and future states of the climate system that identify potential impacts and inform science, service, and stewardship decisions, by providing a basis for assessing climate change impacts on water resources and better supporting decisions for adaptation”.

D. Matching funds/ activities

During this period of the project, no matching funds have been raised.

E. Partners

Since the start of the project, we have set up contact and collaboration with the following academic organizations:

- Florida International University (specifically Mike Sukop and Suzana Mic) for development of flood damage assessment methods;
- Geodesign Technologies (Mike Flaxman), for future land-use scenario’s;
- Wharton School, University of Pennsylvania (Jeff Czajkowski), for flood insurance data.

II. Accomplishments

A. Project timeline and tasks accomplished

The project has a two-year lifetime. Here, we report on the first nine months. During this period we have successfully started the project, and have advanced on the collection of data, development of the models, and analysis of first results. A successful kick-off meeting including a full-day workshop with some 30 people from stakeholder organizations was held. In addition, a dedicated session with some 15 people was held at Miami Dade County offices to inform local stakeholders on the project.

Further, good progress has been made on the development of the databases and model set-up for the two main tasks: robustness analysis (Task 2) and the optimization analysis (Task 3). We have developed working plans for these two tasks (Appendix 1 and 2) that detail the steps required in the analyses.

During the reporting period, the following contracting and administrative procedures have been put in place:

- Contracting with NOAA;
- Subcontract between Deltares USA and Stichting Deltares (The Netherlands);
- Hiring of assistant at Deltares USA (Mr. Veerabhadra Karri).

During the reporting period, we have started the following research tasks, according to the project proposal:

- Task 1 (Data collection):
 - Task 1.1 (Climate and sea-level data collection): scenario data on sea-level and synthetic climate information was already available from SFWMD. Further information is being collected on changes in rainfall.
 - Task 1.2 (Data on flood and drought probabilities, and costing information) data has been collected in the context of the development of the two relevant models for the project (SFWMM model for the robustness analysis; HEC-RAS model for the optimization analysis). In collaboration with economic and infrastructure experts of SFWMD, data is being collected on costs of adaptation measures.
 - Task 1.3 (set-up if the SFWMM model): the model has been run, and output is being transferred to Deltares, for analysis.
- Task 2 (System robustness analysis): The work will focus on water shortages and drought in Miami Dade County. An analysis has been made with the SFWMM model, to assess the frequency and severity of drought events, and impacts on water uses. Specific attention is being paid to the effects on different water uses. Measures that are considered are adjusted cut-back schemes, as well as other measures to reduce drought severity. Appendix 1 provides more details on current work under this task.
- Task 3 (Optimization method): This works will also focus on Miami Dade County, and specifically the C4 basin. . This is because this basin has seen disrupting flood events and is a densely populated part of Miami Dade County and of South Florida. Analyses of climate change impacts and effects of adaptation measures (consisting of increased municipal pumping capacities, increased impounds capacities, increased forward pumping capacities,

and reduced vulnerability of urban areas) are assessed. Appendix 2 provides more details on current work under this task.

- **Task 4 Outreach:** During the reporting period, the following activities were carried out:
 - Kick-off meeting with the project team (see Appendix 3 and 4);
 - Stakeholder workshop (see Appendix 5).

Success indicators for this period as listed in the project proposal have been completed as follows:

Indicator:	Required month:	Completed:
Completion of kick-off meeting	1	Yes
Completion of the internal detailed work plan	3	Yes

The outlook for activities in the second year is as follows:

- Expected progress: in the coming period the results will be further analyzed, and
- The intermediate (second) project-team meeting is planned for the week of September 21-25, 2015 to take place in Delft, The Netherlands. This meeting will include all project partners (Deltares USA, South Florida Water Management District, and Stichting Deltares). Also, partners from SFWMD take the opportunity to visit other water management organizations in The Netherlands.
- Outreach (final workshop), planned for mid-2016
- Publications that are planned during the second project-year:
 - Project report on robustness analysis
 - Project report on optimization method
 - Journal article

B. Application of your findings to inform decision making

The findings of the project will be of direct relevance to local stakeholders, including the South Florida Water Management District (SFWMD), and Miami Dade County. We are using the SFWMM model, and HEC-RAS model developed by SFWMD, for the analysis of future climate change impacts, and assessment of adaptation options. During the stakeholder workshop, it has become clear that these results can be very helpful to inform decisions by these organizations.

For SFWMD, the continuous collaboration, and joint publication of results in reports and a journal article will secure the transfer of information to them. In the final project .workshop, planned for mid-2016, we will communicate results to the wider audience (see attendee list in Appendix 5).

C. Planned methods to transfer information and lessons learned

As detailed in the project proposal, we have the following activities, to disseminate the project results:

- Two Outreach Workshops (kick-off and final workshop);
- Project website (to be developed by Deltares USA);
- The final project report;
- Peer-reviewed scientific journal article on the optimization method application;

D. Significant deviations from proposed work plan

We have made some adjustments to the scientific content of the project, concerning the exact focus of the two approaches. These adjustments have been made after initial discussions within the project team (including the local South Florida Water Management District) and appraisal of the local situation. First, the robustness analysis is now focusing on drought risk only, as it was not possible to include flooding in the South Florida Water Management Model (SFWMM). However, we will attempt to reconcile results coming from the two different approaches on robustness and optimization, and indicate whether (if any) tradeoffs may exist between adaptation strategies for drought and flood risk management.

Secondly, the optimization analysis (focusing on flood risk – as planned in the project proposal) has been adjusted to the specific local situation. The application of the method to dike heights in The Netherlands is less relevant for South Florida. Here, other local measures, including forward pumping, increasing capacity of municipal pumps, creation of retention areas, and adjusted building codes are likely to be more effective. Therefore, these measures will be included now, rather than the increase of dikes or canal embankments.

E. Completed publications, white papers, or reports

No reports or papers have yet been completed. During the second project year, two reports, and one journal article will be completed.

III. Graphics

Graphics are included in the Appendices (content: Appendix 1 and 2; photos: Appendix). These can be used by NOAA and external audiences, with proper references.

IV. Website address

No website address is yet available, but this will be made available in due course.

Appendix 1: System robustness for drought risk management in Miami Dade County

Introduction

System Robustness Analysis (SRA) provides insight in the sensitivity of a system to extreme weather events. Because climate change may affect the frequency and/or magnitude of these events, robustness analysis examines a range of events that are plausible both now and in the future. Understanding the relationship between extreme events and their impact on the system is believed to aid in drafting robust management strategies that increase the system's ability to deal with both frequent and rare events, now as well as in the future.

Work plan

The work plan consists of the following five steps, each answering a specific sub research question. The emphasis of the research is however on Step 3 to 5.

1. *Problem definition and system boundaries*

What are the existing problems?

2. *Scenarios and model runs*

What is the plausible range of climate pressures South Florida will face in the future? And how do different climate pressures affect the water availability in the study area?

3. *System robustness framework*

Which robustness criteria are suitable for drought risk in Miami Dade County? And which levels of impact and associated drought vulnerability are meaningful thresholds for drought risk management? (see also below for details)

4. *Strategies*

What can be done to reduce the impacts?

5. *Evaluation*

How well do the strategies perform?

Elaboration on Step 3:

The first step in this RSA is to establish the relationship between the drought severity and corresponding drought impact: the *response curve* (Figure 1). This curve visualizes the impacts that can be expected under a range of drought events of different severity. Based on the curve we will try to define the following robustness criteria:

1. Resistance threshold: under which disturbance conditions will socio-economic impacts begin to occur? In other words: to what extent can the system withstand droughts?
2. Proportionality: how gradual does the impact increase with increasing disturbance severity?
3. Manageability: in which range of disturbance conditions are impacts still manageable? In other words: when do impacts exceed a societally unacceptable level?

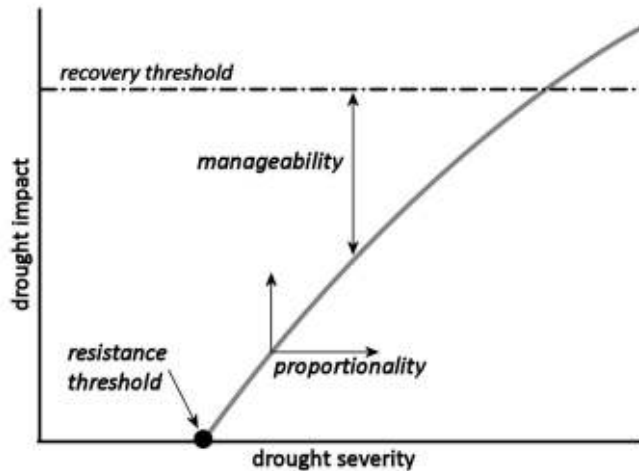


Figure 1. Example response curve: relationship between drought severity and drought impact, and robustness criteria.

Study area

The study area for this research is the county of Miami Dade. The area is mainly urban and the highest populated county in South Florida with 2.5 Million inhabitants. The county is likely to face more frequent and prolonged periods of droughts in the future (Obeysekera et al., 2014). Another water management challenge is the threat from sea level rise which is likely to cause salt water intrusion into some of the public water supply well fields which are located close to the coast. In this way deterioration of water quality might also add to future water scarcity in the area.

In the current system, the South Dade Conveyance System, supply water from lake Okeechobee during dry season for irrigation and aquifer recharging. During a drought, when certain thresholds (trigger levels) in lake Okeechobee and ground water stage are exceeded, the District Emergency Operations Center (EOC) is activated. The EOC will then enforce water use cutbacks based on a contingency plan.

Climate scenarios

We will use synthetic climate change scenarios, similar to the scenarios used by Obeysekera et al. (2014). Different predictions for precipitation, temperature and sea level rise are combined to

create the scenarios. From the combined scenarios each drought event yields one point in the drought severity – drought impact plane. Together these points will yield the response curve.

The following low, middle and high end predictions are available for the 2065 horizon, see

Table 2. Based on this, the synthetic climate scenarios as shown in

Table 2, will be used.

Table 1. Climate change predictions for 2065.

Prediction:	Low end	Middle	High end	
Variable:				Units
Precipitation	-10	0	+10	Percentage
Temperature	0	+1.5		Degrees Centigrade
Sea level rise		+1.5		feet

Table 2. Synthetic climate change scenarios.

Variable:	Precipitation	Temperature	Sea level rise
Units:	Percentage	Degrees Centigrade	feet
Scenarios:			
Base (historical)	-	-	-
-RF	-10%	-	-
+ET	0%	+1.5	+1.5
-RF+ET	-10%	+1.5	+1.5

Preliminary model results

The South Florida Water Management Model (SFWMM) is the main model used for this part of the project. Based on forcing data of meteorology and water demand, the model calculates the available water and distributes it amongst users. Based the meteorological forcing data and the water budget data from the model, meteorological and hydrological droughts are determined and used to quantify drought severity. The model also determines water cutbacks per user are used to quantify the drought impact.

First results of drought severity are obtained for Lake Okeechobee. The water budget from the SFWMM is shown in Figure 2. Based on this water budget and meteorological forcing data, two drought indicators are calculated: 1) the monthly standardized precipitation index (SPI), an indicator for meteorological droughts; and 2) drought deficit volume, a hydrological drought indicator. A negative SPI shows a negative anomaly in precipitation, indicating a meteorological drought. A larger negative SPI indicates a more severe drought. The drought deficit volume is the total water volume below a certain threshold, here defined as the 10% quantile. Different dry

spells (meteorological droughts) can pool together causing a prolonged duration of a hydrological drought. (One of) these drought indicators will be used to quantify drought severity in the response curves.

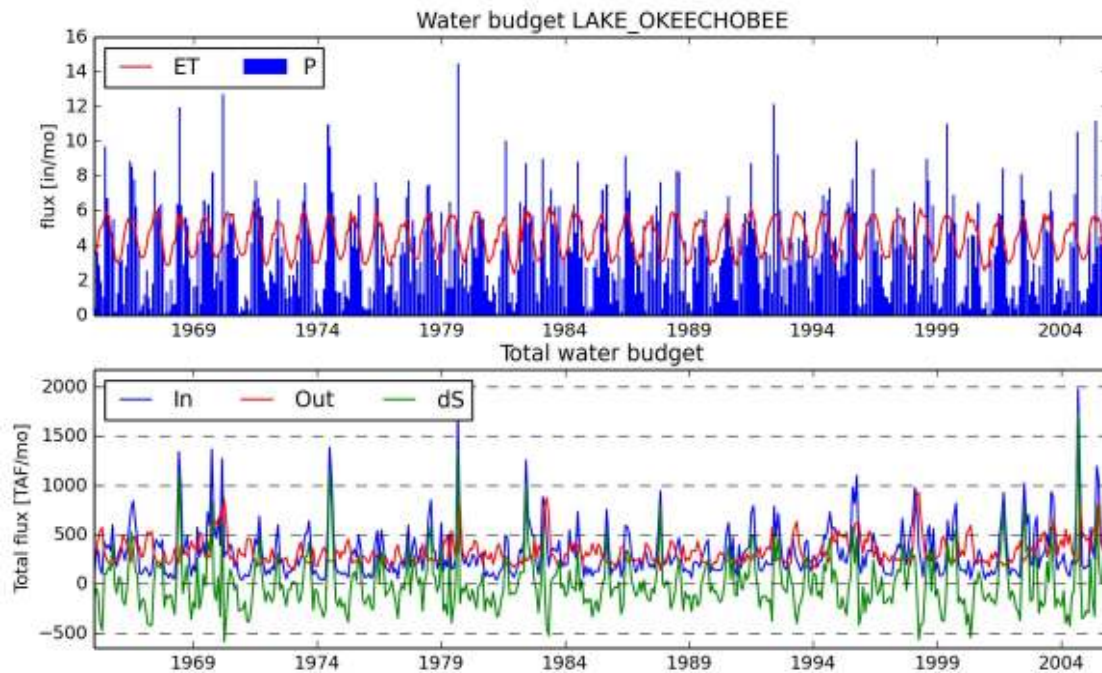


Figure 2. Water budget Lake Okeechobee (output from SFWMM model).

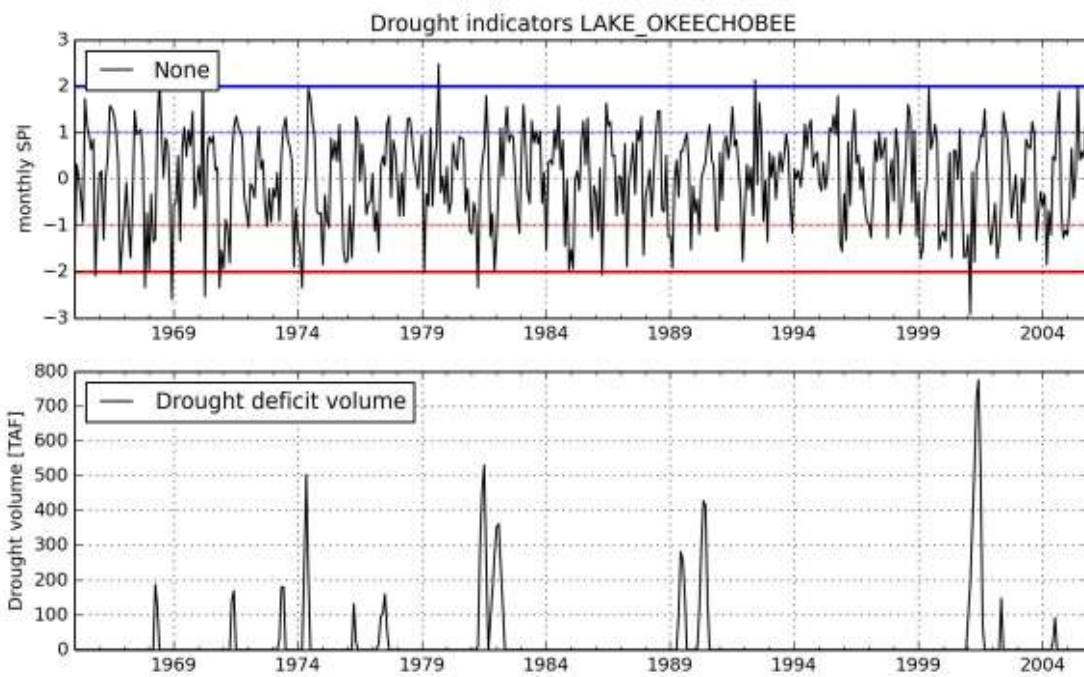


Figure 3. Drought indicators for Lake Okeechobee: the Standardized Precipitation Index (SPI) and Drought Deficit Volume (output from SFWMM model).

Planned activities

	Activity	Data/outcome	Status
1	Define scenarios	Table with scenarios	done
2	Define necessary output from SFWMM model	Indicators based on water budget files and impact based performance measure	done
3	Study current MODFLOW output	Define gradient that is trigger for losing well-field	ongoing
4	Run SFWMM model with scenarios, no measures	Water budget and performance measures	ongoing
5	Create response curve for reference	Reference Response curve for - Water quantity - Water quality	Mid June
6	Define measures	Set of measures	Start Mid June
7	Implement measures in SFWMM model for measures		Start July
8	Create response curves for model runs with measures		Start July

References

Obeysekera, J., Barnes, J., & Nungesser, M. (2014). Climate Sensitivity Runs and Regional Hydrologic Modeling for Predicting the Response of the Greater Florida Everglades Ecosystem to Climate Change. *Environmental Management*. doi:10.1007/s00267-014-0315-x

Appendix 2: Economic optimization method for optimal timing and level of investment in risk reduction/ adaptation

Original versus revised plan

In the original plan, the use of an existing economic optimization model (*OptimaliseRing*) for determining optimal long term investment strategies in dikes (timing and size of dike investments; optimal return periods for floods) was foreseen, as well as the development of alternative adaptation strategies in which dikes were replaced with alternative measures. During the kick-off webinars, SFWMD indicated that there were no actual relevant case studies for applying the dike optimization model. The attention was therefore shifted to the optimization of the urban drainage system for C4-basin, a basin located in the city of Miami. This means that instead of using an existing optimization model, a new model has to be formulated, and data needs to be generated.

Description of the C4-basin case study area

The C4 basin is in the central and western part of the city of Miami. It has a population of about 100,000 persons, especially Hispanics which moved to the basin after 1960. The basin is drained by the C4 canal. Floods happen frequently, especially in the municipality of Sweetwater. After floods in the beginning of the 21st century, an emergency impoundment area was created in the western part and forward pumps were installed in the eastern part of the basin. A long term outlook for the basin, taking into account the impacts of climate change (sea level, rainfall) and socio-economic development, is however lacking.

Objective of the case study

The objective of the case study is to develop and apply an optimization method for optimal investments strategies for flood risk reduction in the C4 basin. The method is expected to result in alternative investment strategies in flood risk reduction measures, including an assessment of the robustness of such strategies. Optimal means that the (present value) of the total cost of all investment and remaining flood damages is minimized over the long term (horizon 2100 and beyond).



Figure 4: Basins in Miami City

Stepwise approach

We take the following structured approach:

1. **Assess the existing performance of the C4-basin.** The basin is modeled in HEC-RAS, after which water levels (“stages”) are determined for different return periods for all 32 sub- basins of the C4 basin. The stages are fed into a relative simple GIS based flood damage model, developed under the project, to determine the average expected damages (AED, in USD/year) in the basins.
2. **Assess the future performance of the C4-basin.** Similar to step 1, the future performance of the C4 basin is assessed. This step assumes a high year 2100 climate change and a high socio economic scenario, and no additional measures taken in the basin. The resulting AED is calculated. For years before 2100, the AED is interpolated between its existing value and future 2100 value.
3. **Identify and assess different type of risk reduction measures.** Risk reduction measures will be analyses in HEC-RAS and the resulting risk reduction calculated. Costs of the measures will be collected from various sources.
4. **Optimize the performance of the C4-basin.** An optimization model will be developed and an optimal long run adaptation strategy determined, assuming high scenarios.
5. **Repeat steps 2-4 for other scenarios.** Steps 2-4 will be repeated, assuming medium and lower scenarios for 2100.
6. **Compare optimal strategies, identify no/low regret measures.** The optimal strategies for different scenarios will be compared, and no/low regret measures and future options be identified.

Data requirements, activities & progress

Table 3: Data Requirements, activities, progress.

No	Description of data	Activities	Progress
1	Stages in the basin for different return periods	Model C4 in HEC-RAS	Finished
		Run model and prepare output	Ongoing
2	Flood damages for different stages	Develop flood damage model	Ongoing
3	Climate change and land use scenarios	Collect data on existing scenarios	Ongoing
4	Identify potential measures and estimate cost of measures	Analyze results from first runs without adaptation measures Discussions Collect from different sources	Ongoing
5	Optimization model	Develop optimization model for C4 basin	Not started yet

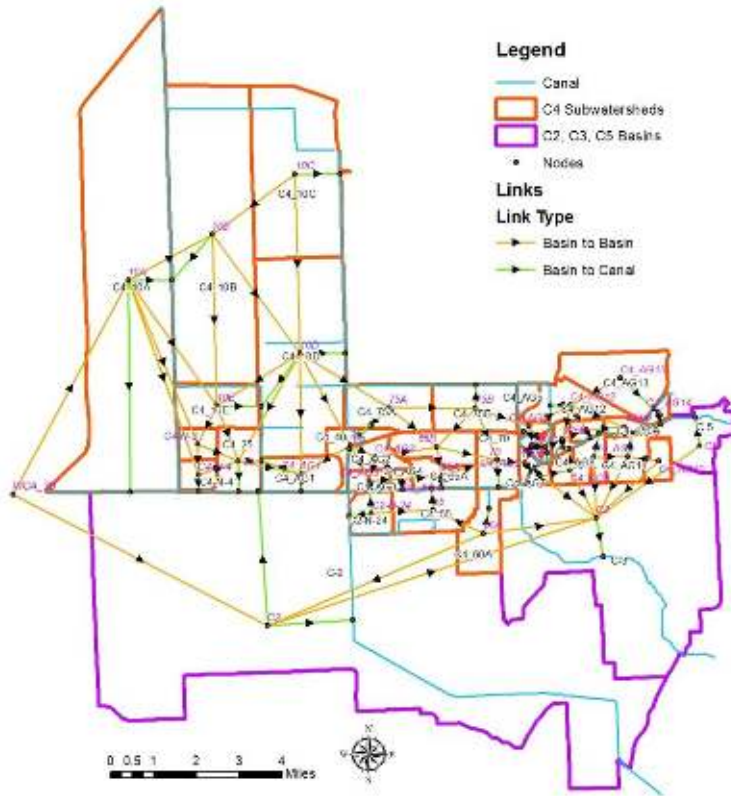


Figure 5: The C4 basin modelled in HEC RAS.

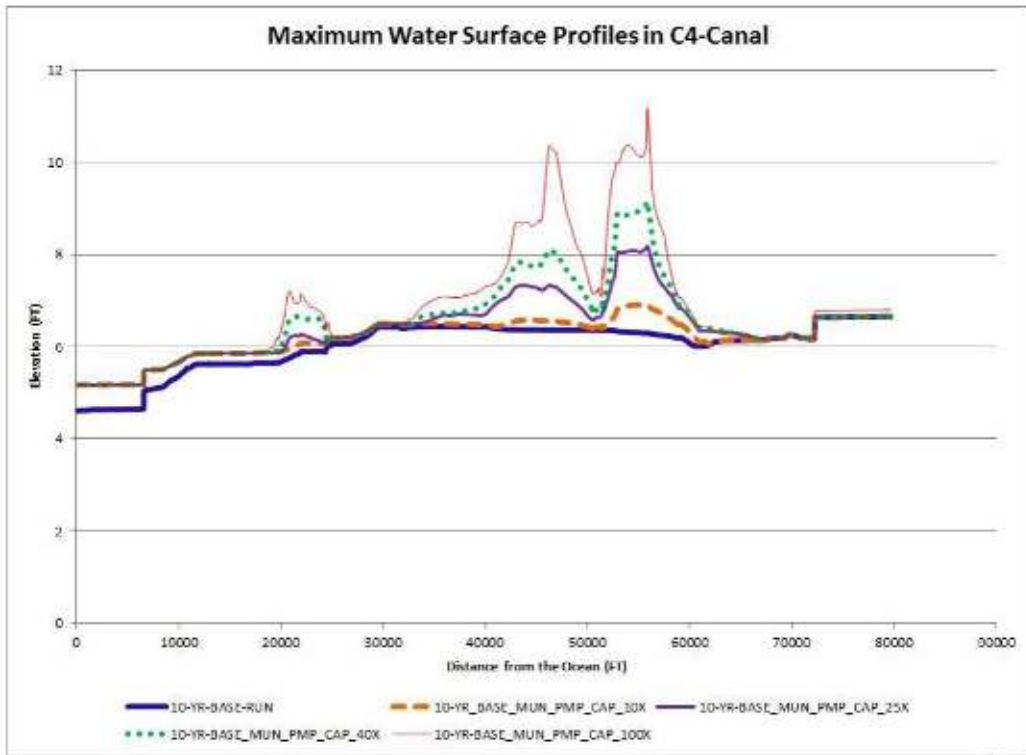


Figure 6: Example output from HEC-RAS for the C4 Canal.

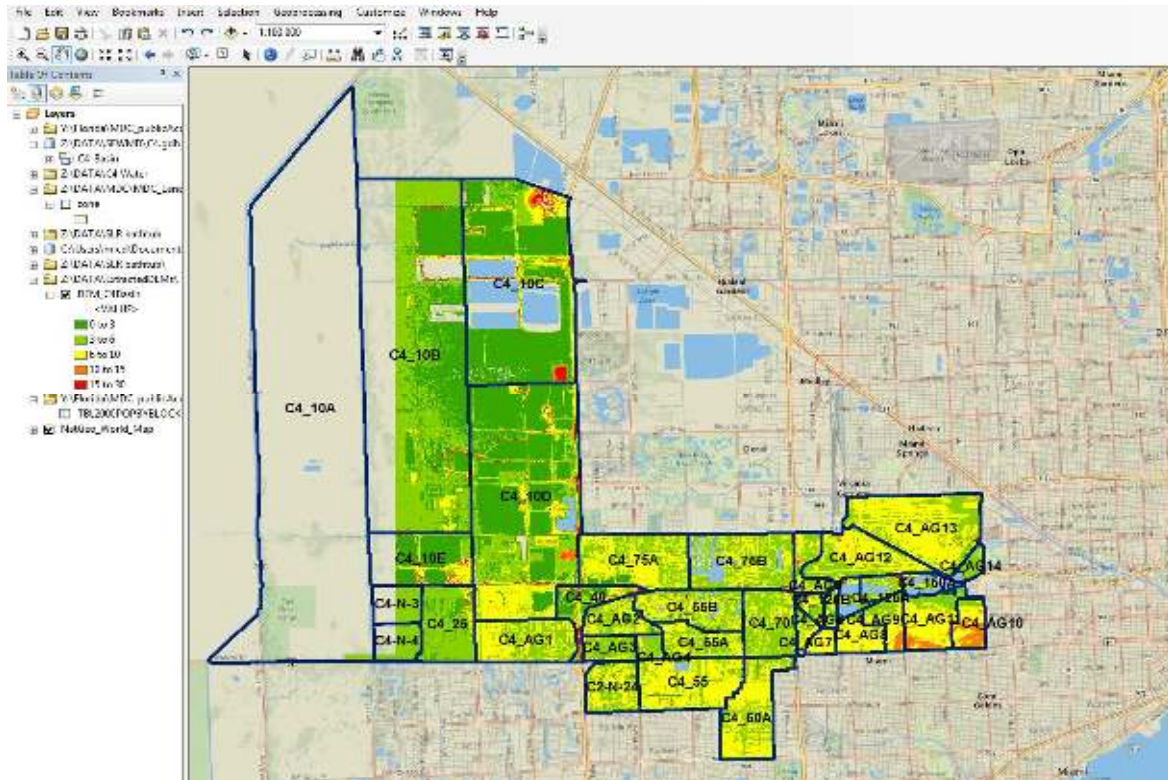


Figure 7: Digital Elevation Model for the C4 basin, used as input for flood damage modelling.

Appendix 3: Kick-off meeting program 23-26 March, 2015

Goals for the meeting:

- To present the project to local experts and some stakeholders, and get their views on our approach, intended results, and also the measures we will propose for the area;
- To meet with the entire project team (SFWMD, Deltares USA, Deltares Netherlands) and discuss progress of the work and next steps;
- To develop a plan for the coming period, with agreements on responsibilities, tasks and deadlines;
- To visit Miami Dade county, interact with officials from the county, and to visit critical sites related to floods and droughts.

Program for the meeting:

Day	Location	Activities	Persons
Sunday 22 March	Air travel	<ul style="list-style-type: none"> • Travel Netherlands-Florida (afternoon) 	Jarl, Dirk, Laurens
	Hotel St. Michel , 162 Alcazar Ave, Coral Gables, FL 33134, Tel. 305-444-1666		Deltares team

Monday 23 March	Stephen P. Clark Center , 111 NW First St., 12th Floor Rear Conference Room, Miami, FL 33128, Tel. 305 375-5593 (Lisa Klopp)	<ul style="list-style-type: none"> • 9-12: Working Meeting with SFWMD, Miami Dade County, and Water and Sewer Department • 12-1: Lunch 	Jeff, Obey, Jenifer, Veera, Jarl, Dirk, Laurens, Nichole, Virginia, and Marcia and others
	Site visits in Miami Dade county	<ul style="list-style-type: none"> • 1-5: Field visit to Miami Dade county sites (afternoon): <ul style="list-style-type: none"> ○ Stop at S-26 ○ Travel to S-25B and see the structure and pump station ○ Travel along Tamiami Trail, possibly stop at secondary system pump stations, Sweetwater, etc. ○ Visit the C-4 impoundment • Dinner with project team in Miami 	Jeff, Jenifer, Veera, Jarl, Dirk, Edwin, Laurens, Rohan, Marcia, staff from SFWMD field station
	Hotel St. Michel , 162 Alcazar Ave, Coral Gables, FL 33134, Tel. 305-444-1666		Deltares team

Flood and drought risk management under climate change: strategy evaluation and cost optimization

	Hotel Hampton Inn , Coconut Grove, 2800 SW 28th Terrace, Miami, FL 33133, Tel. 305-448-2800		SFWMD team
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Tuesday 24 March	Miami Dade Water & Sewer Department 3071 SW 38th Ave, Miami, FL 33146	<ul style="list-style-type: none"> External kick-off workshop with experts and stakeholders <ul style="list-style-type: none"> (See separate agenda) 	All, plus external members
	Hotel St. Michel , 162 Alcazar Ave, Coral Gables, FL 33134, Tel. 305-444-1666		Deltares team

Wednesday 25 March	SFWMD, Palm Beach, District Office	<ul style="list-style-type: none"> Working session SFWMD: data, methods Dinner with project team in West Palm Beach 	Jeff, Obey, Jenifer, Veera, Jarl, Dirk, Laurens, and other staff from SFWMD
	Hotel Biba , 320 Belvedere Rd, West Palm Beach, FL 33405, Tel. 561-832-0094		Deltares team

Thursday 26 March	SFWMD, Palm Beach, District Office	<ul style="list-style-type: none"> Additional working session at SFWMD (optional) (morning) 	Obey, Jenifer, Veera, Jarl, Laurens, Dirk
	Everglades Foundation, 18001 Old Cutler Road, Suite 625, Palmetto Bay, FL 33157, Tel. 786-249-4455	<ul style="list-style-type: none"> Visit Everglades Foundation (Miami) (noon) 	Jarl, Dirk, Laurens
	Air travel	<ul style="list-style-type: none"> Travel to airport and departure (afternoon) 	

Appendix 4: Working Meeting report

Monday March 23:

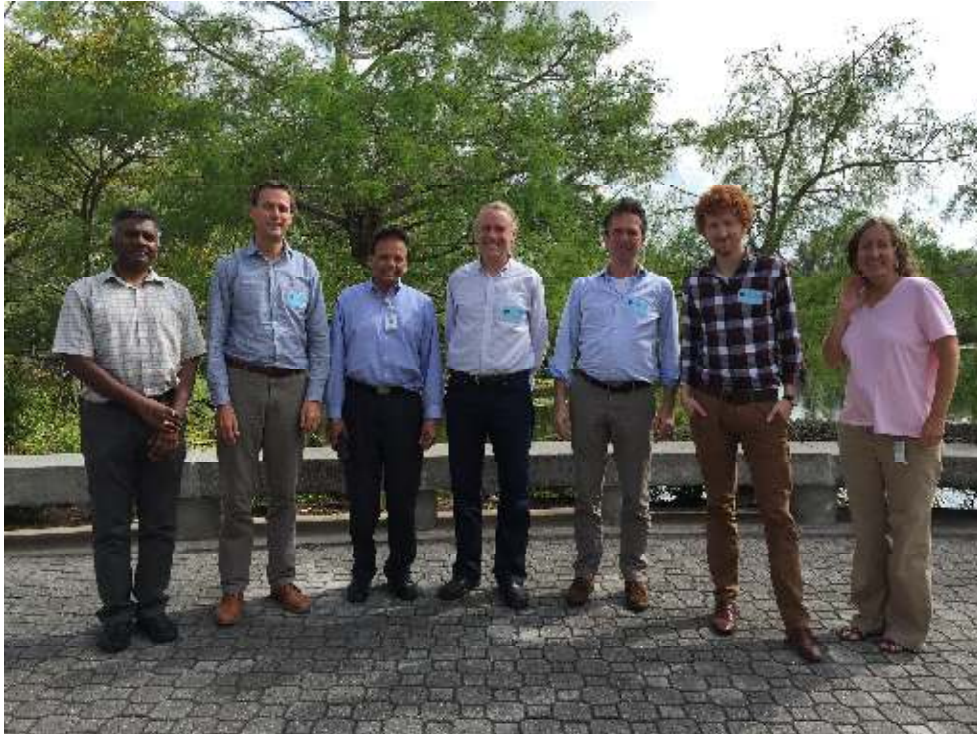
At the offices of Miami Dade County, a meeting was held with the project team and several county departments. Some 15 people were present. The key items discussed were:

- Laurens, Dirk and Jarl briefly explained the goals and set-up of the project to the persons present from Miami Dade County.
- Some important comments and suggestions that were made:
 - Several systems are in place in Miami Dade County for the water supply. Some 90% of total potable water supply is provided through the Water and Sewer Department. Facilities include many wells, reverse osmosis, and a brackish water plant.
 - Minimum water levels in the canals are critical, for the water supply. The system is becoming more flexible, due to increasing desalinization possibilities.
 - Not only the water levels in canals, but also salt-water intrusion into deep wells are a threat.
 - It should be possible to obtain information to assess the economic costs of water cut-backs.
 - A model on flooding using polygons of flooded areas and locations of buildings has been done by the County (Marcia Steelman).
 - Flood inundation analysis has been performed using a digital terrain model (DTM) and “filling” up of this model, rather than using dynamic simulations.
 - A building code exists, that requires buildings to be built 1 ft higher than the 100 year flood event.
 - Development in the C4 basin is very rapid, with implications for impervious surfaces and exposure.
 - Land-use projections have been developed for the period up to 2035. A total of 35 different land-use classes are distinguished.
 - Possible measures to reduce flooding may include: increase pumping capacity; make use of impoundments; create buffer capacity in a “super-canal”; flood wall heights, which are now between 25 and 100-year levels. Also, areas owned by the District west of the C4 basin could be used for additional water storage.
 - The majority of properties have private insurance, rather than reliance on the NFIP scheme.

Wednesday March 25 and Thursday March 26:

- Further working meetings were held at the offices of SFWMD to discuss progress of the work and further needs to data acquisition and model development.

Picture: the Project Team at the offices of SFWMD, West Palm Beach, FL (from left to right: Veerabhadra Karri, Laurens Bouwer, Jayantha Obeysekera, Edwin Welles, Jarl Kind, Dirk Eilander, Jenifer Barnes).



Appendix 5: Stakeholder workshop report

Workshop on Flood and Drought Risk Management in a Changing Environment (March 24, 2015)

Venue: Miami Dade County Water and Sewer Department, 3071 SW 38th Ave, Miami, FL 33146

Opening Remarks and Introductions

- Jeff and Nichole welcome all participants.
- They both indicate that the work of SFWMD and Miami Dade County has inspired them to push forward on the topic of climate change in their own organizations.
- A brief introduction round of all participants follows.

Introduction to the Deltares/SFWMD project funded by NOAA

- **Presentation** by Laurens Bouwer (Deltares).
- A question is asked why the C-4 basin is chosen. Obey will explain in the next presentation.

Brief description of project study sites

- **Presentation** by Jayantha Obeysekera (SFWMD).
- There is a parallel project on Level of Service (LOS), led by Ken Konyha.
- The main problem for flooding is that the level difference between tail and head water are already small, and will get smaller: during king-tide it is difficult to discharge the water.

Regional and local issues (sustainability, water supply and flood protection)

- **Presentation** by Nichole Hefty (Miami Dade County).
- Adaptation planning in Miami Dade has begun in 2006 with the Climate Change Advisory Task Force.
- A key activity is the South-east Florida Regional Climate Change Compact: which involves Broward, Fort Lauderdale, Miami Dade, and Monroe. The Compact has produced sea-level rise scenario projections, analyzed flood impacts (using a ‘bathtub’ approach), and made a greenhouse gas inventory. The Climate Change Compact will be incorporated into a non-profit.
- The Climate Compact has a Climate Indicators Working Group, for water supply they produce indicators using chlorites.
- New legislation is coming along, with 7 resolutions based on the Miami Dade Sea Level Rise Task Force, of which three are relevant for this project.
- **Presentation** by Virginia Walsh (Water and Sewer Department)
- There has been good success in to substantially decrease demand, by placing permanent restrictions. There is also potential for more demand reduction.
- Key issue is water treatment: the effects of peak flows during extreme events with sea-level rise.
- Also, the functioning of wells with salt-water intrusion is critical. There is a study using MOD-FLOW with a scenario simulation for the period 2011-2040.
- The 20-year water supply facilities work plan (report) has a section on climate change.

- Water supply is critical in the area (seems more so than demand side). Supply can however also be increased, through e.g. water treatment. No desalinization is in place yet, but when people are willing to invest water supply can be secured for another 50 years or so.

Long-term climate outlook for South Florida

- **Presentation** by Brian Soden (Miami University).
- Prediction of future changes in climate is very challenging for South Florida, as Florida lies in an area that may see drying or wetting according to the general circulation models (GCMs), projections are more robust for other areas in the US.
- Regional climate models tend to give slightly better results compared to GCMs. The reintroduction of flux adjustment (which was abandoned by the modeling community) gives major improvement in the simulation of the historical climatology.
- A question is asked how to make use of climate projections. It is advised to use climate model output for analyzing overall changes in rainfall, e.g. rainy days, even from GCMs. A large area around Florida has to be chosen, not just the southern part.

Optimization of flood risk management as applied in the Netherlands and plans for the study in Florida

- **Presentation** by Jarl Kind (Deltares).
- A question is asked on the interaction of the C4 basin with adjacent basins? Within the C4 the interactions with adjacent (sub-)basins are considered, but not with other basins, these are considered to be independent.
- Land-use change will be considered as well, in the flood impact analysis.
- The timing of investment decisions will be optimized using AIMMS software, and we will consider different scenarios of increase in risk, and different sets of measures. The approach will minimize risk costs as well as investment and maintenance costs.
- What measures should be considered? Increased dredging would be an option, not done much dredging has been done since the canals were built. But there are limitations to what can be done, as it is costly, and there are complications. Conveyance is increased by dredging, but pumping capacity needs to be upgraded, and there is much downstream expensive infrastructure that needs to be upgraded.
- The effect on ground water needs to be considered, because of reduction in the land head due to increased pumping. Salt water may also leak around the structures. Miami Dade County has been monitoring this process upstream of the structures.
- With the SLOSH model (Sea Lake and Overland Surge from Hurricanes, model administered by NOAA) there is information on e.g. how many homes are flooded, developed by the Department of Emergency Management.
- The Water and Sewer Department is studying the feasibility of building a tunnel, which in concept would be 6 miles long, but it is unknown how thus will that affect ground and surface water.

Salt water intrusion modeling in Miami Dade County

- **Presentation** by Eric Swain (USGS).
- The USGS has done research on the effects of storm surges, including effects on structures.

- In addition the impact on salinity from salt water inundation is assessed, with effects considered for surface water salinity as well as groundwater salinity. The effects on salinity may last up to 8 years, plus combination of other effects, such as increased pumping.

Robustness analysis of drought risk management

- **Presentation** by Dirk Eilander (Deltares).
- Florida International University is developing cost functions from water supply shortages as well as flooding.
- It may be required to take into account non-compliance of cut-backs if this is substantial. For instance, irrigation systems are not metered, these are direct wells, and cut backs do not work then.
- The plan is to come up with a series of scenarios for sea-level rise and rainfall etc. to be used by different organizations.

Closing comments

- All the participants are thanked for their questions, contribution to the discussion, and ideas and input for the project.
- The second (and final) workshop towards the end of the project is announced.

Pictures: impressions from the stakeholder workshop



Flood and drought risk management under climate change: strategy evaluation and cost optimization



**Workshop on Flood and Drought Risk
Management in a Changing Environment
March 24, 2015**

AGENDA

**March 24,
2015**

9 am – 4 pm

**Venue: Miami
Dade Water &
Sewer
Department
3071 SW 38th
Ave,
Miami,
Florida 33146
(Douglas
Road and US1
(behind the
metro-rail
station)**

- 0900-0930 Opening Remarks and Introductions
(Nichole Hefty, Virginia Walsh, Jeff Kivett)
- 0930- 10:00 Introduction to the
NOAA/Deltares/SFWMDproject funded by NOAA
(Laurens Bouwer, Deltares)
- 10:00-10:15 Brief description of project sites (Obey)
- 10:15-10:30 Break
- 10:30-11:30 Regional and local issues (sustainability,
water supply and flood protection)
 - Nichole Hefty, Miami Dade County)
 - Virginia Walsh (Water and Sewer Department)
 - Marcia Steelman (Miami Dade County)
- 11:30-12:00 Long-term climate outlook for South Florida
(Brian Soden, RSMAS)
- 12:00-1:00 Lunch (but we may order in)
- 1:00-1:45 Optimization of flood risk management as
applied in The Netherlands and plans for Florida Study
(Jarl Kind, Deltares)
- 1:45-2:15 Saltwater Intrusion Modeling in Miami-Dade
County (Eric Swain, USGS)
- 2:15-2:45 Robustness analysis of drought risk
management (Dirk Eilander, Deltares)
- 2:45-3:45 Feedback from participants (all)
- 3:45-4:00 Closing Comments (Project Team)

Participant list, Workshop on Flood and Drought Risk Management (March 24, 2015)

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