**Examples of Unexpected Near-Term Impacts of Global Climate Change: Sea Level Rise and Water Resource Issues in Southeast Florida**

***Many of the most prominent impacts of global climate change (or at least those focused on by environmental activists and the popular press, things like melting glacial ice, polar habitat changes, extreme weather) are, for many people, distant effects, either in terms of geography or time – this is particularly true in Florida and the Caribbean. However, in low-lying coastal areas all along the US eastern seaboard, climate change presents here-and-now challenges that will require remedies in as little as a few years. Nowhere is this more true than in southeast Florida, home to 5.5 million people, much of the U.S sugarcane and winter fruit and vegetable industry, and the primary U.S. port for the Caribbean cruise and tourism industry. In Florida climate change is having real effects on people and industries today, and is a primary focus for urban planners and regional regulatory agencies.***

***In this exercise we will focus on some relatively unexpected but real, short-term issues produced by climate change: water resource and quality problems caused by sea level rise.***

**Background Reading:** ***Southeast Florida's Resilient Water Resources*** (Center for Urban and Environmental Solutions at Florida Atlantic University; <http://www.ces.fau.edu/files/projects/climate_change/SE_Florida_Resilient_Water_Resources.pdf>). **Read the Executive Summary and pages 1-52, and definitely look at the diagrams - they tell the story!**

**Necessary Tool: Google Earth(TM),** a global **Geospatial Information System** (GIS) which we can examine for elevation and photographic data.

**Necessary File for Google Earth:** SE Florida Flood Control Structures.kml (Google Earth bookmark file)

***As you do this activity, have Google Earth open so you can examine real data for elevations and land features in this region.***

**1) Some Background: where does SE Florida's drinking water come from?**

***Figure 1 at the beginning of the document, and the figures and text from page 13 through page 24 explain the geological background for southeastern Florida.***

**a) Based on the reading, the Biscayne aquifer is the primary source for fresh water in southeast Florida:**

**i)** What is this aquifer geologically? (i.e., what rock is it made of?)

**ii)** Is the aquifer Confined (capped with an impermeable rock layer) or Unconfined?

**iii)** Where is this aquifer **Recharged**, and how is it recharged?

**iv)** How high above sea level is the **Water Table** in this aquifer, and how does this height compare to the land height locally?

**b) Like the Kissimmee River and the Everglades, water flow in the Biscayne aquifer runs from inland to the ocean. Figure 1 depicts overall water flow in the Biscayne aquifer, and Figure 11 offers a schematic profile view of the freshwater-seawater interface zone in the aquifer, where its flowing freshwater reaches the sea.**

**i)** Why does water in the Biscayne aquifer flow from inland to the ocean (specifically, what force or forces drive this flow)?

**ii)** What is required for an aquifer or any flowing water to have and maintain hydraulic head?

**iii)** Using Google Earth, examine the **Gradient** (change in land elevation with distance) from lake Okeechobee south to Homestead and the Everglades - using the Path function, run a line due south from the southern shores of Okeechobee. What is the elevation change?

**iv)** What is the elevation change moving west to east from the Everglades to the Atlantic coast? (hint - do your line somewhere north of the Miami airport, and run your cursor along your line to see if there is any elevation change between your endpoints).

**v)** Assuming that the Water Table is at the surface in the Everglades (this is a reasonable assumption), what is the Hydraulic Head, in meters and in feet, of the Biscayne Aquifer?

**vi)** How does the Biscayne aquifer's fresh water interface with seawater where the two come into contact?

**2) How much Sea Level Rise will there be?**

***Section 4.1, pages 26-29, provides a nice summary of current sea level rise estimates globally, and for south Florida (don't bother with the Quadratic Acceleration Model section, but Figure 31, a map of how much of south Florida would be underwater with a one meter rise in sea level, is pretty shocking!).***

**a)** What is the Average annual sea level rise in south Florida, based on local tide gauges?

**b)** How much will sea level rise in 10 years (by 2021)? In 20 years (2031)? In 30 years (2041)?

**3) Sea Level Rise and its impact on Freshwater resources in the Biscayne Aquifer**

***Read about the process of Saltwater Intrusion in coastal aquifers on pages 33-35.***

**a)** What is the ratio of the height above sea level of the water table in the Biscayne aquifer and the depth at which saltwater intrusion into the aquifer is encountered, based on the Ghyben-Herzberg equation?

**i)** Given this ratio, and your estimate of hydraulic head of the aquifer from **2b.v.** above (basically just a measure of water table change from source to drainage), how deep is the saltwater intrusion zone beneath the land surface under Miami airport (or thereabouts)?

**ii)** Taking your 2041 sea level rise estimate as an example, and looking carefully at Figure 32, how high would the water table be above sea level in 2041?

**iii)** Noting the change in ii) above, how far below the surface under Miami airport will we encounter salt water?

**iv)** As you move from the airport to the coast, does the depth to saltwater get shallower or deeper?

**v)** What kinds of problems could these changes in depth to saltwater in the aquifer create?

**4) Impacts of Sea Level Rise on Flood Control and Surface Water Systems:**

***Section 3.4.3 discusses the principles of stormwater drainage in southeast Florida, and Sections 4.2.2, 4.2.3, and 4.2.4 focus on different aspects of stormwater and surface water impacts related to climate change. Figures 37 and 38 depict the two common flood/flow control structures used in southeast Florida***

***Open the file "Southeast Florida Flood Control Structures.kml" in Google Earth. This file is a set of bookmark locations for coastal flood control structures and inland waterflow control structures for managing the Everglades Water Conservation Zone. Turn off the Everglades structures for the time being, so we can focus on the coastal structures.***

**a)** Fly in to the different flood control bookmark sites for a close-up look at the flood control structures. Are these **Passive** structures (i.e., sluice-gate dikes as in Figure 37) or **Active** structures (i.e., pumping stations as in Figure 38)?

i) How does a Passive structure like a sluice gate control floods and waterflow?

ii) How do the locations of these structures change from north to south along the Florida Atlantic coast? Why does this change?

iii) What will happen to the effectiveness of these structures as flood or water flow control features with progressive sea level rise?

iv) How much less effective, overall, will these structures be at flood control by 2041? **(see Figure 39 to answer this question!)**

***Turn off the Coastal control structure bookmarks, and turn on the Everglades bookmarks for examination.***

**b)** Fly in for closeups of the Everglades control structures. Are these passive structures, active structures, or both?

**i)** How does the function of the Everglades control structures differ from the coastal control structures? (see Figures 20 and 21 for a schematic explanation)

**ii)** Which, if any, of the Everglades control structures will become problematic with progressive sea level rise, and why?