# Everglades project - Florida Bay Algal Blooms

**Project Overview and Background:**

The structure and function of both the Everglades and Florida Bay, which are physically and ecologically linked, are strongly influenced by fresh water flow. A major component of this influence involves the hydrologic modification of nutrient availability via: 1) changes in external nutrient loading, transport, and export; and 2) effects on internal nutrient cycling. Ongoing projects, such as the C-111 Project and CERP projects (especially the C-111 Spreader and Decompartmentalization), that are modifying water management structures and operations for the purposes of environmental protection and restoration commonly focus on direct hydrologic targets and ecological targets that are strongly influenced by hydrologic conditions. However, such changes also influence biogeochemical processes (including primary and secondary productivity) and water quality. For Florida Bay, a major concern regarding Everglades Restoration is that increasing fresh water flow will also increase nutrient loading and consequently increase the frequency, extent, and magnitude of algal blooms (Brand 2002). This issue has received considerable attention (National Research Council 2002) and is one of the critical uncertainties identified for CERP in the RECOVER Monitoring and Assessment Plan and the associated ecological conceptual model of Florida Bay (Rudnick et al. 2005)

Understanding the effects of changing fresh water flow on Florida Bay water quality, particularly regarding the occurrence of phytoplankton blooms, also requires: 1) estimation of nutrient loading to the southern wetlands from canals; 2) understanding how changing flow affects nutrient (both N and P) transformation, retention, and transport through the southern marshes (especially saline marshes) to the Bay; and 3) understanding of nutrient cycling within the Bay (see Rudnick et al. 2005 for a more extensive discussion). Changing flow and salinity can directly and indirectly affect nutrient availability and blooms. Salinity can directly affect phosphorus availability via ionic strength effects on P sorption and desorption on carbonate particles (the primary component of Florida Bay muds) (DeKanel and Morse 1978). Changes in seagrass community structure driven by changing salinity may also have a strong effect on the availability of nutrients within the water column. The occurrence of algal blooms in Florida Bay has commonly been linked to seagrass die-off events, both as consequence of die-off and a cause of die-off (Zieman et al. 1999, Rudnick et al. 2005, Rudnick et al. 2007).

**Management and Restoration Objectives:**

Water quality can be a major constraint on the success of restoration and other water management efforts. With regard to Florida Bay water quality, the primary objective is for water management to do no harm to Florida Bay. Algal blooms can cause such harm via the shading of seagrass beds and potentially causing sponge mortality (Dennison et al. 1993, Butler et al. 1995). Restoration performance measures (RECOVER and Florida Bay and Florida Keys Feasibility Study) include nutrient loading and chlorophyll-a concentration targets that would be associated with minimal phytoplankton bloom activity and sufficient light for sustainable seagrass communities. The objective of the monitoring, research, and modeling proposed here would provide a basis for quantifying the status and trends of nutrient inputs to the bay and water quality conditions within the bay, understanding the relationship of these inputs and conditions with freshwater flow, and providing a capability to forecast the water quality consequences of alternative water management plans.

**Methodological Approach:**

Meeting the objectives above requires a combination of approaches, including monitoring, measurement of nutrient fluxes from multiple sources, experiments on factors influencing nutrient availability, and synthesis and quantitative analysis through modeling. Long-term hydrologic and water quality monitoring is managed by the District (mostly outside of the Everglades Division) and other agencies. The Everglades Division has been managing smaller scale hydrologic and water quality monitoring along transects from canal sources through the southern Everglades wetlands (Taylor Slough and the C-111 Basin) and into Florida Bay. Measurements along these transects include nutrient transport and loading to Florida Bay via major creeks in the salinity transition zone (Davis et al 2003, Sutula et al. 2003, Childers et al. 2006). We plan to continue these studies, but also need similar characterization and nutrient flux studies through ponds and creeks in the transition zone west of Taylor Slough, where Restoration changes are likely to be most pronounced and where nutrient concentrations tend to be higher than along the northeastern Florida Bay coast. Studies of nutrient loading of Whitewater Bay (downstream of Shark Slough and expected to receive much more fresh water with implementation of the Decompartmentalization Project) have been initiated as part of the Florida Coastal Everglades LTER (with Everglades Division participation), but nutrient retention or transport through this bay have not been measured to date. While logistically challenging, documenting and understanding of ecosystem structure and processes within Whitewater Bay is needed for CERP assessment and we intend to initiate this assessment within five years.

Fine-scale spatial patterns of water quality within the Bay, ponds, and creeks (especially in association with fresh water sources) are mapped using the boat-board Dataflow system (Madden and Day 1992) and will be mapped in Whitewater Bay. Dataflow measures seven parameters (including fluorescence of chlorophyll a fluorescence and dissolved organic matter) every five seconds. New instruments, including a multiple fluorometer and nutrient probes, will be tested and added to Dataflow as technologies become available. Additional spatial mapping of ground water sources within Florida Bay is also being investigated to identify possible sites where ground water nutrient sources may influence algal productivity and blooms. Below-ground resistivity and bay water radon (Swarzenski et al. 2006) will be mapped in a subset of bay regions and Whitewater Bay. We are currently working with UGSS to map the eastern boundary basins of Florida Bay and the approach appears promising for identifying areas where groundwater nutrient fluxes are likely to be highest.

A series of experiments on the bioavailability (decomposition rate) of dissolved organic matter have been run (see 2008 SFER Chapter 12) and an upcoming workshop on the state of our knowledge on this subject will guide future research. New experiments on the effects of salinity on benthic nutrient fluxes, in particular testing effects on phosphorus fluxes from different sediments and soils are a high priority. This includes experiments on the drying and inundation of saline wetlands.

Integration and application of information from this project requires several levels of numerical analysis, including calculations of nutrient budgets (improvements of the budget in Rudnick et al. 1999), statistical analysis of monitoring and Dataflow data, mass balance modeling, and dynamic water quality modeling. These approaches are described in the Synthesis and Integration section above.

**Application of Results:**

Water quality protection is a core mission of the SFWMD and water quality assessments thus are a fundamental part of all modifications of operations and water management structures. While such assessments typically focus on regulatory concerns, ecosystem management and restoration require analysis of nutrient processing, transport, and downstream effects throughout the ecosystem. For Florida Bay, nutrient loading is of particular concern because of its recent history of extensive and prolonged phytoplankton blooms. Thus, the proposed downstream studies are an integral part of the Combined Structural and Operational Plan (for operation of the C-111 Project and Modified Water Deliveries to ENP Project), the C-111 Spreader Project, the Florida Bay and Florida Keys Feasibility Study (FBFKFS, which is evaluating the adequacy of CERP for Florida Bay restoration), and RECOVER.

In particular, a water quality model that is under development as part of the FBFKFS is highly dependent upon results from the proposed project.

Public concerns regarding water management effects on Florida Bay water quality are widespread and either need to be quantitatively refuted or addressed via project modifications to improve water quality (or prevent degradation). The District is legally obligated to protect water quality all parts of the Everglades Protection Area, including Florida Bay. The success of CERP depends in large part on success within this most visible portion of the Greater Everglades Ecosystem and the path to such success can be illuminated by information proposed in this project.