Greater Everglades Performance Measure

Sulfate Concentrations in Surface Water

Last Date Revised: March 2, 2007

Acceptance Status: Accepted

1.0 Desired Restoration Condition

Maintain or reduce sulfate concentrations to one ppm or less (approximates marsh background concentrations) in surface water throughout the Greater Everglades wetlands.

1.1 Predictive Metric and Target

The target is to approach 0.0 metric tons per year load of conservative tracer load into the Everglades, and approach 0.0 mg/m2/yr tracer load into marshes from canals when bypasses occur.

1.2 Assessment Parameter and Target

Maintain or reduce sulfate concentrations to one ppm or less (approximates marsh background concentrations) in surface water throughout the Greater Everglades wetlands.

2.0 Justification

CERP implementation will result in increasing or redistributing the flow of water to the Everglades, restoration goals, could increase the amount of sulfate entering the ecosystem, thereby exacerbating the mercury problem. This could in turn redistribute the zone of maximum methylmercury production southward into Everglades National Park (Orem 2004).

Sulfur is common in nature and is a natural ingredient of rainfall, surface water and groundwater. Sulfur is often used as a secondary additive to fertilizer to adjust soil pH in order to allow crops to uptake nutrients more readily. Recent studies have demonstrated that a major contributor of sulfate to the Everglades system is the Everglades Agricultural Area (EAA) (Bates et al. 2002, Orem 2004). An application rate of 33 pounds of sulfur per acre of EAA soil has been calculated from local purchasing records (Schuenenman 2001). This results in thousands of pounds of this chemical entering the South Florida ecosystem.

Sulfate/sulfide concentrations are of special interest in the Everglades since they have been implicated as a primary driving force, via microbial sulfate reduction, in mercury methylation and subsequent bioaccumulation in this wetland system. Although sulfide in porewater is theorized to compete with dissolved mercury for organic binding sites, Everglades sulfur enrichment is considered incompatible with Everglades restoration objectives. Elevated sulfide is of ecological concern and at high concentrations can be toxic to plants (Bradley and Morris 1990, Lamars et al. 1998). Sulfate concentrations in surface water in predrainage Everglades were likely to have been very low, similar to concentrations in the more pristine areas of freshwater wetlands, including Everglades National Park (Bates el. 2002). Surface water in northern portions of the Everglades is heavily contaminated with sulfate, with the highest concentrations observed in canals and marsh areas receiving canal discharges. Concentrations in northern Water Conservation Areas (WCAs) 3A and 2 commonly

exceed 30 parts per million (ppm), while concentrations in EAA canals during the wet season commonly exceed 100 ppm. In contrast, concentrations in rainfall or the interior marsh within WCA 3A or Everglades National Park are typically one ppm or less (Scheidt et al. 2000).

Water quality standards have not been developed for sulfate or sulfide.

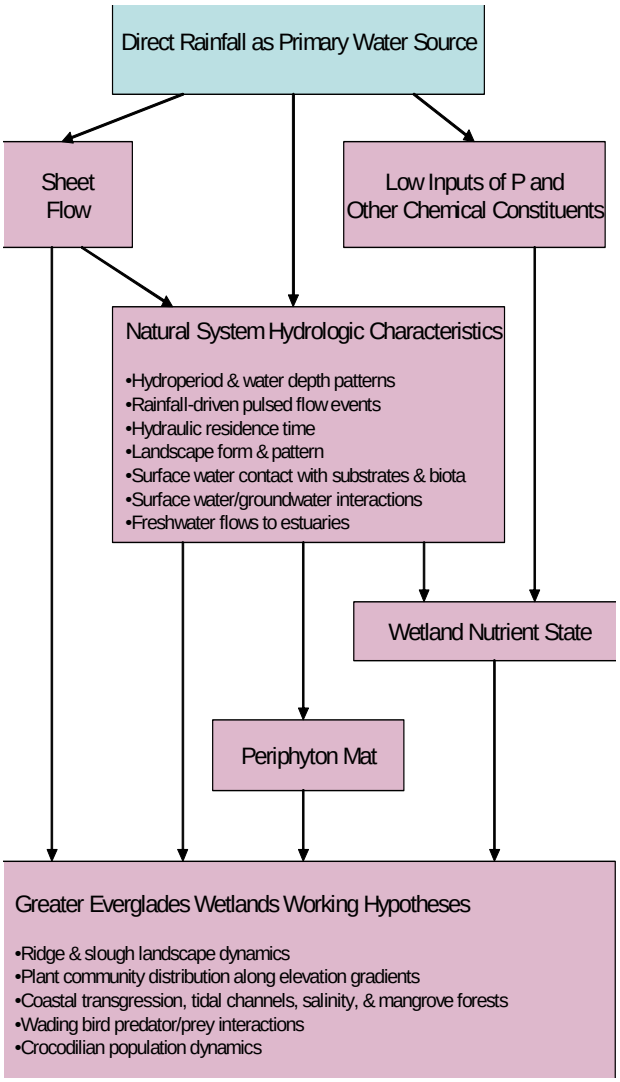
3.0 Scientific Basis

3.1 Relationship to Conceptual Ecological Models

The indicator for this performance measure is a stressor in the following Conceptual Ecological Models:

Regional Models
South Florida Ecosystem Assessment: Phase I/II Everglades Stressor Interactions (Stober et al. 2001)

Conceptual Ecological Models
Integrated Hydrology and Water Quality (RECOVER 2006)



3.2 Relationship to Adaptive Assessment Hypothesis Clusters

Ecological Premise: The pre-drainage Greater Everglades wetlands system was characterized by hydrologic inputs (primarily from direct rainfall) and by extended hydroperiods. Natural conditions were characterized by oligotrophic conditions with low phosphorus and sulfur concentrations in surface waters having defined zones of low or high conductivity as compared to present conditions. An overriding expectation of CERP is that it will restore hydroperiods by providing freshwater inflows and restored hydropatterns to the Greater Everglades wetlands without increasing nutrient loads or subjecting more of the system (particularly the more pristine areas) either to elevated concentrations of surface water phosphorus, nitrogen, and sulfur or other constituents that alter the natural zones of conductivity in the freshwater regions, thereby improving overall water quality throughout the wetland system (RECOVER 2004).

Integrated Hydrology and Water Quality Hypothesis (RECOVER 2006)

Hypothesis 2: Nutrient Inputs and Sheet Flow as Determinants of Wetland Nutrient State in the Everglades. The dominance of direct rainfall as the primary source of water and phosphorus, in combination with sheetflow and related hydrologic and climatic characteristics, resulted in an oligotrophic, phosphorus-limited nutrient state throughout the greater Everglades wetlands prior to drainage.

Rationale: Increased phosphorus concentrations and loads in agricultural runoff water, and replacement of sheet flow with canal flows and point-source discharges, have produced phosphorus concentration gradients downstream of canal discharge structures, shifting wetlands from oligotrophic to eutrophic states. Water column total P concentrations are below ~10 ppb under non-enriched conditions in the Everglades. Most harmful ecological responses to P enrichment occur within a range of mean annual water column total P concentrations between ~10-30 ppb.

Reduction of the magnitude of nutrient inputs to the Greater Everglades will have the following effects:

- Reductions in phosphorus in inflow waters to the Greater Everglades will influence the downstream rate of recovery of ecosystem components.
- Existing gradients of phosphorus, nitrogen and sulfur will decrease between input locations and Everglades National Park.
- Where water quality constituent gradients currently do not exist, none will form.

Reduction of the magnitude of nutrient inputs to the Greater Everglades will lead to reductions in phosphorus in inflow waters to the Greater Everglades and influence the downstream rate of recovery of ecosystem components by decreasing existing gradients of phosphorus, nitrogen and sulfur. Non-impacted areas immediately downstream of impacted areas may be affected by phosphorus currently present in the impacted areas, *i.e.*, presently enriched zones in WCAs will continually move south, especially under sheet flow conditions.

4.0 Evaluation Application

4.1 Evaluation Protocol

4.2 Normalized Performance Output

4.3 Model Output

4.4 Uncertainty

Recognition of model uncertainty is needed when interpreting the ecological significance of model output. The Model Uncertainty Workshop Report provides guidance on the potential implications of uncertainty on model output interpretation (RECOVER 2002).

5.0 Monitoring and Assessment Approach

5.1 MAP Module and Section

See CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research - Greater Everglades Wetlands Module section 3.1.3.1 (RECOVER 2004).

See 2006 Assessment Strategy for the Monitoring and Assessment Plan. Final Draft. (RECOVER 2006)

5.2 Assessment Approach

6.0 Future Tool Development Needed to Support Performance Measure

6.1 Evaluation Tools Needed

Predictive models to evaluate this performance measure are still under development and refinement.

6.2 Assessment Tools Needed

Accessibility to the various data sources through an integrated database is needed for the complete evaluation of these hypotheses and for parameter refinement

7.0 Notes

This performance measure supersedes and addresses GE-10 Greater Everglades Wetlands Sulfate Concentrations in Surface Water (Last Date Revised: September 20, 2005).

8.0 Working Group Members

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References

Bates, A.L., W.H. Orem, J.W. Harvey and E.C. Spiker. 2002. Tracing sulfur in the Florida Everglades. Journal of Environmental Quality 31(1):287-299.

Bradley, P.M., and J.T. Morris. 1990. Influence of oxygen and sulfide concentration on nitrogen uptake kinetics in *Spartinal alterniflora.* Ecology 71:282-287.

Lamars, L., H. Tomassen, and J. Roelofs. 1998. Sulfate-induced eutrophication and phytotoxicity in freshwater wetlands. Environmental Science and Technology 32(2):199-205.

Orem. 2004.

RECOVER 2002. Model Uncertainty Workshop Report: Quantifying and Communicating Model Uncertainty for Decision Making in the Everglades, Restoration Coordination and Verification Program (RECOVER), United States Army Corps of Engineers, Jacksonville District, Jacksonville, Florida, and South Florida Water Management District, West Palm Beach, Florida.

RECOVER. 2004. CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research. Restoration Coordination and Verification Program, c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, Florida, and South Florida Water Management District, West Palm Beach, Florida.

RECOVER. 2006. 2006 Assessment Strategy for the Monitoring and Assessment Plan. Final Draft. c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, Florida, and South Florida Water Management District, West Palm Beach, Florida.

Scheidt, D., J. Stober, R. Jones, and K. Thornton. 2000. South Florida Ecosystem Assessment: Everglades Water Management, Soil Loss, Eutrophication and Habitat. Report No. 904-R-00-003, United States Environmental Protection Agency, West Palm Beach, Florida.

Schueneman, T.J. 2001. Characterization of sulfur sources in the EAA. Proceeding of the Soil and Crop Science Society of Florida 60:49-52.

Stober, Q.J., K. Thornton, R. Jones, J. Richards, C. Ivey, R. Welch, M. Madden, J. Madden, J. Trexler, E. Gaisler, D. Scheidt, and S. Rathbun. 2001. South Florida Ecosystem Assessment: Phase I/II – Everglades Stressor Interactions: Hydropatterns, Eutrophication, Habitat Alteration, and Mercury Contamination (Summary)