APPENDIX B

Data Quality Objectives

SOUTH FLORIDA ECOSYSTEM ASSESSMENT PROJECT
DECISION-BASED DATA QUALITY OBJECTIVES

March 1997

South Florida Ecosystem Assessment Project

Decision-Based Data Quality Objectives

March 1997

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Data Quality Objectives

The Data Quality Objectives (DQOs) were prepared generally following the Guidance for the Data Quality Objectives Process EPA QA/G-4 (EPA 1994). This US Environmental Protection Agency (EPA) Guidance document, however, is not entirely appropriate for research projects. The EPA Quality Assurance Management Staff are in the process of preparing DQO guidance for research projects, but this guidance will not be available until late fall (John Warren, QAMS, personal communication). The South Florida Ecosystem Assessment Project is a research project that, in part, is developing risk-based criteria for decisions because the existing criteria are not appropriate or no criteria exist. Therefore, two separate, but complementary, approaches were used to develop DQOs. The first approach was to use the EPA QA/G-4 documentation as guidance in developing decision-based DQOs, which are discussed in this document. This document uses the EPA QA/6-4 report format. The second approach revised the DQOs originally proposed in the REMAP Research Plan (Stober et al. 1993). These revised DQOs are listed in Appendix A.

Background

In 1989, a Florida panther, an endangered species, died because of mercury toxicosis. Since then, over 2 million acres in South Florida have been placed under fish consumption advisories because of mercury contamination. The EPA Region 4 Science and Ecosystem Support Division (SESD), therefore, was charged by the EPA Regional Administrator to develop an action plan to evaluate the mercury issue and provide a scientific basis for evaluating options and strategies to eliminate mercury contamination in the South Florida Everglades Ecosystem. Subsequently, the Region 4 SESD prepared a research plan, had this plan peer-reviewed, and initiated the study as a Regional Environmental Monitoring and Assessment Program (REMAP) Project. As the Project planning and pilot Project proceeded, it became obvious that the environmental issues in South Florida (eutrophication, mercury contamination habitat alteration, hydroperiod modification) are highly interactive and need to be addressed through an integrated monitoring and assessment program. Therefore, the REMAP Project was expanded to become the South Florida Ecosystem Assessment Project addressing these multiple environmental issues. The variables being measured in this Project will permit answers to questions on these multiple environmental issues. A central goal of the Project, however, remains to answer assessment questions related to the magnitude, extent, trends, and transformation processes in mercury contamination of the South Florida Everglades Ecosystem.

State the Problem - a description of the problem(s) and specification of available resources and relevant deadlines for the study.

(1) *Identify the members of the team* - The team consists of the Region 4 Project Manager (i.e., fisheries biologist), SESD; Assistant Project Manager (natural resources manager), Water Division; Quality Assurance Officer (chemist); Southeast Environmental Research Program manager (microbial ecologist and chemist), Florida International University; spatial statistician, University of Georgia; and systems ecologist and data analysts, FTN Associates, Ltd.

(2) *Identify the primary decision maker(s)* - The primary decision maker is the South Florida Ecosystem Assessment Project Manager. Other decision makers include the Assistant Project Manager, Division Directors for the Water Division and Science and Ecosystem Support Division.

(3) *Develop a concise description of the problem* - Mercury contamination, nutrient loading, hydropattern modification, and habitat alteration are impacting fish and wildlife in the South Florida Everglades Ecosystem. The sources, causes, and interactions among many of these environmental stressors are unknown. Environmentally-sound, cost-effective restoration of the South Florida Everglades Ecosystem, however, depends on identifying these sources, causes and interactions. Almost one billion dollars are estimated to be spent on this restoration effort.

(4) *Specify the available resources and relevant deadlines for the study* - Approximately $1 million dollars/year are needed and available to determine the magnitude, extent, trends and possible causes of the mercury contamination, eutrophication, hydropattern modification and habitat alteration problems. This represents less than 0.1% of the proposed restoration expenditures. The relevant regulatory deadlines are listed in Table 1. These regulatory deadlines extend through 2004, with a major milestone in 1999 when the EPA mercury report is due to the South Florida Ecosystem Restoration Task Force.

Identify the Decision - a statement of the decision that will use environmental data and the actions that could result from this decision.

(1) *Identify the principal study questions* - The principal study questions were identified as part of the original proposal and specification of the DQOs. These seven policy-relevant questions are listed in Table 2.

(2) *Identify alternative actions that could result from resolution of the principal study questions* - The logical alternative actions and pathways that could result in answering these seven questions were identified during the initial phases of the Project. These pathways were incorporated into a Visual Basic computer program to show the logical development of these alternative actions. The expanded logic pathways from this computer program are shown in Figure 1. These logic pathways and alternative action formulations are a major part of the Problem Formulation phase of the Ecological Risk

Table 1. Mercury Related Legislative and Regulatory Deadlines.

Date	Federal	Florida
1995	NPDES Permit for the ENR project (CWA)	
1996	EIS for the Everglades Construction Project (NEPA)	
1996	404 Permit for the Everglades Construction Project (CWA)	
Oct 1997	404 Permit for STA-6 (CWA)	STA-6 NPDES Permit and 402 Certification
Sep 1998	USACOE Central & Southern Florida Project Restudy Plan Draft Report & Draft EIS (WRDA, NEPA)	
Dec 1998		Evaluation of water quality standards for the Everglades Protection Area & EAA canals (EFA)
Jan 1999	STA-1W, 2, & 5 404 Permits (CWA)	STA-1W, 2, & 5 NPDES Permits, 402 Certification (CWA)
Jul 1999	Final Restudy Report and EIS due to Congress (WRDA, NEPA)	
Dec 1999		Report to Governor and Legislature on status of EPA mercury study (EFA)
Dec 2001		Phosphorus criterion rulemaking for Everglades Protection Area and EAA canals (EFA)
Oct 2003	STA-3 & 4 404 Permits (CWA)	STA-3 & 4 NPDES Permits and 404 Certification (CWA)
Dec 2003		Revised water quality standards for the Everglades Protection Area & EAA canals (EFA)
2004	Approval of water quality standards for the Everglades Protection Area & EAA canals (CWA)	

WRDA: Federal Water Resources Development Act
EFA: Florida Everglades Forever Act
CWA: Federal Clean Water Act
STA: Stormwater Treatment Area
EAA: Everglades Agricultural Area
NEPA: Federal National Environmental Policy Act

Table 2. Policy-Relevant Questions Guiding the Project.

Status and Trends
1) What is the magnitude of the mercury problem? What are the current levels of mercury contamination in various species? What ecological resources of interest are being adversely impacted by mercury? 2) What is the extent of the mercury problem? (i.e., what is the geographic distribution of the problem? Is it habitat specific?) 3) Is the problem getting worse, better, or staying the same over time?
Diagnosis and Management
4) What factors are associated with, or contributing to, methylmercury accumulation in sensitive resources? 5) What are the relative contributions and importance of mercury from different sources (e.g., fossil fuel plants, waste incinerators, agricultural management practices, geologic pools, natural peat deposits, global atmospheric background, etc.)? 6) What are the relative risks to different ecological systems and species from mercury contamination? 7) What management alternatives are available to ameliorate or eliminate the mercury contamination problem?

Assessment Framework that forms the foundation of this study. Dichotomous trees were formulated for each of the logic pathways developed during the initial Project phases. These trees were developed prior to the initiation of the field sampling and were used to assist in the formulation of the preliminary project DQOs.

(3) *Combine the principal study questions and the alternative actions into a decision statement* - “Decide how the relative ecological risk from mercury contamination compares with the risks from nutrient additions, hydropattern modification, habitat alteration. Determine if controlling these other stressors will eliminate mercury contamination; if not, determine procedures that can be used to eliminate mercury contamination.”

(4) *Organize multiple decisions* - Multi-decision pathways will be based on the outcomes from the logic pathway analyses shown in Figure 1. These logic and decision pathways will be refined as the Project proceeds and new information is collected and analyzed.

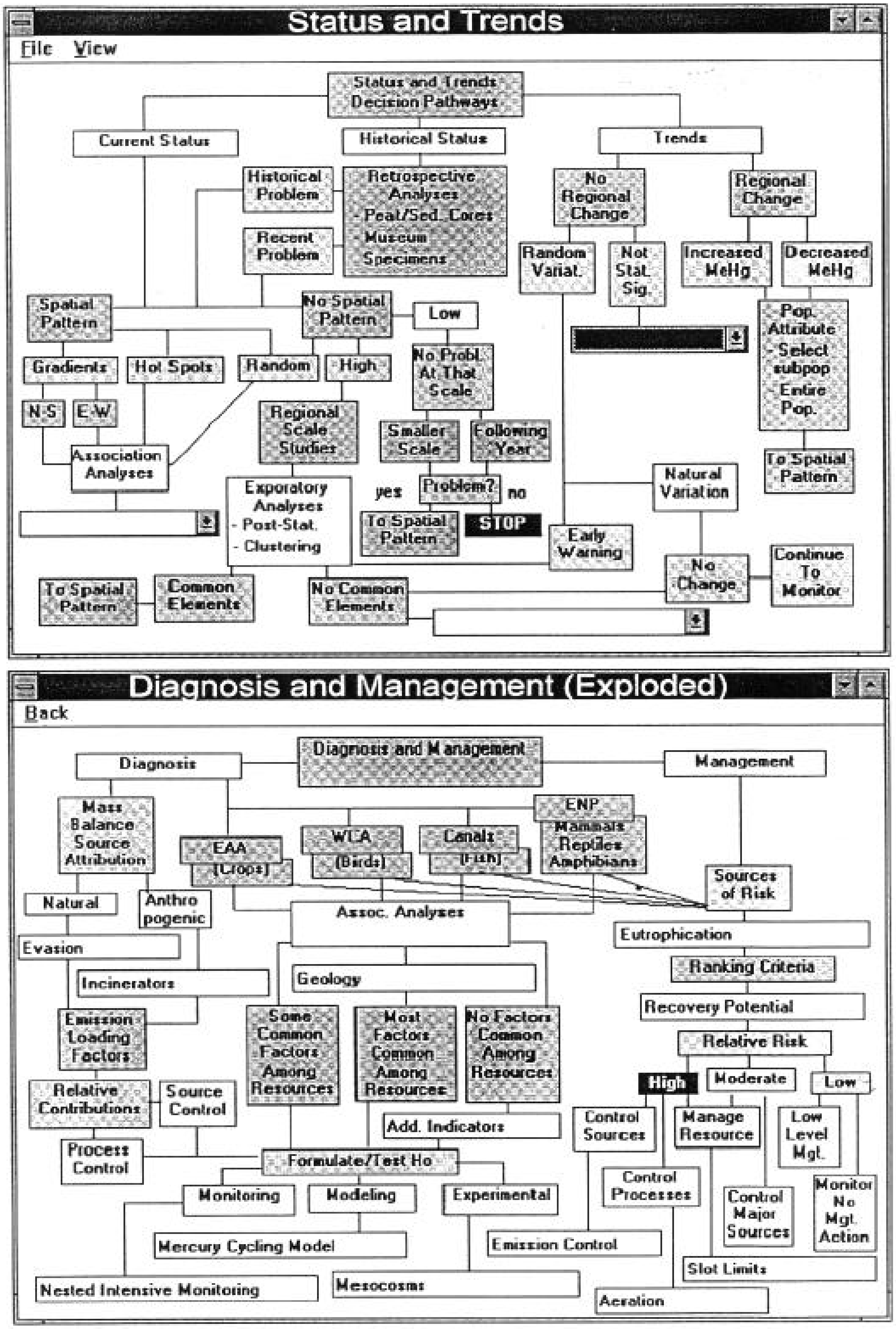

Figure 1. Logic pathways for decisions on status and Trends and Diagnosis and Management Questions. Pathways diagram information and analyses needed to answer the seven policy-relevant questions.

Identify the Inputs to the Decision - a list of the environmental variables or characteristics that will be measured and other information needed to resolve the decision statement.

(1) *Identify the information that will be required to resolve the decision statement* - The information needed to resolve the decision statements is listed in Table 3.

(2) *Determine the sources for each item of information identified* - The South Florida Ecosystem Assessment Project (SFEA) is the primary source of the information needed to address the decision statements. The decision statements can not be resolved without this Project. Additional sources of information also are identified in Table 3.

(3) *Identify the information that is needed to establish the action level* - The criteria that will be used to establish the action level will be:
- (a) Variability - ecological effects significantly different from natural variability
- (b) Endpoints - reproduction, feeding efficiency, behavioral changes, and other ecologically relevant processes, in addition to toxicity
- (c) Temporal scale - chronic versus acute effects
- (d) Spatial scale - small versus large scale effects

For most constituents, regulatory criteria or standards do not exist. The decision will be made using risk-based action levels.

(4) *Confirm that appropriate measurement methods exist to provide the necessary data* - For conventional pollutants, EPA approved methods are being used to measure environmental variables with an approved QAPP. For some constituents, such as total phosphorus, existing EPA methods do not have the resolution needed to detect low-level background concentrations. For other constituents, such as methylmercury in water, soil, and sediment, there are no approved measurement methods. Therefore, experimental measurement methods are being developed for these constituents, with confirmatory analyses being conducted by independent laboratories.

Define the Boundaries of the Study - a detailed description of the spatial and temporal boundaries of the problem, characteristics that define the population of interest, and any practical considerations for the study.

(1) *Specify the characteristics that define the population of interest* - The target population or population of interest are all ecological resources in the South Florida study area. This includes the freshwater wetlands, open water and canals found in the Everglades National Park (ENP), Water Conservation Areas (WCAs), Big Cypress National Preserve (BiCY), and Everglades Agricultural Areas (EAA). The media to be sampled include soil, sediment, water, and biota. The emphasis is on mercury concentrations in biota, especially fish tissue. However, one of the desired outcomes of the Project is better estimates of the type and proportion of ecological resources and the impacts of other stressors on these resources in South Florida.

Table 3. Information Needs, Source and Method.

Measurement Variable	Source	Method
Physical Measurements		
Site location	SFEA	Global Positioning System
Weather	SFEA, NOAA	Visual observation, meteorological stations
Discharge, structure	SFWMD	Gage readings, pump capacity
Water depth	SFEA, SFWMD	Calibrated line, depth recorders
Temperature	SFEA	Thermistor
Peat depth	SFEA	Calibrated probe
Turbidity	SFEA	Turbidimeter
Bulk density	SFEA	Balance, weighing
% Mineral content	SFEA	Combustion furnace
Ash free dry weight	SFEA	Combustion Furnace
Chemical Measurements		
Dissolved oxygen	SFEA	DO probe
Specific conductance	SFEA	Conductivity meter
pH	SFEA	pH meter
Total organic carbon	SFEA	Total carbon analyzer
Total phosphorus	SFEA	New method development
Sulfate	SFEA	New method development
Total mercury	SFEA	New method development
Methymercury	SFEA	New method development
Alkaline phosphatase	SFEA	New method development
Redox potential	SFEA	Volt meter
Biological Measurements		
Resource class (canal, sawgrass marsh, cattails, etc.)	SFEA	Visual inspection
Periphyton presence/absence	SFEA	Visual observation
Chlorophyll a	SFEA	New method development
Soil/Sediment total mercury	SFEA	New method development
Soil/Sediment methylmercury	SFEA	New method development
Fish total mercury	SFEA	New method development

Table 3. Other Information Needs and Sources.

Information Needs	Sources
Water management operation records	SFWMD, COE
Atmospheric mercury deposition/evasion	FL DEP, EPA, FAMS, SFWMD, UFL, FSU
Nutrient loading estimates	SFWMD
Habitat changes	FWS NWI, NPS
Simulated natural hydropatterns	SFWMD
Vegetation patterns and production	NPS, FWS, SFWMD
ENR Project results	SFWMD, FL DEP
Periphyton production - nutrient relationships	SFWMD, FL DEP, FIU, UWI
Organic carbon speciation	USGS
Sulfate reduction/loading	SFWMD, USGS, FIU, UWI
Mercury methylation/demethylation	USGS, SFWMD, UMD, FIU, UFL, UWI
Fish and invertebrate impacts	FWS, NPS, FIU, UFL
Wading bird impact	FWS, NPS, UFL
Large mammal and reptile impacts	FWS, NPS, FIU, UFL, FSU, UGA

(2) *Define the spatial boundary of the decision statement*

(a) *Define the geographic area to which the decision statement applies.* The geographic area being studied, and for which decisions apply, is approximately 160 km long and 60 km wide, resulting in an area of about 9600 km^2. The exact boundaries are listed in Table 4 (next page) and shown in Figure 2.

Table 4. Geographic Area Boundaries.

Boundary	Description
Northern	West from Canal L8 to its junction with Lake Okeechobee and across to the Caloosachatchee River.
Western	Vertical line from the intersection of the Caloosahatchee River and Highway 833 south to the coast (the mangrove region is excluded from the target population).
Southern	Edge of the western mangrove east to the intersection with Highway US 1.
Eastern	Highway US 1 north to its intersection with Highway 27, then along the eastern boundaries of Water Conservation Areas to the Intersection with Canal L8.

(b) *When appropriate, divide the population into strata that have relatively homogeneous characteristics.* Strata of interest were based on the decision statement, rather than on homogeneity of variance. For example, there was less interest in defining the characteristics of the Big Cypress National Preserve (BiCY) than in other designated geographic areas. Therefore, BiCY was sampled with a lower inclusion probability (approximately 1/3 the density of other areas within the study boundaries). In addition, subsequent analyses have indicated the areas north of Alligator Alley, between Alligator Alley and Tamiami Trail, and south of Tamiami Trail have attributes that can influence management and policy decisions.

(3) *Define the temporal boundary*

(a) *Determine the timeframe to which the decision statement applies.* The decision statement applies from the time of the first data collection in April 1994 until at least 2004. The mercury-related legislative and regulatory deadlines are defined in Table 1. However, Project results are applicable to a longer timeframe because the South Florida Ecosystem Restoration Task Force has legislative mandates for hydropattern modification, habitat alteration and eutrophication deadlines beyond 2004 that can be addressed with results from this Project.

(b) *Determine when to collect the data*. Because time and space scales are inexorably coupled, the synoptic sampling approach spatially dictates that the temporal sampling frequency be seasonal. There are two distinct hydrologic seasons in Florida. The dry season extends from November to April and the wet season extends from June until September. May and October are transitional months. Sampling during only one season could result in biased and flawed decisions on

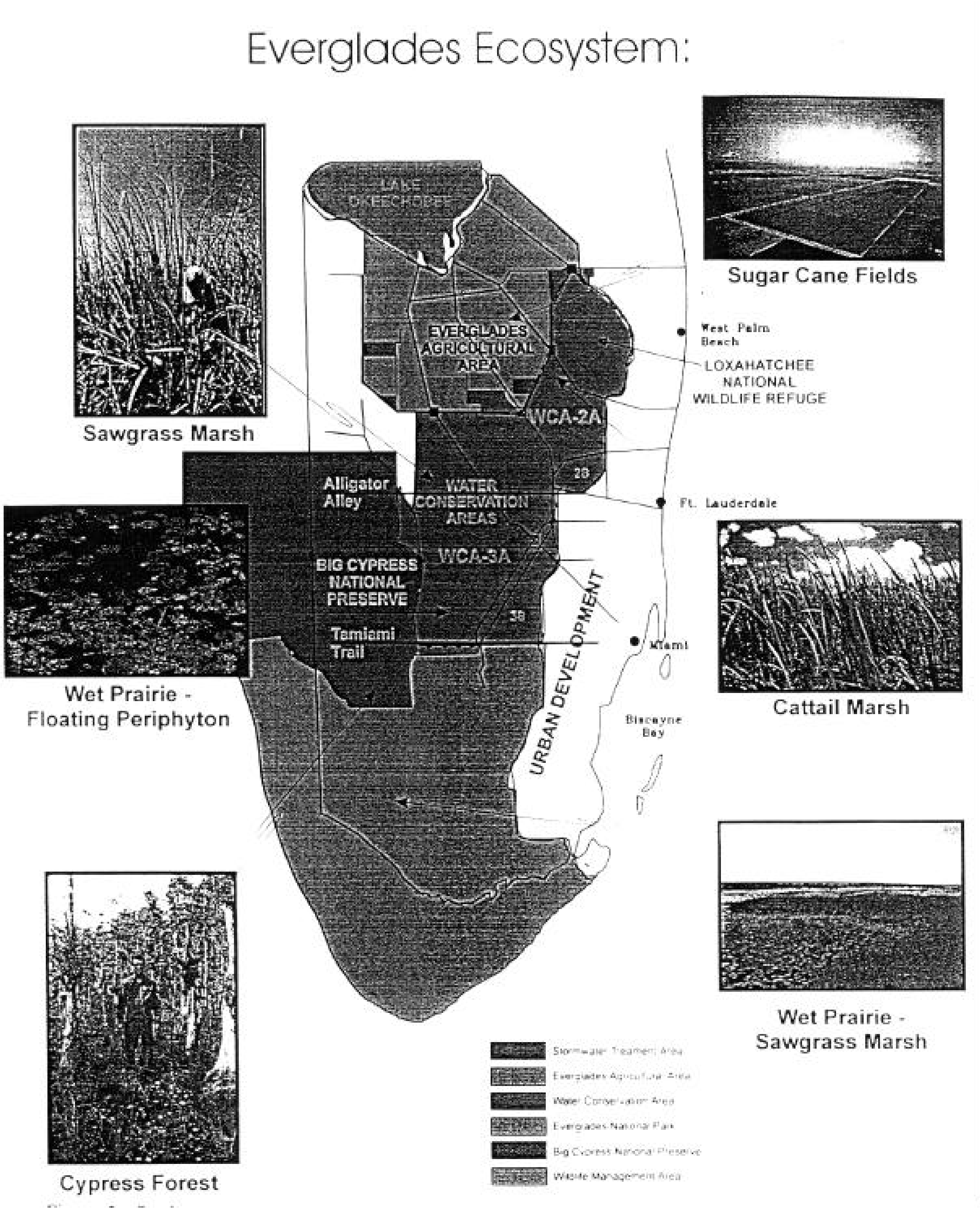

Figure 2. Study area boundaries, major management areas, and Everglades ecosystem community types.

management or regulatory issues, because of seasonal variability. Sampling, therefore, needs to be done during both the dry and wet season. Decisions will be made over the next decade, based, in part, on spatial and temporal trends in information. These trends can not be defensibly determined with only one set (wet and dry season) of data at the beginning and end of the decision time frame. Two reference periods define change, not trends. Power analyses will be conducted to determine the number of sampling intervals needed to detect statistically defensible trends and contribute to the decision process.

(4) *Define the scale of decision making* - Decisions on mercury management and restoration issues must be made for the entire South Florida ecosystem. The environmental issues arose because of small-scale, piecemeal approaches to managing the system.

(5) *Identify practical constraints on data collection* - The large geographic area for sampling, and the need to collect synoptic samples requires that sampling be conducted by multiple teams using helicopters and airboats. The sampling period should be no longer than 10 days to minimize large scale changes in meteorology affecting water depth and quality measurements. The number of samples and sample volume need to be minimized to reduce weight and time for collection, but with sufficient volume to permit precision and accuracy requirements to be achieved. Clean sampling procedures are required for the mercury analyses, both in the field and in the laboratory. Low concentration nutrient analyses also are required because of the ultraoligotrophic condition of the Everglades wetlands.

Develop a Decision Rule - to define the parameter of interest, specify the action level and integrate previous DQO outputs into a single statement that describes a logical basis for choosing among alternative actions.

[NOTE: This DQO guidance statement is not compatible with the South Florida Ecosystem Restoration goals and objectives. The issues in South Florida are not independent; they are highly interactive. Multi-media decisions are required for multiple issues. There is no single statement can be formulated that will permit decisions among alternative actions. The greatest threat to the Everglades ecosystem is to assume these issues are independent and derive one single statement to address all issues. The Project, in part, will determine what the criteria should be for multiple issues such as phosphorus loading, water depth, distribution and timing, methylmercury concentrations in multi-media, and habitat types.**]**

(1) *Specify the statistical parameter that characterizes the population of interest* - REMAP is an exploratory research program so no single statistical parameter has been selected to characterize the population of interest. In addition, the emphasis is not on one single constituent, such as a hazardous material that might exceed a regulatory standard. Rather, several statistical parameters are needed to characterize different population attributes, including:

(a) mean concentrations of selected constituents (see Table 3 for constituents)
(b) cumulative distributions of constituents, by season, by area
(c) distributional differences among constituents
(d) spatial patterns of constituents, and
(e) spatial/temporal associations among constituents.

(2) *Specify the action level(s) for the study* - Three action levels currently exist:

(a) Phase I control target for total phosphorus of 50 μg/L (ppb);
(b) Water total mercury criterion for protection of aquatic life of 12 ng/L (ppt); and
(c) Proposed predator protection level for mercury of 100 μg/kg (ppb) for prey species.

All three of these levels are underprotective. New risk-based action levels need to be determined. Currently, 95% of the marsh has total phosphorus concentrations less than 50 ppb; 100% of the marsh has total mercury concentrations less than 12 ppt, and 68% of the marsh has prey fish species with mercury concentrations greater than 100 ppb (Figure 3). Developing appropriate risk-based action levels for total phosphorus and mercury is one of the objectives of this Project. The detection and minimum quantitation limits for all three of these constituents are less than the respective criterion. Because risk-based action levels are needed, methods with increased sensitivity have been developed and are being tested.

(3) *Develop a decision rule (an "if...then" statement)* - Decision rules express what the decision maker ideally would like to resolve. The decision has been made that revised criterion are needed, based on the information developed to date from the Project. Preliminary decision rules, given this need, are listed in Table 5. Subsequent revisions of the DQO document will expand and refine these decision rules as additional information becomes available. Logic flow paths have been formulated (Figure 1) to increase the probability future information will improve the efficacy of the decision rules.

Specify Tolerable Limits on Decision Errors - the decision maker's tolerable decision error rates based on a consideration of the consequences of making a decision error.

(1) *Determine the possible range of the parameter(s) of interest* - The possible range of the parameters of interest are listed in Table 6. These ranges are based on this Project and other studies conducted in the South Florida Everglades ecosystem.

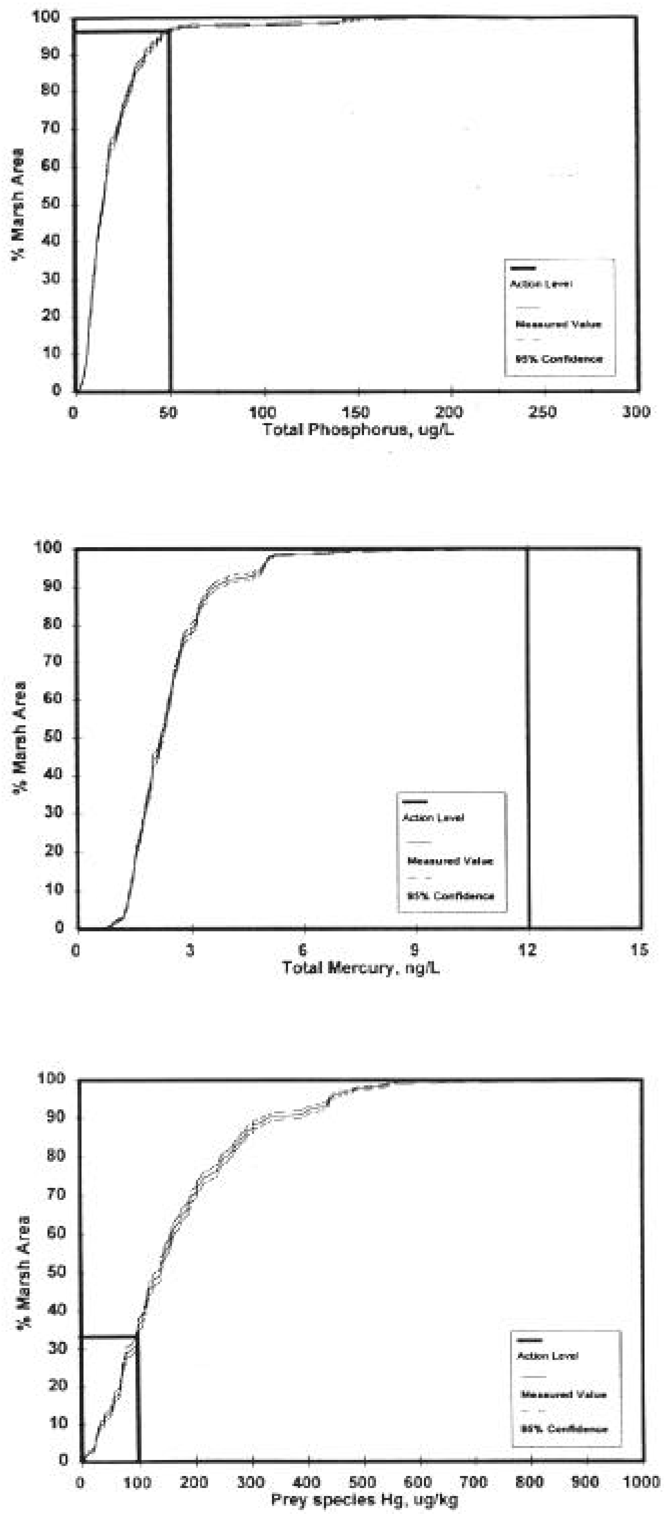

Figure 3. Distribution of total phosphors and total mercury in water and total mercury in a fish prey species, with 95% confidence intervals. **Note**: The existing action levels are under protective because ecological effects are observed from eutrophication and mercury contamination.

Table 5. Preliminary Decision Rules for South Florida.

Decision Rules	
1a	If the South Florida Everglades Ecosystem can not be managed to achieve all desired ecological uses, then a comparative ecological risk assessment shall be conducted to determine which stressors, and their interactions, are placing the system at greatest risk.
1b	If the South Florida Everglades Ecosystem can be managed to achieve all desired ecological uses, then the management, regulatory and control practices shall be maintained.
Based on the results of this comparative risk assessment, the following decision rules might be used:	
2a	If phosphorus concentrations exceed a risk-based action level, then nutrient loads will be reduced until phosphorus concentrations are less than the action level.
2b	If phosphorus concentrations are less than a risk-based action level, then BMPs and other nutrient control programs will be maintained.
3a	If hydropattern modification varies by more than 10% from the desired natural hydropattern rule curve, then the hydropattern will be modified to match the desired natural hydropattern rule curve while maintaining flood control and water supply.
3b	If the hydropattern modification is within 10% of the desired natural hydropattern rule curve, and flood control and water supply purposes are satisfied, then the hydropattern management and operational programs will be maintained.
4a	If hydropattern modification varies by more than 10% from the desired natural rule curve and either flood control and/or water supply requirements can not be satisfied, then alternative flood control and water supply options will be investigated to return the hydropattern to within 10% of the desired natural rule curve.
4b	If hydropattern modification can not be returned to within 10% desired natural rule curve and achieve water supply and/or flood control demands, then a risk-based benefit/cost analysis will be performed to determine which alternatives have the lowest benefit/cost ratio and that use eliminated.
5a	If habitat alteration exceeds risk-based landscape action level metrics, then habitat alternation, a benefit/cost analysis will be done to determine if this habitat alteration including urban development or agricultural production, should be banned and habitat restoration under taken.
5b	If habitat alteration is less than risk-based landscape action level metrics, then habitat alteration will be permitted until these values are within 5% of the lower limit of the action level.

Table 5. Preliminary Decision Rules for South Florida (Continued).

Decision Rules	
6a	If mercury concentrations exceed a risk-based action level, then mercury sources will be controlled until mercury concentrations are less than this risk-based level.
6b	If mercury concentrations are less than the risk-based action level, mercury sources will be controlled to ensure the action level is not exceeded.
7a	If hydropattern modification greater than 10% from the risk-based desired natural rule curve aggravates mercury contamination of fish and wildlife, then the hydroperiod shall be modified to achieve the risk-based action level.
7b	If the hydropattern modification less than 10% of the risk-based desired natural rule curve aggravates mercury contamination of fish and wildlife, then a comparative risk assessment and risk-based benefit/cost analysis shall be conducted to determine which stressor places that system at greatest risk and has the lowest benefit/cost ratio; that stressor then will be reduced.
8a	If nutrient loading exceeds the nutrient risk-based action level and aggravates mercury contamination of fish and wildlife, then nutrient loading shall be reduced to achieve the risk-based action level.
8b	If nutrient loading is less than the nutrient risk-based action level and aggravates mercury contamination of fish and wildlife, then a comparative risk assessment and risk-based benefit/cost analysis shall be conducted to determine which stressor places that system at greatest risk and has the lowest benefit/cost ratio; that stressor then will be reduced.
9a	If habitat alteration exceeds risk-based landscape action level metrics and aggravates mercury contamination of fish and wildlife, then additional habitat alteration shall be banned and habitat restoration under taken.
9b	If habitat alteration is within the risk-based landscape action level metrics and aggravates mercury contamination of fish and wildlife, then a comparative risk assessment and risk-based benefit/cost analysis shall be conducted to determine which stressor places that system at greatest risk and has the lowest benefit/cost ratio; that stressor then will be reduced.

Table 6. Water Constituents Ranges in South Florida.

Measurement Variable	Range			
	Minimum		Maximum	
Physical Measurements				
Site location (deg.)	Latitude 25.30	Longitude 80.22	Latitude 26.93	Longitude 81.13
Weather				
Discharge, structure (m^3/s)	0			
Water depth (ft)	Marsh 0	Canal 0.5	Marsh 8	Canal 25
Temperature (°C)	18		36	
Turbidity (NTU)	0.1	80		
Chemical Measurements				
Dissolved oxygen (mg/L)	0		15	
Specific conductance (μS)	10		2150	
pH (s.u.)	5.5		8.8	
Total organic carbon (mg/L)	5		80	
Total phosphorus (mg/L)	0.001		0.500	
Sulfate (mg/L)	1.0		850	
Total mercury (ng/L)	0.02		12	
Methymercury (ng/L)	0.03		1.5	
Alkaline phosphatase	0.01		8.0	
Biological Measurements				
Resource class *(canal, sawgrass marsh, cattails, etc.)* (Numeric rank)	1		7	
Periphyton presence/absence (1,0)	0		1	
Chlorophyll a (μg/L)	0		100	
Periphyton total mercury (μg/kg)	4		600	
Periphyton methylmercury (μg/kg)	0.08		25	
Fish total mercury (μg/kg)	5.0		1000	

Table 6B. Soil/Sediment Constituents Ranges in South Florida.

Measurement Variable	Range	
	Minimum	Maximum
Physical Measurements		
Peat depth (m)	0	>4.25
Bulk density (g/cc)	0.05	1.4
% Mineral content (%)	3%	99%
Ash free dry weight (%)	1.0	96.0
Redox potential (mV)	-250	+600
Chemical Measurements		
Soil/Sediment total mercury (μg/kg)	3.0	500
Soil/Sediment methylmercury (μg/kg)	0.01	50
Soil/Sediment total phosphorous (μg/kg)	10	9000
Soil/Sediment sulfate (μg/kg)	20	850

(2) *Identify the decision errors and choose the null hypotheses*

(a) *Define both types of decision errors and establish the true state of nature for each decision error*. By convention, a Type I (false positive) error is rejecting the null hypothesis when it is true. A Type II (false negative) error is not rejecting the null hypothesis when it is false. The two types of decision errors for the Project are (I) deciding the risk-based action level is exceeded when it truly is not, and (II) deciding the risk-based action level is not exceeded when it truly is.

The true state of nature for decision error (I) is that the null hypothesis is true.

The true state of nature for decision error (II) is that the null hypothesis is false.

(b) *Specify and evaluate the potential consequences of each decision error.* The consequences of deciding the risk-based action levels are exceeded when they truly are not (decision error I) means there will be increased control costs associated with nutrient and mercury source reduction, restricted urban and agricultural development, habitat restoration, and restricted hydropattern modification around the natural hydropattern rule curve, which could result in flood damage or water supply shortages.

The consequences of deciding the risk-based action levels are not exceeded when they truly are (decision error II) means that ecological restoration of the South Florida Everglades ecosystem will not be successful.

(c) *Establish which decision error has more severe consequences near the action level.* Based on current laws and regulations related to the South Florida Everglades ecosystem (e.g., Everglades Forever Act), the decision II error has the more severe consequences near the action level because of the risk to both ecological and human health and ecological restoration. However, this consequence must be based on a comparative risk assessment and a risk-based benefit/cost analysis of the risks and impacts. The economic consequences are in the billion dollar category for both types of decision errors.

(d) *Define the null hypothesis (baseline condition) and the alternative hypothesis and assign the terms "false positive" and "false negative" to the appropriate decision error*. Null hypotheses for DOQs are not equivalent to experimental null hypotheses for statistical testing. Null hypotheses for DQOs reflect the decision error that has the most adverse potential consequences. The DQO null hypothesis is equal to the true state of nature that exists when the more severe decision error occurs. The null hypotheses for this Project, therefore, would be:

H_o = The comparative ecological risk assessment indicates the interactions among stressors puts the South Florida Everglades ecosystem at risk.
H_o = The risk-based action levels for nutrient concentrations are exceeded.
H_o = The risk-based action levels for mercury concentrations are exceeded.
H_o = The risk-based landscape action level metrics are exceeded.
H_o = The risk-based action levels for hydropattern modification exceed by X% the natural hydropattern rule curve.

A "false positive" has the greatest consequences for each of these hypotheses.

(3) *Specify a range of possible values of the parameter of interest where the consequences of decision errors are relatively minor (gray region)* - The purpose of this research project is to determine the action level values. Until these action levels are defined, it is not possible to specify actual numeric values to an area of minor importance. It is, however, possible to indicate these areas of minor importance will be at the extremes of the distribution. In this portion of the action level curve, there will be a low probability of making either type of decision error.

(4) *Assign probability values to points above and below the action level that reflect the tolerable probability for the occurrence of decision errors.* - The QA G-4 Guidance manual indicates the gray region where greater tolerable errors are permitted are around the action level, with lower tolerable errors around the extreme values. The planning team disagrees with this concept. The greater tolerable errors are permitted at the extemes of the distribution because it is unlikely that large errors in the metric would alter the conclusion that the action level was either exceeded or not exceeded. However, near the action level, particularly as values approach the lower limit of the action level, decision errors can have significant consequences on subsequent actions (Figure 4). Tolerable error around the action level in this region should be no more than 10%.

Optimize the Design - The REMAP monitoring design for South Florida was revised to provide more resource-effective information at reduced cost without compromising the DQOs for the marsh samples. The canal samples will be selected as subjective samples because the first four sampling cycles indicated the marsh processes are more significantly affected by multiple environmental stressors than canal processes in South Florida. Sufficient samples will be collected in the canals so that temporal and spatial trends can be detected over time in loadings to the marsh, but not with the same precision as marsh trends. This improved design will permit answering the original seven policy-relevant questions guiding the Project and establishing the action levels needed for decisions.

Appendix A contains statements for data representativeness, completeness, comparability, precision and accuracy for each of the constituents measured in the EPA Region 4 South Florida Ecosystem Assessment Program. These quantitative DQO criteria will be revised as additional data become available to the program.

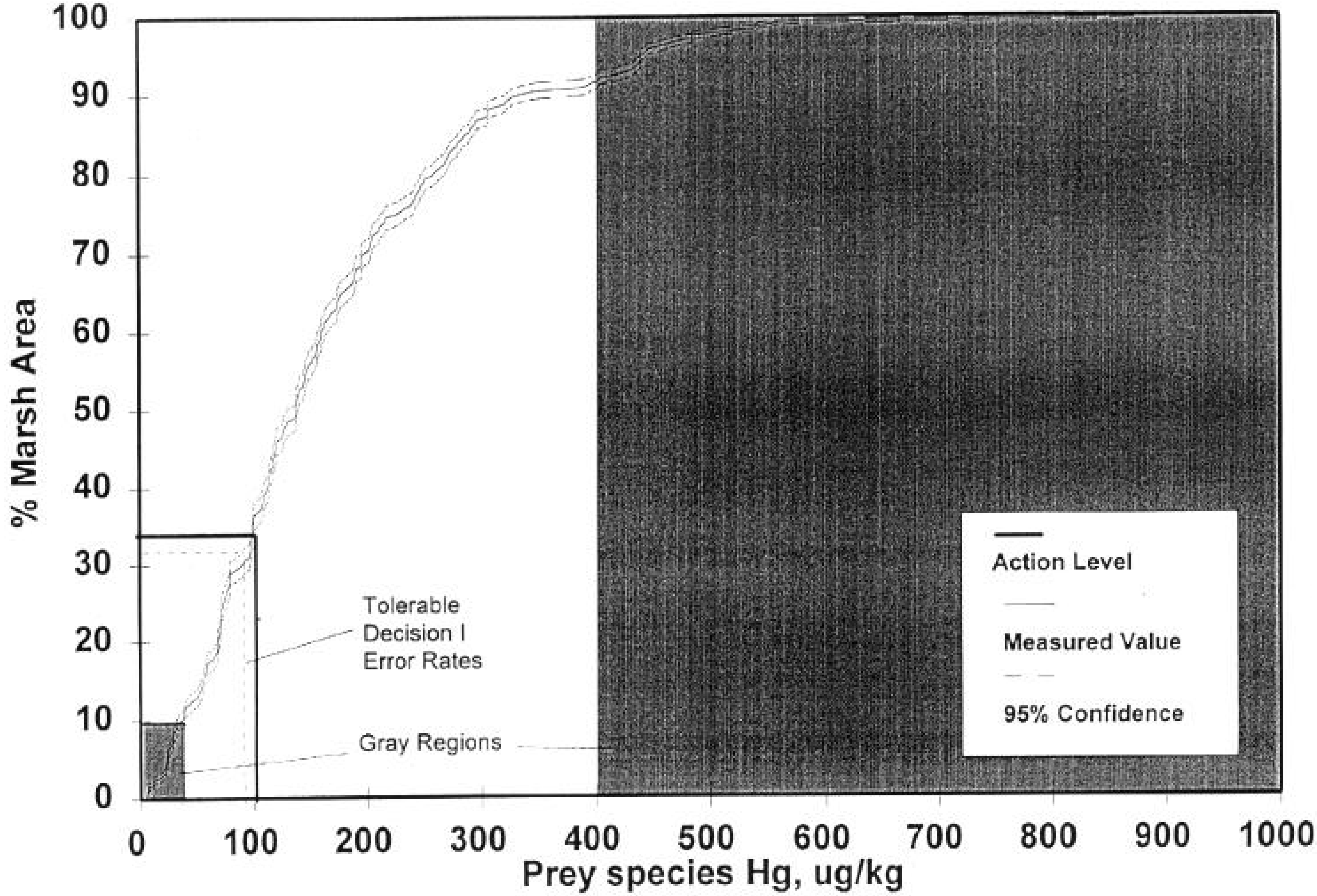

Figure 4. Proposed mercury Action Level for predator prey species identifying The Gray Regions and area for 10% Tolerable Decision 1 Error Rates.

Appendix A

Data Quality Objective Criteria

Table A1A. Water Data Quality Objective Criteria.

Measurement Variable	Representativeness	Completeness	Comparability (Split Samples SOPs, Std. Units)	Field Duplicate Precision (% RSD) @ 95% Confidence	Accuracy (% Recovery)
Physical Measurements					
Site location (deg.)	Design-based statistically representative	90%	SOPs		
Weather	“	“	SOPs	NA	NA
Discharge, structure (m^3/s)	“	“	NA	NA	NA
Water depth (m)	“	“	SOPs	Jerry Provide	
Temperature (°C)	“	“	SOPs	“	$\pm$ 0.15
Turbidity (NTU)	“	“	SOPs	53.8	NA
Chemical Measurements					
Dissolved oxygen (mg/L)	“	“	SOPs	“	$\pm$ 0.2*
Specific conductance (μS)	“	“	SOPs	“	$\pm$ 1
pH (s.u.)	“	“	SOPs	“	$\pm$ 0.2*
Total organic carbon (mg/L)	“	“	SOPs, USGS	16.6	85–115
Total phosphorus (mg/L)	“	“	SOPs, SFWMD	48.1	81–115
Sulfate (mg/L)	“	“	SOPs, USGS	8.07	85–115
Total mercury (ng/L)	“	“	SOPs, Battelle hab.	55.5	70–130

* Actual Units   RDS: Relative Standard Deviation   SOP: Standard Operation Procedures

Table A1A. Water Data Quality Objective Criteria (Continued).

Measurement Variable	Representativeness	Completeness	Comparability (Split Samples SOPs, Std. Units)	Field Duplicate Precision (% RSD) @ 95% Confidence	Accuracy (% Recovery)
Methymercury (ng/L)	“	“	SOPs, Battelle hab.	40.3	70–130
Alkaline phosphatase	“	“	SOPs	23.1	70–130
Biological Measurements					
Resource class *(canal, sawgrass marsh, cattails, etc.)* (Numeric rank)	“	“	SOPs, FWS, NWI	NA	NA
Periphyton presence/absence (1,0)	“	“	SOPs	NA	NA
Chlorophyll a (μg/L)	“	“	SOPs	96.8	NA
Periphyton total mercury (μg/kg)	“	“	SOPs	94.6	70–130
Periphyton methlmercury (μg/kg)	“	“	SOPs	149	70–130
Fish total mercury (μg/kg)	“	“	SOPs, Reg. 4	57.3	70–130

* Actual Units RDS: Relative Standard Deviation SOP: Standard Operation Procedures

Table A1B. Soil/Sediment Data Quality Objective Criteria.

Measurement Variable	Representativeness	Completeness	Comparability (Split Samples SOPs, Std. Units)	Field Duplicate Precision (% RSD) @ 95% Confidence	Accuracy (% Recovery)
Physical Measurements					
Peat depth (m)	"	"	SOPs		
Bulk density (g/cc)	"	"	SOPs	13.90	NA
% Mineral content (%)	"	"	SOPs	22.5	NA
Ash free dry weight (%)	"	"	SOPs	22.5	NA
Redox Potential (mV)	"	"	SOPs	Jerry Provide	
Chemical Measurements					
Soil/Sediment total mercury (μg/kg)	"	"	SOPs, USGS	40.3	70–130
Soil/Sediment methylmercury (μg/kg)	"	"	SOPs, USGS	135	70–130
Soil/Sediment sulfate (μg/kg)	"	"	SOPs, USGS	Jerry Provide	
Total phosphorus in soil (μg/kg)	"	"	SOPs, USGS	38.5	75–125

RDS: Relative Standard Deviation
SOP: Standard Operation Procedures