Final Review Report

Caloosahatchee Minimum Flow
Peer Review Panel – September 27-29, 2000

Submitted to:

South Florida Water Management District

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by

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I. Introduction and Background

A. Minimum Flow Plan Elements

The elements of a minimum flow plan (as per FS 373.042) include the following:

1. Definition of harm, including significant harm as criteria.
2. Determination, based on best available information, of flow regimes that will prevent significant harm from occurring.
3. Development of technical and logistical ability to provide that flow regime to the system.
4. Where necessary, development of a recovery or prevention strategy.
5. Rules, regulations, or other legal bases to assure that those flows will in fact occur.

B. Relationships between Elements

The elements of a minimum flow plan are highly interrelated. Some of the interrelationships include the following:

1. Definition of significant harm as criteria.

How significant harm is defined affects all other elements. The choice of approaches and scientific information is driven by what types of harm are to be avoided. For example, using a *reductio ad absurdum* logical argument, if significant harm were to be defined extremely as something like: *significant harm exists if and only if the system is impacted to the extent that it can never recover and can never again exist in its natural or "normal" state*, the other elements above (2-5) would greatly affected. In particular, determination of flows would be much easier, and it would be much easier (because almost any flow would avert total loss) to find approaches that would avoid total permanent loss, and could be considered to be based on "best-available" science and information. Conversely, if a very stringent definition of significant harm were to be adopted, such as: *significant harm exists if any component of the system is reduced in its abundance, biomass, or ecological functioning to less than 90% of what could be attained under optimal conditions*, it would probably be impossible to find approaches that could be said to assure that significant harm was avoided based on best-available information. How significant harm is defined greatly affects what approaches are feasible and whether those approaches can be concluded to be based on best available information. It also greatly affects elements 3 ,4 and 5.

2. Determination of flow regimes that avoid significant harm

Within this element there are three components: a) finding and /selecting approaches to relate flow to ecological health or well being of components of the system; b) determining, within the realm of existing scientific understanding, if the specific relationships of the approach are scientifically sound and robust (*i.e.*, if they are based on best information available[1]); c) determining which scientifically sound approaches are necessary[2], and which are sufficient, and if any are necessary-and-sufficient in a formal mathematical/logical sense; d) if, as almost always is the case, necessary-and-(fully)sufficient approaches are not identified, determination of a suite approaches that together provide adequate sufficiency, taking into account the practical realities of the limitations of science and the limitations of resources that can be applied to determining minimum flow for any system.

It should be pointed out that just because a particular approach is used in ways that utilize the best available information for that approach, the overall approach to setting minimum flows is not necessarily based on the best available information. There may be other available information that can enhance and improve the overall approach. An approach is based on best available information only if it uses all information that is practically and feasibly available and applicable.

3. Development of technical and logistical capability, including physical infrastructure, to provide that flow regime to the system.

Once the minimum flows have been determined, the mechanisms[3] by which the flows can be attained must be developed. The appropriate mechanisms, in turn, are affected by how significant harm is defined[4] (1) and by the flow regimes determined from scientific information (2). This is an obviously essential element of a minimum flow plan. Without the capacity to provide water, a plan for providing minimum flow is incomplete or nonexistent.

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[1] An important distinction must be made between a plan being "based on" best available information, and being "consistent with" best available information. A plan that can be considered to be based on best available information has formally identified, included, and analyzed the subset of best available information that is pertinent and critical to the plan. A plan that is consistent with best available information is one that has not necessarily included or considered all of the best available information in defining actions, but when the plan is reviewed, it can be concluded that the actions are not contraindicated by the overall body of best available information.

[2] The terms "necessary" and "sufficient" are formal mathematical terms that can be used to evaluate a resource management plan. For example, in determining if a number is a prime number, the condition that the number be a whole number is a necessary condition. However, it is obvious that being a whole number is not sufficient as a condition. The number four is a whole number but is not a prime number. The condition that the number not be divisible by any other whole number (other than the number one) is a sufficient condition. Elements of a resource management plan should be viewed this way as necessary and/or sufficient conditions for attaining the resource management objective. It is not enough that a plan contains elements that are merely necessary. Wherever possible, a plan should include elements that are sufficient.

[3] Mechanisms include physical structures such as dams, reservoirs, canals, etc., as well as water management plans and measures. For example, a plan for diverting, under some circumstances, some water usage (*e.g.*, irrigation) toward maintaining minimum flow is a mechanism.

[4] The types and characteristics of these mechanisms could be affected by how significant harm is defined. For example, if significant harm were defined as to not include harm that occurs when natural droughts occur, a much smaller reservoir could be constructed and still avoid minimum harm. Conversely a much larger reservoir would be needed to avoid harm under a definition that required that minimum flows be provided even during periods of natural drought.

4. Development of a recovery or prevention strategy.

If the minimum flows determined in item 2 are not attainable, FS 373.0421 requires that a recovery strategy, which includes development of additional water supplies and other actions, shall be implemented. Obviously, the strategy is highly dependent on all the preceding elements.

5. Rules, regulations, or other legal bases to assure that those flows will in fact occur.

The legal and regulatory basis for provision of minimum flows can range from absolute (*e.g.*, certain minimum flows shall be provided) to highly conditional (minimum flows may be provided contingent upon other conditions and situations). The legal and regulatory basis greatly effects decisions on what subset of overall best available information should be explicitly included in a plan in order for it to be considered to be based[5] on best available information. For example, under a situation of reasonably absolute provision of minimum flows (provision under almost all foreseeable circumstances, reasonably allowing for "natural" events or act of God), the level of complexity and scientific certainty needed for an approach to be considered based on best available information would be much less than that needed under a situation in which regulations might allow flows to be extremely and/or unpredictably not provided. The latter case would require best available information as to the effects of the failure to provide minimum flows and might require very different approaches and conclusions as to setting minimum flows.

C. Context of this Peer Review

The above discussion is provided for two main reasons: 1) It offers the argument that the components (1-5, above) are not logically, separable or independent. A minimum flow plan is based on all of the components. 2) It provides the context and limitations to the following report of the peer review panel.

There is a third important reason for the discussion. Establishment of minimum flows under FS 373.042 is a new requirement. In most cases, it will be difficult and complicated to set minimum flows, because the technical issues may be unique for each case and the best available information may not be adequate to support scientifically defensible positions. Adaptive management will have to be used to evaluate the effects of low rules and to reset flow rules. Peer review of minimum flows, as mandated by FS 373.042, is similarly difficult and complicated. Finally, the overall process by which minimum flows will be established for water bodies throughout Florida is new and complicated. The Caloosahatchee Estuary minimum flow is one of the first in Florida for a major estuary, and it could influence how MFL is established in other estuaries around the state. It is with that in mind that this review includes discussion of the general process of setting minimum flows for the Caloosahatchee Estuary. It is hoped that such discussion and report will be helpful to establishment of other minimum flows in Florida.

[5] See footnote 1.

The statement of work (SOW) and instructions provided to the panel stated that the definition of significant harm was solely a matter of SFWMD policy, and that it was not open for revision or review by the peer review process. On page 3 of 13, Exhibit "A" To Purchase Order PC C-9696-0503 (Peer Review Panelist SOW) it stated: "The definition of significant harm is also based on policy decisions and assumptions beyond the scope of this peer review." On page 2 of 13 of that document, it was also stated: "However, policy decisions and assumptions are not subject to peer review."

There was considerable discussion of this issue. Although the panel does not endorse the concept that the criteria for establishing minimum flows should not be subject to scientific scrutiny with regards to it being based on best available information, the panel had little choice but to proceed under those stipulations. Whether those stipulations are consistent with the intent of FS 373.042 is a legal issue that the panel is not qualified to address.

The panel members concluded that their only option was to proceed totally under the limitations stipulated by the District without reviewing the technical impacts of the stipulations. Three of the four panel members (Lung, Montagna, and Edwards, have chosen to comment on the definition of significant harm in their overall comments. The Chairman, (Edwards) also agreed that the panel had little choice but to proceed using the District's definition of significant harm, but he felt strongly it should be recorded that such a separation and stipulation was flawed and inappropriate because of the many ways that the significant harm definition/premise affects scientific considerations; any definition of significant harm should be based on some combination of best available science and policy. In his professional opinion, the definition of significant harm adopted by SFWMD is not based on science and it would be concluded to not be based on best scientific information were it to be reviewed in that regard.

However, because of how this review process was structured by the District's SOW and instructions, the panel did not further review the definition of significant harm. Therefore, no part of the review or report should be taken to imply that the panel considers the definition of minimum harm used in the document to be based on best available scientific information.

In that context, the information made available to the panel and the panel's review was focused almost exclusively on element 2, and mainly on components 2a, 2b, and 2c. Some comments on 2d are provided based on further analysis of what was presented and what was not presented for the panel's consideration.

One of the panel members (Montagna) offered the following different words to describe the issues surrounding the fact that the panel was instructed to not include the definition of significant harm in the review. "The panel preceded using the District's definition of significant harm. However, it was clear that there was little scientific input in creating the definition of significant harm. The conceptual relationships among the terms harm, significant harm and serious harm are logical. However, the individual definitions of these terms are vague. For example, how many years are "multiple years" in the definitions of significant harm? These definitions are written by policy makers. The translation from policy to quantitative analysis is lacking. The panel urges the District to include scientific testimony and judgement in future definitions of significant harm. This is another area where adaptive management can be used to increase effectiveness of District policies."

D. Format of the Report

The report was structured to coincide with questions asked and issues raised by the District's SOW. Not every panelist felt compelled to answer each question or to address every issue. Responses of panelists to questions or issues often were complimentary or similar. They were rarely, if ever, contradictory or in opposition to each other. In order to maintain the panelists' comments in their full detail, no attempt was made to edit them or to integrate them beyond organizing them logically with regard to the questions or issues addressed. The panelist is identified (in parenthesis) in each of the comments. Those parts of the report in which no panelist is identified to be the contributor were drafted by the Chairman and were made available for comment and modification by all panel members. Some of the panelists' comments address more than one of the sections of the final report outline agreed upon by the panel. In such cases, the comment is entered in the section indicated by the panelist. The summary and recommendations section is a synthesis of all of the comments. It was drafted by the Chairman and was carefully reviewed, modified and approved by all panel members.

II. General Questions

A. *Does the document present a sound scientific basis for setting initial minimum flows in the Caloosahatchee Estuary (CE)?*

As pointed out above, the entire document was not subject to rigorous scientific review by the panel. The term rigorous scientific review is intended to mean review to determine whether an issue or question was addressed using best available scientific information. In particular, as discussed above, definition of significant harm and other policy issues (Chapter 1) were not rigorously and technically reviewed from a standpoint of evaluation of being based on best available information. Similarly, Chapter 2 – Background Information, was only generally reviewed and the panel makes no assertion as to whether it provides the best available background information. The peer review was focussed primarily on Chapters 3 and 4. Even within those chapters, there were important sections that were not within the scope of the peer review because they were presented as policy and therefore not subject to review (*e.g.*, operating schedules on p. 41). Similarly, technical details of the recovery and prevention strategy (p. 68-70 were not rigorously reviewed, because important technical details such as details of CERP elements and models used to predict post-CERP performance (*e.g.*, in Fig. 19) were not made available in the document or in the meetings – presumably because they are included as policy and/or outside the scope of this review.

However, given all these caveats and clarifications, the panel did have a number of comments that can be considered to generally address the question as to whether the document provided a generally sound initial basis for setting initial minimum flows in the Caloosahatchee Estuary. They are presented below.

(Edwards) The District and staff should be commended for a thorough, well-written document. They did and excellent job of providing the information needed to understand the situation and issues pertinent to the Caloosahatchee Estuary. The document could benefit, as can almost any document, from being edited and rewritten with slight changes. It could be improved by more clearly separating policy issues from scientific issues. The portions describing the actions to be taken to avoid significant harm are very nebulous. It is not clear at all as to what actions, and under what circumstances will the minimum flow be provided to the CE. Even with careful reading, the information on implementation of minimum flows is not sufficient. The conclusions and summary should be rewritten so that they are more clear and concise; a reader should be able to read those sections alone and fully understand the proposed plan.

(Lung) The material presented in the draft report is scientifically sound in terms of the technical approach of developing the minimum flows and levels for the Caloosahatchee River. The use of one species of submerged aquatic vegetation, *Vallisneria* is practical and concise. While there are many living resources in the estuarine system, it is impossible to include multiple species at the present given the extent of the available data for the assessment.

(Montagna) As outlined in the "Peer Review Panel and Advisory Expert" statement of work, a review is requested of the "Technical Documentation to Support Development of Minimum Flows and Levels for the Caloosahatchee River and Estuary." The statement of work asks three general questions: Is the MFL document based on a scientifically defensible approach? Are criteria supported by best available data? Are there other approaches to set criteria for a MFL?

(Montagna) Overall the technical document was well written. In fact, it was the best document of this type the reviewer has ever read. The District can be proud of the efforts put forth by the staff.

(Montagna) My overall opinion is that the document is scientifically sound, and while there are always other approaches (because there are many ways "to skin a cat") the document presents clear, logical, and scientifically correct arguments for basing the MFL on *Vallisneria americana* (commonly referred to as tape grass or wild celery).

(Windom)The use of *Vallisneria* as an environmental indicator of MFL in the Caloosahatchee estuary appears to be appropriate and scientifically defensible, but there are a few issues that still need some attention in the report and in the application of this strategy (i.e. the use of *Vallisneria*). The staff has done a very good job of bringing together a considerable amount of information, but occasionally information or data only alluded to in the report perhaps needs a bit more detail. In a few cases, there may be a need to gather additional information/data.

B. *Are the concepts and approaches sound?*

(Edwards) Although selection of tape grass as a VEC is based on sound thinking and some good science, it leaves a lot to be desired. It is not necessarily that it has to be a case of “either or”. Selection of the tape grass VEC does not have to be either accepted completely as the *sole* consideration, or it has to be rejected. My suggestion is that the approach of using tape grass to estimate minimum flow requirements be adopted, but that the approach be made much more robust by improving the tape grass approach with more study and research on tape grass. More importantly, the approach should be broadened and made more robust by including other, supplemental considerations into it. As amplified in other comments (section II.3.), the selection of tape grass, although based on sound reasoning, as the *sole* consideration for establishing minimum flows is therefore not based on best available information. However, with the addition of a few additional considerations, the setting of minimum flow could be easily considered to be sound and based on best available information.

(Montagna) A scientific approach to set a MFL requires a clearly stated management objective or goal, a methodology to collect and evaluate data to support criteria developed for the goal, a predicted outcome caused by the MFL, and a strategy to monitor ecosystem response to determine if the MFL had the desired effect in achieving the management goal (Montagna et al., 1999). Development of the goal is based in part on definitions of significant, which is a policy issue. Once the definition is set, a goal can be developed for the ecosystem in question.

(Montagna) For the CE, definitions of stress, harm, serious harm, and significant harm are clearly stated, more than once, in the technical document. Given these policy determinations, the management goal can be set. The valued ecosystem component (VEC) approach was used to set the management goal. The VEC is an excellent approach to setting MFL criteria. The VEC is based on the keystone species concept, which is one the few very rigorous ecological principles. In fact, this principle was created from studies of rocky intertidal shores (Paine, 1966) and is one of, if not the, most important contribution of marine ecology to ecological theory. A keystone species is one whose presence or abundance regulates or controls the presence or abundance of other species in an ecosystem. This is caused by ecological processes, *e.g.*, competition, predation, mutalism, commensalism, or parasitism. The document makes a persuasive case that tape grass is a keystone species in the CE. It is well know (and describe fully in the document) that submerged aquatic vegetation (SAV), *e.g.,* tape grass, provides critical habitat for many important species and contributes a significant proportion of the primary production of aquatic environments. The productivity fuels the grazing food web by herbivore use and the detrital food web when it dies or sloughs off and is decomposed by bacteria and fungi.

(Montagna) Having selected criteria, the next step is to determine how tape grass responds to inflow so that a MFL can be evaluated. The methodology used in the document is based on three linked models: an inflow model, a salinity model, and a tape grass model. The output of the inflow model is used to predict modeled salinity. The output of the salinity model is used to predict tape grass shoot abundance. Significant harm is defined as tape grass loss over three years. Reruns of the models were used to predict tape grass abundance changes that might occur with changes in future land use and water management strategies. Based on these reruns, 300 cfs would provide appropriate salinities for tape grass to flourish between November and March.

(Montagna) The methodology is sound, but fraught with uncertainties, because the key output (tape grass abundance) is estimated based on three other estimates. Unfortunately, variance of multiplied estimates increases exponentially. On one hand the estimates may be accurate, but on the other hand the precision range is enormous. This is like a dart thrower using progressively larger targets to increase his score rather than being able to hit a small bulls-eye consistently. The main flaw in the document is not providing an error analysis of the total modeling approach. Uncertainties, which are inherent in modeling, do not invalidate the methodologies used to calculate the MFL. They simply provide the basis and need for additional studies and monitoring. Models can be improved with new understanding, and additional data can be acquired to calibrate and validate the models.

(Montagna) Each of the models requires technical review. Long-term (i.e., 1965-1996) inflow rates are predicted based on a very small data set (1995?) of measured inflow for 1995 land use. Another small data set on measured salinity and inflow is used to predict an empirical relationship between inflow and salinity over the long-term. Growth rates of tape grass measured when exposed to different salinities is used to calculate tape grass abundance.

C. *Are criteria logically supported by best available information?*

(Edwards) The term “best available information” is a complex and frequently misunderstood and misapplied term. The two adjectives, “best” and “available” should be considered separately, as well as conjunctively, in order to assess if something is based on the best rational and scientific understanding reasonably possible. In the specific case of setting minimum flows, an approach, such as the use of a single VEC, itself might be based on the best information available for that VEC, but that does not mean that the approach is based on the best available information. That can be the case for two reasons. First, if the approach is based on a body of knowledge that is very limited, the use of even the best of that body of knowledge does not make the minimum flow *per se* based on the best available information. This is particularly true for an approach based on a technical area (tape grass physiology and dynamics) for which there is so little available information. There may be other information on other considerations for which good and valuable information is available and useful in best determining minimum flow.

(Edwards) As discussed in section I.2, assessment of whether a minimum flow to is determined based on best available information is an matter of sufficiency. The question that needs to be asked is whether or not the approaches are sufficient (in a formal logical sense) to estimate minimum flow. In the case of using the sole *Vallisneria* VEC, it is unlikely that it is sufficient. More importantly, the sufficiency of using this single VEC has not been determined, primarily because the effects of flow on the freshwater portion (upstream of S-79) and on the lower estuary and southern Charlotte Harbor have not been formally evaluated in the process. It may turn out, after proper consideration of these components of the ecosystem, that the Vallisneria VEC approach is sufficient, by virtue of providing adequate minimum flow to avert significant harm to those components. However, this degree of sufficiency has not been addressed in the document and plan. Additionally, the minimum flow plan based on the Vallisneria approach allows for 2 to 2-1/2 months (April, May and early June) with no minimum flow, and probably no flow at all in many years. Failure to address the very serious impacts and harm of such a regime would preclude the proposed plan from being considered to be fully based on best available information. Detailed comments on the freshwater component, the lower estuarine component, and the exclusion of April, May and June are provided in other sections below.

(Lung) The conceptual relationships among the terms Harm, Significant Harm and Serious Harm are logical. However, the individual definitions of these terms are vague. For example, how many years are 'multiple years' in the definition of Significant Harm? It appears that these definitions are written for the policy. The translation from policy to quantitative analysis is lacking.

D. *What major (non-editorial) additions, deletions, or changes should be made to the document?*

Other than general suggestions provided in section II.A., none of the panelists responded to this question.

E. *Are there other approaches to setting the criteria?*

(Edwards) Failure to include any consideration of possible impacts on the lower estuary (e.g., San Carlos Bay, Pine Island Sound, Matlacha Pass, and the lower Caloosahatchee River (downstream of the *Vallisneria* zone) would make the plan not rise to the level of best available science. Salinity models are available, and should provide the ability to model the salinity in the lower estuary fairly accurately, particularly with regard to no flow during April, May and June. That information could be analyzed in light of important juvenile fish habitat (*e.g.*, spotted seatrout) and relative to the general understanding of how low or no flow and resultant high salinity conditions would affect the bays (plankton ecology, energy inflow, nutrient input, etc.) All of this could be done over time from the literature, with perhaps a few key studies done in the CE. That way the District could at least identify potential problems, further assess those problems, and at the very least will be able to say that it did its best to not just ignore them. It is in the best interest of the environment and of the District to be thorough. Those lower estuary components are part of the Charlotte Harbor ecosystem; Charlotte Harbor is part of the National Estuary Program. It is unimaginable that potential impacts of low spring/early summer flow from the CE can be disregarded. All of this should be done in addition to using the *Vallisneria* VEC approach. Ultimately, it may be shown that minimum flows required by *Vallisneria* also prevent significant harm to lower CE (probably only if minimum flows are provided during April, May and June). However, until such an analysis is performed, the plan cannot be considered to be based on best available information.

(Edwards) Similarly, failure to consider effects of flow on upstream (above S-79) portions of the system is a major weakness of the system. During the periods in which a minimum flow of 300 cfs or more is set, it is reasonable to conclude that significant harm will not occur in the freshwater reaches. However, again, the period of April, May, and early June is a period of increased sunlight, temperature and overall biological activity. Severe ecological and water quality problems can be expected to occur if there is no flow during April, May and June. Failure to consider and evaluate the potential for significant harm in the freshwater portions of the system makes any such plan not based on best available information.

(Lung) The USGS has developed a hydrodynamic model for the Charlottes Harbor (Goodwin, 1996). The model domain includes the Caloosahatchee River Estuary. Results from that study should be included in the report for an independent check of the salinity predictions presented in the draft report.

(Lung) Comments by Bruce Boler of Florida DEP raised the issue of water quality of the Caloosahatchee Estuary. Apparently, existing water quality conditions of the Caloosahatchee River and Estuary has not been fully discussed in the draft document by the SFWMD staff. The draft report focuses much on the living resources as opposed to water quality.

(Lung) Salinity prediction is one of key elements in this quantitative assessment. The methodology used by the District and presented in the report should be changed to a mass balance based model. See the specific comments on salinity predictions.

(Montagna) Tape grass may not be the only keystone species in the CE, and more than one species could be used as the VEC to calculate the MFL. Commercial, recreational, and charismatic species have been used as the VEC in other areas. Tape grass however, does have several very important advantages as a VEC for the CE. It is persistent, sedentary, relatively salt-tolerant for a freshwater species, and has characteristics that are easy to measure and monitor. Tape grass is also sensitive to high salinities resulting from low inflow conditions, which is the most important species characteristic necessary to set a MFL. Each estuary or area in Florida, and the US as a whole, will likely have different keystone and VEC species because species are adapted to live where they live.

(Montagna) Overall, the basic approach is sound as is related in my answer to question 1. I don't know that there is another basic approach. The methodology of linking physical models of flow and salinity to biological models of biotic responses is the only methodology that has been used in other MFL studies in a variety of locations around the US.

(Windom) During Panel deliberations, during the public meeting in Ft. Myers, the question was raised as to whether or not water quality could or should be used as criteria for assessing MFL in the Caloosahatchee. The water quality issues pertain primarily to the region immediately upstream of S-79 where the public water supply intake for Ft. Myers is located. The report alludes to this issue (p. 45 and elsewhere) but there are few specifics provided.

(Windom) There are likely to be data on water quality (i.e. salinity, nutrients, algae blooms, etc.) in this region for various discharge rates through S-79. The report implies that the preliminary estimate of MFL to maintain the *Vallisneria* production target is sufficient to minimize the water quality problems that occasionally occur and which affect the public water supply. But an analysis, using existing data, should be provided.

III. Major Technical Issues

A. Salinity Models

The following discussion was provided by Lung. Any additional comments by other panel members are specifically noted.

Salinity Predictions of the Caloosahatchee Estuary

Introduction

The South Florida Water Management District (SFWMD) uses a regression model to predict salinity levels in the Caloosahatchee Estuary under steady-state conditions as part of their work to establish minimum flows and levels for the Caloosahatchee River and Estuary. The model relates the salinity levels in the estuarine system to the freshwater flow rate (in cfs) at S-79. The salinity concentrations predicted by this model represent the steady-state, laterally and vertically averaged levels in the water column.

Bierman (1993, 1997) developed a 1-D dimensional salinity model using the WASP framework for the SFWMD. In that model, the water column is divided into 42 completely mixed segments along the estuary from S-79 to the mouth of the river. First, the hydrodynamic module, DYNHYD was used to simulate the tidal velocity field in the estuary. Second, the EUTRO module of the WASP model was configured to perform mass transport calculations for salinity under dynamic conditions. To support the model calibration analysis, salinity data collected in 1992 were used for comparison with the model results. Bierman (1993) also stated that salinity differences in the vertical direction are insignificant based on the data to justify the depth-averaged model configuration.

Results from the WASP model were compared with observed salinity data in 1992 at 4 locations: Mark H, Ft. Myers, Bridge 31, and S-79. The model results reproduce the temporal trends of salinity levels at these 4 locations. Note that the model results should be construed as daily average salinity concentrations. The temporal trends of the salinity show the response of the system to the time-variable nature of the freshwater flow at S-79, reflecting a wide variation of salinity levels between 0 and 25 ppt in the estuary during 1992.

Regression Model vs. Mass Balance Model

The model was developed using measured flow from S-79 and salinity at the Ft. Myers Marina (22 km upstream of Shell Point) for the period from January 1992 to November 1999 (SFWMD, 2000). The following regression is the salinity model:

$$y = ae^{-bx} + ce^{-dx}$$

(1)

where

y = salinity (in ppt)
x = 30-day back-averaged flow (cfs) at S-79
z = distance upstream of Shell Point (in km)
a = 19
b = 0.002
c = 150
d = 0.25

It is clear that Eq. 1 is a black-box model relating little to the physical insights into the estuarine hydrodynamics and mass transport which is the essence of the salinity prediction. First, the empirical coefficients, a, b, c, and d have no physical meaning. Second, how could the equation be used to predict salinity at any location, x in the estuary if the model is developed using only the salinity data at the Ft. Myers Marina? Even the most basic principle of regression is violated.

Being an empirical model, the regression equation developed by the SFWMD does not and cannot take into account the following factors:

1. Downstream boundary, i.e., salinity levels and tidal conditions at the mouth
2. Wind stress on the water surface
3. Dynamic characteristics of the system response to flow changes
4. Water withdrawal and release below S-79
5. Volume of the water column and duration of the flow changes.

The regression model is steady-state model while the estuarine system rarely reaches a steady-state condition for a good period of time. Lacking these attributes, the predictive capability of the regression model is quite limited. On the other hand, the 1-D salinity model based on the WASP modeling framework is a mass balance model, simulating time-variable salinity concentrations in the water column.

The 1-D salinity model developed by Bierman (1993, 1997) is a timer-variable model and based on the dynamic balance of salt in the entire estuary and is more robust and rigorous than the regression model, Eq. 1. Because of its dynamic nature, the lag time of the freshwater flow on the salinity levels along the estuary is also accounted for. On the other hand, the backward 30-day average flow used in the regression model is not realistic and cannot be used for locations in the estuary under a wide range of freshwater flow rates at S-79. For example, it takes less time for a given freshwater flow rate to impact the salinity at 5 km downstream from S-79 than the salinity at 10 km downstream from S-79. The regression model does not differentiate this because it uses a 30-day average flow rate for all locations.

Hydrodynamic modeling of estuaries has advanced rapidly in the past decade that more sophisticated models are available to simulate salinity concentrations in 1-D, 2-D, or 3-D configurations. For example, Goodwin (1996) developed a hydrodynamic model to simulate tidal flow, circulation, and flushing of the Charlotte Harbor. The Caloosahatchee River Estuary is included in that model which has been calibrated and verified against field observations of stage, discharge, and velocity. Another ongoing modeling effort at the University of Florida with funding from SFWMD is developing a 3-D hydrodynamic model for the Charlotte Harbor (see SFWMD, 2000). Although no model results are available at the present time to assist the development of minimum flows and levels for the Caloosahatchee, the model can be used in the future to assist the SFWMD staff in refining and updating the MFLs.

In conclusion, the 1-D salinity model by Bierman (1993) represents the best available model at the present time to simulate the salinity levels in the Caloosahatchee Estuary and should be used to do assist the development of MLF at the present time. It is also suggested that the model being developed by the University of Florida be used to refine the salinity simulations for the Caloosahatchee Estuary once it is available (i.e., fully calibrated). Given the importance of salinity predictions in establishing the MFL, more quantitative tools such as the hydrodynamic models should be adopted.

Finally, I would use a somewhat similar modeling experience in Virginia to make my point. In 1970's, river basin plans were developed in Virginia using a multiple regression equation as follows:

$$Y = 10138 \frac{(DO_{mix})^{1.094} Q^{0.864} S^{0.06}}{T^{1.423} (DO_{sag})^{1.474}}$$

(2)

where Y = assimilative capacity of the stream (lb BOD/day; 10138 = regression constant; DO_{mix} = in-stream dissolved oxygen concentration (mg/L) following complete mixing; Q = sum of stream flow and waste flow (cfs); T = stream water temperature ©; S = stream bed slope (ft/ft); and DO_{sag} = minimum allowable DO of the stream (mg/L). In addition, 1.094, 0.864, 0.06, 1.423, and 1.474 are regression coefficients.

The justification for using Eq. 2 to quantify the assimilative capacity in the Virginia rivers and streams by then Virginia Water Control Board was lack of quantitative methodology and data. Twenty-five later, Eq. 2 was replaced by a mass balance-based BOD/DO model of streams (Lung and Sobeck, 1999).

Mass balance-based salinity models are widely used in practice these days and they should be used in assessing the MFLs for the Caloosahatchee River Basin.

B. Tape Grass Biology and Model

(Montagna)The MFL of 300 cfs is ultimately based on the model to predict tape grass growth. So, the important question is how good is this model? There are at least three important assumptions: salinity is the limiting and controlling factor when it is above 9 or 10 ppt, there is no spatial or age class variability in growth rates, and factors not included in the model do not affect growth rates. These assumptions are acknowledged as not being robust. The document states "the model was not intended to reproduce an annual cycle of abundance of shoot density" (p. 55). Yet it must do so to because the goal is to allow tape grass to flourish in the spring. To "work around" this limitation, shoot density is reset to $80/m^2$ every October. The limitations of this approach were evident during the review panel field trip. On September 28, 2000, Robert Chamberlain estimated the density was about $20/m^2$. It is unlikely that it would increase by $60/m^2$ over the next three days as the model assumes.

(Edwards) The modeling and understanding of tape grass dynamics and responses to salinity leaves a lot to be desired. Several of the problem areas have already been pointed out. As pointed out above, one of the most serious problems is the resetting of the model to 80 shoots/m2 every spring, independently of what has happened in the previous year and years. This resetting does not seem to be based on best available information. It is based on no information. However, that aspect of the model can and should be studied and modified through field and laboratory studies.

(Edwards) the understanding and modeling of tape grass dynamics so far has been restricted to static or steady state salinity conditions. Tape grass may respond very differently to a mean salinity of 15 ppt that is based on a regime varying from 5 ppt to 25 ppt over periods of several days, than it would to a regime of an almost constant salinity of 15 ppt. The former is much more realistic and comparable to what would be expected to occur in the CE, yet the effects of such regime are essentially unknown.

(Edwards) The *Vallisneria* model used a maximum shoot density (K) of only 120/m2, whereas, Bortone and Turpin (2000) seemed to have reported much higher densities in the Caloosahatchee, and Zamuda (1976) reported a seasonal mean of 200 shoots/m2 in the Pamlico Estuary. Clearly 120 shoots/ m^2 is not very dense, and represents shoots each separated by 8 to 10 cm (3 to 4 in).

(Edwards) Setting significant harm as occurring when shoot density is only 20/m2 may be arbitrarily too low. This low density of shoots would provide very little habitat value to many other SAV-dependent VECs. A higher value of K in the model might result in shoot density decreasing more rapidly when salinity was high. In any event, this points out the uncertain nature of the model on which the minimum flow is proposed to be set. This is another aspect of the plan that does not rise to the level of best available science, although it could and should be brought to that level with field studies that can be feasibly conducted. It is very likely that any reasonable estimate of threshold at which habitat value of tape grass is harmed would be much higher than 20 shoots/m^2.

(Montagna) The strongest part of the tape grass model is the relationship between growth rate and salinity, which was measured in vitro in mesocosm experiments. Growth rates for two different conditions were measured, so the model can accommodate temporal variability of net growth rates at a seasonal scale, wet or dry. Variability of the intrinsic growth rate on shorter temporal scales ranging from diel to monthly are not know, but are likely to exist. The model is empirical, simulating growth as a function of salinity, but includes sloughing of leaves. This is important because sloughing is likely a very important demographic feature of tape grass populations. Sloughing, which is natural, may also be the dominant cause of loss of tape grass in fall.

(Montagna) Validation of the model was a relative weakness. Shoot abundances in the field were measured and compared to model predictions over a 9-month period from October 1998 to June 1999. Unfortunately, there was no statistically significant correlation ($p = 0.106$) between modeled and measured shoot abundance. The model did predict the maximum shoot abundance and the general seasonal trend, but underestimated the lowest shoot abundance. Overall, the variance of measured shoot abundances was so great that a constant value of shoot abundance would have likely done as well as the model. There are two problems: insufficient replication of measured shoot abundance and calculation for insufficient cycles of the model. A simple solution is more data, because power to detect change increases with sample size. Additional data is needed to improve calibration and validation of the model. More data from the manual field monitoring and the acoustic mapping could be used to improve the model coefficients and validate the predicted shoot densities.

(Montagna) A complete, life cycle and physiologically based, model would be a substantial improvement over using just salinity in the growth rate model. Such a model would include the demographics of the SAV and the energetic responses to nutrients and light. The current model includes just two aspects of the demographics: salinity tolerance and sloughing, but none of the energetics. Other important demographic parameters include losses to herbivory and age *(i.e.* leaf length) class structure. Including energetics would allow modeling the plant at salinities below 10 ppt, which would improve the ability to predict shoot density year-round. Whereas the complete approach is common for terrestrial plants, the authors know of only one study that has done this for SAV (Kaldy and Dunton,1999; 2000; Kaldy *et al.*, 1999). So, this is a research recommendation, not a criticism of the current effort. The current model is a good start, using the best currently available data.

C. Bathymetric Considerations which May Relate to the Use of *Vallisneria.*

(Windom) There appears to be sufficient data to suggest that the growth of *Vallisneria americana* is a sensitive indicator of salinity for the purpose of managing MFL in the Caloosahatchee Estuary. The information supporting this, as presented in the document has been, however, obtained mainly from experimental observations. These observations, along with a simple salinity model (discussed more fully elsewhere in this review), have been used to predict minimum flows through S-79 necessary to maintain *Vallisneria* at a density above 20 shoots/m^2.

(Windom) The concern is that minimum flows predicted using this approach may not reflect the overall cause/effect relationship between environmental conditions and *Vallisneria* growth as it exists in the estuarine region of the Caloosahatchee under consideration. This is mainly because there may be other environmental conditions and/or processes which may affect *Vallisneria* growth. The following summarizes other questions that should be addressed and information which should be provided to evaluate better the approach to assessing MFL, using *Vallisneria* as an indicator:

(Windom) It is clear that there must be some bathymetric control of *Vallisneria* growth in the Caloosahatchee Estuary if for no other reason than light penetration, but no information was provided which addresses this. A map of *Vallisneria* distribution in relation to depth (i.e. bathymetry) would be helpful in judging the potential effects of turbidity on growth as well as susceptibility of *Vallisneria* beds to erosion and sedimentation. This information would also be useful in interpreting results of future surveys of grass beds and there response to environmental change. For example, high discharge events could have significant effect on *Vallisneria* distribution due to erosion or silting of beds.

(Windom) A better description of the lateral salinity distribution in the vicinity of the *Vallisneria* grass beds is needed in relation to various discharge (i.e. flow across S79) conditions. It is likely, given the relatively long residence time of water in the upper estuarine region, that freshwater released through S79 will mix down estuary as a uniform front but channeling along one side of the estuary may be a possibility and should be addressed.

(Windom) Finally, the existence of relatively luxuriant stands of *Typha* along the North shore of the estuary in the vicinity of the *Vallisneria* beds suggests a sustained supply of freshwater. This could be the result of fresh groundwater seepage. If this is the case *Vallisneria* beds could be influenced more by groundwater supply than surface freshwater supply, although the temporal variability of the two inputs (for example during drought) may be similar. Groundwater seepage in coastal areas is also usually nutrient rich (Corbett et al., 1999; Cable et al. 1996; D'Elia et al., 1979) and submerged grass distributions are often influenced by the pattern of the seepage. While a study of groundwater seepage patterns in the vicinity of the *Vallisneria* beds is probably not warranted, some additional information addressing this concern is needed. A questions which might be answered easily is: Are grass beds (and *Typha*), allowing for bathymetric controls, more common on the North shore than on the South? Groundwater seepage is likely more important along the north shore.

D. Forms of Significant Harm

(Edwards) The specific definition of minimum harm on p.73 of the document: "Significant harm occurs if the habitat function of this community is lost for three consecutive years or more" is not supported by best available information. Although the panel was instructed to not consider the general definition of significant harm being that which occurred over multiple years, the point being addressed here is not the definition, but the use of incorrect scientific reasoning. That some species that utilize tape grass habitat have short life spans is not relevant. All of these species are part of larger populations for the CE and southern portion of the Charlotte Harbor system. Connection between significant harm and longevity would only be valid if the species under consideration were limited by spawning stock size. This is not the case with most important species in CE and Charlotte Harbor. None of the important species like spotted seatrout, red drum, snook, sheepshead, etc. are considered by the Florida Fish and Wildlife Commission to have such low populations in the Charlotte Harbor system that they are recruitment limited. Best understanding of such species' biology is that they are habitat limited, and probably limited by availability of juvenile habitat of the kind that tape grass can provide under proper flow and salinity conditions. The fact that a species would suffer lower populations if tape grass was reduced for even one year is independent of its life span.

(Edwards) The general definition of significant harm proposed by SFWMD is: "Significant harm is the loss of specific water resource functions that take multiple years to recover and result from a change in surface water or ground water hydrology." Does loss of significant abundance of organisms over multiple years constitute significant loss? If not, why not? If important populations are reduced by impacts occurring in one year, the loss will persist over the life span of the species impacted. For most the species that are important in the CE (*e.g.*, spotted seatrout, red drum, blue crab), little or no compensation (for the loss in one year occurs in subsequent years). Spotted seatrout is an important VEC that would utilize *Vallisneria* in the CE (if it were available in a high-density condition) as a nursery habitat in April, May and June. If say 20% of the young-of-the-year seatrout in the CE system were to be lost because of no inflow and resultant lack of tape grass habitat occurring in one year (or because zero minimum flow was required in April-June), the population would experience decreased abundance and size structure for at least four or five years, until the time at which that age class would normally have contributed little to the overall population (because their numbers would naturally have declined, due to natural mortality and fishing mortality, to a small fraction of the total population). By this logical analysis, harm that occurs due to lack of minimum flow in a single year would persist and therefore would take multiple years to recover. Therefore, such harm could be considered to be significant harm even under the proposed SFWMD definition.

IV. Specific Technical Issues

(Edwards) The aspect of the minimum flow plan that would disregard and not include the months of April, May and even June has little or no scientific justification. These are the times of lowest flow, highest biological activity, and greatest utilization of SAV by important juvenile fishes and crustaceans. The exclusion of those months from minimum flow is not based on best available information. For example, peak recruitment of postlarval pink shrimp occurs in spring and early summer (Bielsa, Murdoch and Labisky, 1993). Therefore, decline in *Vallisneria* in April, May and June would be extremely serious. Under the proposed plan and definition, serious harm could occur every year to pink shrimp, because *Vallisneria* would be greatly impacted by high salinity that would occur during those months in which minimum flow is not required or provided. Also, adult and juvenile blue crabs would suffer from declines in tape grass coverage and density that would occur during April, May and early June, if no minimum flow was provided.

At most, the exclusion of May, June and July is based on some idea that tape grass can withstand exposure to high salinity for weeks, but even that information is not quantitative with regard to the ultimate effects on tape grass dynamics (e.g., whether it is appropriate to reset the model to 80 shoots/m2). Doering *et al.* (1999) concluded only that *Vallisneria* could withstand salinity of 15 ppt for 6 weeks. The period not covered under minimum flow requirement could be 9 to 12 weeks, depending onset of rainy season conditions. It is possible that a constantly low salinity regime and a constant or averaged 300 cfs may not be needed or desired in April, May and in early June (during years when the rainy season onset is delayed). The document presents little in the way of information to support the exclusion of those months, even from the standpoint of *Vallisneria* dynamics, let alone from considerations of the tape grass dependent VECs, the lower estuary, and the freshwater riverine component.

Under the proposed minimum flow plan, no minimum flow is required during the May-June period. The impacts of no flow on the upstream, freshwater portion of the system are completely neglected for that time period. It very hard to imagine that the Caloosahatchee River would not be adversely effected by almost three months in which there could be no flow. Like the tape grass biota issue, this issue of minimum flow requirements of the freshwater river should be added to the overall plan, but not at the expense of rejecting the *Vallisneria* VEC approach. To fail to consider this issue, would make the setting of minimum flow have to be considered to not be based[6] on best available information.

(Edwards) *Is 300 cfs really the best estimate for minimum flow?*— Earlier work by Chamberlain and Doering (1998) suggested that 300 cfs would only serve to maintain

[6] Again, refer to footnote 1.

Vallisneria in the system. They stated: "Discharges that approach 400-500 cfs will provide salinity conditions of ≤ 10 ppt within the portion of the estuary that support most of the total V. americana coverage. To provide salinity conducive for V. americana throughout its entire 18 km range will require mean monthly discharges of approximately 800 cfs." They also stated: Analysis of historical S-79 discharges determined that attaining the 300 cfs (required to maintain Vallisneria in the system) minimum inflow will be a concern only during the November-May period." This analysis was made using the Bierman (1993) hydrological model. Apparently, part of the reduction from recommended discharges of 400-500 cfs above was due to shifting to the use of Chamberlain's statistical salinity model. This Peer Review report strongly supports the utilization of the former model, and doing so might then lead to the logical conclusion that minimum flow should be nearer the formerly recommended 400-500 cfs. This is particularly worthy of consideration in view of the uncertainties in the *Vallisneria* model (as detailed in section II.B). Incidentally, Chamberlain and Doering (1998) indicated the need for minimum flows during the period December-May, instead of during the period of November through March. In numerous reports and publications, SFWMD scientists have recommended minimum flows ranging from 300 to 800 cfs during the dry season, not just during part of the dry season.

(Edwards) In reviewing many of the earlier documents, it appears that there has been an effort or at least some propensity to over time continually reduce the estimates of minimum flow and to shorten the duration of the season in which minimum flow would be required. Pressures to tighten estimates in these directions are probably not unexpected in an agency that has to balance multiple uses and values of water resources. The prevailing philosophy in resource management, recognizing that high levels of scientific uncertainty are normal, has become one of precautionary, conservative approaches toward establishing resource management criteria. A precautionary approach toward setting minimum flows in the Caloosahatchee would be more in line with best available information than a finely honed attempt to estimate the very lowest minimum flows possible.

(Edwards) One of the main justifications for using tape grass submerged aquatic vegetation (SAV) as the basis for establishing minimum flows was that SAV is important as habitat for other VECs, such as fish, shrimp and crabs. However, SFWMD has little or no information on this, or else they chose to not present what they have. SFWMD biologist Robert Chamberlain has been studying fauna for years, but no information or data was presented in the document. The ecological value of tape grass should be verified in the CE, and study of how salinity regime affects organisms utilizing the tape grass should also be made. It is of little value to protect tape grass, if the minimum flow salinity regime results in a significantly harmed biota. The greatest harm to tape grass biota probably would come from too much flow and salinities that were too low. However, this should be determined by studies that should be started immediately.

(Edwards) Public comment and documents (letter of September 8, 2000 from E.F. Stallings, Ph.D. to S. Burns, SFWMD) raised the issue of the proposed definition of significant harm and the minimum flows set under this definition resulting in harm to

Manatees. Manatees are attracted to the warm water discharge of the electrical power generating facility near the areas of highest tape grass abundance in the CE. The effect of reduced tape grass biomass (as allowed by the District's definitions of harm) on Manatees is beyond the expertise of anyone on this panel. However, it is an issue that should be carefully explored by expert manatee biologists. Also, the letter makes a strong point that when it comes to an endangered species, the District may not be at liberty to define significant harm strictly on a policy basis.

(Lung) Specific comments on the three-dimensional modeling of the effects of various freshwater flow regimes in the estuary.─First, it should be pointed out that only a one-dimensional methodology of predicting salinity levels in the Caloosahatchee Estuary under steady-state conditions is presented in the draft report. That methodology is based on a regression formulae relating the freshwater flow at S-79 and the salinity level at a given location in the estuary. See a separate write-up for comments on salinity predictions.

(Lung) Specific Comments on implementation.─In light of the fact that very limited data are available in the analysis (particularly in the salinity predictions), additional data collection is needed once the MFLs are finalized and implemented. Further, the Vallisneria growth has not been verified with data. That is, model coefficients, K, r1, and r2 in the model must be verified with field data. At the present time, there are three artificial knobs in the model, i.e., resetting blade length, shoot density, and blade density at the start of the dry season. Because of these knobs, the predicting capability of the model is significantly reduced. In fact, resetting these parameters may easily violate mass balance in the system.

(Lung) Specific Comments on Post-Audit.─Like many wastewater treatment plant upgrade projects, it is necessary to conduct a post-audit study to assess the impact of the MFL on the Caloosahatchee River Estuary ecosystem. To support a post-audit, continuing field monitoring is required so that the pre- and post- implementation of MFL data can be compared to detect any significant changes in the ecosystem, using statistical methods.

(Lung) In additional to comparing the field data, the models such as the salinity prediction model and Vallisneria growth model must be reviewed again to determine if they could predict the changes, if any, following the implementation of the MFL. This is particularly important as the growth model presented in the draft MDL report is not supported by any data. How do we know the growth predictions are correct?

(Lung) Specific Comments on Water Quality of the Caloosahatchee River Estuary.─Discussions on water quality of the Caloosahatchee River and Estuary are insufficient as pointed out by Bruce Boler of Florida Department of Environmental Protection (FDEP). Since the water quality in the Caloosahatchee Basin is not just threatened by altered freshwater inputs, nutrient loads, etc. parts of the estuary, the river and a number of tributaries are "impaired" due to exceedances of water quality standards.

Data from FDEP's 305(b) report and 303(d) report should be used and included in a discussion of the water quality conditions in the SFWMD's final MDL report.

Further, an assessment of the impact of the MFL on the water quality should also be included in the final report. Such an analysis may be performed in conjunction with the TMDL studies currently being conducted for the Caloosahatchee River Basin. That is, data and model results from the TMDL studies should be used in the assessment.

V. Implementation, monitoring and adaptive management

(Edwards) FS 373.0421 states: "Minimum flows and levels shall be reevaluated periodically and revised as needed." In view of the early developmental stage and uncertainty of the models and biological information on which the CE minimum flow is based, any plan accepted and based on this document should be reviewed and modified within 5 to 7 years.

(Edwards) During that time (5-7 years), research essential to improving and refining the plan should be conducted by the District. Three main areas of research should be included: 1) additional studies of *Vallisneria*/salinity relationships, including responses to variable salinity regimes, 2) studies of macrofaunal utilization of *Vallisneria* relative to tape grass density and ambient salinity regime, 3) studies to determine optimal timing and delivery patterns for minimum flows, so as to optimize the effects on tape grass and associated important VECs like juvenile fishes, shrimp and crabs, and improved salinity-flow models.

(Edwards) It is not very clear as to whether the independent scientific peer review described in FS 373.042 is to also consider and evaluate the scientific basis for a "recovery or prevention strategy" described in FS 373.0421. However, the Caloosahatchee MFL Peer Review Panel was not provided with full technical details of the proposed recovery plan. For example, the models used to estimate flows attainable by CERP year 2020 with restudy (Fig. 19) were not presented to the panel for review. Therefore, the panel is not presenting conclusions as to the recovery strategy being based on best information available. This includes the short term recovery strategy that will cover up to 20 years of time. During that time it is likely that significant harm, even by the most liberal definition (liberal in the sense that harm must be extremely great before it is considered significant), will occur very often and very intensively. The report suggests that some steps to ameliorate the harm during the period before the CERP modifications are completed, but the report is very vague as to how that would be attained. The panel cannot determine if the recovery strategy itself is based on best available information or sound scientific reasoning. If such consideration, review and technical opinion is needed, it will require a separate review process.

(Edwards) SFWMD has plans for a major re-plumbing of South Florida (CERP). Based on their plans for the CE and for the related impacts due to the Everglades restoration program, the District hydrologists used a land-use, spreadsheet model to estimate CE flow using historical rainfall, projected (2020) land use patterns, new structural changes, etc. Figure 19 seemed to show that they the system would attain good minimum flows and very rarely damage the modeled *Vallisneria* growth/density. However, the panel was not presented with any details of the flow model. Therefore, we must be clear that we have not included that aspect in any assessment of best available information. What we have done, is almost completely restrict our review, analysis and report to elements 2a, 2b, 2c, and slightly to 2d. That is what we were instructed and led to do by our instructions and the document. It needs to be clearly stated that the panel is not putting any sort of best available information stamp of approval on the part of the plan that says that the capacity for providing 300 cfs (or any other flow) will ever exist. As a matter of fact, those modeled flows and modeled tape grass impacts are based on 2020 population and land use – about the time that the all the structural changes to the system will go online. SW Florida, and particularly the Ft. Myers to Naples area, is one of the fastest growing areas in the nation. We have no idea what will happen to water availability to the CE after a few years of growth. So the plan starts to become inadequate or obsolete almost immediately after it begins. The panel was not given anything or asked to review anything having to do with actual implementation of a plan to provide CE minimum flows. Therefore, we do not offer any conclusions as to the implementation being based on best available information.

VI. Editorial Suggestions

General: The document would benefit from the addition of an executive summary. The conclusions at the end provide most of what should be in the summary, but the reader would be helped by knowing in advance what conclusions were drawn from the study.(Windom)

General: A list of acronyms used in the document should be provided up front. Most are defined once in the document, but some are not as best as I can tell. It gets a bit tedious to be flipping through pages looking for where an acronym is defined. (Windom)

General: It would be helpful if a consistent set of units were used throughout. For example, flow is referred to in cfs, acre ft., and MGD. All could be used, but referenced to one so the reader could make better comparisons. (Windom)

General: The text is very redundant. Some of this is necessary, but not all of it. (Windom)

Page 9: *last line of the paragraph*: Table 1 does not include winds and relative humidity data

Second paragraph: Missing word in fifth line (awkward sentence)

Page 10:

Second paragraph: “Lake Flint” and “Beautiful Island? And other locations don’t mean much for a reader who is not familiar with local geography. They’re not indicated in Figure 4.

Page 11: There is no Legend for Figure 4. Worthless without that.

Paragraph Two: It would be useful to indicate locations of locks on the map (Figure 4)

Penultimate line: Missing “in” after “use”

Page 12: Figure 5. A little busy.

Page 14: *First paragraph*: The fluxes that are discussed in this paragraph are not related to geography. They must refer to a tidally influenced area and should be indicated as such.

Page 15: I would suggest enlarging this figure to a full page. It’s difficult to see any patterns well.

Page 16: *Second paragraph under “Lake Okeechobee”*: The third sentence is not clear to me.

Last paragraph: Use same nomenclature as shown in Table 2 (e.g. Level 1, 2, 3, not Level I, II, III).

Page 19: *First paragraph under “Water Supply”*: What about submarine groundwater discharge from the unconfined surface aquifer system? Any estimates of this loss? (Windom)

Page 20: *Second paragraph*: What’s MIKE SHE?

Table 4: Why is greatest public supply use during the November-May part of the year? Probably something should be said about this. (Windom)

Page 22: *Fourth paragraph*: What about nutrient inputs to the estuary associated with submarine groundwater discharge. (Windom)

Page 25: I’m surprised that endangered plant species (e.g. orchids, ferns, etc.) are not mentioned. (Windom)

Page 26: *Table 5*: Can you produce a floral list like this? Plants are in far more danger than animals *vis a vis* water; they can’t migrate. (Windom)

Page 38: *Last paragraph, third sentence*: I don't believe this is a true statement under any circumstance much less here. The statement has really no meaning as far as I can see. I do agree with the next sentence though. (Windom)

Page 40: Where is C-19? It doesn't show up in Figure 5. *Penultimate paragraph; last sentence*: I don't understand what 1.25 inches of drainage means. Is there a time term missing? (Windom)

Page 44: *Last paragraph*: This doesn't seem to agree with discussion on page 21, regarding water supply. (Windom)

Page 46: *Second paragraph, first sentence*: "…thus include protection (of) natural systems…"(Windom)

Third paragraph, second sentence: Drop one "and" (Windom)

Page 48: *First paragraph*: Here again is the statement suggesting that the health of the estuary reflects the health of the watershed. I don't believe you can support such a statement. (Windom)

Page 49: *Second full paragraph, penultimate full sentence*: Too many "the"s.
First bullet: Surely estuarine species can tolerate 2-3,000 cfs for some period. A duration specification needs to be added to this statement. (Windom)

Page 52: *Next to last bullet*: I don't understand this comment. You either need one or you don't. What does "but not an extensive persistent one" mean? Pulsing freshwater? This would imply a zero discharge at S-79 is okay from time to time. The last bullet appears to contradict this bullet. (Windom)

Page 54: *Last bullet*: Remove one "to". (Windom)

Pages 60-62: The downstream location for the purpose of assessing harm is very confusing. The document switches, between miles and kilometers. Which is it? (Windom)

Pages 63-65: Does this assessment of harm/significant harm take into account duration of salinity increase as discussed in the bullets listed on page 56. (Windom)

Page 65: *First sentence of this section*: Remove first "the". (Windom)

Page 66: *Last paragraph, second sentence*: "…occurrence (of) salt water…" (Windom)

Page 68: *Top of page 3*: Should be 14,835 not 124,835 ac ft. (Windom)

Table 1: The text is inconsistent with the table. Providing the range or standard deviation would be enormously helpful. Also, providing the evaporation rate would allow the reader to know instantly how positive inflow is relative to outflow. You must also state over what time period these averages were calculated. (Montagna)

Appendix A was not included with the text, it was provided as a separate attachment. It should be under one cover. (Montagna)

General: There is a mixture of English and metric units. Please provide both units everywhere to make the document more readable by the widest possible audience. The worst example is comparing Fig. 13 with Figs. 15 and 16. At first I thought this was two different places: 15 and 24 km, then I realized it was the same because 15 miles = 24 km. (Montagna)

Figs. 15 and 16: Salinity should be the same data, but they do not line up exactly alike. In particular, Fig. 15 has higher peak salinities than in Fig. 16. (Montagna)

VII. Summary and Recommendations

A. Summary

- The Peer Review Panel reviewed the development of minimum flows for the Caloosahatchee River and Estuary.
- The Panel highly commends the District and staff for the thorough and professional way in which the process was conducted and the document developed.
- The Panel's review was constrained (by the District's Statement of Work and instructions to the Panel) to not include definitions of harm or other policy issues.
- Technical issues, including selection of approaches for developing minimum flows, and evaluation of the degree to which such approaches are based on best available information, are greatly affected by definitions of harm and significant harm.
- A single valued ecosystem component (VEC), tape grass (*Vallisneria americana*) approach was proposed by the District as a way to set minimum flows.
- The panel agrees that this approach is logically and scientifically appropriate, useful, practical and feasible as a way to set minimum flows in the CE.
- The fact that the approach and concepts are sound does not and should not mean that other important, practical and feasible considerations should not be included in the process of setting minimum flows – it is not a case of either accepting the tape grass VEC as the sole approach or rejecting it.
- The Panel also recognizes uncertainties, weaknesses, deficiencies and inadequacies inherent in the single tape grass VEC approach.
- These uncertainties are not due to quality of science conducted and assembled by District scientific staff – the science conducted and assembled by the staff is excellent, but is limited in scope and depth.

- The uncertainties are due to more to the quantity of good science that is available on specific subjects critical to the approach including: tape grass dynamics, physiology, and ecological relationships to other VECs; and predictive modeling.
- The tape grass approach information, although very limited, as described above, is itself based on the best of the very limited available information.
- However, due to that limitation, use of a tape grass approach is insufficient in a logical sense, or at least it's sufficiency has yet to be shown based on best available information. In other words, the plan has not demonstrated or documented from best available information that prevention of harm to tape grass is sufficient to prevent harm to all other components of the CE ecosystem.
- Although it is unlikely that any other single approach would be better than the tape grass VEC approach, there are other considerations or approaches that could be practically and feasibly combined with the tape grass VEC approach to insure sufficiency.
- One of the important considerations that should be included in the overall approach to setting minimum flows is consideration of possible harm to the lower estuary components (*e.g.*, lower Caloosahatchee River (below the tape grass zone), San Carlos Bay, Pine Island Sound, and Matlacha Pass).
- The other important consideration that should be incorporated into the overall approach is that of the freshwater portions of the Caloosahatchee River above L-79.
- Neither of these two ecosystem components/considerations are necessarily protected from harm by virtue of tape grass protection.
- It may turn out that minimum flows designed to avert significant harm to tape grass can in fact protect the lower estuary and the freshwater river components. However, until that assumption is established by rigorous study and consideration of scientific knowledge, the plan would not be based on best available information.
- The panel recognized four overarching, major technical issues: 1) salinity modeling, 2) tape grass biology and modeling, 3) bathymetric considerations, and 4) forms of significant harm.
- The panel strongly recommends that a mass-balance modeling approach be used in predicting salinity and assessing minimum flows in the CE, instead of the empirical, statistical-regression, (black-box) modeling approach.
- The tape grass model, on which minimum flows are based under the proposed plan, is extremely limited and has numerous weaknesses (again, not because of scientific inadequacies of District staff, but because of inadequacies of pertinent scientific information on tape grass and tape grass modeling).
- Weaknesses noted in the model include assumptions as to: 1) salinity as the global limiting factor to tape grass growth and survival, 2) lack of variability from spatial or demographic factors, 3) lack of variability in salinity regimes to which the tape grass is exposed, 4) annual recovery to densities of 80 shoots/m^2, a threshold of 20 shoots/m^2 for harm.
- The modeling assumption of annual recovery to densities of 80 shoots/m2 is particularly troublesome, because it is based on assumption. It is particularly important because it is pivotal in assessing conditions under which significant harm occurs and if it takes multiple years to recover. By assumption, the model predicts

that tape grass will always recover every year to a relatively high density, but this may not be true.

- If the tape grass model is applied (as it should be) as a major part of the approach to setting minimum flows, field studies needed to refine the model must be conducted, and model validation must be performed.
- Upgrading the tape grass model to a complete, life cycle an physiologically based model is recommended.
- Bathymetry and related considerations were identified as highly desirable upgrades to the tape grass modeling.
- Bathymetry could also be important and necessary for modeling salinity in the vicinity of tape grass beds.
- Localized groundwater seepage should be investigated and, if found to be substantial, should be added to salinity models.
- The reasoning, based on life history and longevity, that significant harm would occur only if tape grass density were to fall below 20 shoots/m^2 in two successive years, is flawed and is not based on best available information.
- The threshold of 20 shoots/m^2 may be too low and, in any event, is not based on best available information.
- Even within the District's proposed definition of significant harm, it can be argued that harm to juvenile and young-of-the-year stages of important species can be incurred because of failure to provide minimum flow in one year or one season, and, furthermore, that such harm would persist over many years due to the impacts on local population abundance and size/age structure. It would take many years for populations so impacted to recover, and thus this could logically be considered to fall within the definition of significant harm.
- The exclusion of the months of April, May and June from the time during which any minimum flows are required is not based on a careful analysis of best available information, but instead on a vague idea that tape grass can survive exposure to high salinity for weeks. April, May and June are very important to many valued species. They should not be summarily excluded from consideration as to needs for minimum flows.
- There is reasonable doubt as to whether the minimum flow target of 300 cfs is appropriate. Earlier publications by District staff recommended flows in the range of 300-800 cfs, using the Bierman salinity model. Recently, the estimates have been continually decreased, especially after switching to the statistical regression salinity model. It may be appropriate to revise the estimated minimum flow upward again contingent on development of an improved mass-balance, salinity model.
- A widely accepted and prudent approach to resource management science is one of precaution and erring on the side of least damage. Setting minimum flows at the very lowest levels ever estimated by any method is inconsistent with the precautionary approach.
- Consideration of the fauna that are dependent and utilize tape grass as habitat should be incorporated into the overall approach. The main justification for selecting tape grass as the target for protection from significant harm is based on its habitat value to many animals. There is little value in protecting habitat if it does not support other

VECs. The approach and models do not, but should, consider the habitat value of tape grass under different conditions of density and salinity regime.

- Public comment pointed out the potential issue of impacts on reduced tape grass abundance on West Indian manatees, and the legal ramifications because of their endangered species status.
- The plan needs to include verification of the tape grass model, particularly with regard to assumptions or "turnable knobs" in the model.
- During public discussion evidence of water quality problems in the Caloosahatchee River was pointed out. Such impairment should be considered and data from FDEP's 305(b) and 3033(d) reports should be examined as part of the minimum flow setting process and documents.
- Because a minimum flow plan centered around the tape grass model would have a high degree of uncertainty, it is recommended that it be reviewed (as stipulated in FS 373.0421) in 5-7 years.
- Research essential to improving and refining the model, and in examining other considerations in the approach (e.g., lower CE and freshwater Caloosahatchee River) should be conducted during those 5-7 years.
- The recovery or prevention strategy described in the document is vague and unclear. The panel did not and was not asked to review the technical background of the strategy.
- Based on CERP timetables presented in the document, all the modifications needed for the recovery and prevention will not be completed for another 16 to 20 years. During that time, minimum flows will be provided to the CE in a very uncertain and nebulous basis (adaptive management).
- Once the proposed CERP modifications are in place (2016-2020), the estimated flow that can be made available to the CE is based on 2020 population and land use estimates. Therefore, the minimum flow plan, in view of the regions rapid rate of growth, might become obsolete and inadequate almost immediately after its full implementation.

B. Recommendations

- Minimum flows for the Caloosahatchee Estuary should be set by a suite of considerations that are centered around, but not limited to, the proposed *Vallisneria*, tape grass VEC approach.
- The suite should include consideration of the potential for harm to the lower CE and Charlotte Harbor ecosystem, and consideration of the potential for harm to the upper, freshwater reaches of the Caloosahatchee River above S-79.
- The definition of "significant harm" affects the interpretations of data and setting the MFL, so science should be used to determine the level of resource protection.
- The tape grass approach should be refined, improved, and made more robust (using the many detailed recommendations in the report) by additional studies and model verification.
- Mass-balance salinity models should be used as input to the tape grass models.
- Bathymetry and groundwater seepage should be considered with respect to refinement of salinity and tape grass models.

- Minimum flows during the months of April, May and June should be developed relative to considerations potential harm to the lower and upper estuary/river and of the fauna that utilize tape grass as a habitat.
- Minimum flows should be reviewed and revised on a five to seven year cycle.
- Research should be continued during each cycle.
- Providing the minimum flow through 2020 is contingent upon assumed construction of future water management projects, so a contingency plan for providing flow without those assumptions should be developed.
- Long term planning for provision of minimum flows beyond 2020 should be initiated.

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