A Review of

"Proposed Minimum Flows and Levels for the Upper Segment of the Braden River, from Linger Lodge to Lorraine Road"

May 18, 2007 Peer Review Draft Revised

by

Ecological Evaluation Section
Resource Conservation and Development Department
Southwest Florida Water Management District

Prepared by:
Peer Review Panel:

Charles E. Cichra, Ph.D.
Clifford N. Dahm, Ph.D.
Allan Locke, M.S.

September 2007

EXECUTIVE SUMMARY

This is a summary of the Scientific Peer Review Panel's ("Panel") evaluation of the scientific and technical data, assumptions, and methodologies used by the Southwest Florida Water Management District (District) in the development of proposed minimum flows and levels (MFLs) for the upper Braden River, from Linger Lodge to Lorraine Road.

The approach used in setting MFLs for the upper Braden River follows the established protocols that have been effectively used by the District in the past. The Panel continues to endorse the District's overall approach for setting MFLs in riverine ecosystems and finds particularly merit in the use of seasonal building blocks, multiple benchmark periods based on multi-decadal climate variability, the use of multiple analysis tools for protecting both low and high-flow regimes, and the expression of MFLs as percent flow reductions. The application of this approach for the upper Braden River is thorough and defensible. The methodology is sound, the data are appropriate for the task, and the findings are based on best available science. The assumptions, that are inherent in the scientific approaches that are employed, are well documented and represent current understanding of how best to protect healthy aquatic ecosystems. The derived MFLs are reasonable and likely to sustain the ecological health of the Upper Braden River.

Overall, the Panel finds the methodologies used are appropriate, even innovative. The District has added two new techniques for data acquisition and presentation (the Light Detection and Ranging (LiDAR) method to collect transect data for the HEC-RAS models and statistical medians to present historical flow data). District staff members have clearly spent a great deal of time and effort trying to arrive at a scientifically reasonable set of recommendations and have largely succeeded.

The authors are to be commended for addressing one of the most difficult issues when carrying out these types of studies, trying to interpret exactly the intention of the legislators when they drafted the legislation. The discussion, relating a good instream flow standard in the context of the legislation to prevent significant harm, is well thought out and articulate.

However, the Panel continues to believe that the adequacy of the low-flow threshold and the use of a *de facto* significant-harm criterion, based on a 15% reduction in habitat availability, has not been rigorously demonstrated and will remain presumptive until such time as the District commits to the monitoring and assessment necessary to determine whether these criteria are truly protective of the resource. We are concerned that the District, to date, has taken no visible steps to reduce the uncertainty and subjectivity associated with these criteria and urge them to move forward quickly to develop and implement an adaptive management framework that that will facilitate such assessments.

INTRODUCTION

The Southwest Florida Water Management District (SWFWMD) under Florida statutes provides for peer review of methodologies and studies that address the management of water resources within the jurisdiction of the District. The SWFWMD has been directed to establish minimum flows and levels (designated as MFLs) for priority water bodies within its boundaries. This directive is by virtue of SWFWMD's obligation to permit consumptive use of water and a legislative mandate to protect water resources from *significant harm*. According to the Water Resources Act of 1972, *minimum flows* are defined as "the minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area" (Section 373.042 F.S.). A *minimum level* is defined as "the level of groundwater in an aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area." Statutes provide that MFLs shall be calculated using the *best available* information.

The process of analyzing minimum flows and levels for the upper segment of the Braden River is built upon the analyses previously performed on the upper Peace River (SWFWMD 2002), peer reviewed by Gore et al. (2002), the middle Peace River (SWFWMD, 2005a), peer reviewed by Shaw et al. (2005), the Alafia and Myakka Rivers (SWFWMD, 2005b, c), peer reviewed by Cichra et al. (2005), and the upper Hillsborough River (SWFWMD 2007), peer reviewed by Cichra et al. (2007). The upper Braden River MFL methodologies incorporate many of the recommendations of these earlier peer reviews, as well as key improvements developed by District staff. Establishment of minimum flows and levels generally is designed to define thresholds at which further withdrawals would produce significant harm to existing water resources and ecological conditions, if these thresholds were exceeded in the future.

This review follows the organization of the Charge to the Peer Review Panel and the structure of the draft report. It is the job of the Peer Review Panel to assess the strengths and weaknesses of the overall approach, its conclusions, and recommendations. This review is provided to the District with our encouragement to continue to enhance the scientific basis that is firmly established for the decision-making process by the SWFWMD. Extensive editorial comments and errata for the upper Braden River MFL draft report are provided as an Appendix.

THE CHARGE

The charge to the Peer Review Panel contains five basic requirements:

1. Review the District's draft document used to develop provisional minimum levels and flows for the upper Braden River.
2. Review documents and other materials supporting the concepts and data presented in the draft document.
3. Participate in an open (public) meeting at the District's Tampa Service Office for the purpose of discussing directly all issues and concerns regarding the draft report with a goal of developing this report.
4. Provide to the District a written report that includes a review of the data, methodologies, analyses, and conclusions outlined in the draft report.
5. Render follow-up services when required.

We understand that some statutory constraints and conditions affect the District's development of MLFs and that the Governing Board may have also established certain assumptions, conditions and legal and policy interpretations. These *givens* include:

1. the selection of water bodies or aquifers for which minimum levels have initially been set;
2. the determination of the baseline from which "significant harm" is to be determined by the reviewers;
3. the definition of what constitutes "significant harm" to the water resources or ecology of the area;
4. the consideration given to changes and structural alterations to watersheds, surface waters, and aquifers, and the effects and constraints that such changes or alterations have had or placed on the hydrology of a given watershed, surface water, or aquifer; and
5. the adopted method for establishing MFLs for other water bodies and aquifers.

RESULTS OF THE PEER REVIEW

General Approach and MFLs for the Upper Braden River

The general methodology employed in the setting of riverine MFLs by the SWFWMD has been reviewed in some detail and strongly endorsed by past peer reviews (e.g., Gore et al. 2002, Shaw et al. 2005, and Cichra et al. 2005 and 2007). In addition, the approach used by the SWFWMD has now been published in a peer-reviewed journal (Munson et al. 2005; Munson and Delfino 2007), and these papers add further credibility to the procedures employed by the SWFWMD. The efficacy of the approach has been well received in past peer reviews. Thus in this peer review, the Panel has chosen to focus on new elements unique to the upper Braden River MFLs, new insights on the District's approach, and increased elaboration or emphasis on key findings from past peer reviews.

MFL Benchmarks and Resource Protection Goals

Benchmarks and the Atlantic Multidecadal Oscillation (AMO)

Chapter 2 provides a thorough and lengthy overview of the basin. Background information on geographic location, climate, land use, hydrology, and aquatic chemistry is provided. The placing of the hydrology into the context of the Atlantic Multi-decadal Oscillation (AMO) is particularly forward thinking in terms of setting MFLs in systems throughout Florida, where state changes characterized by thresholds and step changes are a very real characteristic of these ecosystems in the past and may well be characteristic in the future.

The Panel continues to endorse and applaud the District's use of multiple benchmark periods for setting MFLs based on multi-decadal climate variability. Although the role of the AMO in influencing various ecological and climate phenomena (e.g., tropical storm frequency) continues to be debated, the District's thorough analysis of climate-streamflow relationships in Florida (SWFWMD 2004) provides a firm foundation for applying these concepts to the development of MFLs for Florida's rivers. As with previous riverine MFLs, beginning with those for the Middle Peace River (SWFWMD 2005a), the District has fully embraced the climate-streamflow issue in developing the MFLs for the upper Braden River by evaluating and identifying limiting flow conditions for two separate benchmark periods based on different climate phases. Use of these two benchmark periods for the Braden River is somewhat problematic because of the relatively short flow record available for the Braden River. Flow records for the Braden River near Lorraine gage site were instead assigned to benchmark periods based on the mid-1990s shift from a cool to a warm AMO phase. Available flow records were split into two periods, 1988 through 1994 and 1995 through 2005 (Figure 2-15 on page 2-23), for analyses used to develop minimum flows and levels criteria and standards. Recommended low-flow thresholds and percent flow reduction criteria are based on the most conservative of these benchmark periods to ensure adequate protection during periods when less rainfall and lower streamflow prevail. The analysis of stream flows in Chapter 2 also does a good job of placing the hydrology of the Braden River and other streams in the context of climate variability and clearly illustrates how such variability is revealed in the data as thresholds or step changes. The peer review panel strongly endorses this approach and recommends that similar approaches should routinely be incorporated when setting MFLs for all rivers in Florida. To our knowledge, SWFWMD is the only water management entity to have adopted such a sophisticated and forward-thinking approach for incorporating climate variability into instream flow determinations.

The Panel feels that streams within the SWFWMD clearly have "lower-flow" and "higher-flow" periods that persist for decades, and previous peer-reviewed work by the District make a strong case that such long-term variability is linked to different phases of the AMO (SWFWMD, 2004; Shaw et al., 2004). The decision to use the lower-flow period to set MFLs is appropriate, as this is conservative, and means that it is not necessary to try to predict the current or future climate cycle. However, the AMO label is not necessary to the analysis or the determination of the MFLs considered here, and pinning the MFL determination on a particular climate cycle potentially leaves the MFL determination open to challenge. We suggest simply referencing earlier District documents that propose the AMO link, and not making a big deal of it in the report. The hypothesized link with AMO has explanatory power, but no real predictive power. Although we are suggesting de-emphasizing the narrative connection with AMO, the panel strongly believes the idea of multidecadal variations in streamflow is valid.

The period of hydrologic record is significantly shorter for the upper Braden River, compared to other river ecosystems where MFLs have been proposed by the SWFWMD in the past, and we feel that uncertainties associated with the limited hydrological record should be carefully acknowledged.

On page 2-17, it is stated, *"Based on the availability of data for the Braden River near Lorraine site, the minimum flows and levels recommended in this report for the upper, freshwater segment of the Braden River were developed for flows measured at this gaging station."* and on pages 4-19 and 4-20, it is stated, *"historic time series data from the Braden River near Lorraine gage site was used to model changes in habitat at two representative sites"*. It would be helpful to the reader if definitions for "natural", "recorded" and "historic" flows were provided. If there are differences between historic and natural flows, then this should be clearly stated.

Seasonal Building Blocks

The SWFWMD has continued to employ a seasonal building block approach (e.g., Postel and Richter 2003) in establishing MFLs for the upper Braden River. The assumptions behind building block methods are based upon simple ecological theory. Organisms and communities, occupying a river, have evolved and adapted their life cycles to flow conditions over a long period of pre-development history (Stanford et al. 1996, Bunn and Arthington 2002). Thus, with limited biological knowledge of specific flow requirements, the best alternative is to maintain or recreate the hydrological conditions under which communities had existed prior to disturbance of the flow regime or allocation of instream flows. Building-block models are the "first-best-approximation" of adequate conditions to meet ecological needs. More often than not, resource agencies have hydrographic records for long periods of time, while little or no biological data are available.

Seasonal hydrological variability is a critical component of the flow regime, and three blocks are defined in the report from the average long-term annual hydrograph. Block 1 considers the low-flow period that occurs during the spring dry season, Block 2 considers the base-flow period during the cooler portion of the year when evapotranspiration rates are often at their lowest levels, and Block 3 considers the high-flow period during the summer/fall wet season. This is a valid approach for setting MFLs because it accounts for expected seasonal variability during a typical year. By contrast, MFLs focused solely upon low flow conditions are inadequate for protecting important river and riparian ecosystem functions that occur at other times of the year, and which are often critical to the viability of aquatic organisms. In response to previous peer review comments (e.g., Shaw et al. 2005), the District now applies the low-flow threshold developed for block 1 year-round, recognizing that low flow conditions can occur at any time. The building block approach is based upon predictably varying hydrological conditions and is a rigorous and defensible approach for the establishment of protective MFLs for the upper Braden River. It also has the advantage of insuring a flow regime with the range of variability essential to the maintenance of stream and river structure and function. Seasonal building blocks also remain a useful conceptual device for communicating MFLs to the public.

The Panel continues to endorse this approach by the District. Nevertheless, as the District's methodology for setting riverine MFLs has evolved, the need for pre-defined seasonal blocks has become less clear. The Panel wonders whether applying all of the tools used to set MFLs, described in the draft report, to all weeks of the year, and using the approach, that has been employed in this and prior studies, of basing compliance standards on the most conservative, or protective, factor would eliminate the need to pre-assign flow blocks.

In Chapter 1, the presentation of medians, in addition to averages, for the flow patterns of the upper Braden River, throughout the period of record (Figure 1.1 on page 1-8) is an informative additional way to summarize the hydrological data. The Panel encourages personnel of the Ecologic Evaluation Section of the SWFWMD to provide both the mean and median of historical flows in all future reports for setting MFLs.

One aspect of Chapter 2 should be expanded. It appears that the upper Braden River may be prone to intermittency. This appears to be a natural condition and one for which the biota are likely adapted. There is, however, no specific spelling out of the very low flows and zero flows that have occurred during the period of record. Block 1 appears to be the period in which very low-flow or no-flow conditions occur reasonably regularly. How many days of zero flow or < 7 cfs flow occur in the three blocks? What is the range of zero flow or < 7 cfs flow days each year during the period of record? This is a river prone to very low flows and possible intermittency, and the Panel thinks that the details of these conditions for the period of record should be clearly spelled out.

The "building block" approach is most acceptable and is an excellent way to address the issue that flows vary significantly throughout the year and different tools need to be applied. For future studies, we encourage the District to explore the possibility of using alternative approaches. For example, develop hydrology data so that the flows for each week can be analyzed using all appropriate tools for that time of year and for that particular range of flows. Specifically, there may be some biological rationale for moving to a weekly time step instead of using a monthly time step when applying the PHABSIM models. With commercial spreadsheet software, analysis can easily be carried out on a weekly time step, or shorter if appropriate, and there may be some valuable knowledge gained. In essence, the District could test an infinite number of habitat evaluation metrics that could prove to be useful for their specific studies.

Resource Protection Goals

Chapter 3 clearly lays out the goals, ecological resources of concern, and key habitat indicators for setting MFLs on the upper Braden River. This discussion is appropriately drawn from past MFLs developed by the District and citations from a wide array of ecological literature. Emphasis here, as in other riverine MFLs in the SWFWMD, is on fish and invertebrate habitat and hydrologic connectivity, both upstream-downstream and laterally between channel and floodplain.

Though these characteristics of the river ecosystem are clearly important, they are but a subset of the factors specifically listed in Florida Statutes that should be considered when setting MFLs (62-40.473 *F.A.C.*). The list (reproduced in Chapter 1 of the draft report) includes recreation, fish and wildlife habitat and fish passage, estuarine resources, transfer of detrital material, maintenance of freshwater storage and supply, aesthetic and scenic attributes, filtration and absorption of nutrients and other pollutants, sediment loads, water quality and navigation. The draft report includes a clear and well-justified argument for preserving ecologically meaningful elements of the flow regime, and at least some mention is made of setting low-flow thresholds to protect passive recreation uses such as canoeing. However, the report never completely addresses how the proposed MFL or the District's approach addresses any of the other factors listed above or why only certain factors were selected for this water body. (Note that in at least one other water management district in Florida, draft MFLs are developed based on one or a few resource protection goals, then a separate assessment is conducted to evaluate how well the draft flows and levels address the protection needs of other factors such as recreation, water quality and sediment loads).

The Panel suggests that, for the upper Braden River and other rivers of Florida, there may be other important ecosystem processes or physical/chemical thresholds from the list that merit consideration by the District in setting MFLs. For example, should there be concern for maintaining a minimum dissolved oxygen level or sustaining temperature below some threshold? Such factors may be especially important in relation to setting the low-flow threshold, which is presently based solely on a presumptive fish passage criterion and an analysis of wetted perimeter. These may be particularly important for streams and rivers that have very low flow or periods of intermittency, such as the Braden River.

Preventing Significant Harm – 15% Change in Habitat Availability

The draft report describes the metrics used to define *"the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area"* as stated in Florida statutes. The authors note that "significant harm" was not defined in statute. The District chose to interpret significant harm as "the loss of flows associated with fish passage and maximization of stream bottom habitat with the least amount of flow and quantifiable reductions in habitat." Overall, this is a reasonable approach from an ecological perspective and likely satisfies the intent of the statute.

The authors state that, *"[in] general, instream flow analysts consider a loss of more than 15% habitat, as compared to undisturbed or current conditions, to be a significant impact on that population or assemblage."* The authors further note, in our opinion, correctly, that *"there are few 'bright lines' which can be relied upon to judge when 'significant harm' occurs. Rather loss of habitat in many cases occurs incrementally as flow decline, often without a clear inflection point or threshold."* Nevertheless, the 15% habitat loss criterion remains one of the least rigorous, most subjective aspects of the District's approach to setting MFLs. Justification for this threshold is based on common professional practice in interpreting the results of PHABSIM analyses (Gore at al. 2002), a review of relevant literature where reported percentage changes ranged from 10 to 33%, and on previous peer reviews that found the 15% threshold to be "reasonable and prudent, especially given the absence of clear guidance in the statute or in the scientific literature on levels of change that would constitute significant harm..." (e.g., Shaw et al. 2005).

The draft upper Braden report continues the District's practice of using a 15% change in habitat availability as the threshold for defining significant harm and now applies this threshold broadly to include both spatial and temporal loss of habitat or connectivity.

The Panel again acknowledges that the use of this criterion is rational and pragmatic, but also recognizes that the specific value of 15% is subjective and has only modest validation or support from the primary literature. Arguments can and likely will be made for both lower and higher percentages of habitat loss to be used for defining significant ecological harm. Other work has been done, in addition to the literature that is already cited, and the Panel believes it would be prudent to expand the literature review to gather as much additional supporting documentation as possible, much of which will be gray literature. Where lower or higher percentages have been used elsewhere, it would be illuminating to understand the rationale for these decisions (e.g., lower percentages used where imperiled or more sensitive species are concerned, higher percentages for more degraded systems, etc.).

What happens if you use a 5% or a 33% reduction in habitat in your analyses? How would these values affect the recommendations for MFLs for an ecosystem like the upper Braden River? The Panel is not advocating doing the analyses on all rivers with multiple values for acceptable habitat loss, but it would be informative to do such a sensitivity analysis for a less difficult river like the upper Braden River. Such an analysis of the sensitivity of the MFLs to setting different thresholds of habitat loss where significant harm occurs would assist in the discussion of why a specific value (e.g., 15%) has been chosen.

More importantly, however, is the need for the District to commit the resources necessary to validate the presumption, that a 15% decrease in spatial or temporal habitat availability or a 15% increase in violations of the low-flow threshold, does not cause significant harm. The District would appear to be in an excellent position to implement monitoring, natural experiments, and other analyses necessary to evaluate the effectiveness of this threshold and establish a framework for adaptive management. Several riverine MFLs have now been developed and adopted by the District using the same or similar criteria, and the infrastructure for field work used to develop these MFLs is still in place. The present drought conditions that prevail over most of Florida as this peer review is written would seem to make for ideal conditions for testing and evaluating assumptions regarding minimum flows. Several previous peer reviews have called on the District to collect additional site-specific data to validate and refine assumptions used in the development of MFLs (Cichra et al. 2005 and 2007; Gore et al. 2002; Shaw et al. 2005), and the District has committed to periodic re-evaluation of its MFLs as structural changes or changes in the watershed warrant. Despite this, the Panel has seen little evidence so far that the District is moving rapidly to implement the needed monitoring or assessment. The Panel strongly believes that without such follow-up, the 15% threshold remains a presumptive criterion vulnerable to legal and scientific challenge.

Analytical Tools Used to Develop MFLs

PHABSIM

Previous peer review reports have discussed at length and affirmed the District's use of the Instream Flow Incremental Methodology (IFIM) and the related Physical Habitat Simulation (PHABSIM) software (Cichra et al. 2005 and 2007; Gore et al. 2002; Shaw et al. 2005). The District likewise employs this methodology to the upper Braden River, using habitat suitability curves for the same suite of three common *Centrarchid* (sunfish) fish species, plus invertebrates that were used in developing MFLs for the Middle Peace, Myakka, Alafia, and upper Hillsborough Rivers. Overall, the District's use of the methodology and its description of the development of habitat suitability curves are consistent with standard practice and follow the recommendations of previous peer reviews.

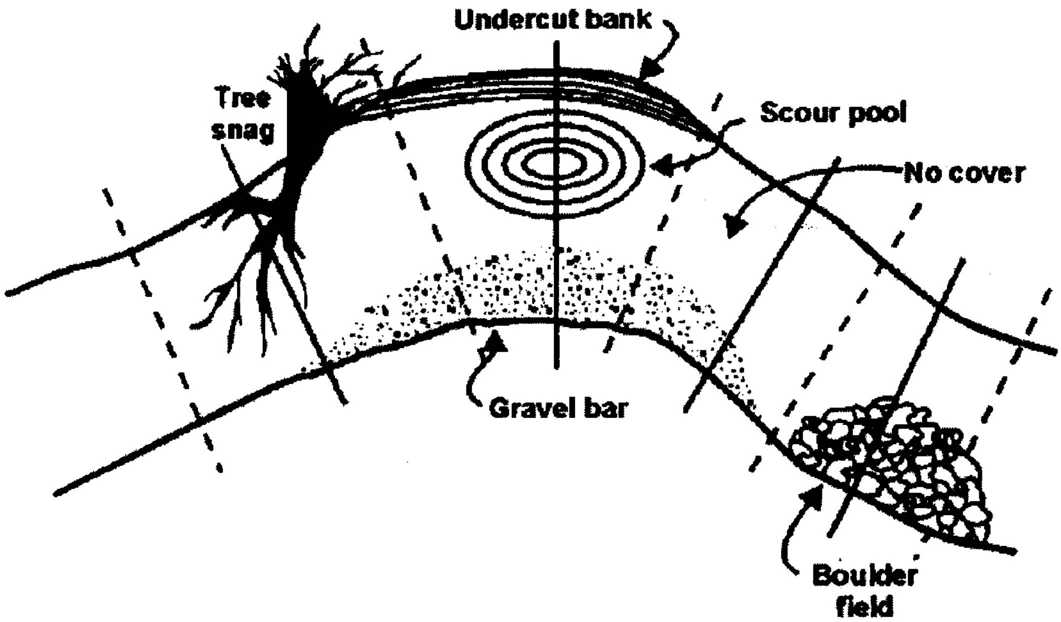
Habitat suitability curves were developed for spotted sunfish (*Lepomis punctatus*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and macroinvertebrate community diversity (Gore et al. 2001, Stuber et al. 1982). These are appropriate species for consideration in rivers of the southern Florida peninsula, and their selection is validated by reported fish abundance data for these rivers. However, the Panel notes that both bluegill and largemouth bass are habitat generalists and are not especially sensitive to changes in hydrologic regime. As such, they may be rather poor choices for use in establishing MFLs, despite the merits of the IFIM/PHABSIM methodology.

In keeping with previous peer reviews, the Panel recommends that the District invest the resources necessary to evaluate whether additional habitat suitability curves should be developed and PHABSIM analyses be conducted for other species that may be more sensitive to hydrological change than those used here. Of particular concern would be any listed, imperiled, or endemic species, species tracked by the Florida Natural Areas Inventory (FNAI), wading birds, and fish species with preferences for stream edges or banks that might be the first places to feel the effects of reduced flows.

The description of the PHABSIM transect(s) location and, in particular, the number of transects should be made more clear. It is not until the third paragraph of section 4.2.2, where it is stated, "*...At each PHABSIM site, tag lines were used to establish three cross-sections...*" The discussion about transects should clearly indicate the number of transects, in this case three, and it would be beneficial to the reader to have an accompanying schematic that shows the exact location of these transects, along with some basic habitat descriptions (see comment below). There are some commonly accepted "guidelines" for applying PHABSIM, however, it is quite acceptable to deviate from these guidelines given site-specific circumstances. For example, it is generally accepted that 5-7 transects are required to describe a riffle – pool sequence. However, given the upper Braden River has an extremely low gradient (it is basically a simple "U" shaped sand bed channel), there are no sudden changes in cover or substrate, the river has very subtle transitions from pools to runs and, the channel is very homogeneous in terms of habitat types, it is not necessary to have more than three transects to describe the available habitat in the river for the species of interest. Adding more transects would not add to the accuracy of the model output. Putting this rationale in the report would be beneficial to the reader.

In Section 4.2.2, there should also be a description on the ratio of habitat types (riffle / run / pool) that are represented in the study site by the three transects. It should also be described somewhere in the report that the ratio of habitat types in the study site is equal to the ratio of these habitat types in the entire reach of the river that the study site represents. A general rule of thumb when using the PHABSIM models is the study site should include at least two entire cycles of riffles and pools or meanders and crossing bars to describe the relative proportions of each feature. It is generally acknowledged these cycles are repeated at 5 to 7 times the width of the channel. Therefore, a representative study site should have a length that at a minimum is 10 to 14 times the channel width. Once again, it is quite acceptable to have a different length for the study site, since this is a "guideline" or "rule-of-thumb", however, it would be beneficial to the reader to state the reasons for the departure from the general guidance.

As mentioned above, having a schematic showing transects and some general features is informative to the reader (see figure below). It is highly recommended to include these diagrams in future reports.



An example of the primary output from the PHABSIM models, namely weighted usable area versus discharge curves are shown in Figure 4-4 on page 4-11. The fry, juvenile and spawning curves seem reasonable and are in the "usual" shape for these types of curves. There are two things that are interesting. First, the adult curve shows that there is relatively the same amount of habitat for the 13 to 100-cfs flow range. This is a fairly wide range of flow, where this life stage is relatively insensitive to changes in flow. The second thing is that the shapes are very different for the adult and juvenile curves. It seems odd that the curves would be so vastly different. Typically, the juvenile and adult life stage curves for a species are usually, but not always, quite similar in shape, with the magnitude for the adult life stage usually being somewhat greater and the mode for the adult curve being shifted slightly to the right. The District may want to re-visit these curves and provide a brief explanation for the apparent differences. Also, there are two scales for the Y-axis for Figure 4-4. Should there only be one scale?

There is no discussion in this section, or elsewhere in the report, regarding species/life stage habitat suitability criteria validation or habitat modeling validation. Effort should be expended to demonstrate that there is generally good agreement between predicted and observed habitat use over different flow rates at the two study sites. For example, observations at 5 cfs should reveal that spotted sunfish juveniles are occupying "optimal" habitat locations as predicted by the model. Similarly, at 120 cfs, there should be observations of spotted sunfish adults in optimal habitat locations. Validation data, no matter how little, goes a long way towards gaining acceptance of the output of these types of predictive habitat models.

The process for deriving Type I habitat suitability criteria (HSC) curves is reasonable in Section 4.3.2.1. However, we suggest that expert-opinion type curves can benefit greatly from even a few observed "use" data. Perhaps, it was not feasible for this study, however, the District should make collecting "use" data for the species of interest a regular program element. It is always reassuring to plot even a few data points to see they fall within the range of the experts' opinions. There is no substitute for real data. It is noted the authors recognize this when they state, *"the District intends to evaluate and develop additional habitat suitability curves for species of interest."* Again, actual biological field data are most valuable.

Using Type II HSC curves from another source has been a fairly common practice. There have been issues raised in the past with the application of "blue book" curves in other PHABSIM applications. Given that HSC curves account for the majority of what the weighted usable area (WUA) curve will be, it is prudent to provide good rationale for using "blue book" curves. Once again, having at least a few actual data points to show the "blue book" HSC curves are applicable, increases the credibility of the output.

Habitat Criteria and Characterization Methods Used to Develop MFLs

FISH PASSAGE

The approach of defining a threshold for loss of fish habitat in terms of percent reduction of fish habitat and setting a low-flow threshold based on fish passage is consistent with today's understanding of maintaining self sufficient populations of fish that are able to move upstream and downstream and between different kinds of aquatic habitat.

Fish passage was used to estimate flows sufficient to permit fish movement throughout the upper Braden River. Flows of this magnitude would also likely permit recreation (i.e., canoeing), though this is not substantiated in the draft report. A fish passage criterion of 0.6 ft was used based in part on size data from large-bodied fishes in Florida streams and minimum fish passage depths used in other instream flow settings elsewhere in the U.S. This criterion has been used to develop previous MFLs (SWFWMD 2002, 2005a, b, c, and 2007) and has been found acceptable by previous peer reviewers (Gore et al. 2002; Cichra et al. 2005 and 2007; Shaw et al. 2005).

This notwithstanding, fish passage depths in the range of 0.5-0.8 ft were originally derived from requirements of migratory salmonids in cool, well-oxygenated waters of the western U.S. The adequacy of these standards for use in Florida's warmwater streams has been questioned by resource managers and peer reviewers. Although no definitive research has yet been conducted on this issue (Hill and Cichra 2002), it is an emerging consensus that minimum depth criteria used in Florida need to be evaluated to ensure that they adequately prevent negative effects associated with low flows in warmwater ecosystems. These include high water temperatures, low dissolved oxygen, algal blooms, increased aquatic plant growth, and increased predatory pressure, in addition to mere physical passage of fish. If flows were to be lowered due to consumptive use of water to a depth of 0.6 ft, when depths would under natural-flow conditions be much greater, would water quality issues arise? Of concern would be dissolved oxygen (DO) and temperature conditions near the limit of tolerance for fish and other aquatic life. If these questions cannot be answered at this point, then the Panel strongly suggests the District commit to studying what the fish passage criterion set as the low-flow threshold means to the aquatic ecosystem (e.g., flow versus DO relationships, fish survival in pools, etc.). Similar to the 15% habitat-loss threshold discussed above, the minimum fish-passage depth, used by the District in this and previous MFLs, is merely a presumptive criterion absent site-specific follow-up studies to evaluate ecological conditions under such a low-flow scenario.

To ensure that there is 0.6 ft of water depth along the thalweg in the entire river reach being addressed, the authors would need to demonstrate that they have undertaken the necessary work to identify the most critical hydraulic control points in the river. This would presumably require a detailed survey of the thalweg for the entire river reach in question in order to determine this critical point of elevation. As the authors note, transects in pools or runs would not be in locations where this critical fish passage point is located. It would be on a rock ledge or other similar natural hydraulic control point. These are "critical" transects and are areas that go dry first as flows are lowered. Longitudinal studies of the thalweg may indeed have been conducted, but the Panel seeks assurances that the identification of hydraulic control points was done systematically, as there is no documentation in the draft report of how control points were selected.

On page 4-18, in the last paragraph, it is stated, *"The flows were determined by adding the 0.6-ft depth fish-passage criterion to the elevation of the lowest spot in the channel and determining the flow necessary to achieve the resultant elevations."* It would be helpful to the reader if the determination of "*...the lowest spot in the channel...*" was more thoroughly described in the report.

WETTED PERIMETER

The biological rationale for using the wetted perimeter, "*...the greatest amount of macroinvertebrate biomass per unit reach of stream occurs on the stream bottom...*" is sound, and it is widely accepted that a break point in the slope of the line represents the point at which there is an accelerated loss of habitat relative to reductions in flow. The authors also clearly point out that one of the difficulties in using this method is that there are no well-defined break points on the line. On page 4-17, it is stated, *"Many cross-section plots displayed no apparent inflection points between the lowest modeled flow and 25 cfs. These cross-sections were located in pool areas, where the water surface elevation may exceed the lowest wetted perimeter inflection point even during low flow periods. For these cross-sections, the lowest wetted perimeter inflection point was established at the lowest modeled flow."* Given that this method should only be applied in shallows, riffles or ledges, it is not clear why the authors choose to establish the "*...wetted perimeter inflection point at the lowest modeled flow.*" Perhaps, it would be better to simply eliminate these transects from the analysis since transects through pools should not be used. The difficulties encountered by the authors raise the question of how appropriate the use of the wetted-perimeter method is in a river like the upper Braden River. As shown in Figure 5-2 on page 5-3, a flow of 5.1 cfs is required to inundate the lowest wetted perimeter inflection point at each of the 20 transects. Perhaps, it would be better to present only those transects that are in known shallow areas, and to not present those transects in pools or runs. The Instream Flow Council recommends this method should only be used in riffle mesohabitat types (Annear et al. 2004). If the transects are located in riffles, that are representative of food producing riffles in the river, then the basis for using the method should be adequate for this river.

DAYS OF FLOODPLAIN INUNDATION

Low-gradient rivers, like the upper Braden River, have extensive floodplains. Floodplains support complex and diverse plant communities, whose distribution is determined by small changes in microtopography and average length of annual inundation or hydroperiod. Plant communities are often adapted to the average annual flow regime and decline if flood frequency is altered. Extensive floodplains are often critical to many forms of aquatic life. For example, river biota migrate onto floodplains for foraging and spawning during floods. In addition, periodic flooding stimulates biogeochemical transformations in floodplain soils, which benefit both floodplain and riverine productivity.

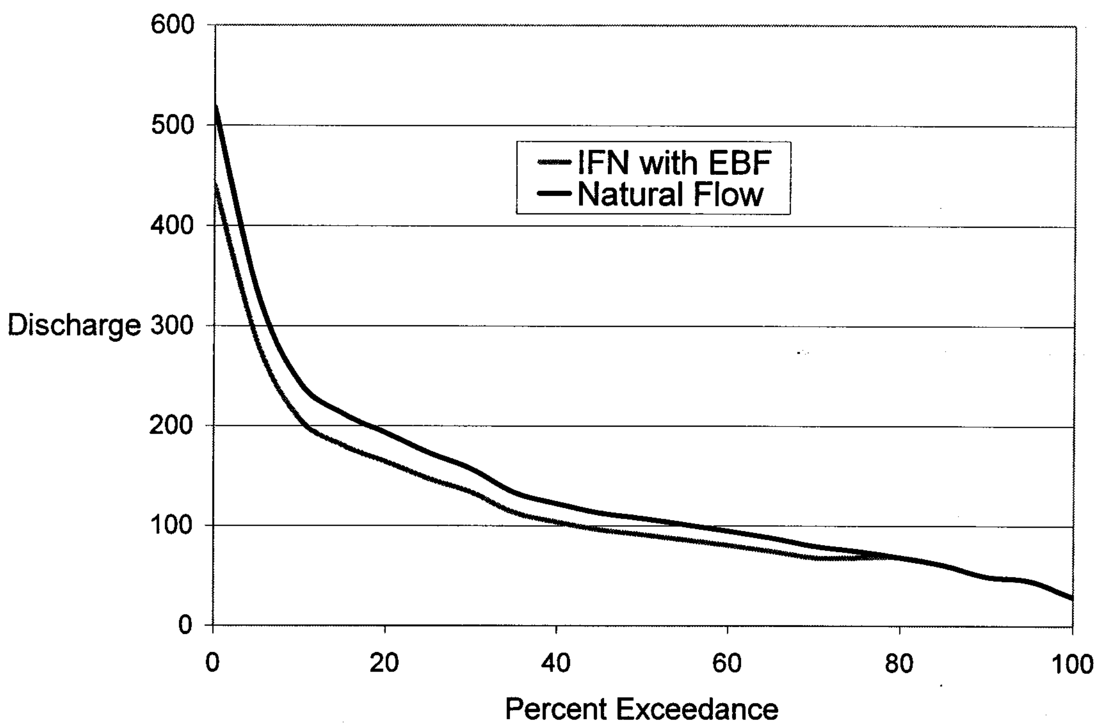
The District has recognized the critical role of floods in proposing minimum flows for the upper Braden River. Extensive vegetation and elevation surveys were used to characterize the structure and floristic composition of floodplains. HEC-RAS modeling was used to determine floodplain inundation patterns based on historical benchmark periods. Results of the models were then used to estimate percent-of-flow reductions for Block 3 that would result in no more than a 15% reduction in the number of days of floodplain inundation.

The Panel feels that consideration of high flows and patterns of floodplain inundation is commendable and documentation of methods in the draft report is excellent. The District incorporated the use of LiDAR (Light Detection and Ranging) data to increase the number of cross-sections used in the HEC-RAS modeling. It is commendable that the District continues to incorporate new methods, such as LiDAR, to improve on the quantity and quality of data used in its analyses to develop MFLs.

COMPLIANCE STANDARDS AND PROPOSED MINIMUM FLOWS

The compliance standards, or recommended instream-flow prescription to prevent significant harm, are well articulated. Figure 5-13 on page 5-25 is useful, as it shows how the flow reduction factors are applied to each seasonal flow block.

It is always a challenge to know how much information to include (e.g., tables and graphs) to illustrate what is a very complex subject matter to a wide array of potential readers. The Panel notes that flow-duration curves (see figure below), the common currency of hydrologists, are a useful way to present information of this type and may be beneficial to the reader in that the full range of flows that can occur in any given time step can be seen. It also is easy to see where the low-flow threshold occurs in terms of a percent exceedance value relative to historic natural low flows. Water users, current and future, are interested in the low-flow threshold and this format quickly shows them the frequency, for any given time step, at which they would have to rely on storage and stop pumping directly from surface water.



The peer review panel endorses the District's proposed minimum flows for the upper Braden River and finds them to be based on sound science and best available information, subject to our comments and recommendations, as noted above. We believe that the consideration of two separate benchmark periods based on climate regimes and multiple assessment methods and habitat criteria for identifying the limiting-flow reductions in each seasonal block represents best practice for determining instream-flow needs and demonstrates a commitment to a comprehensive aquatic ecosystem approach to this very challenging issue. We again commend the District for specifying minimum flows in terms of allowable percent flow reductions for different seasonal blocks and a low-flow threshold applicable at all times of the year. This "percent-of-flow approach," combined with seasonal building blocks, has been recognized as one of the best ways of protecting multiple functions and values of river systems under a wide range of flow conditions (Postel and Richter 2003). The proposed short and long-term compliance standards proposed in the report are pragmatic and logical means of implementing the findings of the report in a regulatory context.

It is interesting to note that ecosystem functions requiring higher flows tolerate a lower percent reduction than those for low flows, perhaps due to differences in the way the 15% habitat loss threshold is interpreted for different metrics (e.g., temporal loss of habitat with floodplain functions vs. spatial loss of habitat for PHABSIM). The recommended percent-of-flow reductions for the upper Braden River appear to be quite consistent with those prescribed for other rivers in the SWFWMD. In fact, a table comparing the flow reduction values for upper Braden River with those of other rivers in the SWFWMD, with proposed or adopted MFLs, might be useful to include in the report.

The specific recommendations for MFLs for the upper Braden River presented in Chapter 5 are reasonable and defensible. The approach presented in detail in the draft document is scientifically well justified and applies multiple metrics in making the recommendations for the MFLs. We endorse the derived recommendations within the report and believe that they provide adequate protection to the river, while permitting some human use of river water throughout the annual hydrograph, except under minimal-flow conditions (a low-flow threshold of 7 cfs). It would be informative to have additional hydrological information presented in Chapter 2 that allows the reader to place the low-flow threshold of 7 cfs into an historical context of flows that have occurred in the upper Braden River during the period of river gauging.

Evaluating Assumptions and Adaptive Management

We applaud the District's commitment to periodic reassessment of the MFLs for the upper Braden River and other water bodies as structural alterations or substantial changes in watershed conditions occur. However, the Panel thinks that this commitment does not go far enough, and we are concerned that the District has so far taken no visible steps to assess some of the more uncertain and subjective elements of its MFL approach, namely the adequacy of the 15% habitat reduction criterion and the low-flow threshold. We strongly recommend that the District begin now to develop and implement the process and methodology by which such assessment would occur. We recommend that an adaptive management framework be adopted for evaluating the effectiveness of the proposed MFLs for the upper Braden River and other rivers, where similar MFLs have already been adopted. Such a framework should include ongoing evaluation of the effectiveness of the MFLs based on long-term monitoring of key ecosystem and water resource values, specifically focusing on ecological conditions that occur at or near the low-flow threshold and 15% habitat reduction scenarios.

Glossary of Terms

The District is to be commended for using an inter-disciplinary team approach to setting MFLs in the upper Braden River. Addressing the varying flow ranges, extremely low flows to high flows that inundate the associated wetlands, while using a variety of tools is commendable.

When an inter-disciplinary team is assembled, one of the challenges is to ensure everyone has the same understanding of the many terms that are used in such studies. For example, the term "historical" flow can have different interpretations across disciplines. Also, if the intended audience for the report is other District staff, colleagues, Board Members and the public, then having a glossary would help the reader to better understand the many terms that are common to such studies. Studies of this nature are inherently complex, they are never simple, so having a glossary helps to clarify the many terms that are used.

REFERENCES

Annear, T., I. Chisholm, H. Beecher, A. Locke, and 13 other authors. 2004. Instream flows for riverine resource stewardship, revised edition. Instream Flow Council, Cheyenne, WY. 268 pp.

Bunn, S.E., and A.H. Arthington. 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management 30: 492-507.

Bovee, K.D., B.L. Lamb, J.M. Bartholow, C.B. Stalnaker, J. Taylor, and J. Henriksen. 1998. Stream habitat analysis using the instream flow incremental methodology. U.S. Geological Survey, Biol. Res. Div., Info. and Tech. Rpt. USGS/BRD-1998-004.

Cichra, C.E., C.N. Dahm, and D.T. Shaw. 2005. A Review of "Alafia River Minimum Flows and Levels Freshwater Segment including Lithia and Buckhorn Springs" March 21, 2005 Draft, and "Proposed Minimum Flows and Levels for the Upper Segment of the Myakka River, from Myakka City to SR72" August 10, 2005 Draft. 33 pp.

Cichra, C.E., C.N. Dahm, A. Locke, D.T. Shaw, and M. Stewart. 2007. A Review of "Proposed Minimum Flows and Levels for the Upper Segment of the Hillsborough River, from Crystal Springs to Morris Bridge, and Crystal Springs" January 20, 2007 Draft. 37 pp.

Davies, B.R., M.C. Thoms, K.F. Walker, J.H. O'Keeffe, and J.A. Gore. 1994. Dryland rivers: their ecology, conservation, and management. Pp. 484-511 in: P. Calow and G.E. Petts (eds.) The Rivers Handbook. Volume 2. Blackwell Scientific Publishers, London.

Enfield, D.B., A.M. Mestas-Nuñez, and P.J. Trimble. 2001. The Atlantic multidecadal oscillation and its relation to rainfall and river flows in the continental U.S. Geophysical Research Letters 28: 2077-2080.

Gore, J.A., and R.M. Bryant, Jr. 1990. Temporal shifts in physical habitat of the crayfish, *Orconectes neglectus* (Faxon). Hydrobiologia 199: 131-142.

Gore, J.A., J.B. Layzer, and J. Mead. 2001. Macroinvertebrate instream flow studies after 20 years: a role in stream and river restoration. Regulated Rivers 17: 527-542.

Gore, J.A., and J. Mead. 2002. The benefits and dangers of ecohydrological models to water resource management decisions. In: Ecohydrology: A New Paradigm, United Nations/UNESCO, Geneva and Cambridge University Press.

Gore, J.A., and J.M. Nestler. 1988. Instream flow studies in perspective. Regulated Rivers 2: 93-101.

Gore, J.A., C. Dahm, and C. Klimas. 2002. A review of "Upper Peace River: an analysis of minimum flows and levels". August 25, 2002 Draft. Prepared for the Southwest Florida Water Management District. Brooksville, FL. 30 pp.

Hill, J.E., and C.E. Cichra. 2002. Minimum Flows and Levels Criteria Development, Evaluation of the Importance of Water Depth and Frequency of Water Levels/Flows on Fish Population Dynamics: Literature Review and Summary, Special Publication SJ2002-SP1, St. Johns River Water Management District, Palatka, Florida, February 2002. 40 pp.

HSW Engineering, Inc. 2004. Evaluation of the Effects of the Proposed Minimum Flows and Levels Regime on Water Resource Values on the St. Johns River between SR528 and SR46, Report prepared for St. Johns River Water Management District, Palatka, Florida, November 2004, 159 pp.

Munson, A.B., J.J. Delfino, and D.A. Leeper. 2005. Determining minimum levels: The Florida experience. Journal of the American Water Resources Association 41:1-10.

Munson, A.B., and J.J. Delfino. 2007. Minimum wet season flows and levels in southwest Florida Rivers. Journal of the American Water Resources Association 43:522-532.

Odum, H.T. 1957. Trophic structure and productivity of Silver Spring, Florida. Ecological Monographs 27: 55-112.

Poff, N.L., and J.V. Ward. 1989. Implications of streamflow variability and predictability for lotic community structure: a regional analysis of streamflow patterns. Canadian Journal of Fisheries and Aquatic Sciences 46: 1805-1818.

Postel, S., and B. Richter. 2003. Rivers for Life: Managing Water for People and Nature. Island Press. Washington D.C. 253 pp.

Resh, V.H., A.V. Brown, A.P. Covich, M.E. Gurtz, H.W. Li, G.W. Minshall, S.R. Reice, A.L. Sheldon, J.B. Wallace, and R. Wissmar. 1988. The role of disturbance in stream ecology. Journal of the North American Benthological Society 7: 433-455.

Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. Conservation Biology 10: 1163-1174.

Richter, B.D., J.V. Baumgartner, R. Wiggington, and D.P. Braun. 1997. How much water does a river need? Freshwater Biology 37: 231-249.

Shaw, D.T., D.S. Gutzler, and C.N. Dahm. 2004. Peer Review Comments on "Florida River Flow Patterns and the Atlantic Multidecadal Oscillation" Report prepared for Southwest Florida Water Management District, December 2004, 10 pp.

Shaw, D.T., C.N. Dahm, and S.W. Golladay. 2005. A Review of "Proposed Minimum Flows and Levels for the Middle Segment of the Peace River, from Zolfo Springs to Arcadia." Report prepared for Southwest Florida Water Management District, June 2005, 23 pp.

Southwest Florida Water Management District. 2007. Proposed Minimum Flows and Levels for the Upper Segment of the Hillsborough River, from Crystal Springs to Morris Bridge, and Crystal Springs. Peer Review Draft, January 30, 2007. Ecologic Evaluation Section, Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District. 2005a. Proposed minimum flows and levels for the middle segment of the Peace River, from Zolfo Springs to Arcadia. Draft. Ecologic Evaluation Section. Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District. 2005b. Alafia River Minimum Flows and Levels Freshwater Segment including Lithia and Buckhorn Springs. Draft – March 21, 2005. Ecologic Evaluation Section, Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District, 2005c. Proposed Minimum Flows and Levels for the Upper Segment of the Myakka River, from Myakka City to SR 72. Draft – August 10, 2005. Ecologic Evaluation Section, Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District 2004. Florida river flow patterns and the Atlantic Multidecadal Oscillation. Draft. Ecologic Evaluation Section. Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District 2002. Upper Peace River: an analysis of minimum flows and levels. Draft. Ecologic Evaluation Section. Resource Conservation and Development Department. Brooksville, FL.

Stanford, J.A., J.V. Ward, W.J. Liss, C.A. Frissell, R.N. Williams, J.A. Lichatowich, and C.C. Coutant. 1996. A general protocol for restoration of regulated rivers. Regulated Rivers 12: 391-413.

Statzner, B., J.A. Gore, and V.H. Resh. 1988. Hydraulic stream ecology: observed patterns and potential applications. Journal of the North American Benthological Society 7: 307-360.

Stuber, R.J., G. Gebhardt, and O.E. Maughan. 1982. Habitat suitability index models: largemouth bass. U.S. Fish and Wildlife Service. FWS/OBS – 82/10.16. U.S. Government Printing Office. Washington D.C.

Errata / comments by page number in May 18, 2007 upper Braden River MFL peer review draft report

i	2.4.2 – fix page number at end of entry
ii	4.7.2 – fix page number at end of entry
iii	5.5.5 – remove “ .” after 5.5.5 and before “Short-Term Compliance….”
iv	Figure 2-14 – fix reference error at end of entry
viii	Table 5-8 – fix page number at end of entry
ix	Last sentence – change “site” to “sites”
x	3rd paragraph, line 9 - change “period or record” to “period of record”
1-1	1st paragraph, line 3 – remove space in “determi ned”
1-1	2nd paragraph, line 13 – add comma after “significant harm”
1-2	Top, point 10 - remove the ” after Navigation
1-4	Line 10 – change “multiple flows” to “multiple flow”
1-9	3rd paragraph, line 9 - change “of three” to “of the three”
2-1	Bottom paragraph, line 4 – add comma after “Dam”
2-1	Bottom paragraph, line 7/8 – change “585 million gallon” to “585 million gallons”
2-2	Line 4 – add commas after “MFLs” and “River”
2-2	2nd paragraph, line 2 – add comma after “(1911 to 2004)”
2-4	Last line on page – add comma after “e.g.”
2-7	Table 2-1 title – hyphenate “53,487 acre”
2-7	Table 2-1, last column – delete “%” signs after numbers
2-8	Table 2-2 title, line 2 – change comma to colon after “periods”
2-8	Table 2-2, last column – delete “%” signs after numbers
2-11	Table 2-3 title, line 2 – change comma to colon after “periods”
2-11	Table 2-3, last column – delete “%” signs after numbers
2-14	2nd paragraph, line 11 – should “St. Mary’s” be possessive?
2-15	Figure 2-12 – make all 3 x-axis labels the same
2-16	2nd paragraph, line 3 – add comma after “(2003)”
2-16	2nd paragraph, line 7 – add comma after “At the same time”
2-16	3rd paragraph, line 9 – hyphenate “low flow” when used as an adjective as in this sentence and in numerous places elsewhere in the text
2-16	3rd paragraph, line 12 – hyphenate “bimodal flow”
2-18	Line 16 - change “multidecadal times periods” to “multidecadal time periods”
2-19	Figure 2-14 title, last line – change “Thiel” to “Theil”
2-19	Figure 2-14, 3 figure legends – Define “o”, “.”, and “..”
2-20	Table 2-4 title - change (XAnnq) to (XAnnQ)
2-21	Table 2-5, column titles – add space between “Median of” and “1970”
2-22	1st paragraph, line 7 – shouldn’t the benchmark period be “1970 through 1999” rather than “1970 through 1994” – see Figure 2-14, Table 2-4, Table 2-5, last line of page?
2-23	1st line – shouldn’t “1994” be “1999”?
2-23	Figure 2-15 – add “Day of Year” as x-axis label
2-23	2nd last line on page – delete space in “50 %” to be consistent with other percentages

2-24	1st paragraph, lines 2 and 5 – hyphenate "low flow" and "high flow"
2-24	2nd paragraph, line 1 – delete "very"
2-24	2nd paragraph, line 2/3 – "Table 2-7" should be "Table 2-6"
2-24	3rd paragraph, line 3 - change "day110" to "day 110"
2-24	3rd paragraph, line 5 – change "(rather than 176)" to "(rather than 175)"
2-24	3rd paragraph, line 8 – change "used for previously" to "used previously"
2-24	Last line of text – add period at end of sentence
2-24	Table 2-6 title, line 2 – hyphenate "high flow"
2-27	Last paragraph, line 11 – change "seems like" to "seems likely"
2-27	Last paragraph, line 13 - change "other studied" to "others studied"
2-29	Figure 2-18 – add ")" to end of each of the 3 y-axis labels
2-32	Table 2-8 - Is the minimum pH for the Peace at Arcadia really 0.7?
2-32	Table 2-8 – Change "Nitroghen" to "Nitrogen" after "Nitrate+Nitrite"
3-1	1st Paragraph, line 1 - change "an MFLs determination" to "a MFLs determination"
3-1	Last paragraph, line 7 – add comma after "(1998)"
3-1	Last paragraph, line 7 – change "PHABSIM noted," to "PHABSIM, noted"
3-1	Last paragraph, line 11 – delete comma after "acknowledged that"
3-3	1st full paragraph, line 8 – add comma after "Richter 2003)"
3-3	1st full paragraph, line 9 – add comma after "African rivers"
3-3	1st full paragraph, line 15 – hyphenate "low flow"
3-7	1st paragraph, last sentence – change "effect" to "affect"
4-1	1st sentence – change "Methods used were" to "A number of methods were used"
4-1	3rd paragraph, line 9 – change "and lower reaches of tributaries" to "and the lower reaches of its tributaries"
4-2	Last line – add period to end of sentence
4-7	1st sentence – change "A variety … were" to "A variety … was"
4-8	3rd paragraph, line 12 – change "20%side" to "20% side"
4-8	3rd paragraph, line 13 – change "othrophotographs" to "orthophotographs"
4-12	Figure 4-5 title – change "40 %" to "40%"
4-12	Last paragraph, line 12 – change "of the data." to "of the survey."
4-17	Top title – hyphenate "Low Flow"
4-17	1st paragraph, lines 3,7, and 10 – hyphenate "low flow" before "threshold"
4-18	Figure 4-7 - Consider significant figures when identifying the inflection point. A value of 4.1 or 4 cfs seems more realistic than 4.09 cfs.
4-19	Section 4.6, lines 1 and 4 - hyphenate "low flow"
4-19	Section 4.6.1, 2nd paragraph, line 3 – based on Table 4-1, "April 20 to June 24" should be "May 7 to June 19"
4-19	Section 4.6.1, 1st paragraph, line 3 – change "was used" to "were used"
4-19	Section 4.6.1, 2nd paragraph, last line – hyphenate "low flow"
4-20	1st line - hyphenate "low flow"
4-20	Section 4.7.1, 1st paragraph, line 3 – add comma after "periods"
4-20	Section 4.7.1, 1st paragraph, line 4 – add comma after "PHABSIM"
4-20	Section 4.7.1, 1st paragraph, line 4 – shouldn't "1988-1993 and from 1994-2005" read "1988-1994 and from 1995-2005"?

4-20	Section 4.7.1, 2nd paragraph, line 5 – based on Table 4-1, “October 28 of one year to April 19” should be “October 25 of one year to May 6”
4-20	Section 4.7.1, 2nd paragraph, line 8 – add comma after “Block 2”
4-21	1st full paragraph, last line – hyphenate “low flow”
4-21	Section 4.8, 2nd paragraph, line 2 - based on Table 4-1, “June 25 to October 27” Should be “June 20 to October 24”
4-22	Section 4.8.1, line 8 – shouldn’t “1989 through 1993 and from 1994 through 2005” read “1988 through 1994 and from 1995 through 2005”?
4-22	1st line - change “Loraine” to “Lorraine”
5-1	1st 2 paragraphs – hyphenate “low flow” when used before “threshold” (5 places)
5-1	Section 5.2, heading - hyphenate “low flow”
5-1	Section 5.2.1, line 7 – hyphenate “low flow” before “periods”
5-2	Figure 5-1 title, line 3 – delete space after “Lorraine” and before “,”
5-3	Section 5.2.3, heading - hyphenate “low flow”
5-3	1st paragraph – hyphenate “low flow” when used before “threshold” (3 places)
5-4	3rd paragraph, line 3 – delete “the month of”
5-4	3rd paragraph, line 6 – change “time periods, respectively” to “time periods for the two sites, respectively”
5-6	1st 2 lines - move to bottom of page 5-5
5-6	Section 5.3.2, point 1 - hyphenate “low flow”
5-6	Section 5.3.2, last sentence - change “percent-of flow” to “percent-of-flow”
5-6	Section 5.3.2, last sentence, last line - hyphenate “low flow”
5-6	Section 5.4, line 3 - change “Long-term” to “long-term”
5-6	Section 5.4, line 6 – add comma after “inflection points”
5-6	Section 5.4, last line – hyphenate “low flow”
5-8	Table 5-2 title, line 1 – delete extra space between “of” and “floodplain”
5-8	Why reference Table 5-7 before Tables 5-3, 5-4, 5-5, and 5-6? Move contents of Table 5-7 to Table 5-3 and shifts contents of Tables 5-3 to 5-6 back one table
5-10	Last paragraph – capitalize “transects” in 4 places (?)
5-12	Last paragraph, lines 2 and 5 - change “soils conditions” to “soil conditions”
5-13	1st line – change “not saturated” to “non-saturated”
5-13	2nd line - capitalize “transects”
5-13	Table 5-5, last column heading – change “Not Saturated” to “Non-Saturated”
5-14	1st paragraph, line 3 - change “too low” to “too infrequently”
5-14	Last paragraph, line 6 - change “geomorhpological” to “geomorphological”
5-14	Last paragraph, last line - change “through1994” to “through 1994”
5-15	Table 5-7 title - change “geomorhpological” to “geomorphological”
5-15	Table 5-7 last footnote – change “Flows required at to inundate” to “Flows required to inundate”
5-15	Table 5-7 last footnote – change “transect” to “transects”
5-15	Table 5-7 last footnote – delete extra space between “than” and “the 1%”
5-15	Last paragraph, line 6 - change “Block3” to “Block 3”
5-15	Last paragraph, line 8 – change “1 %” “1%”
5-16	Line 2 – add comma after “reductions”
5-16	Line 3 – add comma after “achieved”

5-16	Line 10 - change "also show that" to "also shows that"
5-17	Figure 5-8 title, line 2 – change "from at the USGS" to "from the USGS"
5-17	Section 5.4.4, point 1 – hyphenate "low flow"
5-17	Section 5.4.4, point 2 – hyphenate "low flow"
5-17	Section 5.4.4, point 3 – change "flow above 54" to "flows above 54"
5-18	Section 5.5.1, 1st paragraph, line 5 – change "," to "." after "time-series analyses"
5-18	Section 5.5.1, 2nd paragraph, line 4 – change "," to "." after "(Figure 5-9)"
5-20	Last line – delete extra space between "Pringle et al." and "1988"
5-22	Line 2 – hyphenate "medium flow"
5-24	Section 5.5.5, point 1 - hyphenate "low flow"
5-25	Section 5.6, line 7 – add comma after "River" and "MFLs"
5-25	Figure 5-13 title, line 4 – add comma after "natural flow"
5-25	Figure 5-13 title, line 4 – add "withdrawal," after "maximum allowable"
5-25	Figure 5-13 title, line 5 – hyphenate "Low Flow" and "High Flow"
6-2	Brussock et al. – add comma after "Brown"
6-2	Bunn and Arthington - remove period after "Management"
6-2	Cherry et al. – change "96 p" to "96 pp."
6-3	Goldenberg et al. - change "Nestas-Nunez" to "Mestas-Nunez"
6-4	Junk et al. – add comma after "Bayley"
6-4	All 3 Kelly et al. MFL reports are listed as "165 pp + appendix" – check for accuracy
6-5	1st line – delete space between "FL" and "."
6-5	Kohler et al. – missing initials for Nordenson and Baker
6-5	Kohler et al. – change "13 p" to "13 pp."
6-5	Kuensler - capitalize the book title
6-5	Manly et al. - capitalize book title
6-5	Munson and Delfino (2007) - add page numbers for the reference (522-532), and Place the journal article title in lower case
6-6	Shaw et al. - change "23pp" to "23 pp"
6-6	Smith and Stopp - capitalize the book title
6-7	Stuber et al. – add comma after "Gebhardt"
6-7	Trommer et al. – add comma after "DelCharco"