

NC STATE UNIVERSITY | *Institute for* EMERGING ISSUES



Proceedings of the IEI/SOG/NRLI Forum
on the
Report of the Ecological Flows Science Advisory Board:
What Does it Mean for Water Planning and Policy?

Mary Lou Addor
Natural Resources Leadership Institute

Diane Cherry
Institute for Emerging Issues

Richard Whisnant
UNC School of Government

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Introduction

North Carolina is blessed with abundant precipitation and water resources. To ensure that all water users will have ample fresh water supplies far into the future, the State has begun building hydrologic models for each of North Carolina's major river basins. These models, coupled with demand projections from local water supply plans, give water resource managers the ability to accurately assess the probability that any given area of the state will face surface water shortfalls.

Ecological Flows Science Advisory Board

In 2010, the North Carolina General Assembly created a Science Advisory Board (SAB) to advise the Department of Environment and Natural Resources (DENR) on ways to refine the State's river basin hydrologic models. In the past, these models have looked only at extractive uses. The State had no method for assessing the many important in-stream uses of water other than costly, site-specific studies typically associated with permits. The legislature recognized the need to improve the State's water planning by developing state-of-the-art ways to model in-stream needs, particularly the water needs for fish and other aquatic species.

The legislature directed the SAB to be focused on science, rather than on water policy, with members required to have backgrounds in aquatic ecology or related fields. Appendix 1 contains the relevant portions of S.L. 2010-143, which directed the creation of the SAB. The sixteen members and their alternates represented a wide range of water users and scientific perspectives. Appendix 2 provides the full list of all SAB members. DENR created a supporting webpage, <http://www.ncwater.org/?page=366>, to post SAB proceedings, detailed summaries of its twenty-eight meetings, and the final comprehensive report.

The SAB met twenty-eight times over the three-year period. The Natural Resources Leadership Institute at NC State University administered and facilitated each of the meetings. In addition, other organizations such as Research Triangle Institute, the U.S. Geological Survey, The Nature Conservancy, and DENR itself, conducted and reviewed research outside formal meetings that were summarized and presented back to the entire SAB. Some of this work is important enough in the field of aquatic ecology to stand on its own and will likely result in independent scientific journal publications.

As part of its work, the SAB reviewed the science of ecological flow analysis and attempts by other states to incorporate it into their water resources planning. The SAB considered studies in North Carolina and elsewhere on the relationships between flow and habitat and between flow and biological condition. The various lines of inquiry are detailed in the SAB report, submitted to DENR in the fall of 2013. At the forum, they were summarized by Chris Goudreau, Special Projects Coordinator of the N.C. Wildlife Resources Commission. His presentation is provided in Appendix 5 (Goudreau presentation to forum).

Recommendations of the SAB to DENR

The SAB reached a consensus on recommendations to DENR. The four primary recommendations were as follows:

- (1) to use a flow-by percentage between 80 and 90% as an indicator of potential low-flow related problems;
- (2) in considering the cumulative impact of present and future withdrawals, to use the date of the authorizing legislation (2010) as a baseline for identifying areas of possible concern;
- (3) to augment the flow-by analysis with some accounting for critical low flows; and
- (4) to flag areas with a predicted 5-10% reduction in biological response.

The SAB also identified areas where the data did not allow clear conclusions on ecological flows, suggesting the need for further research. Chief among these gaps were coastal and headwaters streams. The SAB report was submitted to DENR in the fall of 2013. Following its receipt, DENR requested and received public comments on the report in late 2013.

Stakeholder forum

At a forum held on March 21, 2014, hosted by the Institute for Emerging Issues at N.C. State University in partnership with N.C. State's Natural Resources Leadership Institute and the UNC School of Government, a diverse group of stakeholders was asked to respond to the SAB report. The forum planners and authors of this document believed there was a need to bring the work of the SAB to the attention of a wider group of people interested in water resource planning and policy in North Carolina. The forum was designed to give those people a summary of the SAB work, an update on DENR's response to the SAB report, and a chance to give feedback on the report and its potential use.

Forum attendees included representatives of local government and public utilities, state government, public interest groups, researchers, consultants and engineers. Appendix 3 provides a list of registered forum attendees and the forum agenda. The forum began with a summary of the SAB process (see Appendix 5), DENR's plans in response to the SAB report (see Appendix 6), and a structured means for the participants to give feedback. That feedback is recorded and presented in the section below.

Tom Fransen presented DENR's response to the SAB work (see Appendix 6). He made clear that DENR sees the SAB report as a planning tool, not a substitute for existing permit or environmental review processes. The ecological flows analysis provides a way to determine which, if any, areas of the state need closer scrutiny when there are changes in flow regimes. DENR plans to use the flow-by recommendation, with a trigger level of 85% (absent an existing flow-by requirement), as a marker for stream reaches where closer scrutiny is needed. DENR does not plan to implement the biological response or critical low-flow recommendations at this time, pending further evaluation. Next steps for DENR include a peer review of the SAB report and a technical memo outlining its use in conjunction with the hydrologic models.

Recommendations from forum participants

As the planners had hoped, the forum participants' responses provide a rich and diverse set of recommendations on qualities, problems and possible refinements to the SAB report. Anyone interested in water resources planning in the Southeastern United States would benefit from reading the responses in full. Many of them are aimed at particular facets of the water planning, policy and research worlds. On the whole, the forum participants were supportive of the SAB's work and report. Most concerns centered on how the report will be used and how it will be understood by elected officials and others who may not be steeped in the science of aquatic ecology or hydrology.

As a result of this primary set of concerns, one important general recommendation emerged: DENR should move quickly to prepare a technical memo explaining how the SAB report will be used in conjunction with its hydrologic models, and should also prepare some simpler explanation for interested persons to better understand the context for ecological flows analysis as a planning tool. This simpler explanation should help allay fears that the SAB report will create new regulatory hurdles. In fact, the SAB work was designed from the outset to provide a planning tool that simply helps assure all North Carolina water users—urban and rural, businesses and residences—that they will have the fresh water they need for decades to come. The work of the SAB should help State government focus its limited resources on areas that might, someday, experience water shortages. At the forum, Tom Fransen indicated that a draft technical memo was already in preparation, along with training materials for interested members of the public.

Responses to the SAB report

The participants broke into three discussion groups to give their responses to the report. The responses were focused on four questions:

1. What's valuable in the report and why?
2. What concerns do you have about the report and why?
3. What do you understand the least and/or need more education about?
4. Do you have suggestions for further research or refinement of this work?

The discussion groups were facilitated by Mary Lou Addor, Diane Cherry, and Richard Whisnant; the responses were generated by the participants; and Alexia Kelley, Allison Hawkins, and Grizel Gonzalez-Jeuck recorded the responses for the forum proceedings.

1. WHAT'S VALUABLE IN THE REPORT AND WHY?

General perceptions about the Ecological Flows Science Advisory Board

- Overall impressive job by SAB.
- Range of engagement/expertise included to produce report info is positive.
- Looked broadly at a significant set of information to come to an informed decision based on science.

General perceptions about value of the report

- Great report on best available science.
- The report itself- one of the first efforts in the South.
- Good baseline report.
- Up to this point there was nothing in the planning process to deal with ecological considerations – this is a huge leap forward. A gap has been filled with this report – the information gap. Need action to come from the report. Ecological flows were taken into account before, but had no baseline. Now that all this information has been consolidated this will be a tremendous resource.
- Excellent effort to evaluate the extent to which “ecological flow” can be accurately defined.
- Establishes baseline that will not continually shift.
- Creates an adaptable process.
- Comprehensive but digestible summary of state of science around ecological flows.
- Ecological healthgives helpful information.
- The science behind ecological flow.
- The report gives ecological flows a place at the table.
- The report represents a starting point for the stream flow conversation.
- Developed with input from various stakeholders.
- Report shows state of science, valuable background information and pushes science forward.

Planning vs policy emphasis

- Emphasis that the report should be used as a planning tool.
- Planning approach captures/accounts for cumulative impacts.
- Planning approach allows “flags” or concerns to hopefully be addressed before impacts to ecological integrity occur.
- Report provides a platform for NC to make a much needed policy on instream/ecological flows.

Practical/useful information in the report

- Places scientific findings in terms relevant to water resources management and policy.
- Flow classification is useful.
- Glossary. Glossary. Glossary.
- Definitions are valuable.
- Graphs illustrating habitat of various flows.
- Graphic Illustration in general.

Review of strategies in other states

- Identifies strategies being used elsewhere that are not justifiable in NC, based on analysis of NC data.
- Examination (limited) of methods used in other places for same issue.
- The report has screened various approaches to establishing ecological flows and provided recommendations as to their applicability in NC.

Applicability to North Carolina

- Understanding of NC knowledge base.
- Provides state of the science understanding of the ecological flow needs in NC rivers and streams using NC data.
- Approach shown to protect North Carolina resources (i.e. tested with PHABSim or biological sampling data).

Applicability to DWR's Work

- Tool will allow DWR to incorporate updates to tool in regard to on-the-ground changes.
- Potential to move resources planning to a sustainable basis.
- May help to avert litigation over endangered species, water rights.
- Provided a resource tool that DENR can put into practical use when making decisions.
- The review of eco flow approaches is valuable, as well as the recommendation for ecological flows planning approach. Why: A planning approach will help target limited DWR resources to the places in greatest need on more-intense in-stream flow studies.
- The report is critical to future water use in NC because it can provide a basis for ensuring provision of ecosystem services for future generations. DENR should go ahead and adopt all the recommendations.
- Provides DWR with quality methods for flow planning.
- Could ensure sustainability of flows in NC – DENR should adopt.
- Need to understand what basic level of stream water supports all uses.
- Need to understand existing demands
- Need to prioritize uses if possible

Applicability to Local Government

- Could assist local government and utilities for planning best water sources in future.
- May help to avert litigation over endangered species, water rights.
- Creates a critical data point to add to water management discussions.

Applicability to Researchers

- Will be used to fill data gaps.
- Valuable to document research and information gaps and needs that may guide future investments to improve/refine and extend ecological flows discussion and impacts (for example, coastal information gaps, additional metrics needed).
- Identifies additional information and knowledge needed to refine quantification of ecological flows.

Process that supported/continue to support the work of the EFSAB

- Begins to engage community, water users and the public.
- As a process person, good to understand how recommendations developed.
- Good transparent process to develop report recommendations.
- Report can be used to engage scientific community, water users, and public.
- Group with diverse backgrounds came together and reached consensus.

Responsiveness to ecological considerations (not in lieu of other interests but in tandem with them)

- Advanced water planning may allow for targeted investments that both support economic growth (through information) and protect environmental values (open space, healthy rivers).
- Shines light on relative importance of maintaining flow for ecological needs.
- History and need for ecological flow development.
- Protection of natural flow variability.
- Shows the benefits of protecting natural flows, problems deviating from those flows.

Specific science-based generated information

- Research into correlating biological response to degree of flow alteration is very valuable; it's ground breaking work.
- Tying the ecological health to a flow-by % gives modelers a relatively simple parameter to utilize in gauging withdrawal impacts.
- Flow-by approach to ecological flows is a very important, positive development in how we look at stream flow in NC.
- Actual predictions of flow that are needed to maintain ecological integrity.
- Different methods to determine appropriate flow regimes.

Results from the report found to be of value

- Trend setting analysis to establish correlation between biotic and hydrologic data alterations.
- Relationships between statistics and ecology.
- Scientifically-credible in-stream flow recommendations.
- The attempt to figure out how stream flow characteristics are related to ecological habitat function and set a framework for its evaluation and acknowledging that we as a society need to balance our water needs and patterns of use with ecosystem health.
- Highlights the needs of headwaters streams.
- Provides strategy for assessing amount of water needed in streams to maintain ecological integrity.
- Discussion of cumulative impacts and baseline “status” is valuable for discussion.

2. WHAT CONCERNS DO YOU HAVE ABOUT THE REPORT AND WHY?

Postponement of Critical Low-Flow Component

- Concerned that critical low flow piece is not being implemented – understand the desire for more analysis, but the [component] need not be lost.
- Two categories: threatened and endangered – important regulatory system already in play. Of more concern: Fishable use in Clean Water Act and how critical low flow may impact that. DENR could investigate these
- Concern with low flow, especially headwaters – reasonable that at certain times flow will be zero and wild swings in natural regimes. Further conceptual challenges from a water planning perspective.
- Drought response plans address critical low-flow but they don’t address ecological flow for local governments.
- Threshold needs to be integrated into model to protect species from “crisis”.

Postponement of Biological Response Component

- Not going to use the info on biological response, which is a critical data point in determining ecological health.

Process to Determine When Evaluation Occurs

- Determine how these flags are going to translate into running out of water, etc.
- Use of a daily step/interval results in large fluctuations, but the Corp of Engineers requires and focuses on a consistent flow in highly managed basins such as the Neuse. Wild fluctuations could cause “more study required” too often.
- For red bin sites, it is vague as to whether additional study may lead to more regulation for users affecting those nodes.
- Unclear how models will be implemented in terms of application and enforcement.

Process to Distribute Water Allocations

- How are water flow allocations going to be worked out?
- It is focused on ecological flows and doesn't deal with allocation of flow resources.
- Relationship between other "needs" not explored.
- Unclear how much consideration is given to robust water supply efforts already being done (these efforts may be addressed during implementation).

Implications Concerns on Economic Development

- Will the report or the manner in which it is used result in negative impacts of our state's efforts to expand economic development?
- From an economic perspective, it gives specific information to companies coming, which can be seen as encouraging because there is less unknown.
- How will planning-aspect bleed over into regulation? Will having this plan dissuade outside companies from coming into the state? Further published guidance explaining how the report will be used could mitigate this.
- But there is still a concern that the companies will write off NC before getting to see this, if the report and its context are not properly presented.

Communication of the Report

- Transparency is very important for future use of the report.
- This is such a scientific document. Translating it into a language that can be understood by a majority of legislature/government officials not involved in this program [could be difficult].
- Report is nested within other decisions within DWR, so the SAB worked very hard to just focus on the science so that others could determine the use of the information.

Implementation Concerns for the Report

Misinterpretation of the report

- Misinterpretation of the report as policy or regulatory rather than recommendations as a planning tool.
- This report would become part of the permitting process causing further delays and increasing the cost to determine the best sources of water for a community.
- Misinterpretation of statute and the planning purpose, and fear of impact on permitting will stifle efforts moving forward.
- How will the report and models ultimately feed into regulatory programs.

Will not be implemented

- Report recommendations may not be implemented.
- A major concern is that it could wind up sitting on the shelf and not be implemented; however, it sounds from the presentations that this is not likely to happen since DENR has already embraced at least portions of the recommendations.
- Implementation won't occur by DENR because resources get shifted to other hot topics and political pressures.
- Implementation of models/plans doesn't stand up to permittee demands.
- Science will be discounted and no policy put in place
- Recommendations will not be implemented over time.

Did not consider all constraints in statute

- Did not examine all constraints in statute in recommendations.
- Comparisons to South Carolina, which had less focus on ecological flow.
- Myopic – no allocation system, so only deals with one small aspect. Moving from riparian state to flow state. Branching out to other aspects, not just ecological flow, is important.
- Basin models do incorporate other aspects, than just flow.
- The report does not answer the biggest question – How will DWR implement an eco-flows analysis in its basin planning? Why: Certain people have raised big concerns. Implications for local water supply.

Use of broad-brush approach

- Acts as a de facto rule since uniform recommendations for all waters instead of unique recommendations for each basin.

Resources to Implement Report

- What support, internal or external to DWR can be identified to move forward with report's next steps or needs?
- The need for integration of this into water management as a whole.
- There are tens of thousands of days in the period of record in these basin models and the driving criteria for bin categorization for each model node can be determined by any one of these days. As such, the DWR is probably going to have to develop additional criteria to really sort out where the problems are – otherwise they may be creating an overwhelming amount of additional analysis and work for themselves
- DWR needs to develop additional criteria to determine where problems are.
- Do we need further DENR study? Especially with the current political situation at DENR
- Limited resources to carry forward.

Unclear Timeline for Implementation

- Unclear what (if any) time frame for DWR actions – to incorporate recommendations and/or complete additional research to address recommendations is defined as “open ended” timeline will be challenging to execute/implement for DWR.

Contributions of Organizations

- Perhaps does not fully describe/detail the somewhat piecemeal nature of the assorted work efforts that contributed to the report.

Future Opportunities for the EFSAB

- How the report will be implemented and future opportunities for the EFSAB to contribute to the process.
- Role of the board after completion is unclear. To date it seems DWR is expected to defend the science of the report but they may not know the details enough to do this.
 - Pro: Protects the integrity of science and the process of Board.
 - Con: may be unable to use tool if not defended appropriately.

Aspects of Offline Storage

- Does not account for skimming to offline storage at higher rates during flood conditions.
- Offline storage can help reduce problems, but model doesn't allow for more than 15% storage. This strategy should be incorporated into the models.
- Response: 15% at high flow is a lot of water.
- It's not that models can handle more than 15%, it's how model is parameterized. Not just skimming, but also reallocation.

Limitations of the Research

Lacks peer review

- The peer review – reviews can be greatly influenced by the personalities and/or ideologies of the reviewers – I encourage careful selection of objective, credible, rational reviewers – preferably selected by some independent third party, not DENR.
- Fail to understand the need/value in further DENR study, especially in view of the lack of credibility that DENR top level management have engendered with the public by their shift in philosophy under the present administration.
- Sounds like during public comment there was a question about reviewing science. Is the science under review too?
- Review process needs improvement.

More site specific studies

- Any determination of whether flow-by is good enough? Possible for further research section
- Insufficient model runs to understand application consequences.
- Need site specific studies
- Minimal data points in Catawba and Yadkin basins.

Species Data

- Was impact mitigated with other habitat?
- Were species native to area?

Age of Data

- How old was data used in education?

Baseline Data Approach

- DWR needs to also model natural conditions as well as baseline to do comparisons.
- Needs to model natural condition as well as baseline (2010).
- 2010 data used in baseline....Was there enough water in the stream to protect the biological communities in 2010?

Larger Bodies of Water Data

- Majority of data is from wadeable water bodies – what about larger bodies of water?
- Applicability of approach to large rivers because there's little data to show how large rivers respond.

Lack of Eco-region representation

- DWR modeling just assumes 85% randomly – should be more basin-specific.
- Prevailing ecological conditions were based on only 14 sites?
- More observed data would strengthen models.
- Lack of data to represent all the ecoregions of the state equally.
- The assumption that coastal streams are less “altered” in terms of hydrology and salinity.

Data not included

- Ambient data was not used.
- No climate projection, predictions, or input.
- Not very much emphasis on restoration of impacted ecology due to inadequate flows.

3. WHAT DO YOU UNDERSTAND THE LEAST AND/OR NEED MORE EDUCATION ABOUT?

Application of the Recommendations by DWR

Use in long-range water planning •

- How DWR will use results.
- How will agency really use this?
- How DWR application will impact offline storage alternative.
- How is flow-by assessed?
- How water allocation decisions will actually be made as we approach limits of sustainability in some basins.
- How is adaptive management going to be implemented?
- Will this promote more wastewater treatment discharge, make available?
- Will this improve assimilative capacity in streams for WUT?

Timeline for review of recommendations DWR put on hold

- The critical low flow component.
- As Tom indicated there will be times when flows get below this level but could it still be useful for planning if tweaked?
- For the portion of the flow that is below the critical low-flow threshold how will further study be done?

Linking all water uses (essential and ecological)

- What is DENR's intention with implementing these results and what does this do for flows planned at water treatment facilities not yet used?
- Discussion of essential uses as compared to all uses and modeling approach and implementation.
- How is model used/applied under DWR for emergency water allocations requests? (also in relation to essential needs considerations).
- The "direct" line between guidance "rule" "law" and how this will affect the interested community.
- As time goes on and water users (e.g. municipalities/utilities) start the permitting process for future supplies identified in their local supply plans, if those water supply projects turn out to force "red bin" conditions at model nodes and additional study is required, will DWR be asking the utilities to pay for the additional studies? Will bin conditions be used as reason for determining preferential water supply projects?
- Droughts plans may be instituted by water providers, but what if there is no significant reduction in water usage by customers?

In working with other agency mandates

- How will DWR apply results in U.S. Army Corps of Engineers' mandated flow regions?

In working with current projects

- How will it affect "new" projects, such as the Cleveland County project? *Approval by EMC*
- What does the EMC's approval of the models actual mean? Approve it as planning process or impose flow-by-requirements?

Treatment of Existing/Prevailing Conditions

- Under existing conditions how often do streams/river basins fall below the flow needed for ecological integrity? Only during drought years? Or more regularly?
- Unclear about permit "conditions" and how grandfathering will work when assessing prevailing conditions. Some withdrawals have a minimum and maximum so conditions will alter based on what operation is in use currently.
- How much difference is there between existing permit conditions and new flow-by conditions?
- What if the baseline is already stressed?

Additional Explanations

Modeling

- How model can effectively apply daily flow-by when not designed to do so.
- How data inputs into the flow models can affect the outcome. What is the quality of the data? What are the sources? Is any of the data subjective?
- Interaction of "flashiness" with ecological flows analysis.

About the Report

- It is not likely the report or the issues will be understood by local and state level policy makers and elected officials.
- The statistics behind the biological response curves are complex and while I trust them, they need to be made understandable by the public.
- The science!
- I don't entirely understand where things go from here and how much more study DENR intends to conduct on those recommendations they chose to adopt at this juncture.
- Importance of eco-flows to protect aquatic life and down-stream users (public education is needed).
- How ecological flows can be used to assure higher flows as well as protect from dewatering streams.

Work of RTI

- Influence of upstream land use conditions on calculated eco-deficits.
- Would be helpful to have more information/explanation on the flow ecology graphs that came out of the RTI research.
- The statistical analysis data filtering associated with the biological response thresholds.

Classification of Rivers and Streams

- Scientific rationale for not proposing any type of stream classification; deviation from ELOHA framework.
- Headwaters- what different questions were posed? Can you prioritize? • Coastal plain reactions/impact from upstream flow changes.

4. DO YOU HAVE SUGGESTIONS FOR FURTHER RESEARCH OR REFINEMENT OF THIS WORK?

Furthering the Work

Next Steps for DWR

- DWR/EMC should publish a TM (technical memo) that describes the way it will implement ecological flows analysis in its basin plan.
- Eco-flows should be integrated in some hydrological models [now] so that we can learn from and improve them.
- See how implementation works in modeling/planning for one or two basins and adjust if needed.
- EMC help [support] DENR.
- Interested in bringing up level of understanding of competing demands for water.

Ensure Legal Analysis

- Re-examine statutory mandate vs. results.
- Legal analysis of whether uniform standard is de facto rule and thus banned.
- Emphasize/make part of law that SAB recommendations can't be used for water use permitting/how DENR responds to water availability measures.

Next Steps for EFSAB

- Bring EFSAB back together or keep group together as recommendations are implemented and where are opportunities for future contribution.

Coordination of Future Research

- How can we coordinate efforts to get more intensive research conducted?
- What proactive steps can be made to address "gaps" in next steps outlined in report?
- Define next steps or opportunities for additional research and the specific research needed.

Strategies for Monitoring

- Determine what additional monitoring is needed in order to improve the knowledge needed that will assist in better understanding the impacts of flow on biological communities. Advise the division of Water Resources to make these a priority.
- How can the efforts of DWR to incorporate these recommendations be evaluated over time to understand their impact on planning efforts?

Public outreach and education

- Hold workshops after public hearing and peer review.

Addendums to Report

- Add the term “flow-by” to glossary.

Peer Review

- Should the Instream Flow Council be considered as the only peer group to involve?

Expand Understanding/Knowledge About:

Adaptive Management

- Adaptive management: what do models say? What does field response say? How is the information fed back into the model or expressed in permitting?

Coastal and Headwaters Research and Ecological Flows

- Examine how results are applied for fishable use under CWA.
- Additional research pertaining to how to plan for streams that fall outside scope of report: 1. Coastal, 2. Headwaters.
- Planning for changes in flows along coast as sea level rises.
- Coastal area recommendations should at some point be developed.

Land Use Change and Ecological Flows

- Model land use change and water for planning.
- Research limitations, limited exploration of impact of variables (indirect), such as climate change, land use change, integration of water quality with flow (see refinement of work).
- Land use change increases storm water run-off, surface and groundwater recharge and alters flows.
- Future incorporation of land use and population change and climate variability projection will be important components.
- Useful to have a credible way to integrate impervious surface/changes to baseflow.

Climate Change and Ecological Flows

- Implications of climate change (use downscale climate models to change inflow)?

Economic Benefits and Ecological Flows

- Economic benefits of protecting river flows and river ecology.
- Further conversation/study may be needed on the relationship between ecological flows and ground water levels.

Minimum, Low and Critical Flows

- Impact of setting minimum flow thresholds.
- Were drought plans intended to address ecological flow?
- Define critical low flows to augment flow-by approach.
- Will stream reaches be able to be impaired because of low flow?

Current PHABSIM Data

- Analyze additional PHABSIM sites for habitat response to different flow management strategies.
- Re-run some of the remaining PHABSIM sites that are left on the shelf.
- Does reduced ecological flow help replace nature habitat if reduced and get rid of invasive species?

Continued Biological Sampling

- More biological sampling to cover parts/systems in the state that are underrepresented.
- More long term data sets to collect biological samples at sites as flow conditions change over time.
- Expand number of fish monitoring sites to adjacent states. • Develop curves for additional species/guilds/taxa.

Eco-deficit Approach

- Further refinement, peer review of eco deficit approach.
- Quantify change in geographic prevalence and magnitude of eco-deficits under future climate and economic development scenarios.

Larger River Data

- More basin specific.
- Larger water bodies, original focus was mainly on wadeable.
- Large river data.

Aspects of Modeling

- Examine whether OASIS model can achieve statutory requirement of ecological flow determinations.
- How will model represent quality and quantity if not site specific?
- Applying the findings of the SAB, do the model results (i.e. predictors) match up well with the WQ sampling and biodiversity sampling for certain stream segments where such sampling has been completed? This may have been done already?
- Ability of hydrologic models to capture future land use changes and resulting flow changes because they use historical flow records.
- More modeling should be undertaken to incorporate watershed condition into water resource planning in addition to the flow considerations.
- Need to determine whether analysis of nodes on a daily basis is going to be productive or going to bog down the analysis/planning
- Examination of “unaltered” hydrology.

Appendices

1. Session Law 2010-143 (in relevant part), directing the creation of the Ecological Flows Science Advisory Board
2. List of EFSAB members and alternates
3. Registered participants at the forum
4. Forum agenda
5. Presentation by Chris Goudreau summarizing the SAB report
6. Presentation by Tom Fransen explaining DENR's plans for report implementation

App. 1 Relevant parts of legislation creating the EFSAB (emphasis added)
SESSION LAW 2010-143
HOUSE BILL 1743

The General Assembly of North Carolina enacts:

....

SECTION 2. G.S. 143-355 is amended by adding a new subsection to read:

"(o) Basinwide Hydrologic Models. – The Department shall develop a basinwide hydrologic model for each of the 17 major river basins in the State as provided in this subsection.

(1) Definitions. – As used in this subsection:

- a. "Ecological flow" means the stream flow necessary to protect ecological integrity.
- b. "Ecological integrity" means the ability of an aquatic system to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to prevailing ecological conditions and, when subject to disruption, to recover and continue to provide the natural goods and services that normally accrue from the system.
- c. "Groundwater resource" means any water flowing or lying under the surface of the earth or contained within an aquifer.
- d. "Prevailing ecological conditions" means the ecological conditions determined by reference to the applicable period of record of the United States Geological Survey stream gauge data, including data reflecting the ecological conditions that exist after the construction and operation of existing flow modification devices, such as dams, but excluding data collected when stream flow is temporarily affected by in-stream construction activity.
- e. "Surface water resource" means any lake, pond, river, stream, creek, run, spring, or other water flowing or lying on the surface of the earth.

....

(4) Ecological flow. – The Department shall characterize the ecology in the different river basins and identify the flow necessary to maintain ecological integrity. **The Department shall create a Science Advisory Board to assist the Department in characterizing the natural ecology and identifying the flow requirements. The Science Advisory Board shall include representatives from the Divisions of Water Resources and Water Quality of the Department, the North Carolina Wildlife Resources Commission, the North Carolina Marine Fisheries Commission, and the Natural Heritage Program. The Department shall also invite participation by the United States Fish and Wildlife Service; the National Marine Fisheries Service; representatives of organizations representing agriculture, forestry, manufacturing, electric public utilities, and local governments, with expertise in aquatic ecology and habitat; and other individuals or organizations with expertise in aquatic ecology and habitat.** The Department shall ask the Science Advisory Board to review any report or study submitted to the Department for consideration that is relevant to characterizing the ecology of the different river basins and identifying flow requirements for maintenance of ecological integrity. The Department shall consider such other information, including site specific analyses, that either the Board or the Department considers relevant to determining ecological flow requirements.

App. 2 Science Advisory Board members and alternates

Ecological Flows Science Advisory Board Members By Affiliation

Feb 8, 2011, updated August 13, 2013

1. **Agriculture**
Dr. Jeff Hinshaw, Extension Fisheries Specialist, NCSU
Alternate – David Williams, NC Division of Soil and Water Conservation
2. **Electric Public Utilities**
Hugh Barwick, Senior Environmental Resource Manager – Duke Energy Carolinas
Alternate – Thomas Thompson, Duke Energy Carolinas
3. **Environmental Non-Governmental Organizations**
Sam Pearsall, Southeast Regional Manager for Land, Water & Wildlife, Environmental Defense
Alternate – Rebecca Benner, The Nature Conservancy
4. **Local Governments**
Linda Diebolt, Environmental Scientist - Hazen & Sawyer
Alternate - Rusty Rozzelle, Water Quality Program Manager – Mecklenburg County Land Use and Environmental Services
5. **NC American Water Works Association (AWWA-WEA)**
Jaime Henkels Robinson – Associate Project Manager – CH2M Hill
6. **NC Division of Water Resources (DWR)**
Fred Tarver, Aquatic Ecology Branch – DWR
Alternate- Ian McMillan, DWR
7. **NC Division of Water Quality (DWQ)**
Jay Sauber, Chief - Environmental Sciences Section - DWQ
8. **NC Environmental Management Commission (EMC)**
9. **NC Forestry Association**
Bill Swartley, Program Head – Forestry Non-Point Source Branch, Division of Forest Resources – Dept. of Agriculture
Alternate- Peter Caldwell- USDA Forest Service
10. **NC Natural Heritage Program (NHP)**
Judy Ratcliffe, NHP
11. **NC Marine Fisheries Commission**
Dr. Bob Christian, Biology Dept. - East Carolina University
Alternate – Scott Chappel, NC Division of Marine Fisheries
12. **NC Wildlife Resources Commission (WRC)**
Chris Goudreau, Special Projects Coordinator – WRC
Alternate- Vann Stancil, Special Projects Coordinator – WRC

13. US Geological Survey (USGS)

Tom Cuffney, USGS - Raleigh

Alternate - Holly Weyers, Director-NC Water Science Center

14. US Fish and Wildlife Service (USFWS)

Mark Cantrell, Asheville Field Office - USFWS

Alternate - Sarah McRae, Ecological Services Branch - USFWS, Raleigh

15. US National Marine Fisheries Service (NMFS)

Fritz Rohde, Senior Biologist, NMFS

16. Academic Research

Amy Pickle, Nicolas Institute, Duke University

A list of Ecological Flows Science Advisory Board members and alternates who have served the science board in the following capacities but are no longer serving in these roles for various reasons are recognized for their contributions:

- Jessi Baker, **NC Division of Marine Fisheries** (Alternate to Bob Christian, Eastern Carolina University)
- Donnie Brewer, **Environmental Management Commission – Water Quality and Water Allocation Committees**
- Cat Burns, **The Nature Conservancy** (Alternate to Sam Pearsall, Environmental Defense Fund)
- Vernon Cox, **NC Dept of Agriculture and Consumer Services** (Alternate to Dr. Jeff Hinshaw, NC State University)
- John Crutchfield, **Progress Energy Carolinas**
- Jim Mead, **Division of Water Resources**
- Amy Pickle, **Environmental Management Commission – Water Quality and Water Allocation Committees**
- Steve Reed, **Division of Water Resources** (Alternate to Jim Mead, Division of Water Resources)
- Arlene Roman, **City of Gastonia** (Alternate to Linda Diebolt, Local Governments)

App. 3 List of Registered Forum Participants

Name	Title	Organization
Mary Lou Addor	Director & Specialist	NC State University, Extension, Natural Resources Leadership Institute
Robin Aldina	Energy Analyst	North Carolina Sustainable Energy Association
Robert Belk	Associate	Hazen and Sawyer
Tim Broome	Water Resources Engineer	Johnston County, Department of Public Utilities
David Brown	Project Director	University of North Carolina at Chapel Hill School of Government
Diane Cherry	Environments Policy Manager	Institute for Emerging Issues, NC State University
Chandra Coats	Director of Public Utilities	Johnston County
Ray Cox	Engineer	Highfill Infrastructure Engineering
Vernon Cox	Director	North Carolina Department of Agriculture and Consumer Services, Plant Industry Division
Nora Deamer	Water Basin Planner	Department of Environment and Natural Resources, Division of Water Resources
Shannon Deaton	Program Manager	North Carolina Wildlife Resources Commission
Scott Farmer	Water Resources Engineer	City of Greenville Public Utilities
Bob George	President	The George Institute
Grizel JeuckConzalez	Master's Degree Candidate & Facilitator	NC State University
Chris Goudreau	Special Projects Coordinator	North Carolina Wildlife Resources Commission
Kevin Greer	Assistant Public	City of Hickory

	Services Director	
Pat Harris	Director	North Carolina Department of Agriculture and Consumer Services, Division of Soil and Water Conservation
Bill Holman	North Carolina Director	The Conservation Fund
Preston Howard	President	North Carolina Manufacturers Alliance
Jeff Hughes	Director	University of North Carolina Environmental Finance Center
Jim Johnson	Partner	Blount Street Advisors
Alexia Kelley	Facilitator	Natural Resources Leadership Institute
Keith Larick	Environmental Programs Specialist	North Carolina Department of Agriculture and Consumer Services
George Matthis	President	River Guardian Foundation
Grady McCallie	Policy Director	North Carolina Conservation Network
Dan McLawhorn	Associate City Attorney	City of Raleigh
Jim Mead	(Retired) Water Resources Specialist	North Carolina Department of Environment & Natural Resources
Sydney Miller	Water Resources Engineer	Town of Cary
Steven Nebiker	Water Resources Engineer	HydroLogics
Reed Palmer	Senior Principal Engineer	Hazen and Sawyer
Heather Patt	Water Basin Planner	Department of Environment and Natural Resources, Division of Water Resources
Sam Pearsall	Scientist	North Carolina Environmental Defense Fund
Amy Pickle	Director of State Policy	Duke University, Nicholas Institute for Environmental Policy Solutions

Peter Raabe	North Carolina Conservation Director	American Rivers
Rhett Register	Science Writer & Editor	Water Resources Research Institute, University of North Carolina System
Heather Saunders Benson	Senior Planner, Water Resources	Triangle J Council of Governments
Adam Sharpe	Project Manager	CH2M Hill
Nancy Sharpless	Facilitator	Natural Resources Leadership Institute
David Springer	Water Resources Plant Engineer	City of Greenville Utilities Commission
Vann Stancil	Special Project Coordinator	North Carolina Wildlife Resources Commission
Fred Tarver	Aquatic Ecology Specialist	North Carolina Department of Environment and Natural Resources, Division of Water Resources
Ivan Urlaub	Executive Director	North Carolina Sustainable Energy Association
Kenneth Waldroup	Assistant Public Utilities Director	City of Raleigh
Forrest Westall	Executive Director	Upper Neuse River Basin Association
Richard Whisnant	Prof. of Public Law & Policy	UNC Chapel Hill School of Government
Susan White	Executive Director	Water Resources Research Institute, University of North Carolina System & North Carolina Sea Grant Program
Anthony Whitehead	Water Quality Manager	City of Greenville Utilities Commission
David Williams	Deputy Director	North Carolina Department of Agriculture and Consumer Services, Division of Soil and Water Conservation

App. 4 Forum Agenda

James B. Hunt, Jr. Library, NC State University Rooms B & C, Second Floor

- 8:15 a.m. Breakfast Served
Provided by Institute for Emerging Issues, Natural Resources Leadership Institute and School of Government
- 8:40 - 8:50 a.m. Welcome & Goals of the Meeting
Diane Cherry, Environments Policy Manager, Institute for Emerging Issues & **Mary Lou Addor**, Director, Natural Resources Leadership Institute & Extension Organizational Development
- Understanding the charge and the work of the Science Advisory Board (SAB)
 - Understanding the Ecological Flows Report
 - Implications for DENR's work
 - General comments on the report and understanding how to become better educated about it
- 8:50 - 9:20 a.m. North Carolina Ecological Flows Science Advisory Board Recommendations
Chris Goudreau, Special Projects Coordinator, N.C. Wildlife Resources Commission
- How the SAB came to be
 - SAB's work
 - Recommendations in the report
- 9:20 - 9:50 a.m. Implementation of the Report & Recommendations
Tom Fransen, Water Resources Section Planning Chief, Division of Water Resources, NC Department of Environment & Natural Resources
- How DENR will implement the report and its use in hydrologic modeling
 - What are DENR's next steps
- 9:50 – 10:00 a.m. Break
- 10:00 - 10:20 a.m. Clarifying Questions for Chris & Tom
-

Facilitated by **Richard Whisnant**, Professor of Public Law and Policy, UNC Chapel Hill School of Government

10:20 - 11:20 a.m. Breakout Sessions: Rooms 4101, 4105, and 4107

Facilitated by **Richard Whisnant, Diane Cherry & Mary Lou Addor**

Recorders: **Allison Hawkins**, Institute for Emerging Issues; **Grizel Gonzalez- Jeuck**, Natural Resources Leadership Institute; **Alexia Kelley**, Natural Resources Leadership Institute

Break into three concurrent groups to answer these questions below. Please note your affiliation when you answer the questions (*public interest groups, researchers, consultants, local government & public utility, state government, other*):

1. What's valuable in the report and why?
2. What concerns do you have about the report and why?
3. What do you understand the least and/or need more education about?
4. Do you have suggestions for further research or refinement of this work?

Highlight within each group what you would like reported out

11:20 – 11:45 a.m. Small Group Report Back

- Group 1
- Group 2
- Group 3

11:45 a.m. Next Steps & Adjourn

- Conference proceedings available on the EFSAB website
- Summary of work available for public distribution

App. 5 Presentation by Chris Goudreau summarizing the SAB report

Recommendations of the North Carolina Ecological Flows Science Advisory Board

Institute for Emerging Issues

March 21, 2014

Chris Goudreau

N.C. Wildlife Resources Commission

Background

- Session Law 2010-143
- Requires DENR to develop basinwide hydrologic models for each of the 17 major river basins in NC
- Simulate flows to determine if adequate water is available to meet all needs, including essential water uses and ecological flows
- Does not:
 - replace site-specific studies
 - vary existing permits/licenses

What are Ecological Flows?

- The Session Law defines ecological flow as “the stream flow necessary to protect ecological integrity.”
- Ecological integrity is defined (in S.L.) as “the ability of an aquatic system to **support and maintain a balanced, integrated, adaptive community of organisms** having a species composition, diversity, and functional organization comparable to **prevailing ecological conditions** and, when subject to disruption, to recover and continue to provide the natural goods and services that normally accrue from the system.”
- “prevailing” not in original def. (Karr and Dudley 1981)

Ecological Flows Science Advisory Board

- SL 2010-143 directs DENR to “create a Science Advisory Board to assist the Department in **characterizing the natural ecology** and **identifying the flow requirements.**”
- Role:
 - water resource planning
 - recommend scientifically-based methods or approaches and ecological flow requirements
- Not a role:
 - water-use permitting
 - recommending how DENR responds to a water-availability issue
 - advising DENR on how to use the EFSAB recommendations

Makeup of the EFSAB

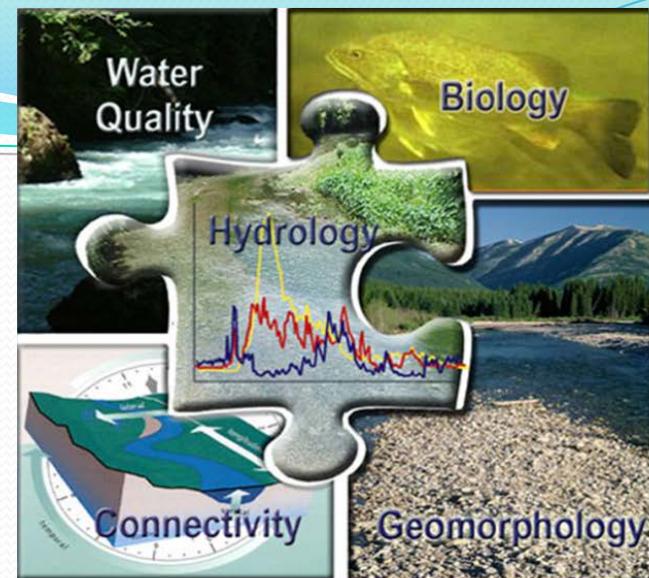
1. Academic Research – Duke University
2. Agriculture – NC State University; NC Division of Soil and Water Conservation
3. Electric Public Utilities – Duke Energy Carolinas
4. Environmental NGOs – Environmental Defense Fund; The Nature Conservancy
5. Local Governments – Hazen & Sawyer; Mecklenburg County
6. NC American Water Works Association – CH2M HILL
7. NC Division of Water Resources
8. NC Division of Water Quality
9. NC Environmental Management Commission
10. NC Forestry Association – NC Forest Service; USDA Forest Service
11. NC Natural Heritage Program
12. NC Marine Fisheries Commission – East Carolina University; NC Division of Coastal Management
13. NC Wildlife Resources Commission
14. US Geological Survey
15. US Fish and Wildlife Service
16. US National Marine Fisheries Service

Facilitation provided by N.C. State University's Natural Resources Leadership Institute and NCSU Cooperative Extension

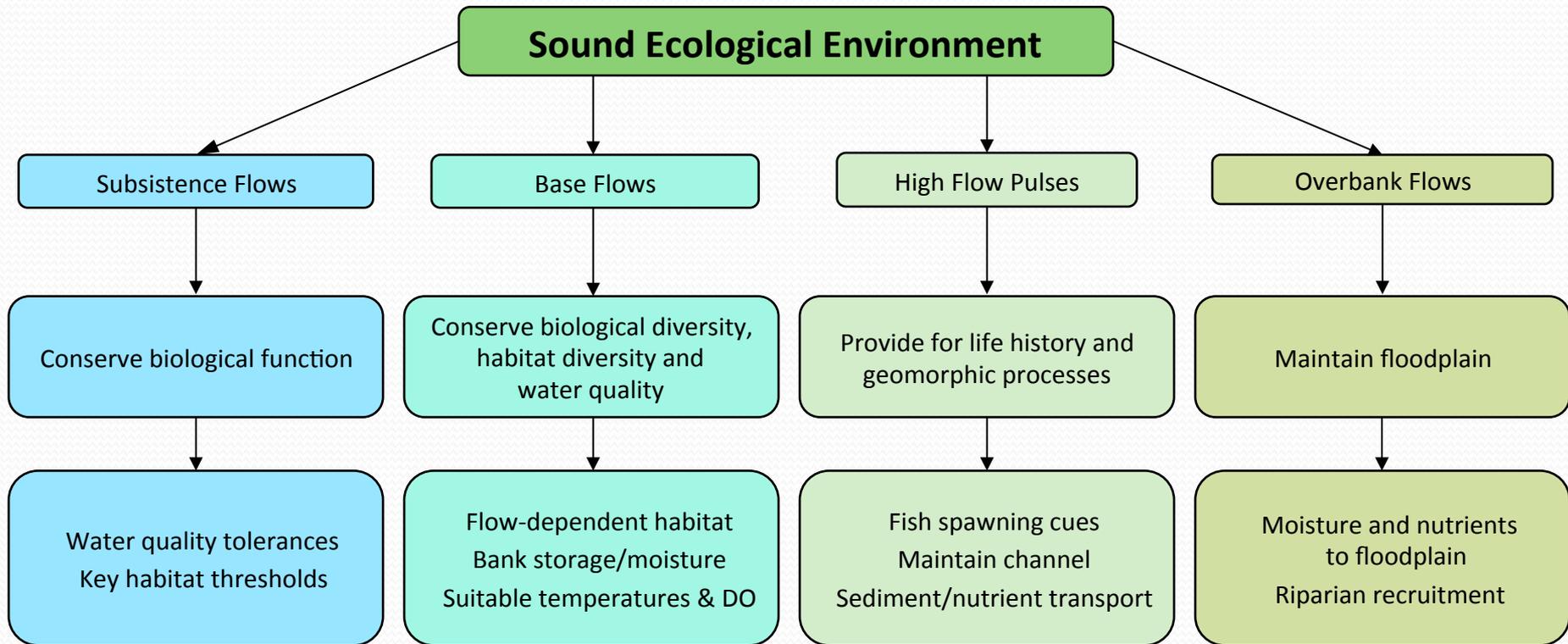
Met 28 times between November 2010 and October 2013

Importance of Flow

- “Master variable” of riverine systems
- Determines water quality, biology, physical habitat, and energy transfer
- All components of the flow regime (magnitude, duration, frequency, timing, and rate of change), including natural variability, are important to maintaining ecological integrity
- Natural variability of flows includes intra-annual and inter-annual variability and consists of extreme low flows, low flows, high flow pulses, small floods, and large floods
- Collectively, these concepts are known as the “natural flow paradigm”

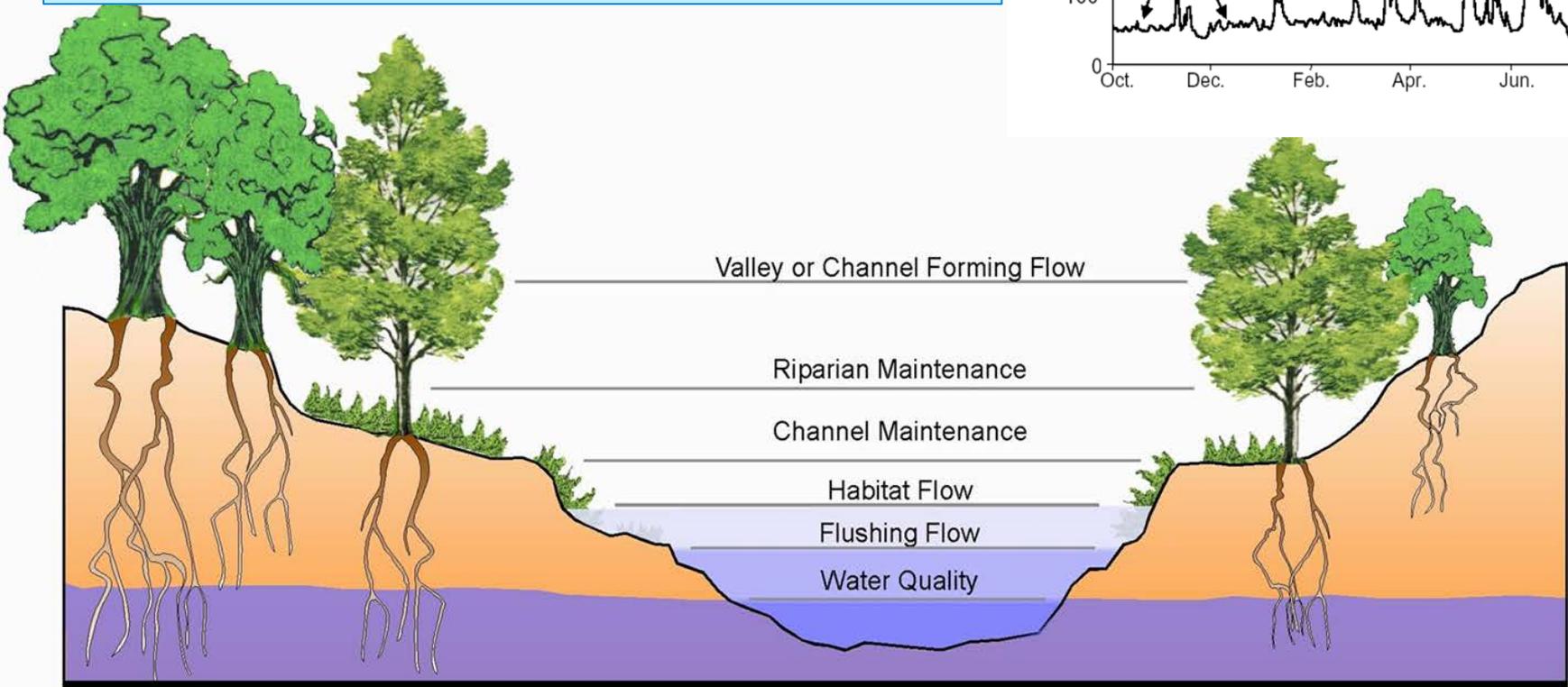
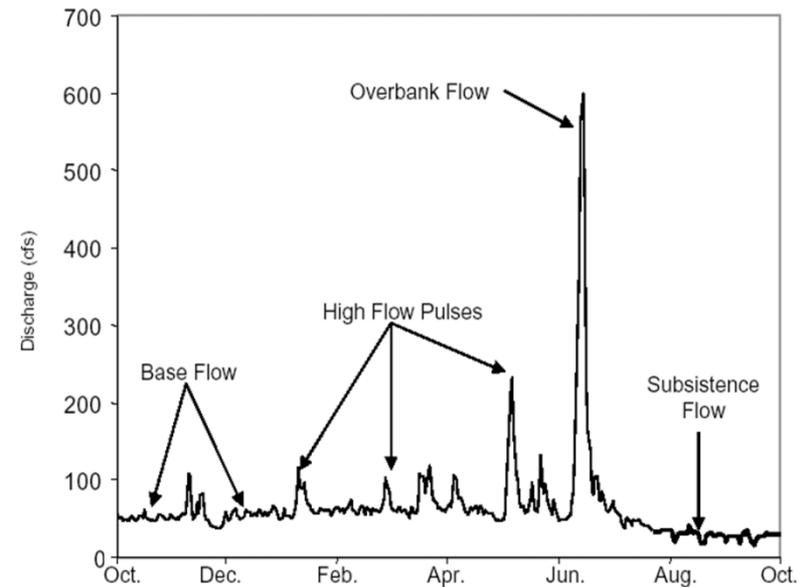


Flow Regime Tied to Ecology



Flow Components

Many studies have shown that altering one or more flow regime components can significantly impact biota

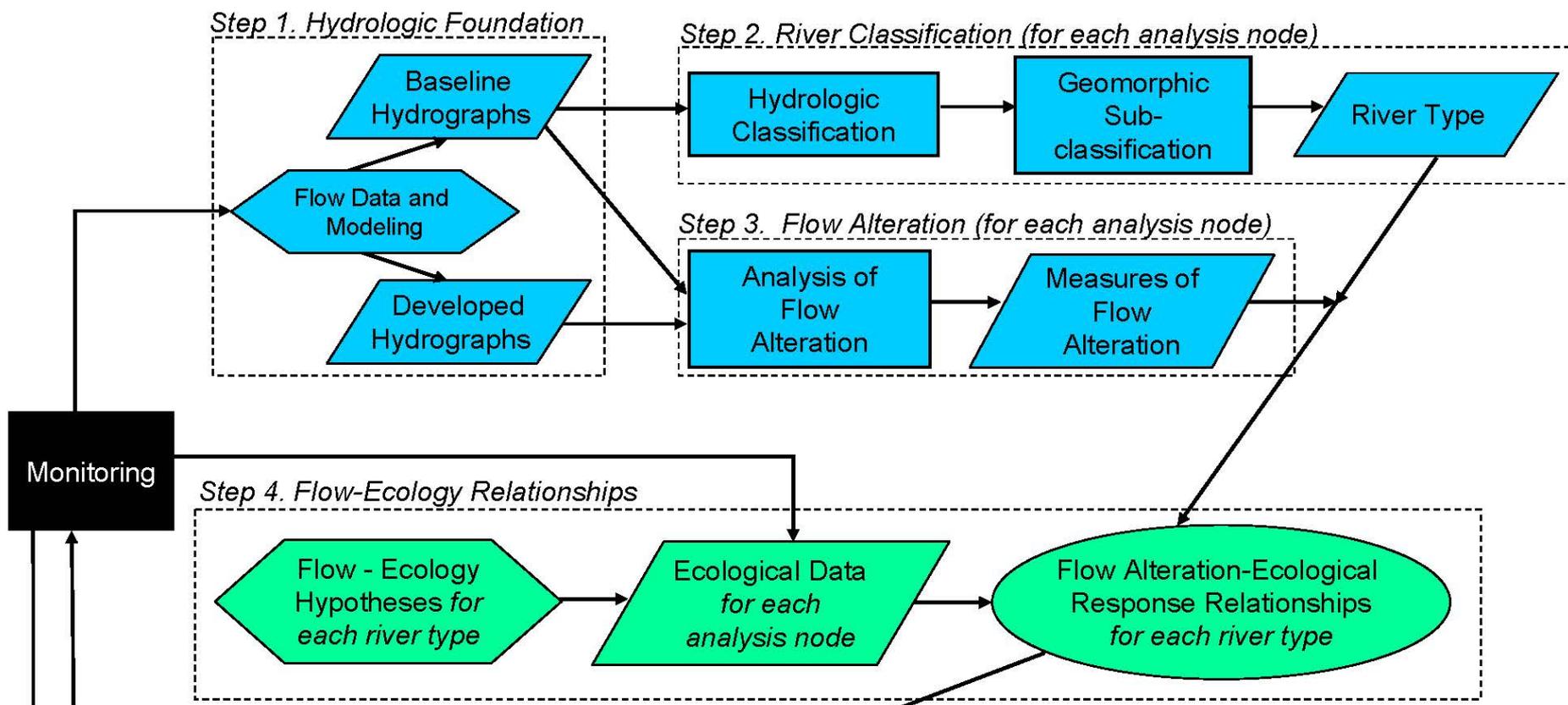


ELOHA (Ecological Limits of Hydrologic Alteration)

- Start with regional hydrologic models
- Identify stream types expected to respond differently to flow alteration
- Model ecological responses to flow alteration for each stream type
- Use ecological models with socially-determined objectives to decide on flow requirements
- Monitor outcomes, improve models, repeat

ELOHA

SCIENTIFIC PROCESS



Advancing the Science: Stream Classification

- DWR worked with a consultant to characterize and classify North Carolina streams based on flow characteristics from USGS gage data
- Resulted in a classification scheme comprised of seven stream classes that generally reflected stream size and flow stability

Class Characteristics – Hydrologic

Descriptive Index	North Carolina Stream Class						
	A	B	C	D	E	F	G
Median Daily Flow (CFS)	Small 126	Small 97	Large 1295	Small 48	Very Large 2470	Medium 490	Very Small 10
Median Daily Variable (%)	Moderate 128	Stable 107	Stable/Low 80	Flashy/High 206	Moderate 118	Stable/Low 91	Flashy/High 239
Percent of Daily Flow Volume Are Very Low Flows	1	4	5	1	2	4	0
Percent of Daily Flow Volume Are Low Flows	3	7	8	3	4	7	1
Percent of Daily Flow Volume Are Average Flows	33	39	42	25	32	40	22
Percent of Daily Flow Volume Are High Flows	26	20	19	19	23	20	19
Percent of Daily Flow Volume Are Very High Flows	40	32	27	53	39	29	57
Predictability (%)	Low 49	Moderate 65	High 75	Low 51	High 74	High 74	Very Low 37
Distribution of Annual Flow Among Five Flow States	4085782 A & H	3408071 A & VH	2883263 L & A	5538508 VH	4127314 A & H	3162172 L & A	5914233 VH

Advancing the Science: Stream Classification

Problems

- Classes generated from hydrology derived from USGS gages often differed from hydrology created from the WaterFALL rain-runoff model
- Stream hydrology classification approach should not be extrapolated beyond the USGS gages to ungaged sites
- Dropped this approach

Characterizing Stream Ecology

- Covered in DENR basin water quality plans
- In light of other findings, EFSAB report gives summary descriptions based on eco-region and stream size

Basic Streams in NC



Mountain

- Less altered
- Steep
- Cold-Cool

Piedmont

- More altered
- Moderate
- Cool-Warm

Coast

- Less altered
- Flat
- Warm
- Tidal / non-tidal

Headwater

- Drainage area <10 km²
- All parts of the state
- Comprise majority of mileage
- Limited hydrologic and biologic data

Types of Eco-flow Recommendations

- Minimum Flow Threshold
- Statistically-based Standard
- Percent of Flow Standard

Minimum Flow Threshold

- May be a single value or seasonally adjusted (e.g., South Carolina)
- Can be based on low-flow statistic (e.g., 7Q10) or a percentage of mean annual flow (MAF)
- Reduces inter- and intra-annual variability
- Can “flat-line” the hydrograph if withdrawal is large

Statistically-Based Standard

- Flow components include:
 - Critical low, low, high flow pulses, small floods, high floods
 - Wet, normal, dry years
- For each component, includes magnitude, duration, frequency, season
- Tied to ecologically significant events
 - e.g., spawning, floodplain rejuvenation, fry/juvenile growth, migration, sediment movement, channel maintenance
- Hard to implement in a model

Percent of Flow Standard

- Remove X% of water flowing by for a given time step
 - X generally 6 – 20%
 - Time step can be daily, weekly, etc.
 - X can differ by season
- Percent-of-flow is easiest way to maintain all five flow components and variability
- aka “flow-by”

Strategies to Determine Ecological Flows

- Reviewed many other states and regions
- **Habitat response models**
 - Habitat quantity and quality are measured relative to flow
 - Indirect and intermediate measure of expected biological response
- **Biological response models**
 - Composition and structure of the biological community is measured relative to flow

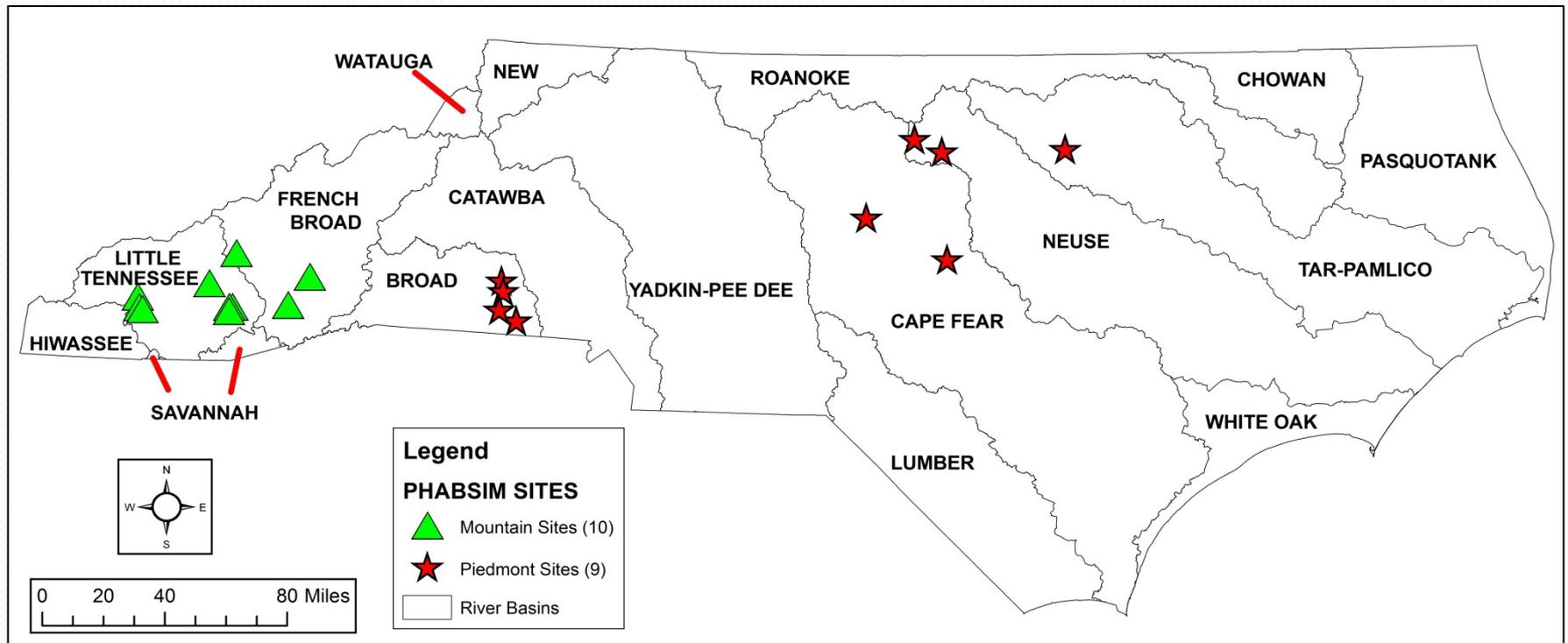
Strategies to Determine Ecological Flows

- **Coastal systems**
 - Low gradient and tidally-influenced streams function differently from other inland streams
 - Flow may play a secondary role to other factors including tides, salt concentration, and community structure and function
- **Approaches**
 - Inflow-based – keep flow within prescribed bounds
 - Condition-based – set flow to maintain a specified condition (e.g., salinity) at a given point in the estuary
 - Resource-based – sets flow based on the requirements of specific resources (e.g., shrimp)

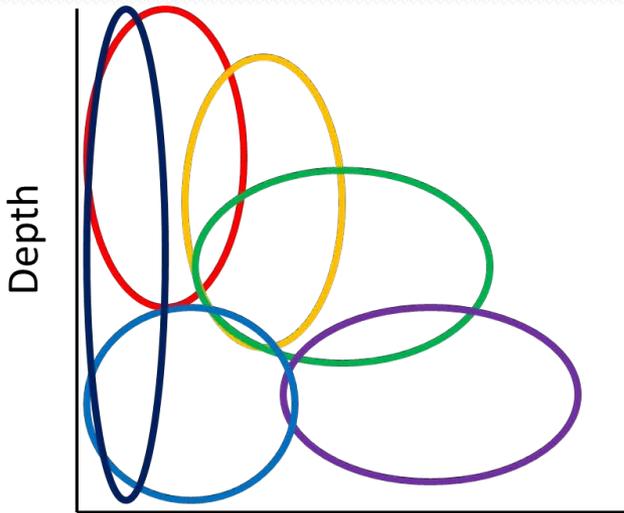
Advancing the Science: Flow-Habitat Relationships

- Habitat response models
 - Uses a suite of biota habitat preference curves to ensure that all types of habitat are represented
 - PHABSIM
 - Common habitat model
 - Used in NC for hydro relicensing and water withdrawal studies

Flow-Habitat Studies in NC

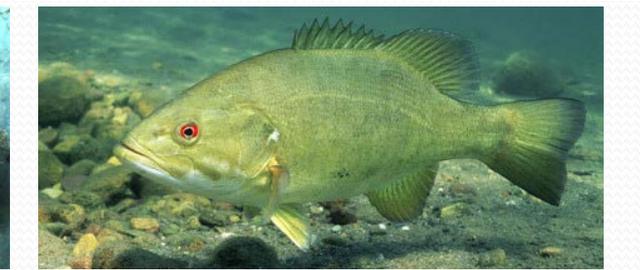


Advancing the Science: Flow-Habitat Relationships

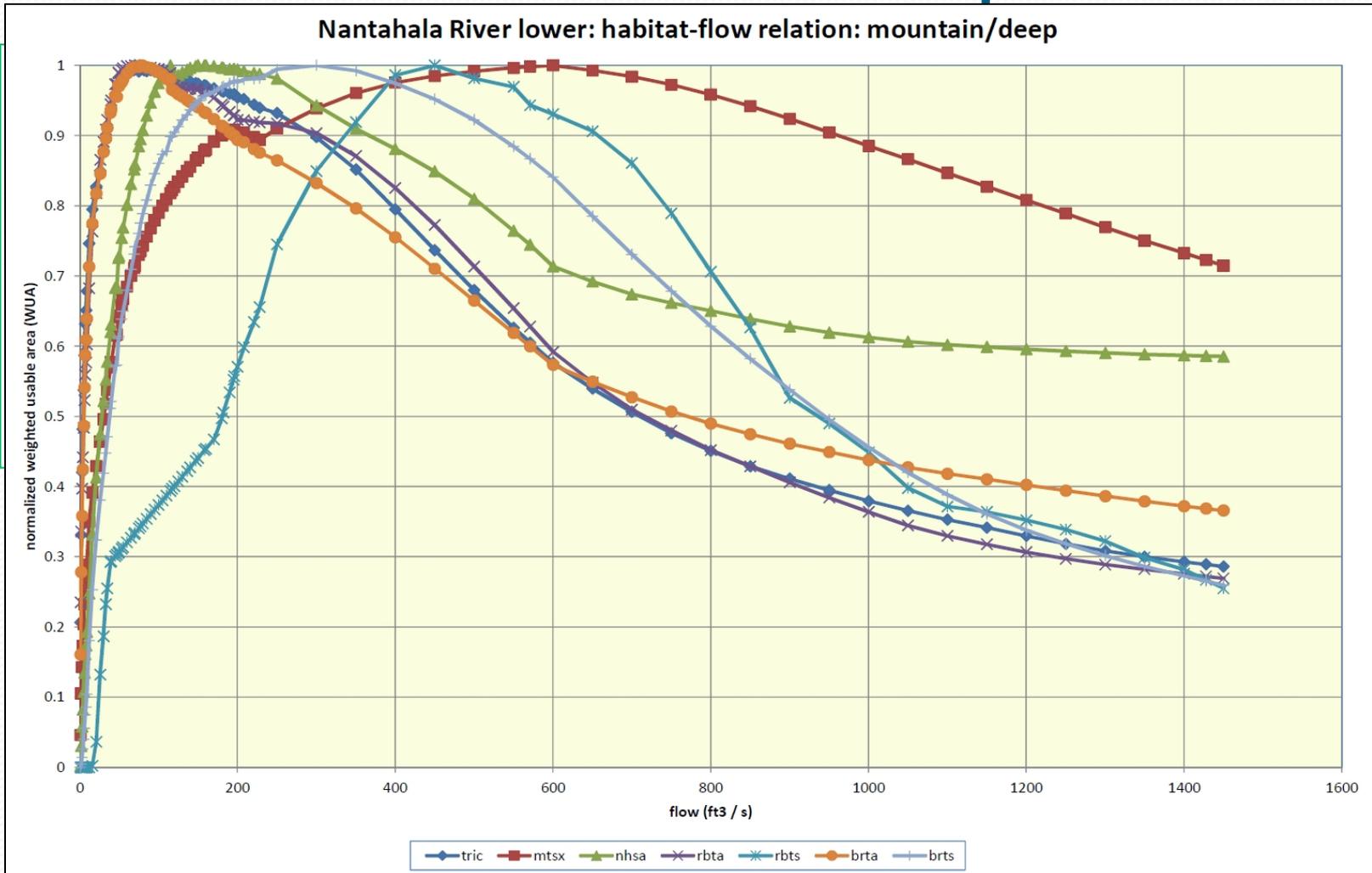


Velocity

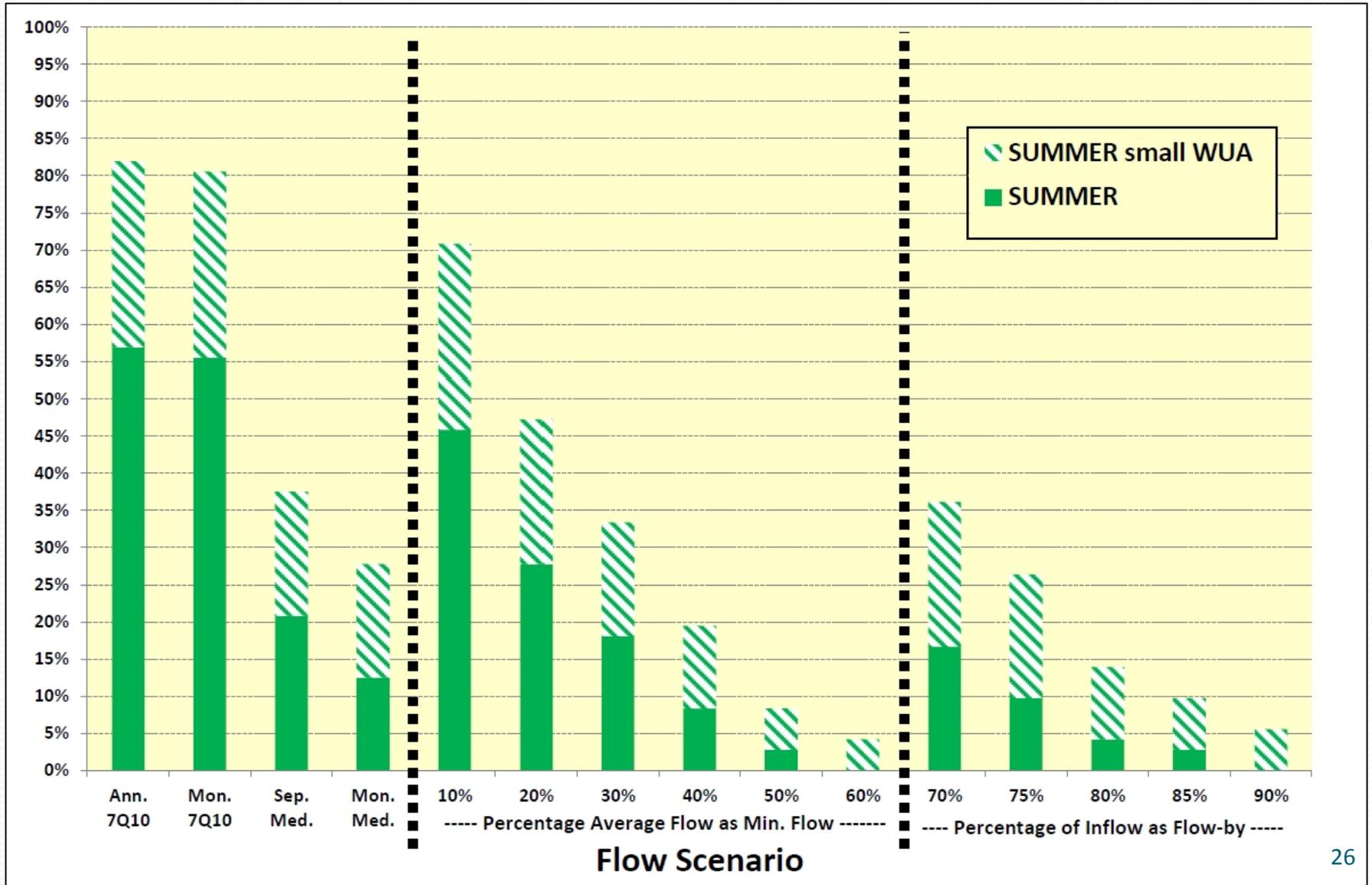
- Pool
- Pool-Run
- Riffle-Run
- Riffle
- Margin
- Backwater



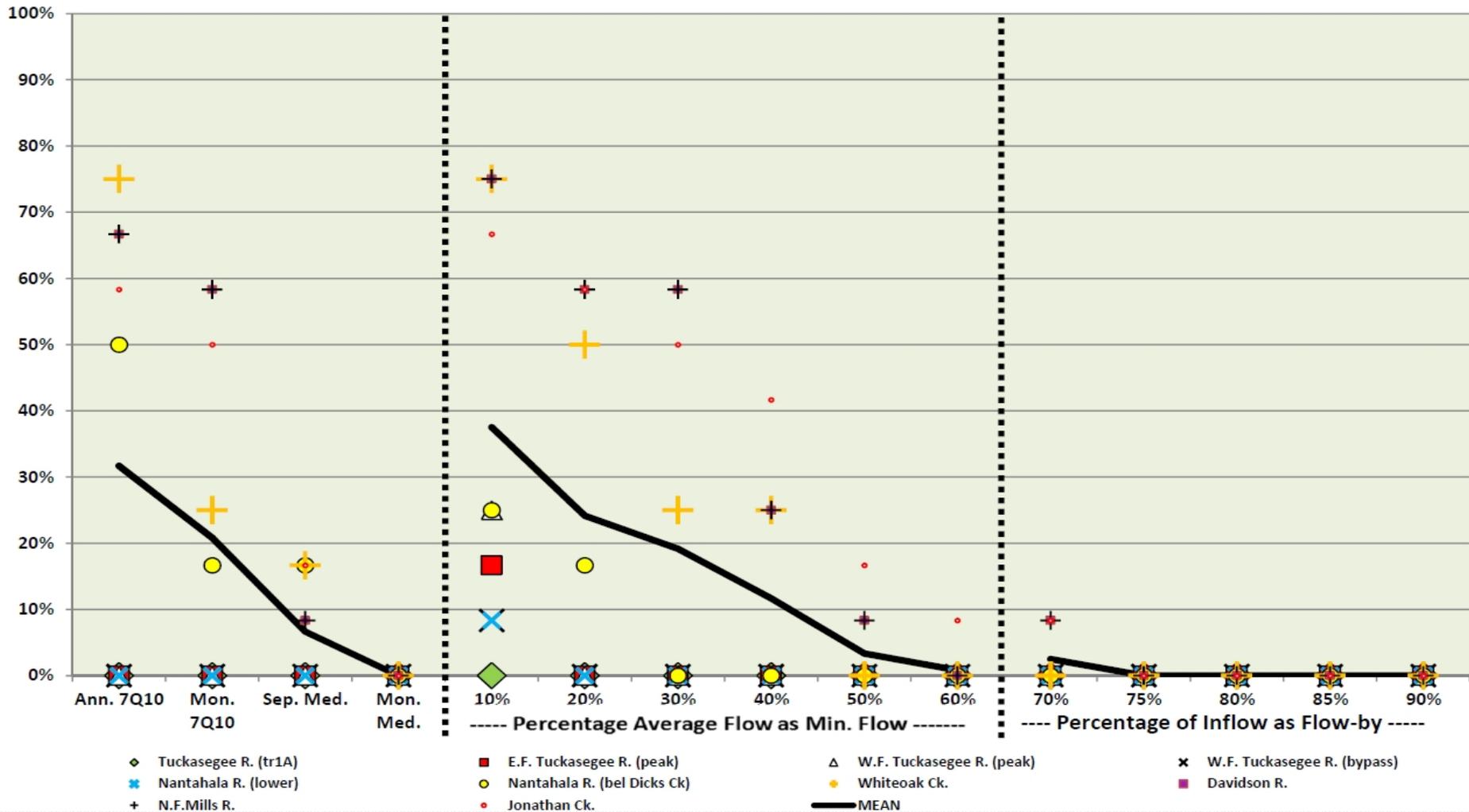
Advancing the Science: Flow-Habitat Relationships



Percent of Piedmont Sites not Protecting 80% of Habitat for Deep Guild



Percent of Mountain Sites not Protecting 80% of Habitat for Shallow Guild



Advancing the Science:

Flow-Habitat Relationships

- Generally, flow scenarios that deviate most from the unaltered condition were least protective of habitat (i.e., more water is better)
- Less clear, which flow scenarios were consistently best when considering all permutations of region, season, guild group
- More could be done to expand the number of sites, but these are intensive efforts; the easiest sites have been done

Advancing the Science: Flow-Ecology Relationships

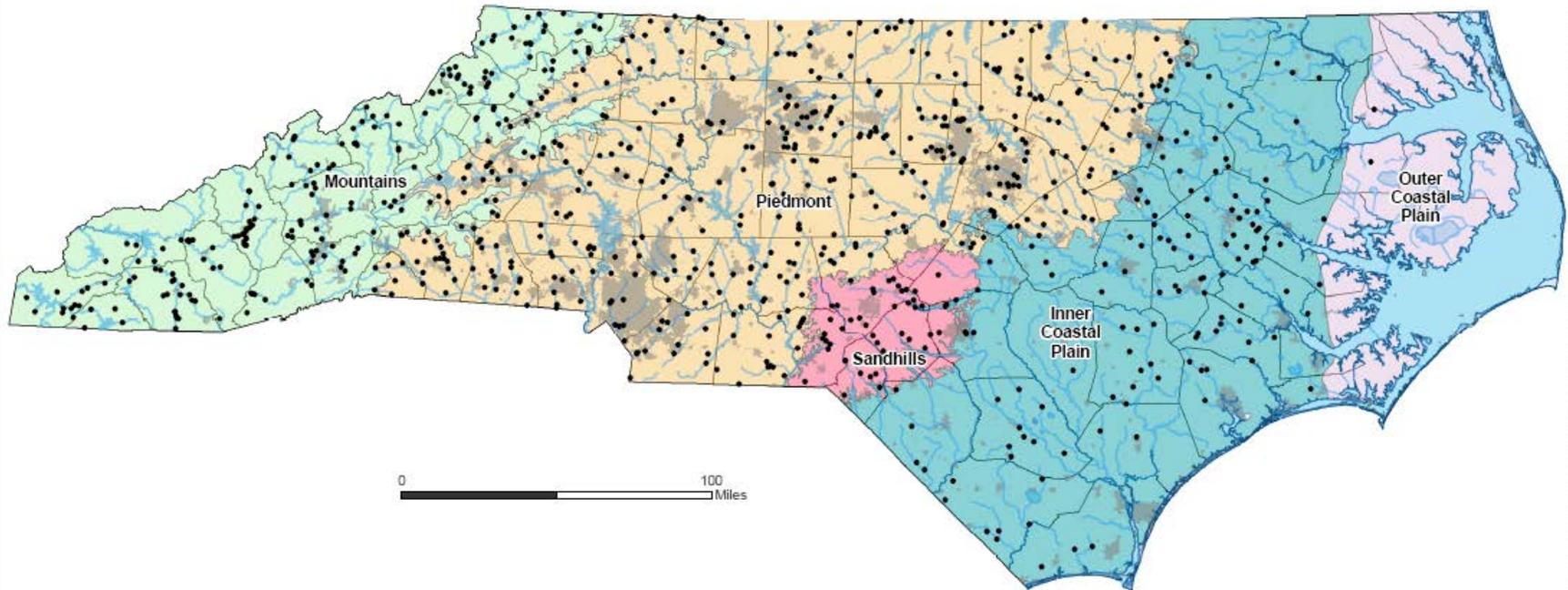
- Ecological integrity inferred from fish or benthic macroinvertebrate community structure metrics
- Two basic approaches
 - Relate biological conditions to flow across a range of flow conditions (space for time)
 - Relate changes in biological condition to flow at a site over time
- Organizations outside of the EFSAB tried both approaches and reported their results to the Board
 - RTI International (RTI) and USGS – used space for time
 - The Nature Conservancy – used both approaches

Advancing the Science: Flow-Ecology Relationships

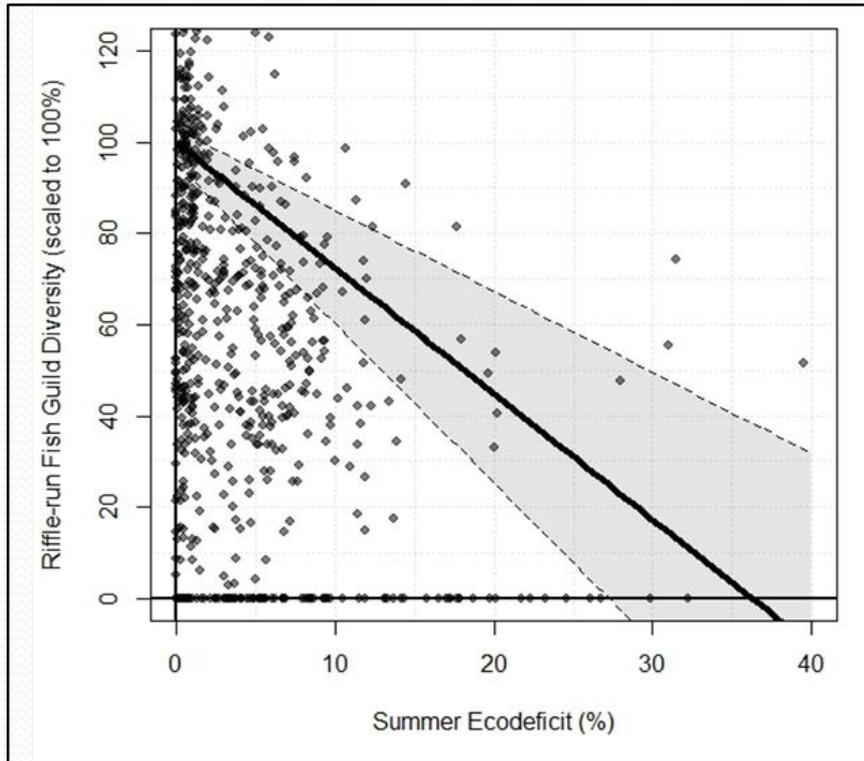
- 649 fish and 1,227 benthos “wadeable” sites across NC
- RTI/USGS conducted numerous statistical analyses to find meaningful relationships between fish/benthos and flow metrics
- Significant relationships were found between six flow metrics and:
 - Shannon-Weaver Diversity Index of the riffle-run fish guild
 - EPT taxa richness
- Flow metrics – annual and seasonal ecodeficits and reductions in the average 30-day minimum flow
- Attempted to include other explanatory factors (e.g., stream size and basin characteristics), but these were unsuccessful

Fish Dataset

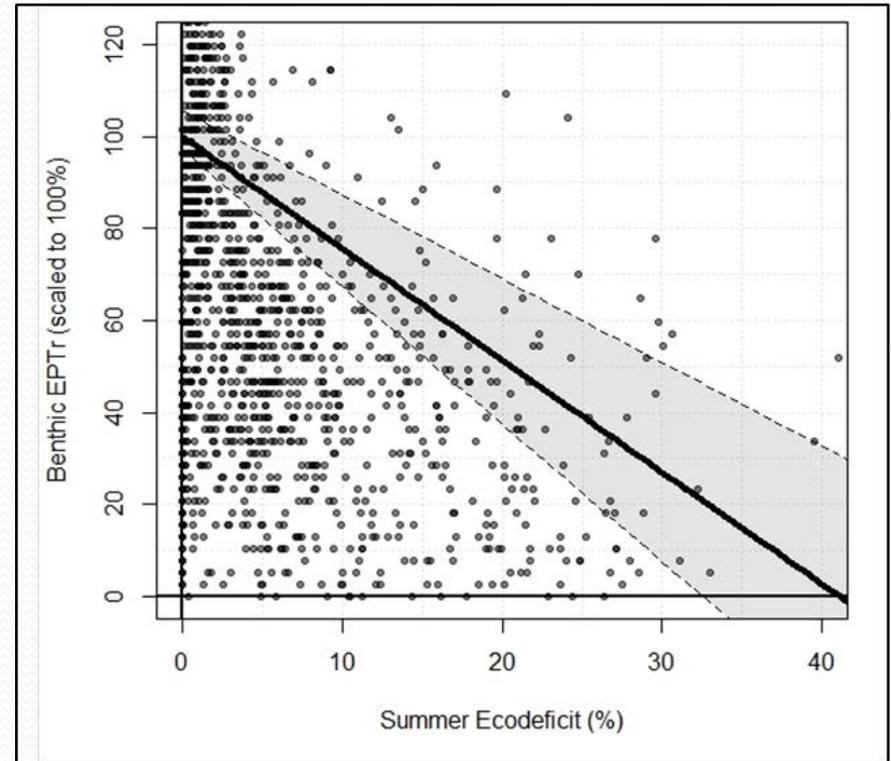
- NCDWQ wadeable streams data; not trout



Advancing the Science: Flow-Ecology Relationships



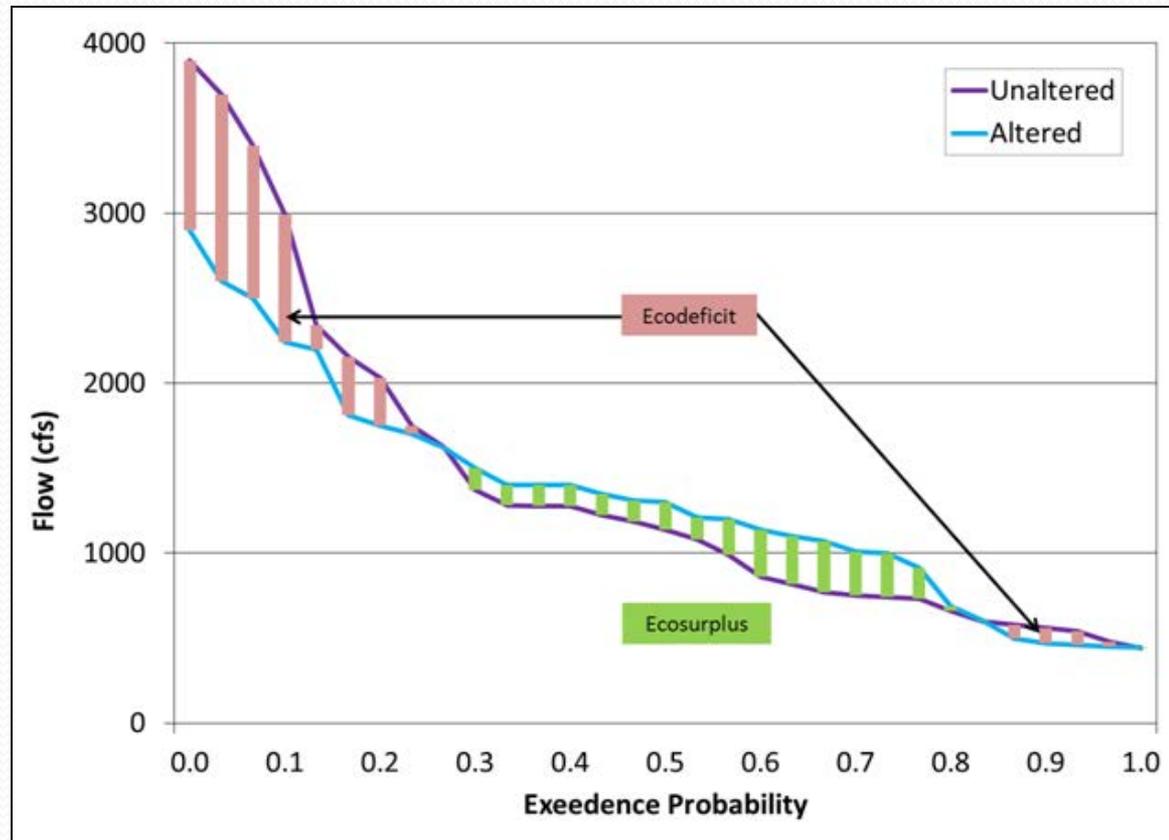
Fish



Benthos

Advancing the Science: Flow-Ecology Relationships

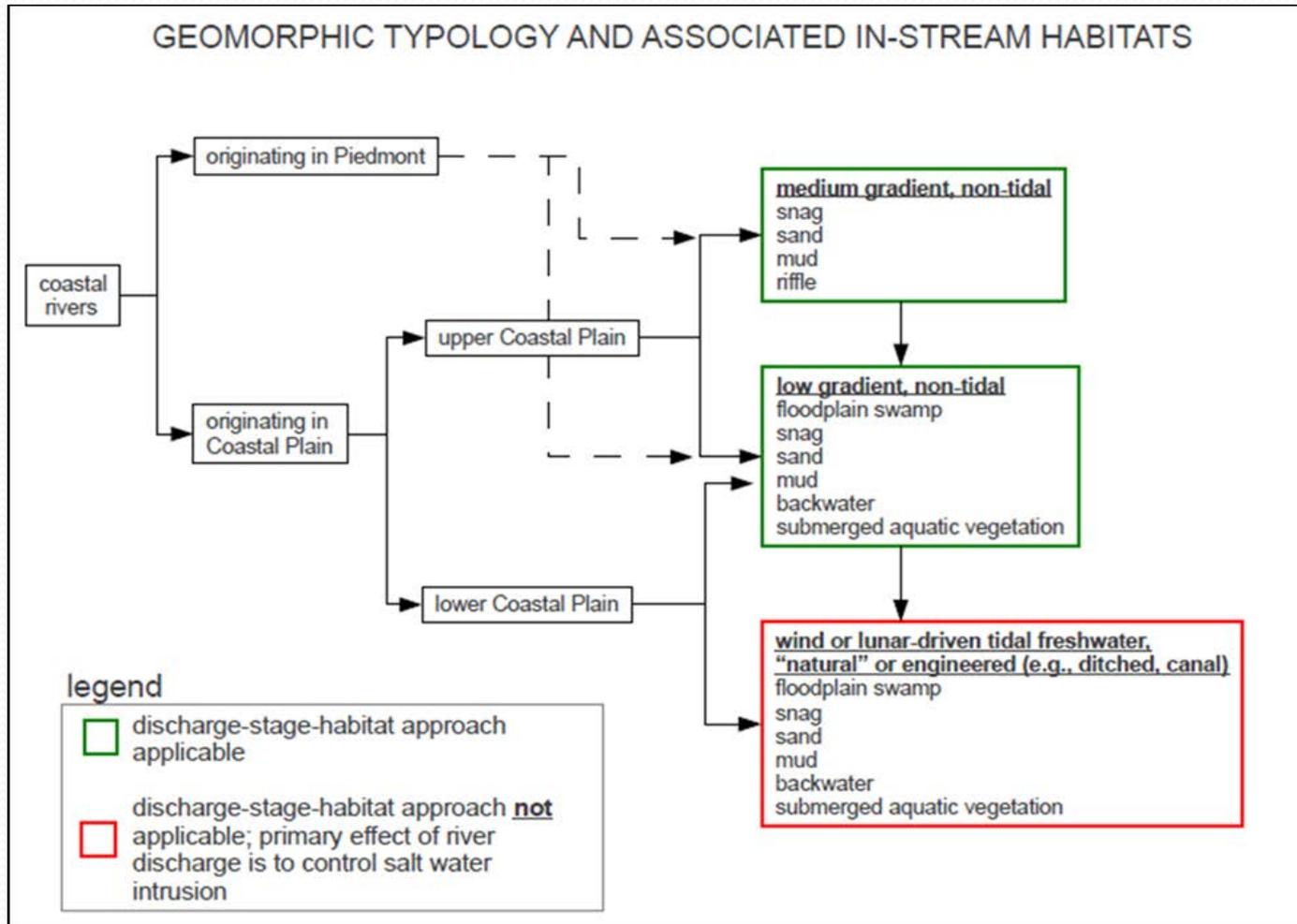
- Ecodeficit – sum of reductions in flow between altered and unaltered flow duration curves
- Auto-correlation among 100+ flow metrics



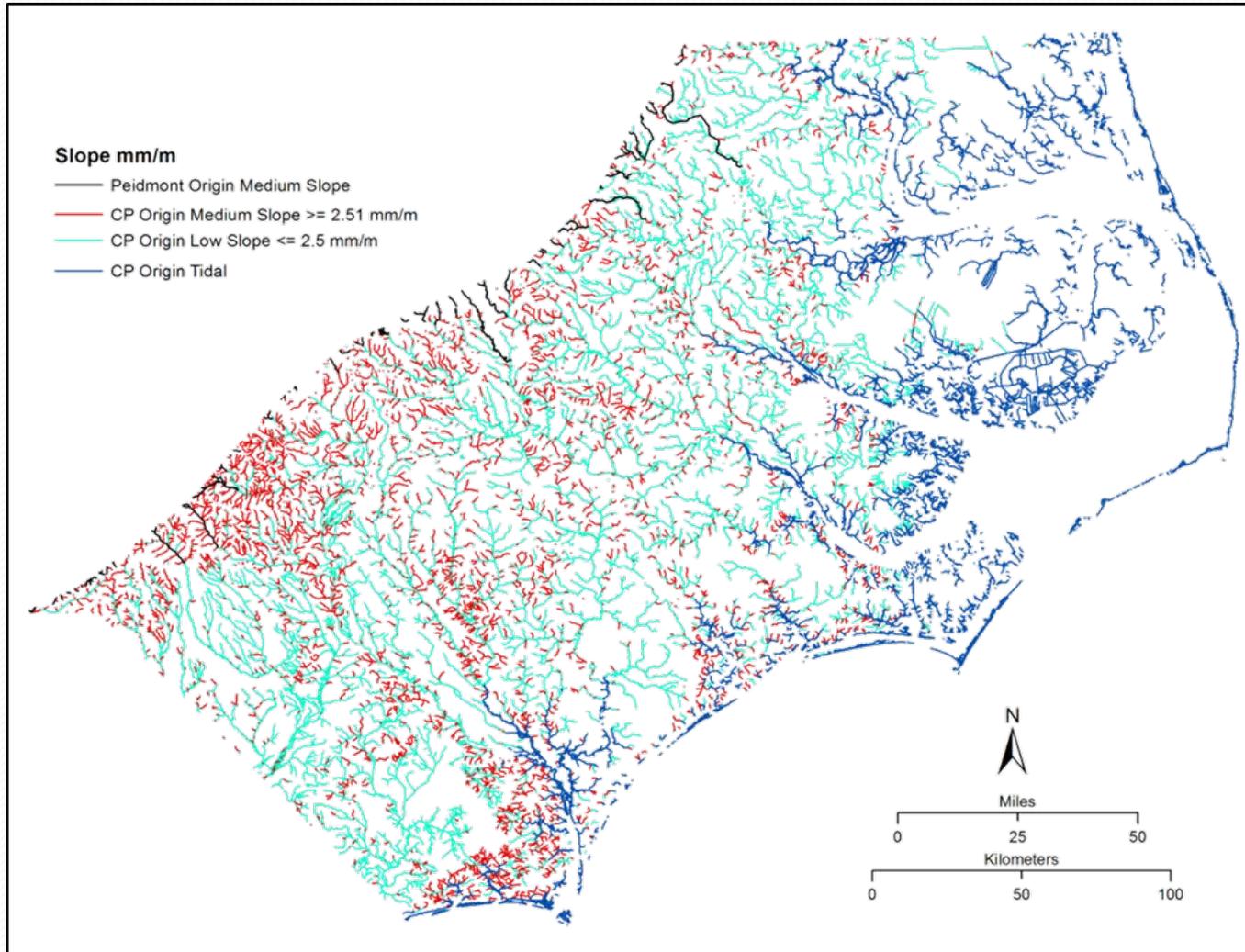
Advancing the Science: Flow-Ecology Relationships

- The Nature Conservancy
 - Fish diversity and abundance
 - 141 wadeable sites in Roanoke, Cape Fear, Tar, and Little Tennessee basins
 - Compared to flow for the period of 1992 – 2009
- Many sites saw little change in fish diversity/abundance over time
 - However, fish abundance and diversity declined in portions of the Cape Fear and Tar basins
- To understand the direct influence of water withdrawals, only sites located downstream of known water withdrawals were analyzed further (N=14)
- Negative relationship between fish diversity and the relative size of the water withdrawal; statistically significant, but low explanatory power
 - 10% ↓ in MAF → 5-10% ↓ in species diversity
 - 50% ↓ in MAF → 25- 30% ↓ in species diversity

Advancing the Science: Coastal Considerations



Advancing the Science: Coastal Considerations



EFSAB Recommendations:

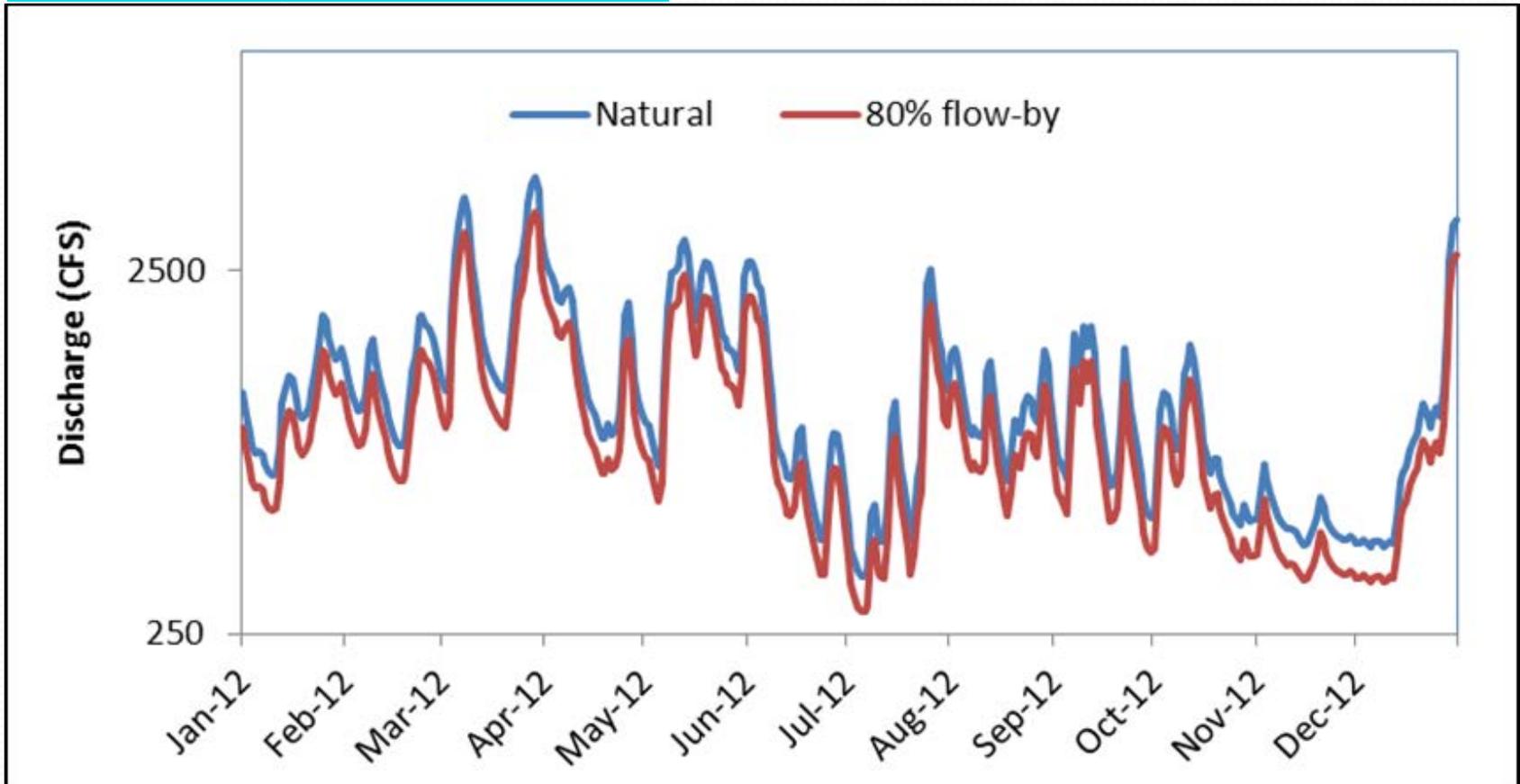
Ecological Flow Standard

Percentage of Flow (1)

- Default statewide approach
- 80-90% of the instantaneous modeled baseline flow
- Why a range?
 - No apparent threshold from habitat response analyses
 - Flow-by percentages >80% were most consistently protective
 - No consensus on a single flow-by percentage by the EFSAB
 - Similar to values from other jurisdictions
- DENR discretion to select the most appropriate value for planning purposes

EFSAB Recommendations: Ecological Flow Standard

Percentage of Flow (2)

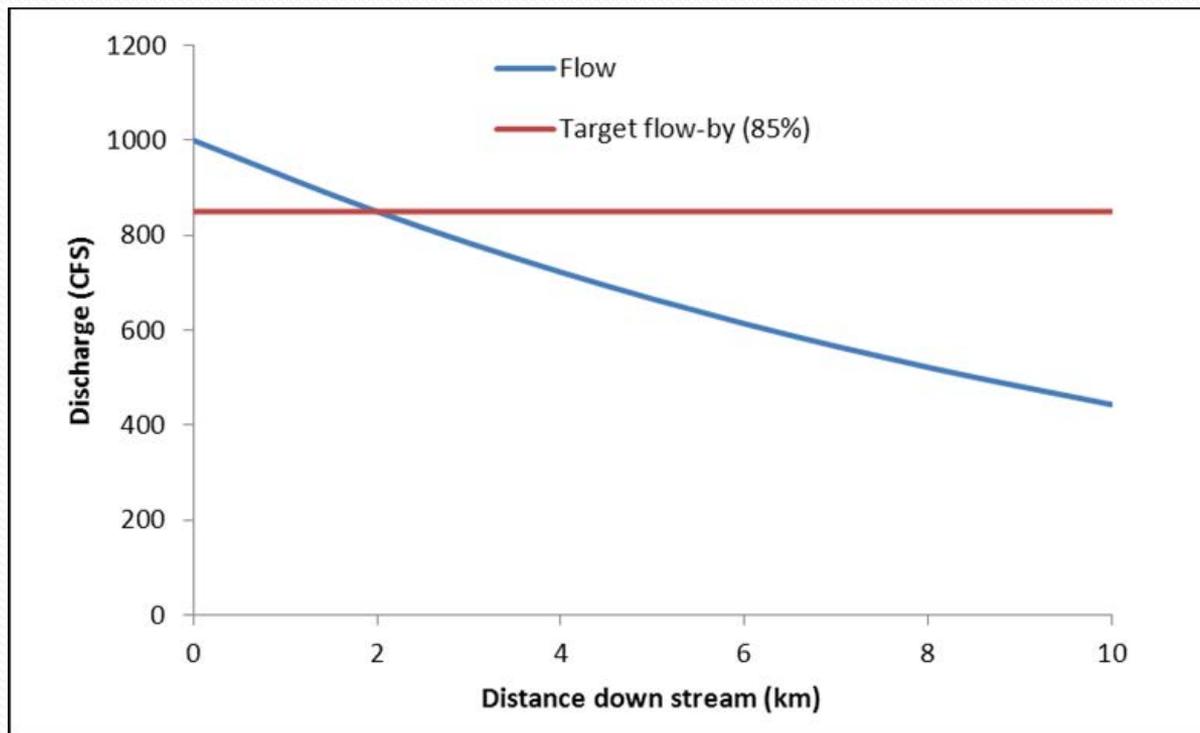


EFSAB Recommendations:

Ecological Flow Standard

Percentage of Flow (3)

- “Instantaneous” = normal time step of the model (typically daily)
- Model cumulative effects to avoid impacts of a series of withdrawals

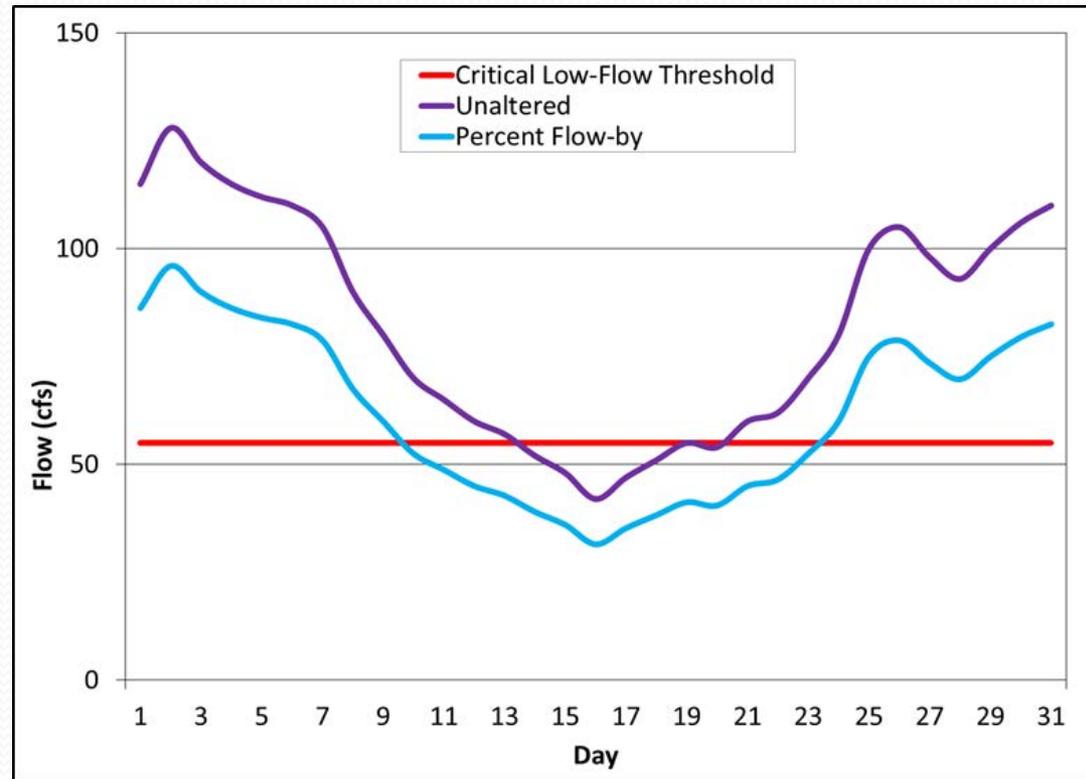


EFSAB Recommendations:

Ecological Flow Standard

Percentage of Flow (4)

- Combine with a critical low-flow component
 - Protect the aquatic ecosystem during periods of drought
 - Prevent increasing the frequency or duration of extreme low flows that are damaging to ecosystem health
- Use 20th percentile flow as a critical low flow (by month)
- **Ecological flow threshold is the larger of the flow-by and critical low-flow values**



EFSAB Recommendations:

Ecological Flow Standard

Percentage of Flow (5)

- Model should include following flow regimes
 - natural (without any withdrawals or returns)
 - baseline (with current withdrawals and returns)
 - projected (with current and future withdrawals and returns)
- Comparisons
 - baseline:natural = how much hydrology has already been altered
 - baseline:future = effects of future withdrawals and returns
- Model updates should keep baseline as 2010 conditions to avoid comparisons to a continually shifting “current” condition

EFSAB Recommendations:

Ecological Flow Standard

Percentage of Flow (6)

- Run basin model with 2 hydrology datasets – full and trimmed (10-90%)

# times threshold exceeded		Condition	DENR Action
Full	Trimmed		
0	0	Green	None
1+	0	Yellow	Begin review of water usage that may be contributing to the deviations. Management tools, including water shortage and drought response plans, should be evaluated for the purpose of maintaining ecological integrity.
1+	1+	Red	Additional review could include actions such as conducting site-specific evaluations or review and modeling of any biological data that are available

EFSAB Recommendations:

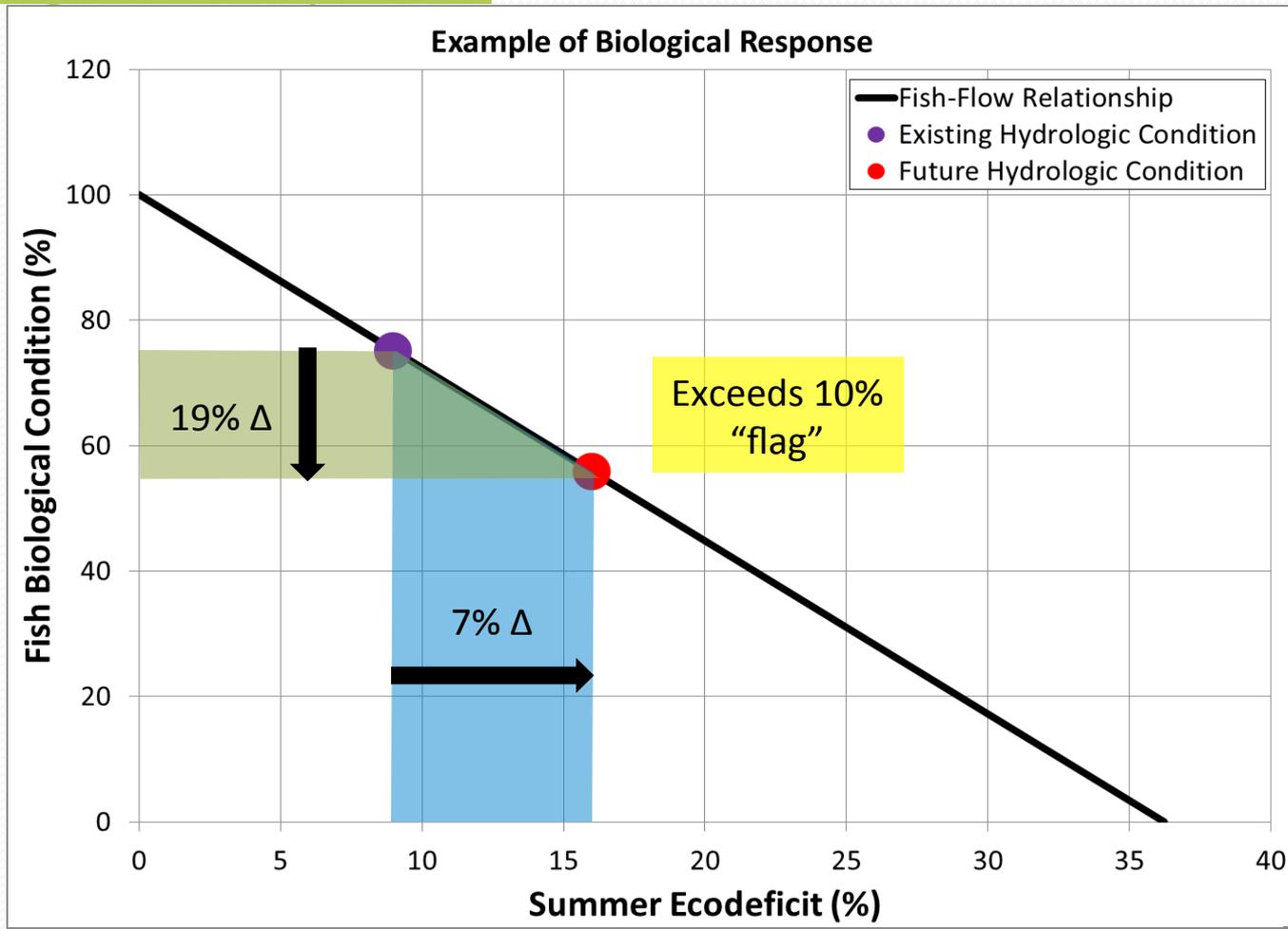
Ecological Flow Standard

Biological Response

- DENR should evaluate the use of these models to assess changes in biological conditions associated with projected changes in flow
- A 5-10% change in biological condition suggested as an initial criterion for further review
 - Based on average range of EPT richness within the invertebrate condition classes (Excellent, Good, Good-Fair, Fair, and Poor) as defined by DENR
 - The 5-10% criterion represents a change of one-quarter to one-half of the width of a condition class

EFSAB Recommendations: Ecological Flow Standard

Biological Response



EFSAB Recommendations:

Ecological Flow Standard

Exceptions – Coastal

- No numerical standards proposed
- Consider the following

Origin	Gradient	Ecological Flow Approach			
		Statewide Recommendation	Habitat Relationship	Downstream Salinity	Overbank Flow
Piedmont	Medium	X	X	X	
Coastal Plain	Medium	X	X	X	
Coastal Plain	Low		X	X	X
Coastal Plain	Wind or tidally driven flow			X	X

EFSAB Recommendations:

Ecological Flow Standard

Exceptions – Headwaters

- Streams with drainage basins $<10 \text{ km}^2$, DENR should conduct additional analyses to determine the potential for impact
 - Limited biological and hydrologic data
 - Higher vulnerability to disturbance
 - Statewide approach may not adequately protect

EFSAB Recommendations:

Other

- Listed Species

- For planning purposes, portions of basins (e.g., nodes) that include listed species should be treated by DENR as needing additional analysis in consultation with WRC, NMFS and USFWS

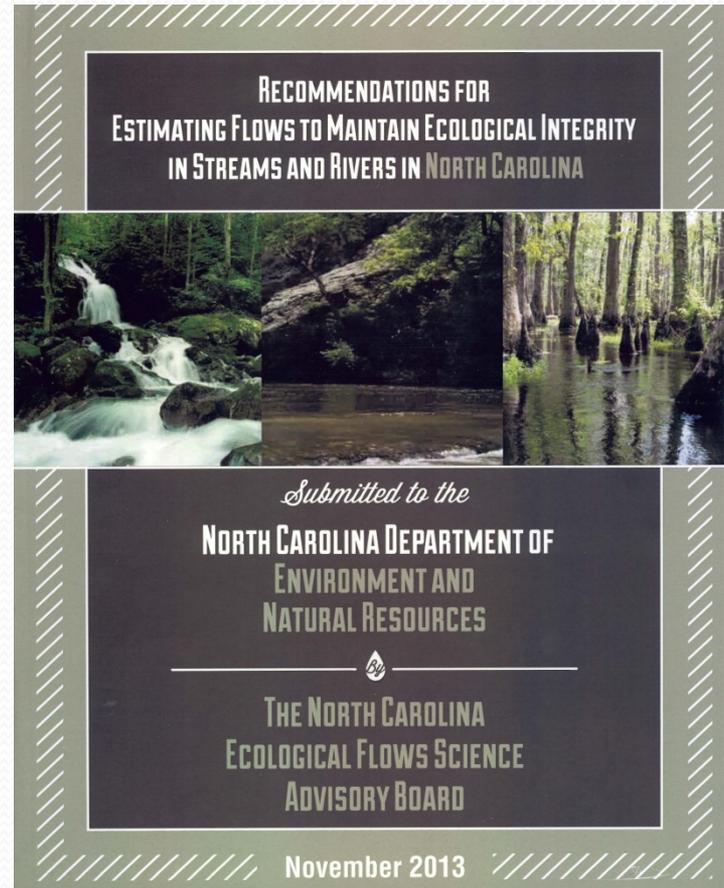
- Adaptive Management

- Emphasize new data (hydrologic and biological) collection and evaluation in headwaters, in the coastal plain, and in large rivers
- Validate ecological thresholds
- Track impact of flow changes
- Modify characterizations, target flows, and thresholds based on new data, changing conditions and lessons learned

Thanks!

- DWR Website of EFSAB:
<http://ncwater.org/?page=366>

Chris Goudreau
Special Projects Coordinator
NC Wildlife Resources Commission
828-652-4360
chris.goudreau@ncwildlife.org



App. 6 Presentation by Tom Fransen explaining DENR's plans for report implementation

Report of the Ecological Flows SAB

What does it mean for water planning and policy?

March 21, 2014

Institute of Emerging Issues
UNC School of Government
Natural Resources Leadership Institute

Tom Fransen
Division of Water Resources, NC DENR

RECOMMENDATIONS FOR
ESTIMATING FLOWS TO MAINTAIN ECOLOGICAL INTEGRITY
IN STREAMS AND RIVERS IN NORTH CAROLINA



Submitted to the
NORTH CAROLINA DEPARTMENT OF
ENVIRONMENT AND
NATURAL RESOURCES


THE NORTH CAROLINA
ECOLOGICAL FLOWS SCIENCE
ADVISORY BOARD

November 2013

Presentation Outline

- 1. How is DWR going to use the EFSAB's report recommendations?**
- 2. How the pieces fit together.**
- 3. Next Steps**

Background

The ERC's 2008 Report of the Water Allocation Study resulted in several session laws passed in 2009 And 2010. Session law 2010-143 was one of these Bills.

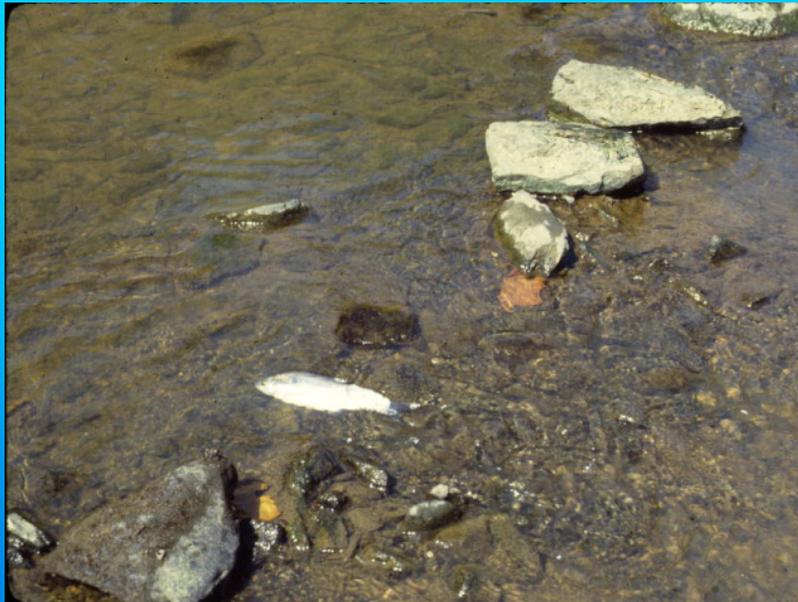
In addition to setting up the EFSAB, session law 2010-143 also included:

- Requirements for DENR to do a hydrologic model for each major river basin.
- The models need to answer 3 questions:
 1. Locations and time ecological flows may be adversely impacted.
 2. Locations and time yield may be inadequate to meet all essential uses.
 3. Locations and time yield may be inadequate to meet all needs.
- EMC model approval.
- Model approval is not rule making.
- The models and EFSAB report will not vary any existing or impose any additional regulations.

**2008 Report of the
Water Allocation Study**
of the NC Environmental Review Commission



How will DWR implement an EFSAB recommendation? Modeling and Planning



**Modeling and Planning
Can Help Prevent This**

**... When Instream Flows
are Included
in the Equation**

How will DWR implement the EFSAB recommendation?

➤ **Planning tool**

- Will not override existing permits, such as FERC license.
 - Will not replace site specific studies.
 - Will not change the SEPA minimum criteria – 20% 7Q10
- During the planning process if ecologic integrity is determined or projected to be adversely impacted, we will flag the river reach for additional studies.

EFSAB Recommendations:

Ecological Flow Standard

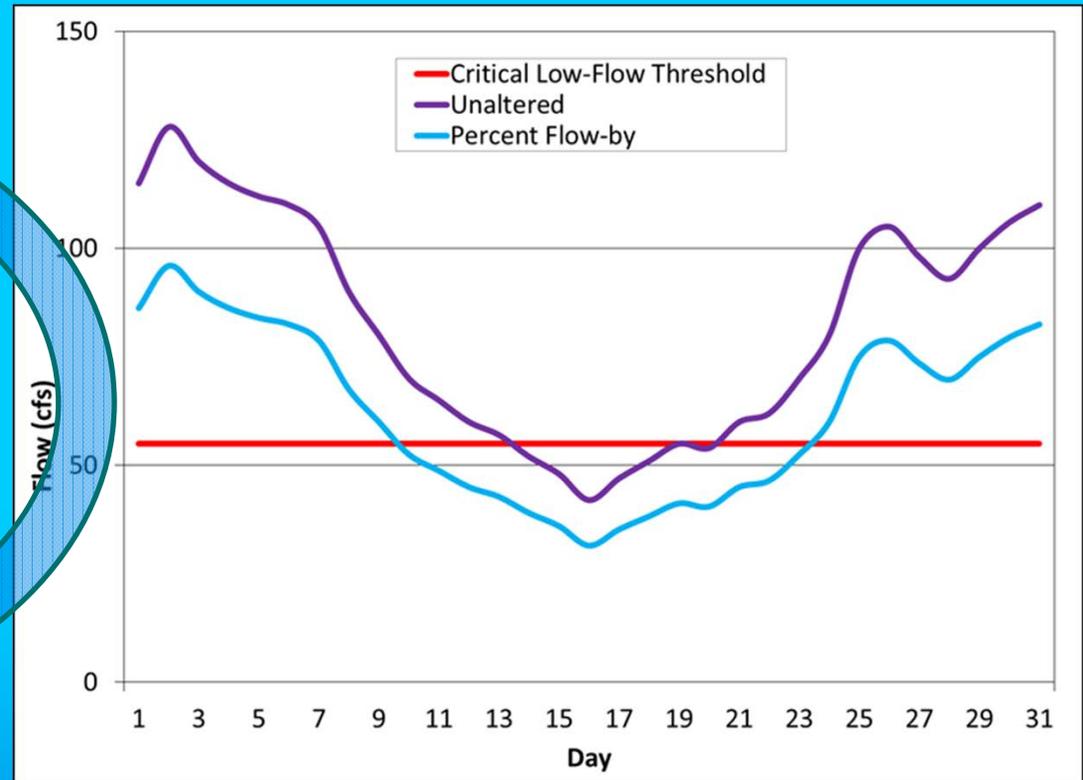
Biological Response

- DENR should evaluate the use of these models to assess changes in biological conditions associated with projected changes in flow
- A 5-10% change in biological condition suggested as an initial criterion for further review
 - Based on average range of EPT richness within the invertebrate condition classes (Excellent, Good, Good-Fair, Fair, and Poor) as defined by DENR
 - The 5-10% criterion represents a change of one-quarter to one-half of the width of a condition class
- **DWR needs to do additional evaluation before we include in our planning process.**

EFSAB Recommendations: Ecological Flow Standard

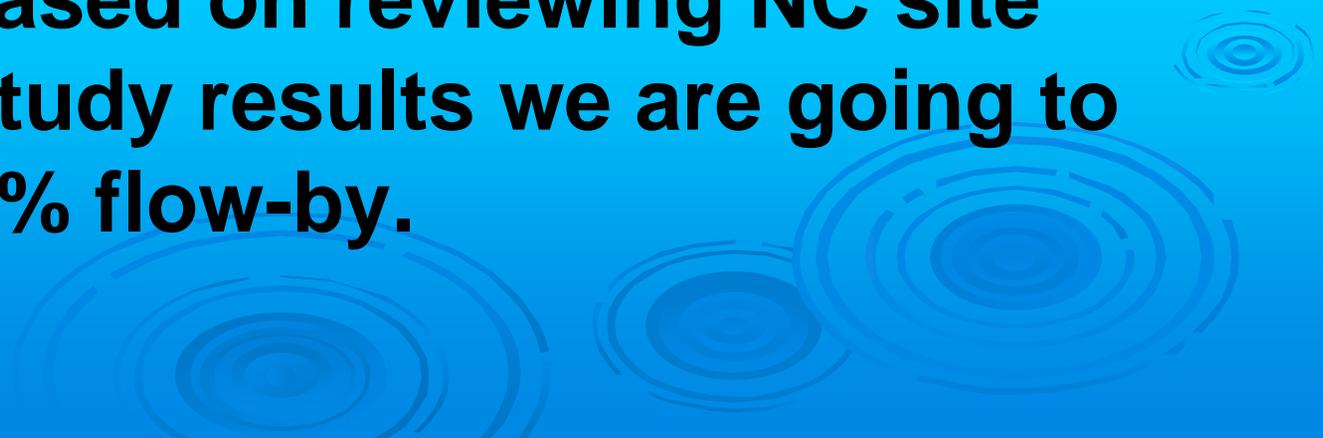
Percentage of Flow

- Combine with a critical low-flow component
 - Protect the aquatic ecosystem during periods of drought
 - Prevent increasing the frequency or duration of extreme low flows that are damaging to ecosystem health
- Use 20th percentile flow as a critical low flow (by month)
- Ecological flow threshold is the larger of the flow-by and critical low-flow values



DWR is going to use an 85% flow-by without the critical low-flow. We need to do additional evaluation before including in our planning process.

Initial Planning Approach

- **DWR is going to use the flow-by approach for planning purposes if there are no existing permitted flow requirements.**
 - **EFSAB's report gave the range of 80% to 90%. Based on reviewing NC site specific study results we are going to use an 85% flow-by.**
- 

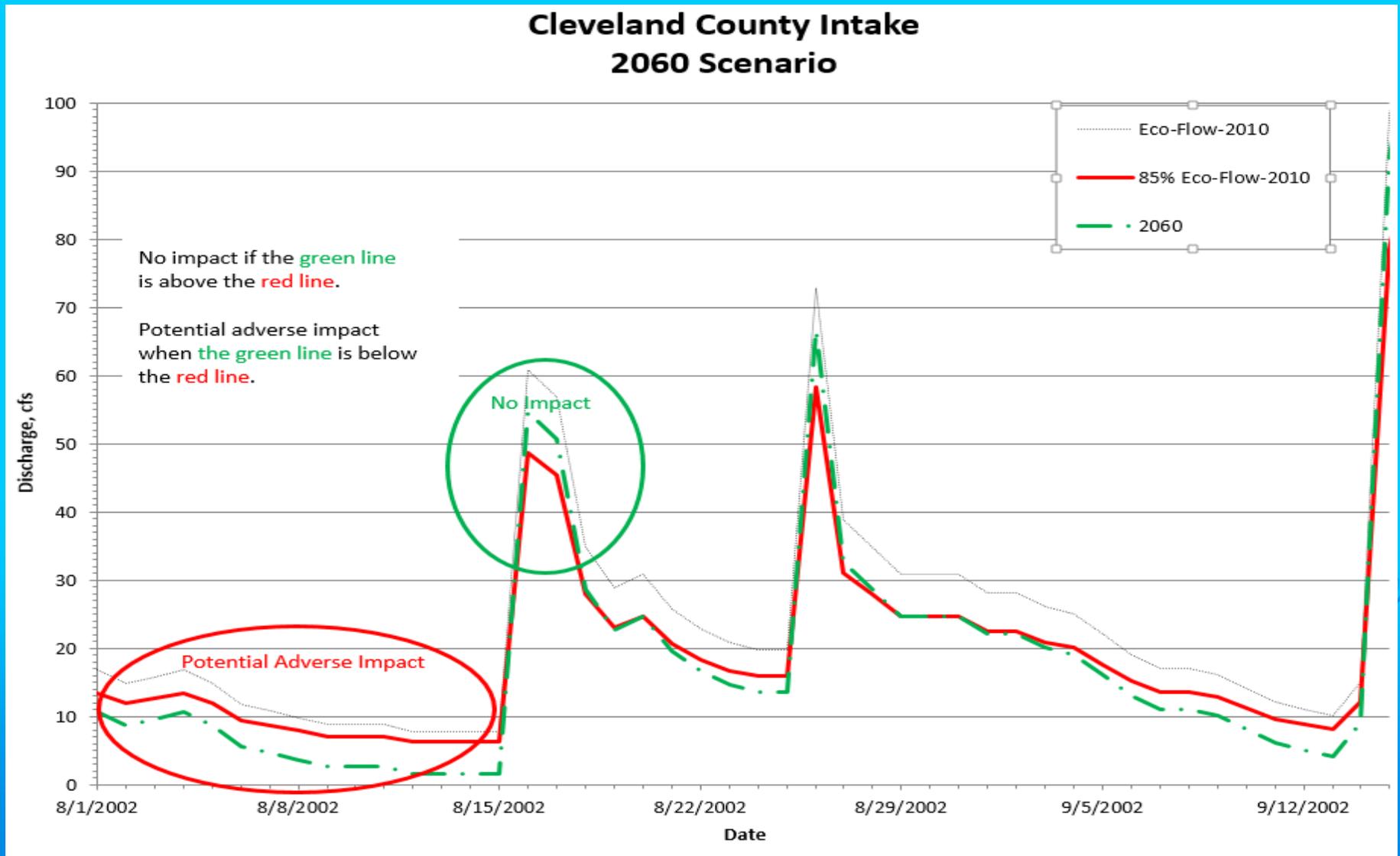
Example Using the 85% Flow-By

For modeling purposes we will use ECOFLOW-2010 as the prevailing ecological conditions. We will evaluate ecological flows at all river nodes as follows:

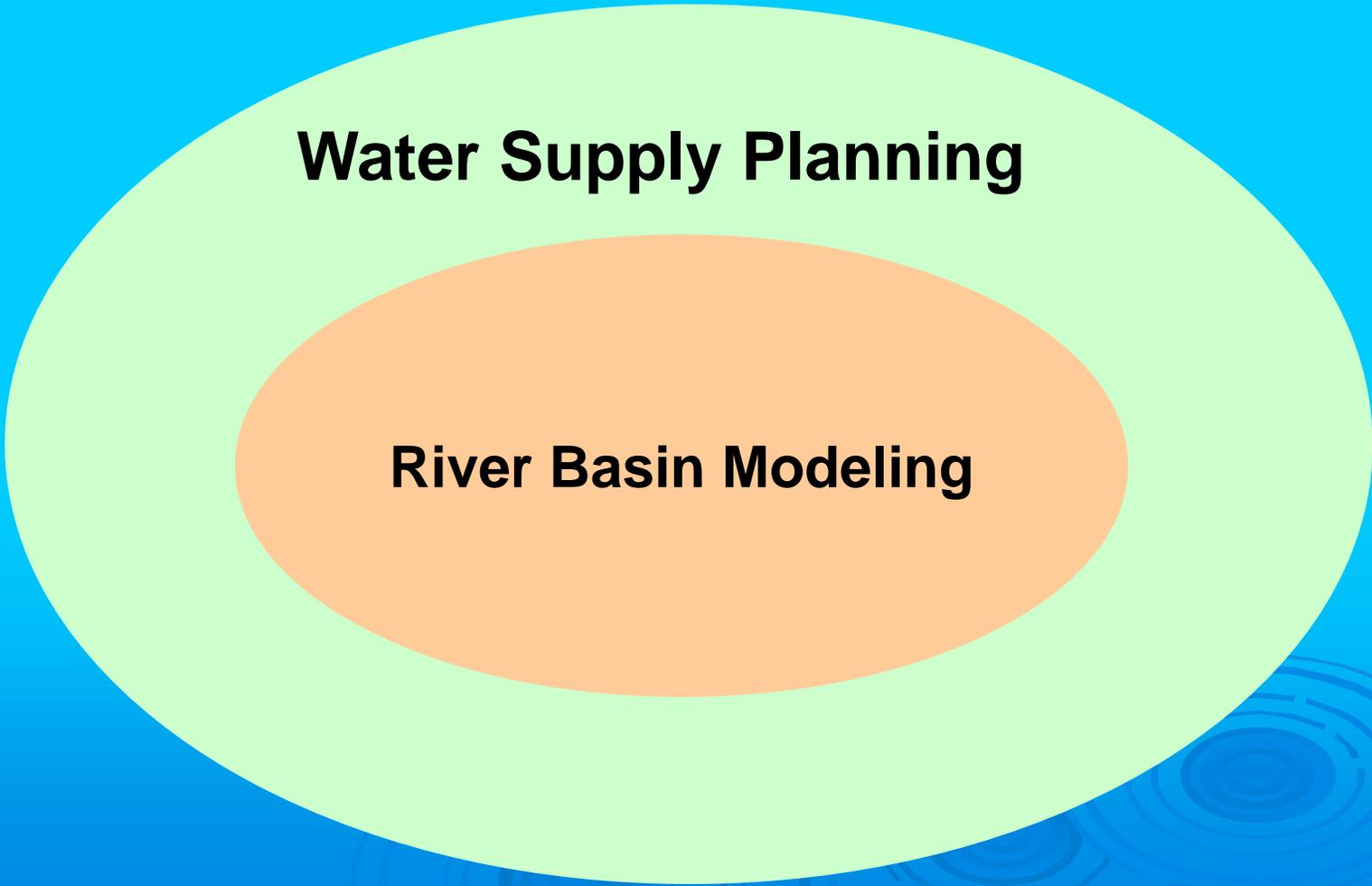
- Use the ecological flow requirements in permits, for example FERC licenses. Ecological flow is adversely impacted if the permitted flow requirements are violated.
- If there are no permitted flows, ecological flow is adversely impacted will be evaluated using the approach of an 85% flow by requirement.

# Times Threshold Exceeded		Condition	Action
Full	Trimmed 10% - 90%		
0	0	Green	None
1+	0	Yellow	Review existing management policies and water usage to determine what maybe contributing to the deviations.
1+	1+	Red	Additional review needed. Review could include review of existing biological data, or site-specific evaluation.

85% Flow-By Example



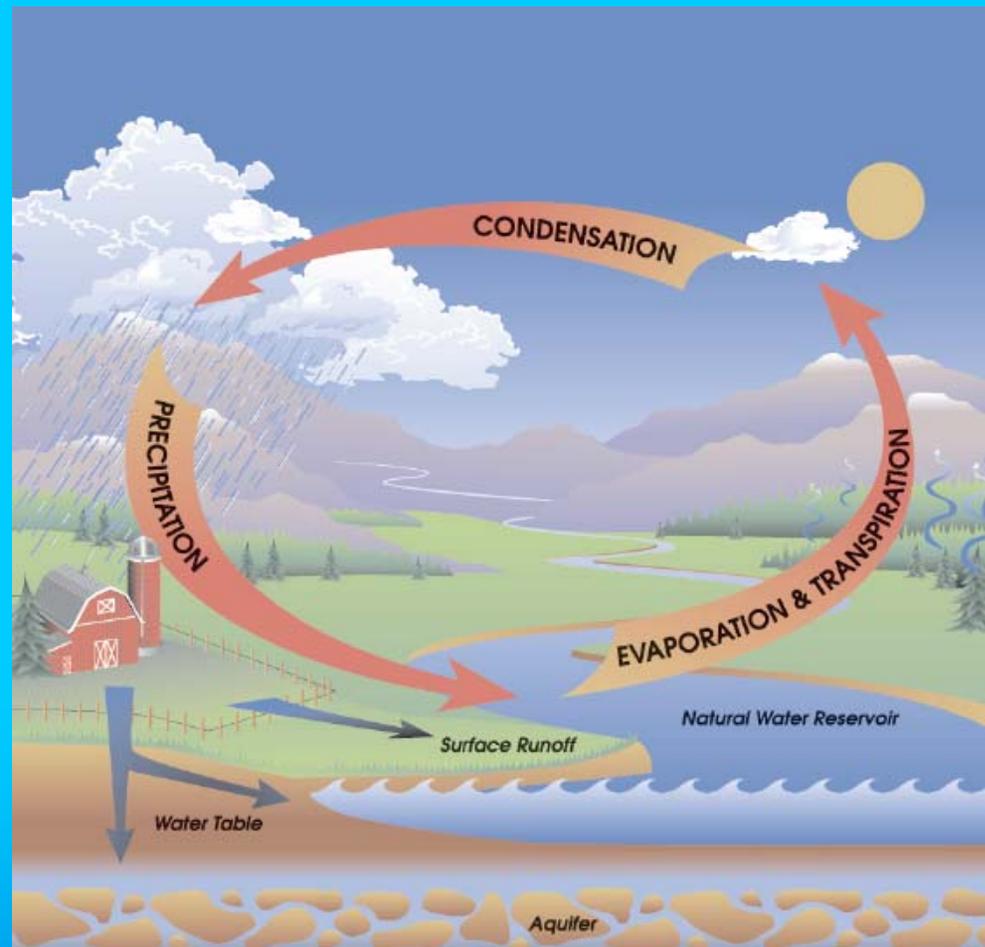
Water Resources Planning & Modeling



Water Supply Planning

River Basin Modeling

Hydrologic Cycle



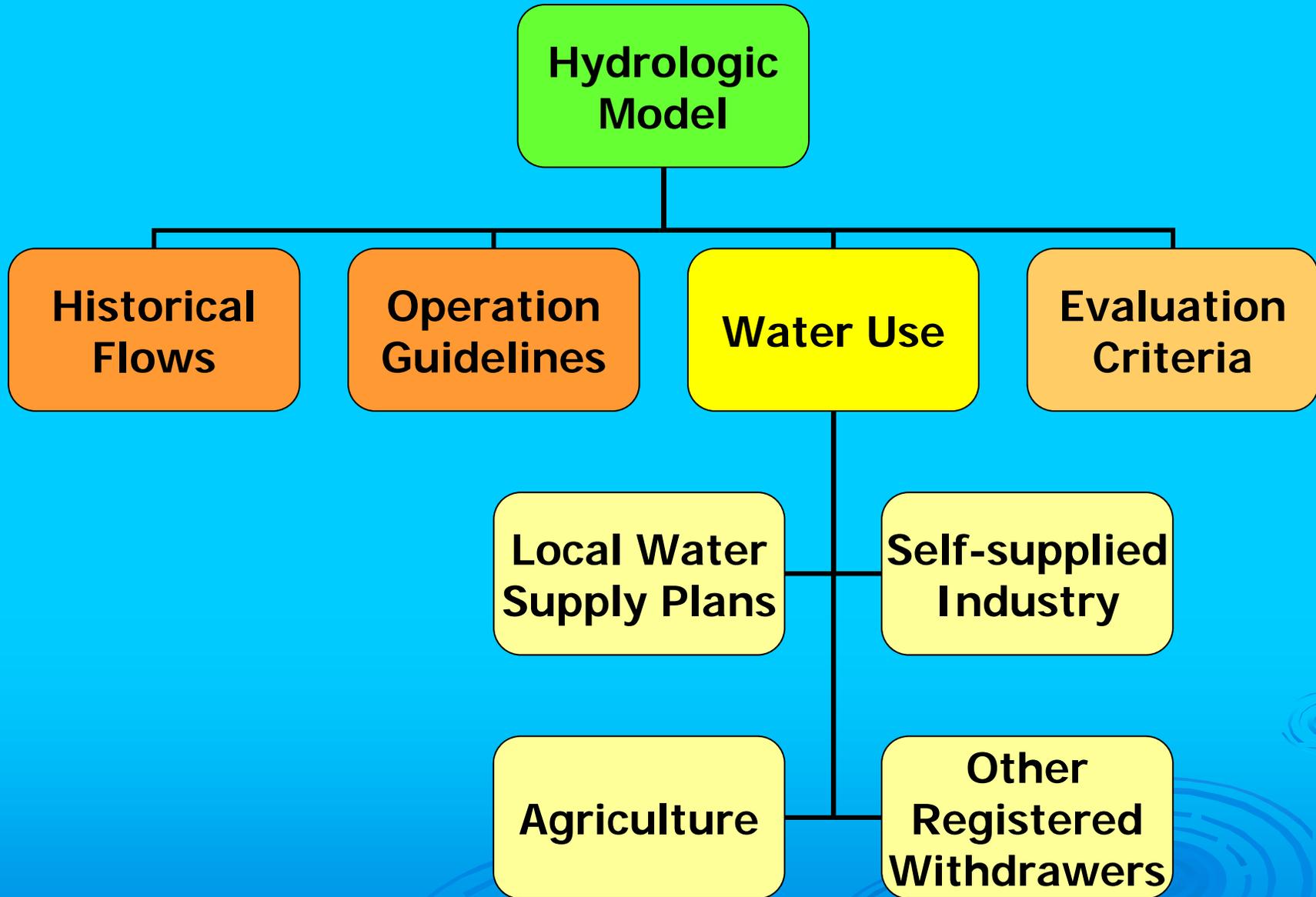
- **Water Balance Model**
 - $\text{Inflow} - \text{Outflow} = \text{Change in Storage}$
- **Model is like a checkbook**
 - $\text{Inflow} = \text{Salary}$
 - $\text{Outflow} = \text{Expenses}$
 - $\text{Storage} = \text{Bank Account}$
- **The complexity is developing the data and equations to describe the 3 variables.**

“All models are wrong, but some are useful.”

Andrew Gelman, Professor of statistics at Columbia

Model Basics:

- Models water quantity as water moves downstream considering additions and deletions at specified locations.
- Built on OASIS with OCL™ platform developed by HydroLogics, Inc.
- Not for flood analysis
- Does not model water quality
- Does not directly model ground water



Operations Guidelines

Examples

- **Quantity and timing of specific flows**
 - Aquatic habitats
 - Water quality protection
 - ✓ Intake coverage
 - Recreation
- **Reservoir water level limits and timing**
 - Structural limits
 - Aquatic habitat protection
 - ✓ Intake coverage
 - Boat ramp access
 - Authorized purposes and storage allocations



Water Use

Principle Data

- **Water Withdrawal Registrations**
 - **Agriculture > 1,000,000 gallons per day**
 - **Non-agriculture > 100,000 gallons per day**
- **Local Water Supply Plans**
 - **Local Government Water Systems**
 - **Other Large Community Water Systems**

Data Sources

- **Municipal & Industrial Withdrawals**
 - DWR
 - Water Users
- **Wastewater Discharges (NPDES)**
 - DWQ
 - Dischargers
- **Agricultural Water Use**
 - National Agricultural Statistics Service (NASS)
 - Ag Statistics from NC Dept. of Agriculture (NCDA)
 - Ag Extension Agents and Questionnaire



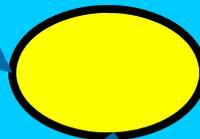
Municipal & Industrial Data Analysis

- **Withdrawals & Discharges**
 - 1930s to *Current Year*
 - Monthly Time Series
- **Fill Gaps in Series**
 - Linear Interpolation – Census Data
 - User Records of Facility Start/Stop Dates

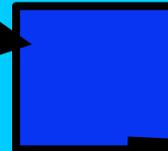


BRWA System - Simplified

Flow from
upstream
Broad River

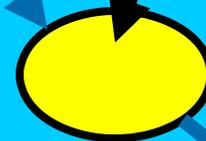


BRWA total
withdrawal



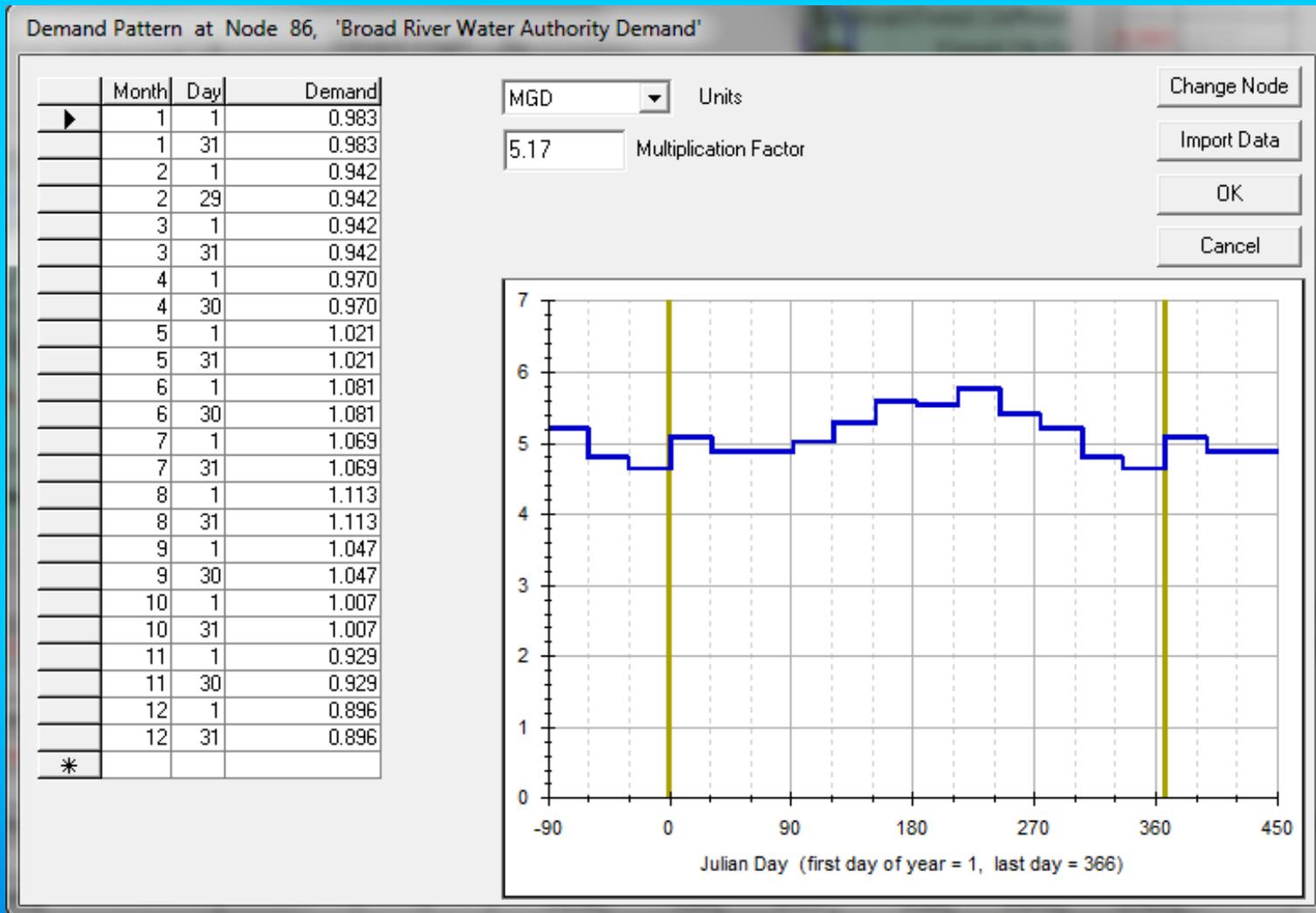
Spindale
sales/wastewater
discharge to 2nd
Broad

Rutherfordton
sales/wastewater
discharge

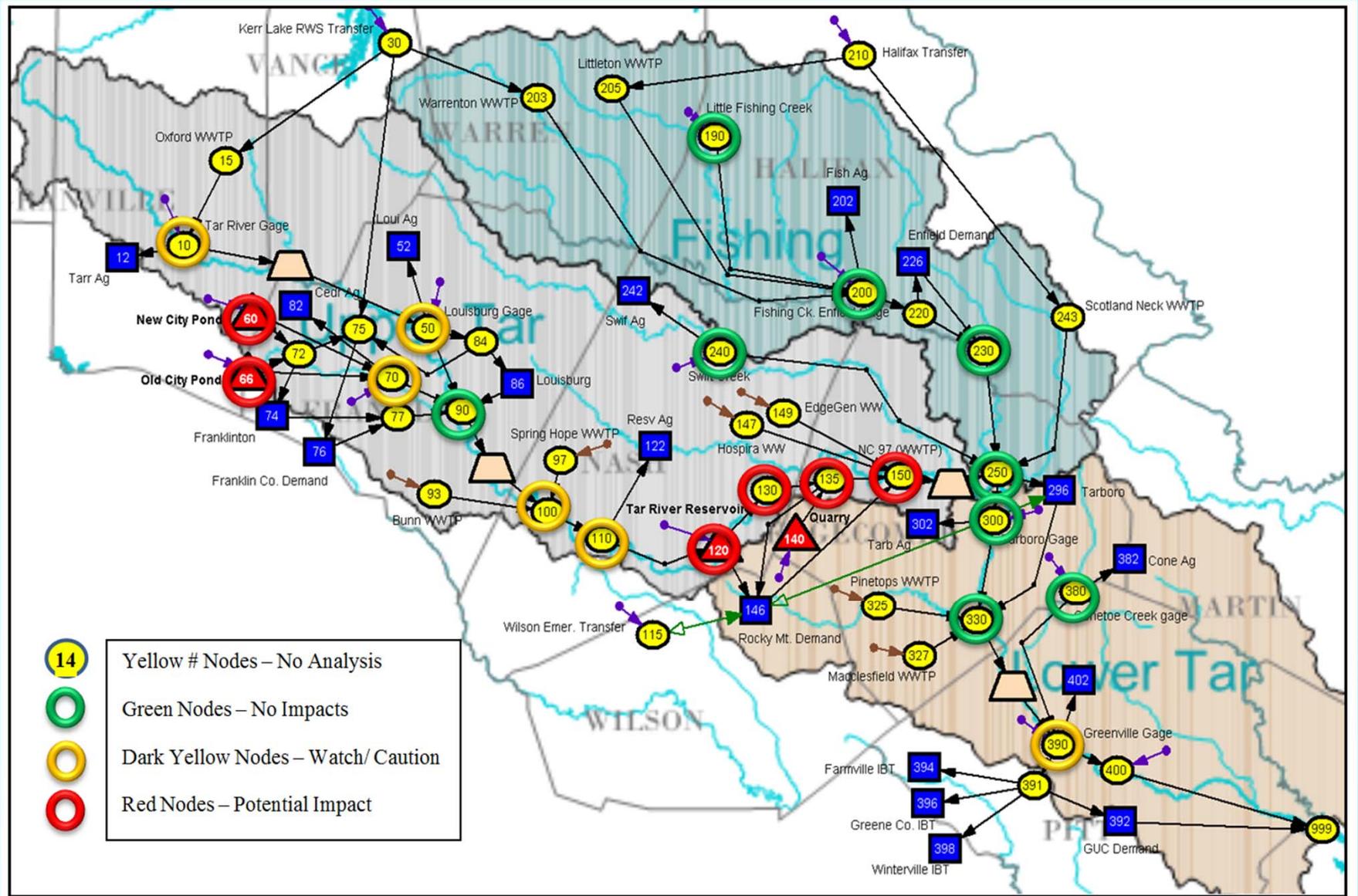


Broad River
flow

Demand Pattern



Tar Basin 2030 - Eco-Flow Impacts



Yield To Meet All Needs and Essential Needs

- **Yield to meet all needs**
 - All withdrawals - run the model without drought plans. Meets all withdrawals if no shortages.
 - Combine the withdrawal and ecological flow analyzes to determine if the yield for all needs are met.
- **Yield to meet essential needs**
 - Essential withdrawals - run the model with drought plans. Meets essential withdrawals if no shortages.
 - Combine the withdrawal and ecological flow analyzes to determine if the yield for essential needs are met.

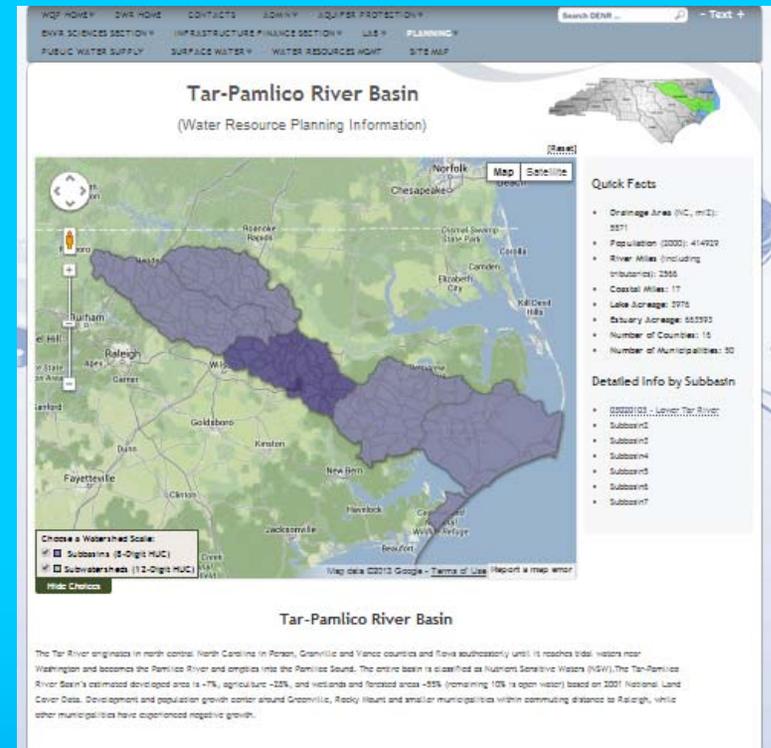


Division of Water Resources Initial Basin Planning Yield and Ecological Flow Node Evaluation Procedure

	Withdrawal Evaluation		Ecological Flows Evaluation	All Needs Evaluation			All Needs Evaluation		
	Withdrawals to meet all needs (Model without drought plans.)	Withdrawals to meet essential needs (Model with drought plans.)		Yield may be adequate to meet all needs.	Yield may be adequate to meet all needs but needs additional review.	Yield may be inadequate to meet all needs.	Yield may be adequate to meet essential needs.	Yield may be adequate to meet essential needs but needs additional review.	Yield may be inadequate to meet essential needs.
Withdrawals Nodes									
No Shortages									
Shortage or minimum flow violation or reservoir depletion.									
Permitted Ecological Flow Nodes									
All days able to meet permitted flow requirements.									
One or more days not able to meet permit requirements.									
Non-Permitted Ecological Flow Nodes									
No flows below 85% of the eco-flow 2010 baseline.									
No flows between the 10th and 90th percentile below 85% of the eco-flow 2010 baseline.									
One or more days flows between the 10th and 90th percentile are below 85% of the eco-flow 2010 baseline.									
			Composite Node Rating						

New Integrated River Basin Planning Vision

- The concern about basin scale won't be an issue.
 - Data will carry 3 geospatial tags.
 - HUC
 - Hydrogeological
 - Political
 - We will be able to provide assessments by river basin, watershed, a ground water prospective, county, or group of counties. Eventually allow user defined assessments areas.
- The Division only collects and maintains data we use. We don't ask for and store the same information multiple times in multiple locations.



Questions

BROAD RIVER BASIN HYDROLOGIC MODEL

Developed by
HydroLogics, Inc.

for
North Carolina
Division of Water Resources

[CLICK TO CONTINUE](#)

An application of OASIS with OCL covered by U.S. Patent Nos. 6,882,883 and 6,581,027 © 2010

**ROANOKE RIVER BASIN RESERVOIR OPERATIONS MODEL
VERSION 5**

developed by
HydroLogics, Inc.

for
Appalachian Power Company
The Nature Conservancy, NC Chapter
NC Dept. of Environment and Natural Resources
Dominion Generation

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An application of OASIS with OCL covered by US Patent Nos. 6,002,863 and 6,581,027. © 2010

CAPE FEAR / NEUSE RIVER BASIN HYDROLOGIC MODEL

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CWWMG Master Plan CHEOPS Model

- Edit Scenario Conditions
- Run Scenarios
- View Output
- Set CHEOPS Options
- Plant Setup
- Nodes Setup
- Exit CHEOPS

Map labels: 1 - Jones, 2 - Rhodhiss, 3 - Hickory, 4 - Lookout Shoals, 5 - Norman, 6 - Mountain Island, 7 - Wylie, 8 - Fishing Creek, 9 - Great Falls-Deerborn, 10 - Rocky Creek-Cedar Creek, 11 - Watauga

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TAR RIVER BASIN HYDROLOGIC MODEL

developed by HydroLogics, Inc.
for North Carolina Division of Water Resources

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Contact Information

Tom Fransen, Water Planning Section Chief
Tom.Fransen@ncdenr.gov
919-707-9015