Ecological Flows Science Advisory Board (EFSAB)
Meeting Summary
November 27, 2012
Archdale Building Hearing Room, Raleigh NC

X APPROVED for distribution Feb 19,2013

Attendance

Members
Hugh Barwick, Duke Energy
Mark Cantrell, US Fish &Wildlife Services
Tom Cuffney, US Geological Survey
Linda Diebolt, Local Governments
Chris Goudreau, NC Wildlife Resources Commission
Jeff Hinshaw, NC State University
Sam Pearsall, Environmental Defense Fund
Amy Pickle, Environmental Mgt. Commission
Judy Ratcliffe, NC Natural Heritage Program
Jaime Robinson (on-line), NCAWWA-WEA
Fritz Rohde, US National Marine Fisheries
Jay Sauber, NC Division of Water Quality
Bill Swartley, NC Division of Forest Resources
Fred Tarver, NC Division of Water Resources

Division of Water Resources
Tom Fransen
Ian McMillan
Don Rayno
Tom Reeder
Sarah Young

Alternates
Jessi Baker, NC Division of Marine Fisheries
Kimberly Meitzen, The Nature Conservancy (for Rebecca Benner)
Vann Stancil, NC Wildlife Resources Commission

Guests:
Johnny Boggs, (affiliation unknown; online)
Ed Bruce, Duke Energy
Craig Caldwell (affiliation unknown; online)
Michele Cutrofello Eddy, RTI
Brian McCrodden, Hydrologics
Jim Mead, Environmental Defense Fund
Lauren Patterson, RTI
Jennifer Phelan, RTI
Narayan Rajbhandaie (Raj), NC Division of Water Quality

NCSU Facilitation Team
Mary Lou Addor, Natural Resource Leadership Institute (NRLI)
Christy Perrin, Watershed Education for Communities and Officials (WECO)
Nancy Sharpless (NRLI)

The purpose of the Ecological Flows Science Advisory Board:
The Ecological Flows Science Advisory Board will advise NC Department Environment and Natural Resources (NCDENR) on an approach to characterize the aquatic ecology of different river basins and methods to determine the flows needed to maintain ecological integrity.

Presentations, reports, and background information about the E-Flows SAB are available at: www.ncwater.org/sab

NOTE: The EFSAB will meet **Feb 19, 2013, 9:15am until 4:15pm** at the Stan Adams Training Facility Jordan Lake Educational State Forest Center Chapel Hill, NC
(see last two pages for meeting agenda topics and directions to location).

Nov 27, 2012:
Summary of Decisions/Recommendations and Proposed Actions

Decisions and Recommendations

1. At the Feb, 2014 meeting, the EFSAB will develop a timeline and outline for the EFSAB report and will consider providing an interim report to the ERC.
2. Noted in a later discussion that OASIS, as approved by the EMC, is here to stay in NC as a tool in water resource decision-making.

Proposed Actions

1. Some EFSAB members discussed finding funds from their own organizations to speed up the **Biological-Environmental Classification (BEC) system study** so that the classification results may help EFSAB with recommendations in 2013, and/or conduct a simultaneous process of developing classification system for benthics.

2. From Tom Reeder's presentation, consider his definition of "Water Security" and how this can guide the work of the EFSAB.
    a. Water Security for NC: robust, resilient water supplies adequate to support future population and economic growth + instream flows capable of supporting NC's diverse natural heritage.

3. Two future situations to consider: if an incursion needs to be made on ecological flows
    a. how long will that ecosystem take to recover?
    b. and more importantly, what is the line that, if crossed, the system will not recover?

4. The EFSAB may want to understand differences in withdrawal and low flow types of impacts versus changes in biological assemblage due to shift in stream class as a result of urbanization.

5. Postpone using WaterFALL to run habitat scenarios given the considerable work to do this. Instead compare WaterFALL with monthly flow duration to see how closely OASIS lines up. If something causes concern then consider Fred's proposal, of running the nine existing instream flow study sites that have an OASIS-generated flow record with a WaterFALL generated flow record. Thus a test of WaterFALL and OASIS flow record interchangeability is possible by comparing the resulting habitat response curves. Otherwise if close enough, don't go through the extra work of doing a time series habitat map.

6. Consideration for EFSAB: determine the kinds of questions you want to ask to help determine the model you want to use. No one model will do everything. A model is a tool that's part of the decision process but not the decision factor. Both WaterFALL and OASIS may add value to the investigation of planning for E-Flows.

7. Small group consisting of Brian, Tom, and Sam, and Michele will develop a 3-way comparison to determine if WaterFALL varies in any consistent way and by what order of magnitude from the other strategies that are available for portions of the state, and thus how WaterFALL varies from OASIS and/or Gauges and whether that variation is consistent or random.

8. The facilitators will maintain a list of what the EFSAB indicates needs to be in the final report. The final decisions on what to include, and the wording of them, will be sorted out during the drafting of the report.

Potential Items for 2013 EFSAB Report to the ERC

1. A proposal was put forth to consider an interim (1-page) report to submit to the ERC by Spring.
    a. The 2013 EFSAB report would describe what ecological flows look like and what you need to know to develop them.
    b. Provide decision-makers with a clear understanding about the kind of information that is needed in order to make the best decisions possible.

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I. Executive Summary

Proposed approach to develop a Biological-Environmental Classification (BEC) system and supporting flow – biology relationships in North Carolina (Jennifer Phelan, RTI)

Jennifer Phelan presented the proposed approach to stream classification that was brainstormed at the last meeting, then further developed since. EDF will pay RTI to conduct this work that has 3 objectives:

1. Develop a new stream classification system based on geographical assemblages of aquatic biota (fish) and associated environmental (physiographic and hydrologic) attributes – Biological-Environmental Classification (BEC) system
2. Determine flow–biology response relationships for each BEC class (based upon biota that occurs within each class
3. Identify which flow metrics are important for determining biological response, then link those significant flow metrics (and associated flow–biology relationships) to each BEC class to support ecological flow determinations.

Questions, Comments, and Concerns Raised

- EFSAB discussed possibilities and difficulties of using historical fish data from before 1970 to have improved fish reference data.
- How to extrapolate relationships to large rivers?
- System could be used to develop class system for benthics.

Proposed Actions or Identified Decisions to be made:

- Some EFSAB members discussed finding funds from their own organizations to speed up the work so results may help EFSAB with recommendations in 2013, and/or conduct a simultaneous process of developing classification system for benthics

Overview of Presentation to Environmental Review Commission (ERC): How Ecological Flows Are a Planning Tool (Tom Reeder)

Tom Reeder recently presented to the Environmental Review Commission (ERC) about the ecological flows project, the current status of the project and the potential impacts that could result from this work. He made the following points to the ERC:

1. The work/focus of the EFSAB is not policy but a review of scientific information to assist NC DWR with future planning
2. For the purposes of the NC DWR, the flow metrics will be placed into the models to help identify areas that would be adversely impacted
3. Then information of adverse impacts will be brought back to the ERC to determine what action to take as a result of areas that would be severely impacted.

Tom reminded the EFSAB that any action that results from the EFSAB will be action that the ERC takes (as the originator of the policy), not the EFSAB, whose responsibility is solely to provide the scientific information. The ERC is expected to take any information provided by NCDWR about ecological flows and determine whether policy will be made or not. He also explained the iterative process of ecological flows and provided examples of the effects in NC, if the ERC designed a policy that maintained ecological flows to the greatest extent possible in NC. A brief overview of what other states are doing was included.

Tom conveyed the importance of ***water security*** for NC future, and the need to focus on a strong water supply for economic growth while at the same time maintaining instream flows. Tom presented the positive outcomes of using this two-prong approach believing you can increase the storage capacity in NC and water supplies without degrading instream flows.

Tom stated to the ERC that he fully expects a report from the EFSAB by the end of 2013. That from the report, the information and recommendations would be used and incorporated into the models to provide an idea of where NC really stands in terms of ecological flows. Tom's expectation is that for a number of NC's river basins, there will not be potential impacts except those with great urban growth.

Questions, Comments, and Concerns Raised

- An individual commented that the science is not readily available from which the EFSAB can provide recommendations and thus is learning from ongoing experiments being conducted in NC and in other states.

- The EFSAB has been very successful in making suggestions for exploring new avenues and thus the work to date has been very valuable.

- Several questions were raised about the need to understand what the recovery time might be for an incursion on the ecological flows. If an incursion needs to be made on the ecological flows: how long will that system take to recover ecologically? Or more importantly, what is line that if crossed, where the system will not recover?

Proposed Actions or Identified Decisions to be made:

- At the Feb, 2014 meeting, the EFSAB will develop a timeline and outline for the EFSAB report and is considering delivering an interim report to the ERC.

Panel Discussion with EFSAB on WaterFALL data and OASIS Modeling (Brian McCrodden, Hydrologics; Michele Cutrofello Eddy, RTI; Tom Fransen & Fred Tarver, NCDWR)

In this session, the EFSAB learned from 4 presenters about the interactions of OASIS and the WaterFALL models, and the potential interactions.

Brian McCrodden's Presentation
Brian McCrodden presented first on the major characteristics of the OASIS Model.

Mass Balance: A patented, mass balance, water resources simulation/optimization model	Runs in two modes ▪ Simulation ▪ Position Analysis
Runs on a daily time step with a 75+ year period of hydrologic record	Purposes: ▪ Alternatives evaluation (planning/finding balance) ▪ Real-time operations (following the plan)

Brian presented that three sources of data are inputted into the OASIS Model: time series data, static data, and operating data. That the output for the OASIS model is pretty standard; it provides tables and graphs of: flows, reservoir elevations, and derived attributes (e.g. habitat availability, energy, revenue, water supply shortages, recreation days).

The strengths of the OASIS model are that it's a systems approach (all management aspects are captured and it allows for investigation of creative solutions), it's fast and easy to use, it can be linked to other models, and the nodes and arcs can be added after the model is "done".

The weaknesses of the model include: no output between nodes, the model is not appropriate for flood routing, and its aspect of stationarity (i.e., assumption that historic hydrology is appropriate for modeling future scenarios).

Questions, Comments, and Concerns Raised

- Question was raised about represented inflow data set and if there was a level of departure that can be envisioned in the future from what we know about the past, where we would think we need to have a reset on what the actual period of record for the inflow should be?

- Other modeling efforts were discussed including CHEOPS for hydropower relicensing and potential modeling TVA has conducted.

Proposed Actions or Identified Decisions to be made:

1. Noted in a later discussion that OASIS as approved by the EMC is here to stay in NC as a tool in water resource decision-making.

Michele Cutrofello Eddy's Presentation

Michele Eddy from Research Triangle Institute (RTI) presented on the status of the WaterFALL model and how it can be used with OASIS. Since the WaterFALL model was introduced in August 2011, Michele updated the EFSAB on how the model was currently being used in its current ecological work for EDF, the resilience study for TNC, the development of a hydrologic foundation for the southeast U.S. for the South Atlantic Landscape Conservation Cooperative (SALCC), and a freshwater assessment pilot study for Louisiana for TNC.

Michele introduced a screenshot of the WaterFALL interface (blue dots represented the alterations and the data was retrieved from databases of withdrawals and crunched to get an average monthly withdrawal return and align with each of these catchments). Each data point tells the researcher whether it's a return or withdrawal, what it is, and the average of those twelve monthly values to consider the long-term impact on these alterations on the stream network moving down through each watershed.

Michele spent time discussing calibration using a variety of performance metrics from automated calibration (volume error over daily flows), to daily hydrographs and flow duration curves, and ecoflow metrics. General findings also aid calibration such as 1) no one area or stream type consistently out-performed others; 2) residuals/errors scattered; no consistent bias; and 3) comparisons between WaterFALL and other rainfall-runoff models for prediction of ecoflow metrics are promising.

Michele suggested that the work being conducted on the Mayo Creek, Mayo Reservoir, and the impacts downstream into Kerr Lake, may be significant to the EFSAB in looking at what impacts occur from alterations. Does it change whether it's a dam? Whether it's a certain withdrawal or return? What are the influences of that?

Questions, Comments, and Concerns Raised

- Regarding the Greensboro slide shown as intermittent flow – caution was raised about interpreting impacts or alterations to the biology solely to withdrawals without considering impacts of urbanization.

Proposed Actions or Identified Decisions to be made:

- The EFSAB may want to understand differences between withdrawal and low flow types of impacts versus changes in biological assemblage due to shift in stream class urbanization.

Tom Fransen's Presentation

Tom addressed DWR's water modeling process. He explained that DWR traditionally looks at basin models and large rivers systems where big withdrawal discharges occur; their focus is on water supply planning and screening for alternatives. In addition, DWR can monitor the implementation of drought plans and determine if those need to be tweaked, and they can anticipate and forecast future changes, including recreational opportunities, to help understand how to manage the resources better. He stated that the EFSAB has been more concerned with the smaller streams and the given data sets of smaller streams when given the ecological discussions, the low flow range is of concern. With water supply planning, the concern is with normal and low flows.

Tom presented on several topics including calibration and certification of OASIS to line up with terms that Michele and Brian used in their presentations, and validation of the models. He also echoed Brian and discussed the concept of Reasonable Representation (how good is good enough)? What do you want to use the model for? If it's for planning, Tom said he would validate the model differently than if there was going to be an implementation of a water allocation permitting program.

With respect to validation of WaterFALL and OASIS, DWR will work with Michele's eco metrics to ensure validation of the models and has tasked his modelers to take a fresh look at how DWR validates its models. DWR is still working with RTI to compare calibration points of WaterFALL. DWR may use WaterFALL like the earlier Tar example, as an alternate inflow record to do the OASIS model. Tom believes OASIS still has the strength to describe the operation of the system much better than WaterFALL. Yet, with WaterFALL, Tom thinks there's a better chance to look at climate change questions that OASIS cannot address, and there may be other alternatives for WaterFALL. As Michele demonstrated she can take WaterFALL data and create an inflow output we need to run into OASIS to work.

Questions, Comments, and Concerns Raised

- Is OASIS a better predictive model perhaps than WaterFALL. What's your basis for that or why would you make that suggestion? Is it the lack of variation?

  What question are you asking will determine the model you use. There can probably be collaboration between the two models. However, if you want to look at an individual river basin, use OASIS for its level of detail; if you want to look at a big regional question like the whole southeast, WaterFALL is definitely more appropriate. And if you're trying to address questions at a basin level, combining the two may work better. It just depends and goes back to the question you're trying to ask. WaterFALL may be better for certain applications where you may not need OASIS to address those questions. Or, you may need the combination of the two or just one. It's what are you trying to answer as to picking the model. No one model will do everything.

Proposed Actions or Identified Decisions to be made:

Consideration for EFSAB: determine the kinds of questions you want to ask to help determine the model you want to use. No one model will do everything. A model is a tool that's part of the decision process but not the decision factor.

Fred Tarver Presentation

Fred presented his perspective about how WaterFALL might be used in habitat modeling, particularly in terms of instream flow modeling, the use of WaterFALL on OASIS and the potential for utilization during instream flow studies and PHABSIM (Physical HABitat SIMulation) and the time series components of IFIM (Instream Flow Incremental Methodology).

Presented at the September, 2012 meeting was a timeline for the development of the OASIS models in the various basins that extended out to 2015 or 2018. If DWR stays on schedule with the development of the OASIS models for the 12 other basins, and the EFSAB wants to look at habitat responses at PHABSIM study sites in these 12 basins using the OASIS flow records, then the EFSAB will have to wait for the development of these OASIS models to create the flow records.

The benefit of the availability of WaterFALL is that the flow records can be created without having to wait for the development of the OASIS basin model of interest. In addition, the nine existing instream flow study sites rerun with an OASIS-generated flow record can be run again with a WaterFALL generated flow record. Thus a test of WaterFALL and OASIS flow record interchangeability is possible by comparing the resulting habitat response curves. Fred would like to pursue this analysis to review the comparison.

Questions of Clarification for Fred, Comments, and Responses:

- What's the decision that will be informed by comparing the results of the two? Not necessarily how good is good enough but to obtain some level of confidence. The WaterFALL periods of record may provide some confidence that actual on-the-ground occurrences are being represented -what is seen if using USGS gauge data.

- There was significant discussion about whether to invest considerable time to run additional habitat models, especially since habitat models are essentially of monthly flow duration or is there another way to get at this information without the additional work?

Proposed Actions or Identified Decisions to be made:

- Postpone using WaterFALL to run habitat scenarios given the considerable work to do this. Instead compare WaterFALL with monthly flow duration to see how closely OASIS lines up. If something causes concern then consider Fred's proposal, otherwise if close enough, don't go through the extra work of doing a time series habitat map.

Revisit Proposed Consensus Principle: Percent Inflow Should be Used as Preferred Flow Metric Moving Forward-- Fred Tarver

At the October, 2012 meeting, 3 consensus principles were proposed. Consensus was not achieved on the principle of using % of inflow as the preferred family of strategies for defining e-flows. The need for greater clarity on what the principle means and why it is being proposed was expressed. Fred Tarver presented at this November meeting on why DWR had proposed using % of inflow as the preferred family of strategies.

Fred showed the results of a hypothetical watershed with some hypothetical water systems under various e-flow scenarios to show how the hypothetical hydrographs respond to the e-flow scenarios and the water withdrawal return scenarios.

Fred noted some things to think about:

I. Nodes on "unaltered" streams and protected watersheds?
II. Alterations in the upper watershed are attenuated in the lower watershed by intervening drainage and discharges. Nodes in lower watershed may not raise a "red flag".
III. When is the "red flag" raised? Any time EFlow is breached? Frequency? Duration? %Q? Seasonal?
IV. Capturing Secondary & Cumulative Impacts?:
V. NC(S)EPA Minimum Criteria: "Improvements to water treatment plants that involve less than 1,000,000 gallons per day added capacity and total design withdrawal less than one- fifth of the 7-day, 10-year low flow of the contributing stream;"
VI. Unregulated withdrawals;
VII. Land use; etc.
VIII. High-flow skimming. There's a lot of available water during high-flow events.
IX. Tidal waters?

A lengthy discussion among the EFSAB ensued.

Questions, Comments and Concerns Raised

1. Board members expressed concerns over the wording of the proposed consensus principle.
    a. Friendly amendment: Percent of inflow is the preferred family of strategies.
        i. Strategies for what?
        ii. I made the proposal, and did not make it in the form of an absolute. I did not suggest that this is the family of strategies that we should adopt. I was just trying to move the cart down the road a little and say that of the three families of strategies that DENR had presented to us, this one produced most consistently the highest quality of results in terms of habitat conservation. I believe that that's empirically true…. That does not mean that in the end we won't have other strategies on the table that we like better, it does not mean that we won't have customized strategies for each of the classes; we might have that. I just was trying to—of the three families of strategies that DENR had presented to us, I think, scientifically, that the third family consistently produced the most habitat conservation. I was basically hoping we would recognize that as a group and put that on our list of things that we had decided.
        iii. It was said, even when you said that just now, two different ways. To say that it retains the most habitat, is different from saying that it's a preferred strategy.
        iv. I think we need to be more clear. The word preferred in there, I think has baggage with it. Unless you define it with more clarity.
        v. Rephrase that as this is the family of strategies that consistently produces the best habitat results.
        vi. I'll object to the term best in that it; it produces the most habitat. It retains the most habitat, but whether or not that's the best or not is getting more into the policy mode of things.
        vii. Is the target here the strategies? Or is it the metric? Or is this the strategy that retains the habitat? Or the greatest potential for ecological processes that will maintain the habitat? Because the habitat is all over the place—it's up and down, back and forth, but it's the ecological processes that will be maintained with this sort of hydrograph.
        viii. Perhaps the best way to have phrased it would have been that we agree that the percent of inflow strategy produces the least impact on the variance in the hydrograph, which is what Fred just showed us.
2. The benefit of using percent flow is that you maintain frequencies and durations. That preserves ecological integrity.
3. We maybe need to vote on whether we think that that's what was presented to us scientifically: % inflow maintains a natural hydrograph with the duration and frequency and these pieces tend toward maintaining ecological integrity, whereas the 7Q10 and even mean annual or mean monthly flows, as demonstrated by Fred's illustrations, cuts that off. It cuts our understanding in the planning process off if we model that versus percent of flow-by. And so the benefit of using percent flow is that it allows us to retain that understanding of how it is, how it looks in relation to the natural flow regime, that you're closer to maintaining frequencies and durations by using that. That's the stronger argument in favor of it preserving ecological integrity.
    a. Are we trying to maintain the most habitat? Is the most habitat the best habitat?
    b. We need to separate the points about maintaining shape and variability similar to the natural hydrograph from the notion of retaining the most habitat.

4. I think the concern was that this third category of strategies looked dangerous as a regulatory strategy, but that was not on the table.

    a. This is for planning purposes, not for regulation.
    b. From a long range planning perspective, in terms of providing a cushion for long-term planning, picking something like % flow-by would be preferable to taking the most drastic other point of view of 7Q10 because if you use that as your threshold to get your long range planning, by the time you reach that threshold, then the water has been allocated, and you don't have much cushion with which to negotiate all the various demands, whether it's in-stream or off-stream. So I think it does provide you a cushion for that long range planning perspective.
5. Percent inflow is not one of the variables that they're using in the BEC project. It is important to link the percent inflow with the variables that they come up with as being important in distinguishing the classes.
    a. There's a real chance that we will arrive at the step three of the RTI work and recognize that we've come up with some variables that are themselves not actually manageable by the Division of Water Resources or plannable by the DWR. But that percent of inflow family of strategies, by maintaining the shape of the hydrograph more perfectly than other strategies may actually give us an approximate tool for handling the variables that we actually come up with. But we won't know that until we get there.
6. I think you run into a lot of danger because of accumulation of impacts and translating that to how does that reflect what the percentage of inflow is? And where within a river system is that point-based percentage defined?
    a. It's a model, the planning part of it is—is the model, so it's something that can be demonstrated in the model, not necessarily as far as like a point in time or point location.
    b. Percentage of inflow is a meaningless concept unless it's tied to a particular size of watershed, in which case you're saying that in this particular watershed we're going to take this percentage of water out based on how much water flows into the watershed. So it's a catchment by catchment or stream segment by stream segment strategy.
7. We do not need to vote on this at this time.

Water Coordination Group *Presenter—Sam Pearsall*

Sam Pearsall informed the EFSAB about the Water Coordination Group, an ad hoc group of researchers that Sam convened to avoid conflict and duplication of effort and to develop as much synergy between and among those projects as possible. He feels that they have had great success in both departments. About 25 percent of the research that that group attempts to coordinate is relevant to the EFSAB's work. Sam indicated that he had wanted to make sure the EFSAB knew about the group so that when the EFSAB hears some of the Coordinating Group's members talking about this, or you heard that some of them had worked on a database in that way, you would know what the context was. He clarified again that it is an ad hoc coordinating committee that does not coordinate water; it coordinates research.

Decommissioning of USGS Gages *Presenter—Judy Ratcliffe*

Judy brought to the attention of the EFSAB the decommissioning of some USGS gages in the Tar-Pamlico basin. Judy suggested that perhaps the EFSAB might want to have a statement of consensus on the significance of maintaining gages over time to the state of North Carolina because the gages provide information necessary for understanding e-flows. She noted that a lot of public entities and private entities use this information and that support from the state may not necessarily always be there over time. She asked if the EFSAB might want to

reiterate as a group how significant that funding is.

Questions, Comments, and Concerns Raised

1. Many gages are at risk or have been discontinued. Once these gages are lost, you have incomplete years of data. Having a really neat model is not going to provide real-time data, nor future data to look back on later. I think it's a good idea for us to make that statement as a group about the value to our work to date as well as in the future.
2. Are there mission-critical gages, or as we go forward with WaterFALL assessment and OASIS assessment, can we identify mission critical gauges?
3. As much as I personally think gages are powerfully, powerfully important, I'm not sure it's in our brief to provide advice to the state about whether or not it should have gages or not.
4. I could see that as part of a final report that says we've developed this recommendation, it's based on these models and so on which use gages to create them and from a scientific standpoint, it's in the best interest of the department and state to have a plan. I don't think we have to get into you want to do XYZ, but that gaging stations—adequate gaging stations need to be maintained going forward in order to keep the science relevant and advance the science.
5. But we should also stipulate that we need to have excellent models and good biological monitoring data.
6. I think acknowledging what we need for robust analysis is appropriate.
7. I think our final report would say here's what we think ecological flows look like and here's what you need to know to develop them.

Proposed Action/Decision Made

1. The facilitators will maintain a list of what the EFSAB indicates needs to be in the final report. The final decisions on what to include, and the wording of them, will be sorted out during the drafting of the report.

Next Meeting: Agenda Topics

The facilitator indicated that before the February meeting, the facilitators will develop executive summaries for the 2011 all meeting summaries which did not have executive summaries. The facilitation team will be developing an overview of the process to date and create an index for the EFSAB to use in developing recommendations and creating the final report.

She then showed several items that had been proposed as potential agenda items for the February 19, 2013 meeting, including:

- RTI status report on the BEC
- TNC status report
- Map Day
- USGS classification
- Comprehensive Discussion of Coastal Issues

She then solicited additional suggestions from the EFSAB, which included:

- Develop the timeline for recommendation-making and production of the EFSAB's Final Report
- Develop a one-page interim report of the EFSAB's progress

The facilitator then presented the proposed meeting dates for 2013:

- February 19
- March 19
- April 16
- May 14
- June 18
- July 16
- August 20
- September 24
- October 22
- December 3

II. Meeting Orientation and Oct 23, 2012 Meeting Summary Approval

Members and alternates of the Ecological Board Science Advisory Board introduced themselves and their affiliations. Guests in attendance and the facilitation team also introduced themselves.

An introduction of the Nov 27 meeting agenda was provided.

The EFSAB approved the October 23, 2013 meeting summary with minor edits. It was reiterated that only two of the three consensus principles listed were fully supported and that those two with full support should not be construed as final principles to guide the work of the EFSAB. Instead, these principles may change or new principles added as the EFSAB continues to meet.

The facilitators introduced a format for offering proposals for discussions and testing for support using the gradients of agreement model listed in the charter. The reason for testing for support is to provide an avenue for each EFSAB member to share his or her rationale about their level of support and specifically, to address any concerns.

1. Record each proposal separately for consideration and discussion
2. Check for understanding-*do we all understand the proposal in the same way?*
3. Revise proposal as needed
4. List levels of support from charter
    a. Level 1: Endorsement (I like it)
    b. Level 2: Endorsement with a minor point of contention (basically I like it)
    c. Level 3: Agreement with reservations (I can live with it)
    d. Level 4: Stand Aside (I don't like it but I don't want to hold up the group)
    e. Level 5: Block (I cannot/will not support the recommendation, decision, or proposal)
5. Poll for level of support of each proposal – *what is your level of support?*
6. Record level of support

III. Proposed Approach to Develop a Biological-Environmental Classification (BEC) System and Supporting Flow-Biology Relationships in North Carolina

Presenter: Jennifer Phelan, RTI; link to Jennifer Phelan's Presentation

Brief Introduction to Classification Systems in NC (Sam Pearsall)
Before the 2010 legislation (session law) passed work was being conducted in NC to develop a hydrological classification system. EDF was working with DWR to develop the EFS stream classification. Background for partnership was that DWR was conducting IFIM & PHABSIM and EDF had just created an e-flow strategy in Texas. The reason I was hired by EDF from TNC was to work on ecological flows in NC. Then there was Nature Conservancy's ELOHA which called for flow based classifications. There were 2 basic assumptions about using flow based classifications to build ecological flows: 1) potential natural aquatic ecosystems are determined by flows; and 2) existing ecosystems are close enough to potential natural aquatic ecosystems so they would correlate very well with hydrologic based classes.

Given these assumptions, the EFS work began with strong support from DWR, and with USGS helping to select appropriate gauges. Once the classification was completed, it was reviewed. DWR tested the EFS against OASIS and came up with some tweaks that were implemented in EFS. The McManamay system was also reviewed. Then EDF/DWR started doing the internal sensitivity of the EFS classes. Alarm bells went off when it turned out clusters weren't as tight as hoped in a cluster based classification system. The EFSAB expressed strong interest in a biologically based class system. So EDF contracted with RTI to test the biofidelity and stopped the project before it finished because EFS and McManamay were not at all congruent, both were too sensitive to flashy variables and thus could not be reliably modeled. Stream classifications determined using WaterFALL versus USGS gage only matched in approximately 50% of sites. Tom Cuffney and others provided better ideas on how to incorporate biota into the classes, so now EDF is hiring RTI to do a new method. Jennifer will explain that in her presentation.

Biological-Environmental Classification System
Developing a stream classification is very important to work of the EFSAB. Two main things:
1) at the last meeting Tom Cuffney presented how a different classification system may work with incorporating biota and physiographic characteristics. We incorporated this idea into these methods- thank you Tom for helping to flesh out this methodology.
2) I'm presenting the project from a conceptual level framework, if you have questions about statistical methods, I'll turn to Lauren (RTI) and Tom.

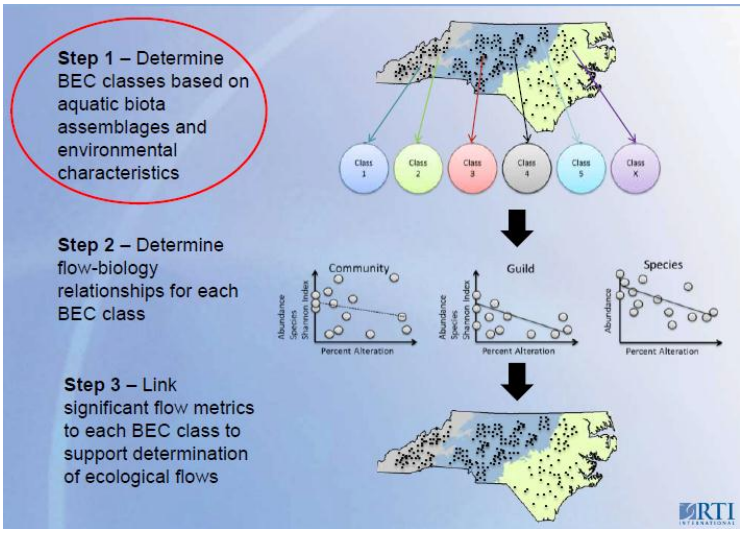
Background- at last meeting I presented the biofidelity analysis- showing we could not continue this analysis. EFS and McManamay stream classifications systems could not be extrapolated beyond catchments with USGS gages. This is a problem because we have to assign classes across the state. Found only 49-64% match between classifications based on USGS gauge versus WaterFALL modeled hydrologic data. It is highlighted by the fact that there are only 270 USGS gauges in NC, but there are 70,000 NHDPlus (enhanced National Hydrography Dataset) catchments that each average ~1.7 sq. km within the state.

It's important to assign classes at as fine a resolution as possible. You can have changes in stream classes up and down a river, as Michele will point out later in her presentation. You can't assign one class to entire watershed based on one of the USGS gauges.

CONCLUSION: Cannot use the EFS or McManamay classification systems; we need a classification system that is:
- Not based on sensitive threshold values
- Consistent and reproducible using USGS stream gage and modeled data
- Easy to understand and implement from state's perspective

- Can be applied throughout state
- Captures the distribution of aquatic biota in North Carolina
- Have to be able to use another source of data to go beyond USGS (with 2nd bullet)

These conclusions are consistent with those presented by Fred in the "Concept Paper" at the last meeting.



EDF contracted with RTI to do a project with 3 objectives

1. Develop a new stream classification system based on geographical assemblages of aquatic biota (fish) and associated environmental (physiographic and hydrologic) attributes – Biological-Environmental Classification (BEC) system
2. Determine flow–biology response relationships for each BEC class (based upon biota that occurs within each class
3. Identify which flow metrics are important for determining biological response. Then link those significant flow metrics (and associated flow–biology relationships) to each BEC class to give to you to support ecological flow determinations. This is quite a bit easier to see in a schematic. I'll walk through these 3 sequential steps and describe them in the rest of this presentation.

Step 1: Iterative, cluster-classification approach using aquatic biota and environmental attribute data to develop BEC classes: Aquatic biota: NC fish (DWQ Fish community dataset) – 858 monitoring stations

Environmental attributes:

- Regional classifications (6 classifications – ecological, physiographic, hydrologic)
- Physiographic (watershed and stream channel) characteristics
- Climatic variables
- Hydrologic variables
- Physiographic

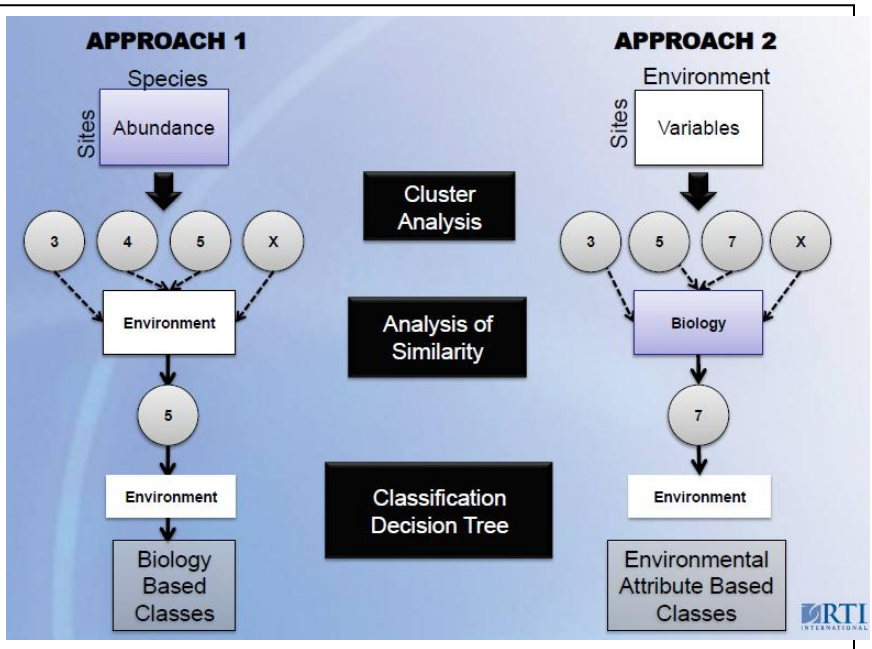
The adjacent table lists specific variables for potential environmental attributes.

Environmental Attributes	Variable
Climatic	Average precipitation
	Average temperature
Physiographic	Elevation
	Channel Width
	Channel Gradient
	Channel Sinuosity
	Local connectivity (stream fragmentation)
	Stream size/Drainage area
	Geology (catchment and local)
Hydrologic	Stream hydrologic regime (ground-water vs. surface water dominated)

These attributes have been used in other classifications- TNC, SALCC, Kim Meitzen is using some of these in her work with TNC for e flows in NC.

We'll use these data sets in a cluster class approach- biological environmental classification (BEC).

See the graphic showing approach 1 & 2.They are the same but each starts with different data sets. Approach 1 (on the left) starts with biological data, Approach 2 starts with environmental attributes being determinants of classes. I'll walk you through them.



Aquatic biota/fish- use a cluster analysis to determine the number of classes that could be used to describe abundances of fish across N, to result in 3, 4, or 5 different classes. This is followed by analysis of similarity to determine the best number of classes that can be used to describe the biota, environmental attributes…basically to maximize association between environmental attributes and biological data. Could theoretically, through this process, identify 5 classes of biological assemblages and associated environmental attributes. Then after we determine the 5 best given the data that we have, then use a classification decision tree to assign the classes and distinguishing features. For example we might find that physiographic region, drainage area size, channel, sinuosity or gradient might be the best attributes, and then we'll determine the threshold values that will separate the different classes. That will determine our biology based classes.

The same approach is used to evaluate environmental attributes – that approach may determine a larger number of classes. This might be because biological data is restricting, and only captured in wadeable streams. Those may come out in environmental attribute approach. There may be some classes determined in the environmental attribute approach that don't have biological data associated with them.

Two different approaches come out of this method.

Step 1: After we get these, hopefully there will be an obvious way to combine them, if not we'll present them to you to see the best way to proceed (use one, or combine for example).

Step 2: Determine flow-biology relationships for each BEC class. Classes will describe assemblages of biota. First develop classes, then develop relationship within each class.
The Flow alteration (expressed as % change):

- Ecologically-relevant flow metrics
  - based on TNC Indicators of Hydrologic Alteration (IHA)
  - NC DENR management-focused

Time Step	Component	Threshold
Monthly	Extreme Low Flow	10th percentile
	Low Flow	25th percentile
	Median Flow	50th percentile
	High Flow	75th percentile
Annual Winter (10– 6) Summer (7–9)	Extreme Low Flow Threshold	10th percentile
	Extreme Low Flow Events	Number of events
	Extreme Low Flow Duration	Maximum

- Generated using WaterFALL model

The Flow metrics we'll use are the ones presented here in the summer, in the RTI internal research project, and were based on TNC indicators of hydrologic alteration. Those selected were focused on low flow metrics, due to DENR management priorities. It would be interesting to look at the influences in changes of high flows, but DENR can't do much with those because they're focusing their planning on the low flows.

Q: You're not ignoring high flows, you have some in there.
R: Yes we do, but it weights towards low flow metrics.

We will express changes in these flows as difference between historic conditions (70's land cover, natural vegetation cover with no instream alterations) vs current with 2006 land cover, withdrawals, and impoundments.

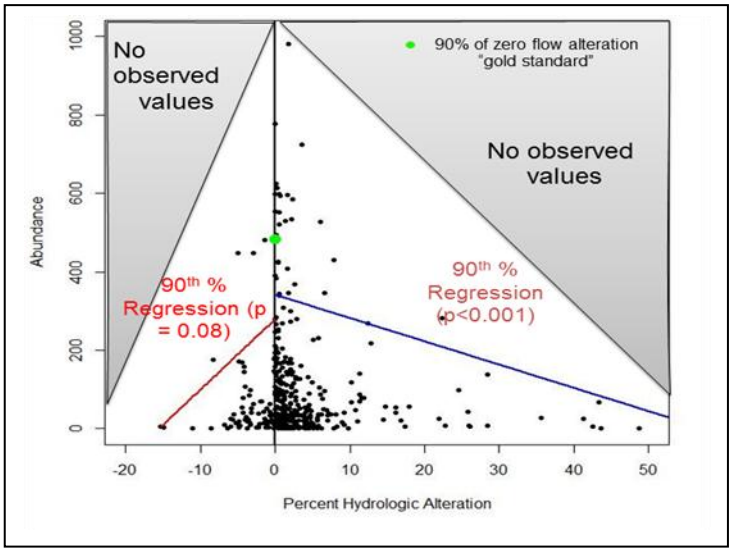
Percent change is of how flows are altered between these 2 different conditions.

Flow alteration – biological response relationships for each class.

- Biological response: (SLIDE 14)
  - NC Fish Community data (858 catchments with monitoring stations)

Level	Analysis metric
- Individual species	- Species abundance (count of individuals)
- Full community	- Number of species (diversity)
- Habitat guilds (6 that Chris presented)	- Shannon Weaver Diversity Index

Analysis
- Space-for-time analysis (on a scatter plot)
- Quantile regression (90th percentile)



With this method (as Mary Davis presented was used for Potomac) the 90th percentile represents the upper limit of response to flow alteration; everything below is a response to the other stresses.

This is an example of the flow-biology relationships we might get. The x axis is % alt, y is abundance. This is real data, the Piedmont riffle-run guild response to January low flows. The % hydrologic alteration (+value) means there is an increase in flow, versus the value is a decrease in flow. Based on 90% regression it means there is an adverse response. We'll try to determine which are the significant metrics that drive the biology in each of the BEC stream classes.

Step 3: After we determine flow-alteration relationships for each class, we will determine significant flow

metrics- which are the drivers, and link back to each BEC class.

- Link statistically significant flow metrics (from the flow-biology analyses) to each BEC class
- Some metrics (associated with individual species analyses) may be associated with more than one BEC class

Then ultimately at that point after linkages have been made we'll hand it over to you to see if it could be useful to help determine ecological flows. The work that Jim has done with PHABSIM could also potentially be assigned to the BEC classes as well. Hopefully the biology flow alteration links and the PHABSIM work will be complimentary.

Questions, Comments, and Responses:

Q: Back when you described Step 2 to determine the flow alteration part, step me back through, how you would determine which data to use to determine flow alteration %?

R: Flow metrics slide- this one? Flow alterations will be expressed in terms of 61 metrics (ecologically relevant flow metrics, in table). The actual flow alteration will be % change, take climate out of picture, run 30-40 year period of climate data through historic 70's land cover, or PNV land cover with no instream flow alterations, then same climatic data through 2006 land cover, with in stream flow alterations and get % change.

C: It's a land cover runoff model to generate that, you're not using gauge data, just a terrain model?

R: Yes, using WaterFALL model.

Q: Current data would include withdrawals and discharges?

C: Unaltered would not be based on dams before 1970. Climate is teased out.

R: It's all modeled, it will not go off gauge data except to calibrate the model.

C: For altered, 2006 data is calibrated within the model where possible using gauge data.

Q: You'll have 2 flow scenarios at each of the 858 fish sampling stations?

R: Exactly, that will allow a scatterplot analysis that for each of 858 stations will have the 2 flow records, historic vs current, expressed as % change of comparison, then % biota as a scatterplot.

Q: About biology data, at the 858 stations, there are different frequencies that each station was sampled at, there are variability in the data sets. Which data set are you selecting?

R: We'll use the most recent measurement, regardless of date, to make it as close to 2006 as possible.

Q: How do you validate the current biological data relevant to historical biological data. Do you use points from 70's, to give you a baseline level that you can compare and look for change, even in unaltered streams? (no) Then how do you validate current biological data? Especially while looking back in time?

C: All we're saying is that there has been this change in flow over history, here is the biology - the biology is now is a reflection of what happened, and the current state in respect to alterations. There are a lot of assumptions being made.

Q: Do you have any unaltered areas you can examine?

C: NC DWQ has some reference condition sites, but our fish community structure program wasn't there in 70s. The power of this approach is to take it in its entirety, to test whether model works. Clearly fish data was collected for the purpose of interpreting water quality not hydrology. We're using it for a different purpose than intended, but it may work. Purpose of running this is to see does it work or not. It's probably our best approach unless we substituted fish for benthics, where there is a larger data set but a great deal more seasonal and other variability. I think it's the right approach and very much worth

pursuing.
Q: I agree, but the question is, how do we know it works, to make that decision- it may seem to work, how do we validate it?

C: Based on what Jay said, might be within scatterplot you can identify reference sample locations and see if they are around the 0 line to see if that area makes sense (the unaltered).

C: Because we don't have pre-post data for all 858 sites, instead you're using space for time by having all 858 points over a large range of space, some with lots of alteration, some with no alterations, none of those have both pre & post alteration data, but because you have so many you have a whole range of degrees of alterations. A geographic spread of data points…

R: What you see here is a scatterplot using 1970s vs current. We're hoping we'll see the % change, especially on the negative side, isn't as large as we would like, with respect to confidence, so we'll exploring using PND (potential natural vegetation data), which we believe will give us a larger range of change.

Q: About lining up the pre- 1970, with pre-1970 fish data or any compilations of fish community data statewide that helps inform of community shifts, scratching my head about the old community surveys conducted by Fred Fish with NCWRC-- there was a classification method. Wondering if that would be useful, or it might help to reconstruct old fish community data, like what we're doing across the Southeast that looks at museum records. Perhaps use museum records, and a compilation of those two to derive a fish community classification for multiple points. Would it be useful or confuse the models.

R: Natural History museum apparently has a lot of 1970 and earlier fish records. We discussed how useful to use those because of water quality issues since it is before the 1971 Clean Water Quality Act. Perhaps it's not wise to use them since there may have been improvements, then what are you comparing?

C: We wouldn't make assumptions that there have been improvements across the boards since then. There have been significant declines since then.

R: But we don't have any of the water quality data. It might confuse things.

C: The strength of approach is consistent collection. If you're going to use abundance data, than you have to have that consistency, if using just presence/absence data, then you have to draw on other resources for information about what those communities look like now. For large rivers and coastal plains….on flip side you have this consistency in collection and we may to carry that forward.

Q: With a space for time approach, one concern is that there are a lot of other factors that will influence the abundance and diversity of the communities I don't know that the 90% percentile will capture that. For my work, I've found gradient, stream size, ecoregion have significant correlation with abundance and diversity. Concern that the space for time replacement might not account in the differences because of other factors.

R: If those become part of the stream classes, those physiographic attributes being large drivers, that will come up in the classification results. Those will separate out by classes, and you can isolate alteration/biological responses to the communities which have already been filtered by the characteristics of that class.

Q: It will be stratified by the time it gets there?

R: Yes. We recognize other stresses will be very important in determining biological responses, and at same time RTI will continue our project, which will do more of a multiple variable analysis to look at importance of other stresses in determining biological response and we'll be able to share that with you. We might find that in this particular fish community water quality or fragmentation is the most important driver. The other reason why we don't want to build that into these relationships is because that would

be challenging for DENR to use- it will be more useful for determining ecological flows to have a single predictive variation. It will be very complicated if has 4-5 factorial relationship.

C: We also have ability to test relationship with other tools post processing. We will develop method to establish index of biological integrity, which will be available to run as one of these multivariate analyses to explain variation from more than hydrological alternation. We also have a number of simultaneous overlaps with the benthic macro- invertebrate program we can use to test this approach. We also have the additional fish community structure analysis that is not represented by most recent sampling, we can do hind casting testing on older alterations to see if they have same results or not. There are a number of ways to test methods after it is completed to see if results are true to intent or explainable by other issues.

R: You could use this system to develop class system for benthics, due to funding limits we could only include fish. It makes sense because you don't want to go whole hog and find out it doesn't work.

Q: When using recent data, our observation is we've been in low rainfall for a while (since 2006), if you use the data from small streams with less than average flows, does that bias your stream classification? That's where the hind cast comes in, it would be useful to look at previously sampled locations, you can do that and see if abundance/diversity has changed over time. In our sampling of streams in drought years we'll see species composition that declines in abundance that increase as flows increase later. Important thing to look at.

R: Yes, we see that (2 other EFSAB members agreed)

R: Yes. Kim is doing a change over time approach, she found there is a lot of change.

C: There is a lot of variability, some stations don't show much change at all, some show quite a bit of change, in both directions. There are fewer stations where they are consistent between each sampling survey.

C: Point there may be if you have an impaired system you're sampling and most tolerant species have reached capacity at abundance…measuring something that stays consistent over time doesn't mean the assemblage (is better?), it may be lowest common denominator have been met…abundances are of the tolerant species. I think that's where checking against IBI is important- we don't want to bring everything down to lowest common denominator of maintaining abundance if that is simply the most tolerant species.

Q: These are for wadeable streams, how do you expand that to the bigger river systems, since it seems like that's where the withdrawals will be?

R: Two ways- one focuses on biology as main driver, its strength will be in wadeable streams. The other focuses on environmental attributes as main driver. We expect to find some streams that come out of that classification approach that won't have biological data. We won't be able to answer question of how to extrapolate to larger streams, that is for you guys to address. We'll present what we come up with, and then you will decide how you want to go from there. It will be a challenge when you don't have any biological responses in big rivers that you can't characterize easily. Same as with coastal areas.

Q: Will guild work that Fritz is doing, will that be applicable? It seems like it might be useful once you've established whether biology or environmental framework will be most robust, then use guild community information for large rivers. We can construct a most likely guild community for larger rivers. Don't know where you'd take it from there, but not outside of realm of possibility to construct it…just like PNV, could have potential biological community.

C: About the 1960s data NCWRC collected, there are issues with it. Data is all hard copy- it would take time to enter it into a database, another thing there were multiple methods used (electrofishing, creosol, rotenone). The other thing, as Jennifer mentioned, it would be good to do this same approach with benthic data as well. Now it seems like not enough money to do both, maybe we could free up money to do that. I'll see if NC WRC can contribute money to this effort to move it forward if it makes it through

first cut.

R: That might be relevant to timeline. What is our timeline- 2 years?

C: Not quite 2 years. Intent is to start work on Jan 1 and finish in Sept. 2014. We can get through Step 1 before EFSAB ends at end of 2013. Step 1 involves 2 separate strategies and convergence of them or comparison of them and choice of one. Not sure we can get thru steps 2-3 in 2013 or not. This committee is not bound to this process- this is something EDF is doing as matter of research to make us smarter. This committee has ability to say if they want to use it or not. Hoping we'll see some convergence of the 2 approaches and have something useful (in 2013).

C: I want to address what Judy brought up, that there is information, not standardized, on large river systems from NC WRC, Duke, Progress Energy, and other work, etc. We can get presence/absence data on guilds out there.

C: I think that the fishes are stronger biological class to use larger water systems, I think fishes.

C: If done with fish we can test with bugs. Another possibility is to find extra money and do parallel process and do with bugs at same time and have 4 alternative strategies.

C: The life cycle and frequency is greater for aquatic insects, if you use them you're not necessarily measuring implications of flow as you are other temporal factors.

R: Other option respective to possibility of additional available money, instead of doing bugs and fish in parallel, you could ramp up fish and do it all in one year, rather than extend the fish over 2 years.

C: NC WRC money could be used to speed that up possibly.

F: Given your timeline- when do you expect the EFSAB to provide feedback?

R: We can get to the final BEC classes in first year (summer or Sept/Oct 2013)

C: This is a statistically intensive process, but getting it done in time to run the step 2 response curves in year 1 is potentially feasible, we may get further down road than we think.

F: You have a handout of an abstract provided by Chris Goudreau, to make you aware that USGS is doing a national classification.

C: They're finishing first draft, should be available 1st of year. I think the important thing for this process we're talking about- they're trying to come up with a set of hydrologic metrics relevant on national level …the list of variables will be important. As soon as I can get that information from Jonathan and get the okay to share it I will.

F: Maybe we can add that to the February agenda.

IV. Overview of Presentation to Environmental Review Commission: How Ecological Flows Are a Planning Tool

Presenter: Tom Reeder, NC Division of Water Resources link to Tom Reeder's presentation

Tom Reeder recently presented (Nov 15, 2012) to the Environmental Review Commission (ERC), on the Ecological Flows project – where the EFSAB was at and what some of the potential impacts could be from this work. This was an hour presentation and is located online at:
www.ncleg.net/documentsites/committees/ERC/2012-2013%20ERC%20Documents/2%20-%20November%2015,%202012/Handouts%20and%20Presentations/2012-1114%20T.Reeder-DENR_Ecological_Flows.pdf

The ERC did express that they are receiving push back about the work of the EFSAB including comments to

disband the EFSAB because it may head in a direction that some constituents do not prefer. Some have suggested picking a number and sticking with it. The ERC is not actively considering this request at this time but rather is taking this input under advisement. Tom reminded the EFSAB of its charge, that the EFSAB was pulled together as a result of NC Session Law and that the NC General Assembly can choose not to convene the EFSAB. In 2013, there is expected to be a lot of water policy regulation introduced in next session of the NC General Assembly. Thus, there may be some changes to the Session Law impacting the EFSAB process in the near future.

What the ERC was interested in hearing from Tom Reeder during his presentation was what could be the potential effects of the outcomes of these scientific discussions on regulated entities in NC. There is confusion about the NC Division of Water Resources (NC DWR) – and it regulatory authority. The NC Division of Water Resources is primarily a planning agency; the agency does implement the Safe Water Drinking Act through the Public Water Supply Section, and implements the Central Coastal Plain Capacity Use Area rules, plus Interbasin Transfers (NC DWR regulatory authority).

There is the perception out there that once the ecological flows are determined, the flows metrics will be inserted into the basin models and become a regulatory tool that entities must comply with. There is general misinformation then, about the role of the EFSAB - to advise NC DWR on planning not regulatory.

Tom made the following points to the ERC:

1. The work/focus of the EFSAB is not policy but a review of scientific information to assist NC DWR with future planning
2. For the purposes of the NC DWR, the flow metrics will be placed into the models to help identify areas that would be adversely impacted
3. Then this information of adverse impacts will be brought back to the ERC to determine what action to take as a result of areas that would be severely impacted.

Tom reminded the ERC that any action that results from the EFSAB will be action that the ERC takes (as the originator of the policy), not the EFSAB, whose responsibility is solely to provide the scientific information. The ERC is expected to take any information provided by NCDWR about ecological flows and determine whether policy will be made or not.

Tom continued to discuss what he introduced to the ERC. He explained the iterative process of ecological flows and provided an *example to the ERC, stating that if the ERC wanted a policy to maintain ecological flows to the greatest extent possible in NC – where would be greatest effects in NC?*

2. Run of river withdrawals (Tom provided a slide of where there are the largest run of river withdrawals in NC and do not have an instream flow target to meet)
3. Public Water Supply (greatest potential could be here)

If the ERC decided to maintain ecological flows to the greatest extent practicable– these could potentially be the areas impacted however, the ERC is not likely to set policy at this level.

Tom also introduced to the ERC what other states are doing with respect to ecological flows. Tom provided an example of 7Q10 regulation being used in South Carolina and a rationale for why simply picking a number is not the most effective approach. He also made the case for why the EFSAB should be allowed to continue on its current course.

Lastly, Tom mentioned the importance of ***water security*** for NC future, and the need to focus on a strong water supply for economic growth while at the same time maintaining instream flows for natural heritage. Tom presented the positive outcomes of using this two-prong approach such as waste water assimilation, protection

of natural heritage, enhancements to recreational and tourism from recreational and commercial fishing,…: instream flows are very important to the future of water security in NC. In Tom's mind, these two approaches are not mutually exclusive – Tom believes you can increase the storage capacity in NC and water supplies without degrading instream flows. Tom used an example such as a quarry with high-skim flow operations.

Tom stated to the ERC that he fully expects a report from the EFSAB by the end of 2013. That from the report, the information and recommendations would be used and incorporated into the models to provide an idea of where NC really stands in terms of ecological flows. Tom's expectation is that for a number of NC's river basins, there will not be potential impacts except those with great urban growth.

Tom advised the EFSAB that if the board wanted to remain relevant to the discussion in NC that the EFSAB should plan on providing a report to the EFSAB at the end of 2013 or preferably sooner that figures out a methodology to calculate ecological flows. He believes that the EFSAB should stay the course and provide the scientific information that a number of General Assembly members would like have in order to do this right and plan for NC's future.

Questions (Q), Comment (C) and Response (R):
C: Tom, this is not just a science advisory board, meaning that the science is not complete so it's not simply looking at the science that's out there and making recommendations with a high degree of confidence but in fact, the EFSAB is learning from ongoing experiments being conducted in NC and in other states on how best to do this. The EFSAB has been very successful in making suggestions for exploring new avenues regardless of whether we have been successful at determining an actual instream flow method, model or equation. In this regard, the work that has been done here has been very valuable – whether the EFSAB continues to exist or not. One thing I continue to wrestle with is: if we make the assumption that what we are trying to do here is provide scientific information that comments on the competitive aspects of water for drinking and water for critters, and even if we are successful in coming up with an ecological flow – there will be times that water for the water supply will "win" regardless. And based on whatever methods we come up with we need to understand what the recovery time might be for such an incursion on the ecological flows. Let's say we decided that ecological flows was equal to X, and was comfortable with that, but a crisis may arise due in the future due to water security or a drought that the political process decides people come first and the incursion needs to be made on the ecological flows. If so – how long will that system take to recover for the ecological? Or most importantly, where do we cross the line where it will not recover? These are considerations the EFSAB has not even begun to consider. Thus if we are successful in coming up with ecological flows – we still have these two situations to wrestle with.

V. WaterFALL Data and OASIS Modeling Panel

Presenters: Brian McCrodden, Hydrologics; Michele Cutrofello Eddy, RTI; Tom Fransen & Fred Tarver, NCDWR

In this session, the EFSAB learned how the OASIS model might be used with the WaterFALL model or as stand-alone model. In addition, the NC DWR provided a vision for modeling including the use of WaterFALL and how WaterFALL can be tested for habitat modeling. The panel included: Brian McCrodden from *Hydrologics* provided an overview of the OASIS model; Michele Eddy from Research Triangle Institute (RTI) presented on the status of the WaterFALL model and how it can be used with OASIS; Tom Fransen introduced DWR's vision of water modeling; and Fred Tarver responded to questions raised as a result of the October DWR concept paper about testing for habitat modeling.

Brian McCrodden link to Brian McCrodden Presentation

Brian began his presentation to the EFSAB by focusing on distinct aspects of the OASIS Model, followed with a discussion on instream flow development and verification using the OASIS model and Brian's perspectives about the strengths and weaknesses of this particular approach.

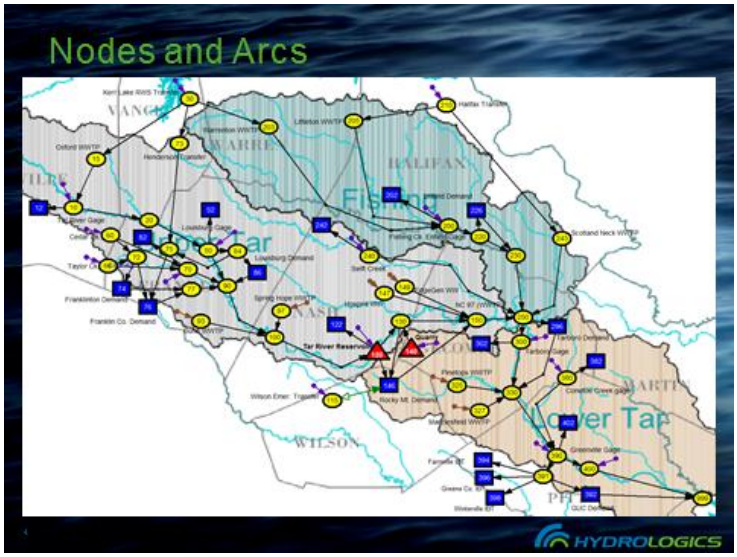
What is OASIS? OASIS is characterized by the following elements:

Mass Balance: A patented, mass balance, water resources simulation/optimization model	Runs in two modes ▪ Simulation ▪ Position Analysis
Runs on a daily timestep with a 75+ year period of hydrologic record	Purposes: ▪ Alternatives evaluation (planning/finding balance) ▪ Real-time operations (following the plan)

OASIS is a mass balance class of model; it is not a physically based model like WaterFALL meaning there are no physical processes modeled in here. It's a big accounting program and a simulation model. Brian stated that if you had enough time, one could do the work on a great big spreadsheet.

OASIS runs over a long period of hydrologic records to ensure understanding about the performance of the system under all different types of hydrologic conditions that have occurred over history. It is known that these systems respond differently to different types of droughts. For example, flow intensity, long duration droughts, early onset droughts, late onset droughts and so on, the response is different and thus there is a need to investigate all of the possible outcomes. One possible drawback in the model is when a researcher looks back at the drought of 1932 – in today's environment with considerations for climate change, how likely is that to reoccur?

OASIS as Simulation Mode and Position Analysis Mode
In using the OASIS simulation mode, there's also a position analysis mode which is useful in real time operations. These features allow the user to look at things like probability-based operations, which are much more sophisticated than most entities follow now; it is a way to bring a little bit more water for beneficial uses out of these systems.



The slide pictured below is of the Tar River Basin and a schematic for that model. It illustrates all the ways that the water can go, all the routes that the water can take either natural or manmade within this system; it's fairly complicated with several major features. The two red triangles designate reservoirs. The blue squares are commandos where water is withdrawn for some purpose. The reservoirs depict a line with a circle on one end and an arrow on the other. This represents a point in the system where there is long turn time series of unregulated inflow and there are about a dozen points in this system where there is a time series of inflow.

OASIS Input and Output

Like most of these models, there is what goes into the model (input) and what comes out of the model (output). Three sources of data are inputted into the OASIS Model:

1. **Time series data**
    a. Unregulated inflows
    b. Evaporation
    c. Precipitation
2. **Static data**
    a. Physical data
        i. Reservoir SAE, turbine characteristics, channel capacities, etc.
        ii. Withdrawals, discharges, demands
3. **Operating Data, e.g.**
    a. Rule curves
    b. Minimum releases/environmental flows
    c. Drought and flood management policies
    d. Energy requirements

Obviously there is a need in the model for all the physical data, reservoir attributes, pipe capacities, spill way capacities, particularly if you're dealing with hydro power simulations. And a need for the operating data which is a strength of this particular model. It's a way to capture almost any conceivable manmade parts of this system and manipulate them, from probability operating rules to basically anything else that there is a desire to look at.

The output for the OASIS model is pretty standard; it provides tables and graphs of:

1. Flows
2. Elevations
3. Derived Attributes (e.g. habitat availability, energy, revenue, water supply shortages, recreation days).

Over the years, Hydrologics has spent time developing derived attributes. Meaning how is some flow information translated into useful biological information or recreational information to determine the number of years a water supplier could have to curtail water supply, the number of days in a given season or when boat ramps would be inaccessible. These things can be derived from these basic points of information.

Inflow Development

Three terms framed the conversation of inflow development: unimpaired, impairment, and methodology.

1. Unimpaired (unregulated, unaltered) inflows necessary for evaluating alternative facilities, operating policies and demand levels
2. Impairments include water withdrawals/discharges and reservoir regulation (including net evaporation)
3. Methodology: Force inflows to match monthly unimpaired gage flows; disaggregate to daily based on a proximate unimpaired gage

The goal of inflow development is a representative record; history will never repeat itself exactly. If unimpaired flows are not used, the system cannot be divorced from its current operation.

Earlier, the point was made about the long-term honing paired record. Again, the reason for the long term record is to look at the variability. However, the model cannot say, "Here is the way the system performed in 1932." The question being asked instead is: "If we had the system as described in this, at whatever alternative we're looking at, and the alternative consisted of the set of facilities, the set of demands and the set of operating policies and we had that system in place in 1932, that's the way it would have performed". The idea is

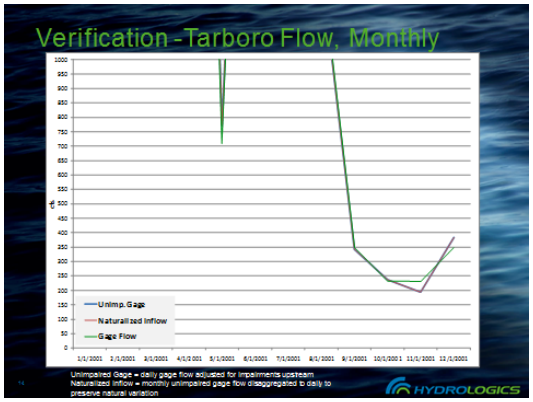
hold all things constant and run the hydrology through the whole thing, then look at the distinct alternatives and do the same thing.

There are a couple of terms in here that need some definition. In the earlier days of Hydrologics, natural flows were referred to as unimpaired flows until others pointed out that there is such a thing as impaired water. Then other folks got their knickers in a knot when you talk about unregulated flows because regulation has a different context. For now, the model uses unaltered flows. Brian said some might object to the use of this term but Brian believes the three terms: unimpaired, unregulated, and unaltered are the same.

The objective is to create a set of inflows, the best that can be determined without any human influence. And then force the inflows to match the USGS gauges of which there are about a dozen long-term ones in this basin, to match those on a monthly basis. The monthly values are then desegregated into daily values using some other unimpaired, unaltered local gauge. So if 5% of the flows in an unaltered gauge occurred on the fifth of the month, then 5% of the monthly flows as inflows to the reservoir occur on that day. The whole inflow development stuff is about 75% of the effort of developing one of these applications meaning there is a ton of work involved. The goal is to generate the representative record that will be close to the historical record but not exactly, as history is never going to exactly repeat itself. The gold standard here is a representative input data set.

The gauges used in the Tar River Basin have unregulated at all of those points. Here are the gauges shown on the map and with a color code that indicates this is sort of a qualitative assessment of how altered they've been over time. Some of them have been in waters that are pretty pristine but more and more are impaired. This is the same set of gauges except they're in upside down order now, showing time in which the gauge was in existence [Slide 10]. This is part of the art and science of hydrologies, extending all of those bars so they all cover the same time period. There are lots of difficult techniques used to do that.

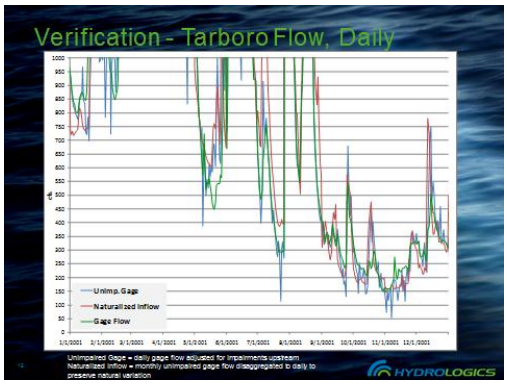
At the point of unimpairing [Slide 11], this is where there's a boatload of data collection goes into this: every withdrawal in the basin, every return in the basin that's over 100,000 gallons per day, reservoir operating records, agricultural withdrawals, and then assessments are made to extend these records. Anything 100000 gpd or more today. For example, there is an effort to collect municipal demands. If one reviews the 1960 records for say the City of Rocky Mount, there are no more demand records. Obviously the town was there and using water but there is a need to extend these backwards in time to try to get all this to match. That's what being done; using a different technique of an upstream gauge and adjusting it to get the inflow for upstream withdrawals and returns, or – and this is more common – to take reservoir operating records, take discharge and back out the effects of evaporation and changes historically (which is complex). Brian reminded the group that when considering all the addition and subtraction, there is the potential to get negative inflows because of the time of travel in these reservoirs so this aspect needs to be unscrambled to come up with a representative data set.



The Test is Verification, not Validation

This is extremely exciting work. Basically it's a big spreadsheet where one tracks all of the regulation upstream, and adds or subtracts whether it's a withdrawal or a return or a change in storage or evaporation. This results in what the gauge was on that particular day historically and the assessment of what it would have been absent all of this other alteration upstream. This is accomplished for the whole 80-year record.

The test here is not really validation, it is verification. The task is to verify that the arithmetic is correct. Meaning if the numbers are correct, there is an expectation that on a monthly basis the stream flow gauges will match the record of flow at that point when the upstream regulation is added and subtracted. Brian described three points that are a bit confusing (and stated the colors are not very clear). The green line is on a monthly basis and is actually what the gauge showed, November of 2001. The other two lines that naturalize the inflow and the unimpaired gauge are actually in years and the reason for the difference between those two lines is the extent of regulation in that month. So that's the way it looks on a monthly basis.



Taking a step further, there is a little more differentiation when the monthly data is desegregated into daily resulting in less of a match. One reason for doing this is there is a lot of demand data is monthly average. To learn what occurs on a given day a match is made on a monthly basis and then replicated. It appears to follow pretty closely with the lines tracked but then again, this is not a highly regulated basin.

In Slide 15, is the verification that 1+1=1 and the verification for the reservoir. The base case was taken which includes all of the regulation, it was run through the model and if it matched, the model is forced to make the same release that the reservoir actually made on each date of the record. Hence if all of these factors are entered correctly and the arithmetic is correct, these lines are coincident, which they are.

Summary of strengths and weaknesses of the OASIS Model:

Strengths of the model include:

1. A systems approach
    a. All management aspects captured, including WSRP
    b. Allows for investigation of creative solutions
2. It's fast
3. It's easy to use
4. Can be linked to other models
5. Nodes and arcs can be added after the model is "done"

It is a real systems approach, which means that all of the existing management aspects and other potential aspects covered, allows for generating very creative solutions that would not be possible at a narrower view. The starting point is the basin scale; it doesn't matter which river basin it is, small or large - start with the whole basin. The potential to narrow in is still available if needed but without the larger view, dynamics of the whole system will be missed, dynamics that could potentially lead to a solution. OASIS is used in interactive settings and during real time negotiations.

The OASIS Model can be linked dynamically with other models – with groundwater models, habitat models, alligator spawning models, salinity models, which means that they talk to each other and each time step. So if it was a water quality model and reservoir would make release, the water quality model would say that's not good enough. This provides an opportunity to go back and change it, and redo it so they talk.

Another point that might be helpful to know is that these things are not hardwired so one can always add nodes, reservoirs, and change physical structures even after the model is done. It is important to note that the only place where there is precision in OASIS is the point where there are the inflow nodes. Everything else between, there can be 14 withdrawals, 6 returns, and a reservoir but if there are none of the inflow nodes in between, then it's all aggregated at the next node where there is an inflow. This means one needs to be very careful in

setting up these things to try to identify the location to generate accurate information. Note that estimates cannot be made from points later on.

Weaknesses of the model include:

1. No output between inflow nodes
2. Not appropriate for flood routing
3. Stationarity

This is not a flood routing model. OASIS does fairly well at high flows. It might get the daily flows right though it's not going to get the hourly peak flow right since it wasn't designed for that purpose. This is mostly a low flow investigation tool.

Regarding stationarity, which is a question of whether twenty years ago when there was consideration that the longer a record, the better the chances in representing the future and that's in big question these days. There is still use for the 80 years, a consideration for Hydrologics, and one of the possible uses of the WaterFALL model in association with this are to generate alternative climates scenarios for running through the model.

Questions of Clarification for Brian McCrodden

Q: I have two questions. Do all of the inflow nodes equal gauges at this time?

R: No, not necessarily. We pick points. For example, the Tar River Reservoir is an inflow node.

C: Ok. So you don't actually have to have a gauge but you do need to have some nearby.

R: In the case of Rocky Mount we're using the downstream gauge to estimate and make the local inflows to that reservoir.

Q: Ok, you touched on the first question I had. It really was about the represented inflow data set and if there was a level of departure that we can envision in the future from what we know about the past, where we would think we need to have a reset on what the actual period of record for the inflow should be? Like you were saying with WaterFALL we would be able to predict climatic changes potentially so that the last 80 years may not in fact lead to an accurate representation of inflow for the next 25 years.

R: If anything, the long-term record probably understates the variability that might be seen in the future; it probably misstates the frequency of occurrences. So let's say in the context of a water supply reservoir, if you look at 80 years you might say that the reservoir has been drawn down 25% say on average once every ten years. If you look at the last 30 years of record, which is what the Weather Service does, you can get the average temperatures over the last 30 years but not over the last 100 years. So you look at the last 30 years you might get a frequency of once in five years. At this point, we are unclear about what to do; even global circulation models are not all that great at this point so there's a lot of uncertainty here. My recommendation would be that you look at both the 80 year period of record and then the 30 year period of record. I do feel pretty confident in saying that in the near term, the next 10-20 years, the climate is going to be more like it has been in the past thirty than what they're projecting a hundred years. So did that kind of get at your question?

C: Yes, it did.

Q: You described the example from the Tar River Basin - what's the availability of the OASIS model for other basins in and around North Carolina?

R: You all may need to help me here. The catalog of them includes the Roanoke model, the Cape Fear, the now combined Cape Fear/Neuse model, the Tar and the Broad. There wasn't a model constructed for the Yadkin Basin but obviously that's sort of tied up in legal mumbo jumbo now. And then there's the CHEOPS model for Catawba-Wateree.

Q: Does TVA have models for the few little bits and pieces of watersheds extending into North Carolina?

R: We did provide a model for Alcoa's system in the Little Tennessee but I don't remember whether it's public or not.
C: TVA does have a scheduling model but they keep that proprietary because…
R: There were some CHEOPS models done on the Nantahala Relicensing project but assume that you are talking about publicly available model information.

Q: A question asked of me at a previous meeting was when you look at those maps, the nodes and blue boxes and triangles, there's no geo spatial component to those geometric figures.
R: Sometimes there is, sometimes there's not. Sometimes these are completed on a blank sheet of paper. Engineers like right angles and everything proportioned and thus when putting it on a map, it gets confusing. Some of them you can put on a map and they look pretty decent, some of them don't. Like around Jordan Lake and the Cape Fear there's so much going on that you've got to put one in Wilson County to be able to read it.

Michele Cutrofello Eddy (RTI)—Status of WaterFALL model and How it can be used with OASIS

link to Michele Cutrofello Eddy's presentation

Since RTI's Watershed and Flow Allocation model (WaterFALL) was introduced in August 2011, Michele updated the EFSAB on how the model was currently being used.

1. Current ecological flow work for EDF
    a. Focused in NC
    b. Assessing the hydrology and biology
    c. Focus on locations with biological monitoring data
2. Current resilience study for TNC
    a. Assessing changes in flow metrics and baseflow contributions to flow as two components of a resiliency study for NC
    b. Summarizing results to HUC12 and HUC8 levels
3. Current development of a hydrologic foundation for the southeast U.S. for SALCC
4. Beginning freshwater assessment pilot study for Louisiana for TNC, which will include interaction with a groundwater model

RTI Projects Using WaterFALL

WaterFALL, at its very basic level is a rainfall-runoff model so it is driven by land use, temperature, precipitation and soils data. The model is physically based. There are currently several projects occurring in the state that are making use of WaterFALL. With each project, RTI learns more about the model and its capabilities, and is able to provide more validation, comparisons, and analyses to ensure additional information throughout the research process.

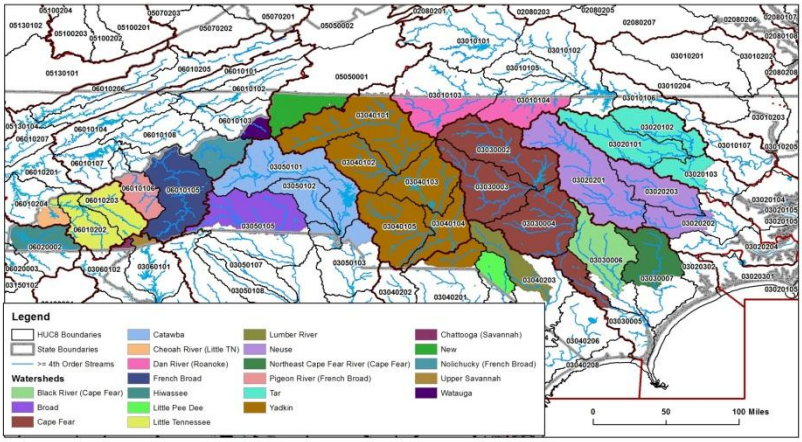
One NC-focused project with EDF is looking at flows at each individual NHDPlus catchment with biological monitoring data. Streamflow will be assessed for unaltered conditions using the Potential Natural Vegetation Cover as the driving land use and for current day, altered conditions using 2006 land use and estimates of human alterations from point withdrawals and returns of flows. The change in streamflow metrics between the two scenarios will be assessed against measures of biological abundance to look for significant relationships. The ultimate goal of this study (further detailed by Jennifer Phelan during this same meeting) is to develop flow – biology relationships that can be used in establishing statewide ecological flows.

The second project is a resilience study being conducted for TNC. Again, focused in NC, the project is assessing changes in flow metrics (between less altered 1970s conditions and current day, altered conditions) and

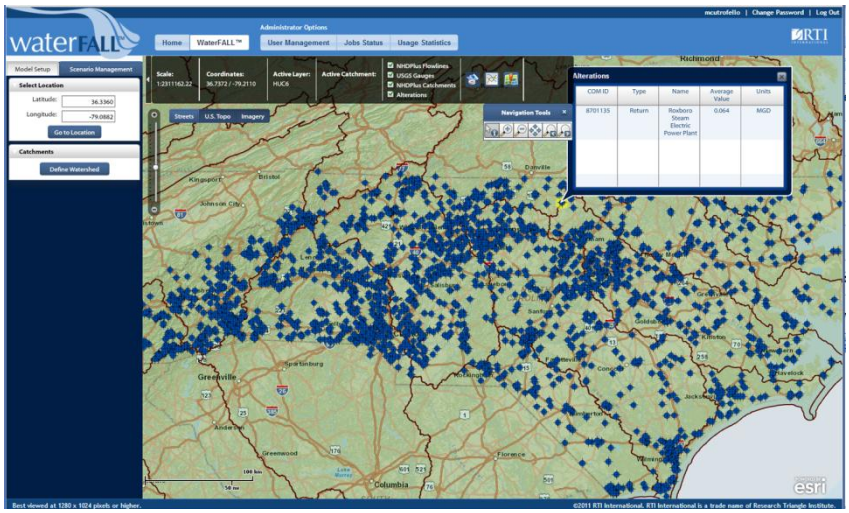
baseflow contributions to flow as two components of a resiliency study. In addition, RTI is summarizing all of North Carolina's data up to HUC12s and HUC8s to help assess which areas of the state are more resilient to the different changes that have occurred.

The objective of the third project is to produce a hydrologic foundation for the SALCC region. An initial set of calibrations has been generated for reference gages within the region for unaltered conditions. The use of the 1970's baseline data and no alterations is intended to provide a picture of what the flows should be like before additional damming and withdrawals. The unaltered flow assessment will be completed for the whole applicable region to produce the hydrologic foundation. In addition, 6 approximately HUC6 watersheds will be assessed for altered conditions (i.e., including withdrawals, returns, and dams) to provide a time series of how the hydrology has changed within those watersheds from the baseline period and to provide a basis for further ecological and hydrological analyses.

Lastly, the fourth project involves a freshwater assessment for Louisiana. An interesting part about this project is the effort to tie a groundwater model into WaterFALL to view more complex interactions, especially in LA, a state deemed water rich though it is believed they are draining themselves dry.



For North Carolina, RTI has modeled all the colored regions with the addition of the Lower Roanoke River (below Roanoke Rapids) (have not remade the map and colored it in). These are the basins modeled for the TNC study. Within each of those basins, there is a streamflow time series for every NHDPlus catchment (approximately 58,000 catchments) for a thirty-year period of record for two different points: 1960 to about 1990 (unaltered simulations) and then 1976 to 2006 (current day, altered simulations).



This is a screenshot of what the WaterFALL interface looks like. The blue dots are alterations; the data was retrieved from DENR's databases of NPDES permits, withdrawals, the public water supply, and the coastal database. Some of the public water supply data was daily, other alterations data was monthly, some reported every four years, and some places didn't report. The data was summarized to get an average monthly withdrawal/return and align each alteration with a catchment. There are approximately 2,700 different alterations tabulated for NC. Each alteration data point is characterized by whether it's a return or withdrawal, what it is (e.g., permit or facility name), and the average alteration flow for each month. These data

are used to consider the long-term impact on these alterations on the stream network cumulatively moving down through the watershed.

Calibration

RTI has an automated calibration method. The researchers use the objective functions to minimize the difference in the volume of flow on a daily and/or monthly time step. The Nash-Sutcliffe Efficiency is also considered. This measure assesses the predictive power of a hydrologic model as compared to the mean of the observed data considering observed variance.

RTI likes to take a few steps further and look at things visually and make some further adjustments. Flow duration curves are used to look at the average behavior of the model across all percentiles of flows and particularly at low flows. Hydrographs are used to view daily agreement across the range of observed flows. Monthly median and mean flows values are viewed to look at the temporal agreement across the year. In addition, eco flow metrics are considered to see how sensitive they are to some of the adjustments with respect to the three parameters that are calibrated. So far the model is robust.

Residuals in ecoflow metric predictions are scattered so there is no place where there is consistent overestimating or underestimating of flows. We've also made a few comparisons between how WaterFALL performs with estimation of metrics to a few other rainfall runoff models and so far, confidence in the model remains.

The daily hydrographs [Slide 6] assist in checking for general patterns and trends, storm peaks and recessions, and the order of magnitude agreement. In this slide, Red is USGS and Blue is WaterFALL. As we move through the calibration process, we make sure to pick up all the recessions and hit the peaks. For the most part you want to be able to catch the storms, and in instances where you missed one, that's going to be something that's coming from your input data and something that, unless you're going back and modifying input datasets, you're not going to be able to change. So we look at the overall big picture.

The flow duration curves [Slide 7] examine high, median, and low flow representations of WaterFALL and check for behavior and magnitude. Flow duration curves provide the probability, 0-100% , of exceeding a certain flow on the Y-axis. So 100% of the time you should be above whatever the flow measurement is at the 100% or right side of the graph. This would probably round up to about 200 and then at almost no time will you reach this. The left side or 0% of the graph is your peak flow, what you're going to expect to see in that very rare flood. These can range. The shape of these curves differs across orders of magnitude depending on the type of stream (i.e., stable baseflow vs. perennial vs. intermittent). So we look at this for the overall behavior to make sure that we're trying to get that same kind of shape. Particularly for the low flows, as Jim pointed out, we want to make sure that we're not dropping off steeply or overestimating for the long period of record. So that's another thing that we can do with our calibration patterns. We can kind of adjust this curve and make sure that we get the behavior of the system right.

Monthly flows [Slide 8] assist to check for seasonality/ patterns and seasonal bias. We have a good amount of seasonality, we've got another stream that's pretty intermittent and we look to make sure, again, that we're getting that monthly behavior so on the flow duration curve that is the overall long-term behavior not accounting for different months. This breaks that down into the monthly sections to make sure we're getting the timing, not just the behavior of the flow over time.

Summary of Calibration Presentation:

1. Variety of performance metrics evaluated

    a. Volume error over daily flows (#) – automated calibration
    b. Nash-Sutcliffe Efficiency for daily flows (#)
    c. Daily hydrograph (visual)
    d. Flow duration curves (visual)
    e. Monthly median and mean volumes (visual & #)
    f. Ecoflow Metrics (#)
2. General findings
    a. No one area or stream type consistently out-performed others
    b. Residuals/errors scattered; no consistent bias (that's good!)
    c. Comparisons between WaterFALL and other rainfall-runoff models for prediction of ecoflow metrics are promising

Brian showed the Tar Oasis node or mockup of how their nodes work together; in slide 9, this is how it would look if WaterFALL provided the inflows. So each color here represents the different section of our network that would ultimately feed into one of their nodes for the desired inflows. So the Tar would be modeling that piece and what we do is we model it all the way down through the whole system. Start upstream and work our way downstream. Every single one of these little polygons in there is one of the catchments where we have a time series of flows. This is run for the whole watershed, working upstream to downstream and then for Oasis what we do is go back and break things apart and say, "Okay, how much flow was generated from the headwaters to this point in the stream?" That becomes the time series that we shift over to Oasis. Then from this point down, how much more water was generated in another time series shifted to Oasis. So we can feed them based on their node by node setup and that's what was accomplished in initial testing before we really finalized our models for North Carolina and before we had our alterations in the system, they had their nodes set up where they said there's alterations.

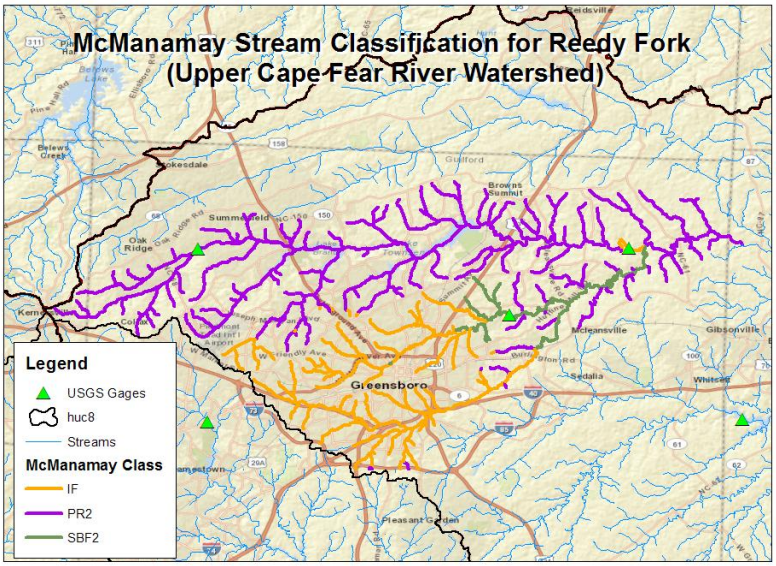
Now we have our alterations on the catchment scale, so another possible trial we could do is run our altered flows all the way through to their reservoir and just feed them in for inflows right there and let them run the reservoir portion and see what happens. The SALCC region [slide 10] that we just are working on now, we've done calibrations for about 60 locations, so these are those locations throughout the southeast region where we have calibrated the WaterFALL to the unaltered conditions so we were focusing on the reference gauges (i.e., unaltered watersheds) as best we could where there's supposed to be no alterations; land use is pretty stable and so now we have flow records from there and we're starting to crunch the data.

This was four randomly selected sites [slide 11] that our clients asked us to look at within those 60 calibrations. What's shown here is there are four bars for each month: a blue one represents extreme low flow, red represents low flow, green is median and purple is high. Those are the percentiles: 10, 20, 50, and 75th percentile flow for each month. What's plotted is the percent difference we observed. The first one off of the axis is 30% difference. This is a reference mark that's starting to be used in literature for a comparison between observed and estimated when conducting eco metric work modeling and it's proposed that that's kind of the error bounds to be careful of because when you're using stream gauges as comparisons in the study, a certain amount of difference (estimated in one study to be 20-30%) can be related directly to different time slices throughout a period of record for a USGS gage. Seeing how the calculation of the different eco flow metrics changed based on that time slice, there is inherent variability within the gauge itself. A finding was that even when you take a 30-year period record or 75-year period record there is this about 30% change that you could see just from where you're slicing up the record. So you can see for the Tallulah River near Georgia it's below the 30% lien for almost all those monthly metrics. Fishing Creek had, probably the larger errors of the model. In the winter months we're doing better. We're still within the error bounds there but we have some sort of seasonal effect here in the Tar and in Deep River, and this occurs very randomly throughout the modeling. So again, this is what I'm saying, that we're not consistently seeing some sort of problem but it is occurring in a few places.

In contrast, the places like Clayton, Georgia and Cove Creek, which is in the Broad near Lake Lure we're doing pretty well at estimating eco flow metrics. Again, these are monthly percentile metrics, one way we start to look at data. Another way is breaking it down to the individual metrics. What we're looking at [slide 11] is September low flows, so the 25th percentile observed on the X axis and WaterFALL's prediction on the Y axis. We're looking at how different we are across our estimations for this one single metric. In this case we've broken it down into the different stream classes that McManamay uses. We used his general classes rather than the seven or eight specific classes (two PRs, two SBFs, perennial streams, stable base flow streams, coastal/swamp intermittent, and intermittent flash streams). We use perennial (PR), stable baseflow (SBF), coastal/swamp intermittent (CSI), and intermittent flashy (IF) as the four classes.

You can see the stable baseflow streams were typically a little larger in size, the perennial streams are a little smaller (lower flows), the coastal/swamp class is kind of in the middle. The metric values are pretty small for intermittent flashy streams for that September low flow metric. But this is what I'm saying: we're doing pretty well at representing that eco flow metric over the spread, and the model predictions aren't biased either way.

Two more examples. When we first showed WaterFALL in its debut back in January of 2010 we were still coming up with this idea to color in the state. Now we're at a point where we can color in the streams within the state.



What is seen here is the headwaters in the Cape Fear watershed. We've run WaterFALL for this portion of the river and used it to assign the McManamay classification to each of the catchments in that sub watershed and each of the stream reaches is color coded according to its classification. The headwaters here within the City of Greensboro are classified as intermittent flashy. But if you look at the closest gauge, if you had used that gauge you would have assumed that it was a more stable baseflow, which is the main channel below Greensboro. And then same thing here, you have more of the perennial stream on the whole stream, you would have seen that with that gauge. But right around the downstream gauge, and this is an altered scenario, the stream is actually classified as intermittent flashy, which is interesting. The main stem is stable here where your smaller tributaries off to the side are more perennial. Several interesting take-aways: you have to think about whether you measure fish or bugs in any of these places and how different it would be.

A final example (slide 13) I've been thinking about and may have a pretty big bearing on what you're doing is the Mayo Creek, on the border of North Carolina and Virginia. In slide 14, the focus is on the Mayo Reservoir and the impacts downstream into Kerr Lake. This is the NHDPlus representation of it. Looking at where the dam is now and traveling downstream. I subtracted out Hyco because I just want to look at what's going on from this reservoir down and focused on three points in the river: (1) right below the dam, (2) right where it should be confluencing with Hyco River, and (3) right before it gets into Kerr Lake. So what we have from that 1970's land use cover, there's no reservoir there yet. It's just the river. We use the 1970s scenario as the unaltered condition. There's no reservoir, there's no power plant compared to 2006 when the reservoir's there and there's

the Mayo Steam Plant that we have the alterations for on monthly values. On slide 16 three sets of graphs are shown. On the left are the monthly flows at the dam. In the middle are monthly flows 8 kilometers downstream which is just above the confluence, and then on the right is the stream at 25 kilometers further all the way downstream right before the stream would enter Kerr Lake. The top row of graphs is the extreme low flows, that 10 percentile flow. The middle row of graphs is the median flows (50th percentile), and the bottom presents the high flows (75th percentile). The blue bars represent what was there before the reservoir and power plant so you see this distinct seasonality across the twelve months whereas now (red bars) the dam regulates the flow and at extreme low flows you just see this very low flat area. You don't have any more of the flushing in the winter months. As you go downstream, in between the dam and the confluence downstream you have the return from the Mayo Steam Plant. So now at that point of the river you still would have had seasonality to the stream but now with the return from the power plant you still have the flashy effects but you've got much higher flow. You've got much higher flow in your summer months and your extreme low flows than you did before. This continues all the way downstream where you used to have that flushing. It's starting to try and come back and overcome the effects of the power plant but it hasn't. So you have much higher stream low flows. At the median and high flow level you do have some of the seasonality that's there, but it's much more extreme than it used to be.

The orange bars represent the streamflows if the dam was there but the power plant was not. Again, you're still having higher flows than you used to in your summer months. So that's one way to look at it. You can see the difference of what's caused by a power plant looking at the red and orange bars. There would have been some seasonality but the dam cut off those high flows, which as Chris pointed out when he did his presentation for us, that's what you want a dam to do, it's supposed to cut out the high flows.

Slide 17 presents the same data but looking at longitudinally downstream. We show three months: March (top row), July (middle row), and November (bottom row). We show three metrics: extreme low flows (left column), median flows (middle column), and high flows (right column). The takeaway from this is that as you move downstream what you wanted to see, and these arrows are where the power plant comes in, what you'd hope to see from these alterations is that these two lines start to meet up again. You want to show that your stream has overcome the alteration of that dam and that reservoir and you can see for the most part, except for November, median and high flows, all these other months you have altered your system. This is what Jay was pointing out earlier – when do you know that you have reached that point of no recovery. This is showing that in space between the dam and the next lake you never recovered from the alteration to your system. Jen's methods: figure out what metrics are even important and then once we have those metrics, not only a point where you have your fish but you can start looking at this sphere of influence, how going downstream, what impacts do you have from all of these alterations. Does it change whether it's a dam, whether it's a certain withdrawal or return and what are the influences of that and then things that you guys were already thinking about, which is seasonality.

Questions of clarification for Michele?

C: Can you go back to that Greensboro slide where you showed it as intermittent? So with those classifications, if you looked at that over time, I would attribute the flashiness around Greensboro to increase in the urbanization and everything. So if you had the time comparison and could look at the length of impact as well, like with the following slides that you showed us – the sphere of influence of urbanization actually has to drive a shift in the type of stream that we would classify it as. So that seems like that's going to be really important in trying to tease out whether we're talking about impact from withdrawal altering the biology of an area versus impacts of urbanization impacting. The assemblage around Greensboro is going to be impaired, whereas maybe downstream when you get further downstream, or it's still remaining perennial, you're not going to see assemblage change due to the land cover changes. And so it seems like that's an aspect we want to be able to pull out from this so that we can understand what we're talking about with

withdrawal and low flow types of impacts versus changes in biological assemblage due to shift in stream class urbanization.

R: Yes. We have those two points. We have that 1970's and 2006 but as Jen said, she's also going back to PMV so we can look at completely naturalized conditions as well. We would have those three points in time to kind of look at.

C: The other question I want to ask is how does conductivity influence the model? Because if there were a lot of new land construction (like the 1800s), there's residual with that. Does that influence the way the model works if you don't have that included as an alteration?

R: Yes. We don't have small dams in the model. There is just not a lot of information on these small dams and their capacity and locations. We have looked at TNC's Barrier Assessment Tool where they've gone through and tried to identify all these points but we're just not quite sure what to do with those locations yet without supporting information. I think there would be a little bit of delay and a little bit of lag in the flow getting downstream because of those interferences in the stream channels, but we don't have enough information to include the impact in the model right now. We have the major dams in WaterFALL now. When we want to include the dam operations in the model we take the time series records of flow releases from the dam and replace the flows coming out predicted by WaterFALL with what was monitored. Again, that would be where Oasis would come in -- let them consider reservoir operations and tell us what's coming out of it so we can continue to predict the flows downstream.

Tom Fransen (DWR)—Hydrologic Modeling Validation & DWR's Use of WaterFALL

Link to Tom Fransen's presentation

Tom addressed DWR's vision of water modeling. I'm glad Brian and Michele went ahead of me as it meant I didn't have to worry about how much you remembered from my earlier presentation on OASIS. Both gave a good summary to help us get started. I think we talked a lot on this already, the fact that our basin models are looking at the large rivers where big withdrawal discharges are. A lot of the EFSABs concerns go to the smaller streams and the data sets are at smaller streams. I know from the ecological discussions that the low flow range is of concern where with water supply we're looking at the normal and low flows. As we move forward with validation we'll work with some of Michele's eco metrics to ensure we're validating the models for what you're doing. I thought it might be helpful to touch on a couple of terms that Michele and Brian already talked about, such as calibration.

Calibration of OASIS

With OASIS, there is limited calibration except with river lag times and things. Michele has a lot more fun with calibration given her rainfall runoff models. Calibration is what we expect consultants to do, to get the knobs turning correctly. Validation then becomes a response where the consultant and DWR, take the model and compare the output against the observed data: how well is it duplicating history, do we have those knobs turned right? So that's really been kind of a joint effort; consultants take the first cut and our modelers take a look at it in more detail.

Certification of OASIS

The certification knob has become the EMC's responsibility since the statute talks about the commission's approval of the model. Certification is taking all this work and say, "Okay, we now have a model that we're comfortable with and we can move forward using it."

Reasonable Representation: What do I want to use the model for?
One of my professors used to say, "We're not making watches and hydrology". We're not trying to get up to the five decimal places. We're just trying to get a reasonable representation. We want to answer the question, "How good is good enough?" To answer this question, you have to ask the question: What do I want to use the model for? If it's for planning, I'm going to look at how I make sure the model's validated differently than if I'm going to have to start implementing a water allocation permitting program.

Yield of Withdrawal Points
To ask the questions that we need to ask, we return to the statute directing the advisory board and ask from a modeling perspective what's the best yield? In other words, what's the yield at the withdrawal points? This mentions groundwater (but its greyed out) because we're really talking about surface water models here. We're not trying to model groundwater; we cannot respond to the question about yields for wells and that type of thing. It only says we have to include groundwater to the extent that we know it. That would be a whole separate modeling effort and separate from what we're trying to do here. Ultimately, the last question about where our ecological flows are impacted, I don't know how to answer that and what I need to include.

The statute gives us very specific questions to ask but we've been using these models a long time, probably about forty years now. Our focus has traditionally been water supply planning and screening for alternatives. Now with the way the drought plans are written for communities and for hydro power operations, we can monitor drought plans to determine if they are doing what they are supposed to or if they need to be tweaked. In hydro power licensing we've looked at future changes and at hydro power generation impacts to allow our power companies to interpret the data. There are a lot of recreational opportunities out there and other things so we're using the models for more than what the statute requires us to do. As Brian mentioned, there is a component to do some forecasting and help us understand how to manage the resources better.

Fresh Look at Validating Models
Because this work is having us compare OASIS or our own modeling techniques to WaterFALL, I've tasked our modelers with taking a fresh look of how we validate models. We're still working on this. As Brian explained, with the inflow records, we start with monthly and from a water supply planning perspective, we're looking for large withdrawals. If the monthly is good, I can get a reasonable representation of what the safe yields are and whether those systems are reliable; the focus then is on those monthly and annual numbers. We're trying to do our validation at those points using the long-term USGS gauges, and where we have good operations records for the reservoirs.

Goodness of Fit Statistics
Michele talked about the first one of these. If you go to literature you'll find all sorts of *what they call goodness of fit statistics for modeling.* There's a link to a model evaluation article that's actually pretty good. It went through a long list of these goodness to fit stats and boiled it down to the top three. What I liked about that article is even though I can generate a lot of statistics, it provided references of how to interpret those as being good or unsatisfactory. I want our modelers to use these kind of tools right now, to go through a few more basin models to make sure what we're seeing in the literature is matching what we're seeing with the models we're currently working on and make sure we're interpreting these the correct way. So you can kind of look at that first set as hard numbers that anybody can duplicate.

Qualitative and Graphical Approaches
When we get into more qualitative and graphical approaches, it still comes down to a judgment call whether it's good or bad. Typically we use the hydrographs like Brian showed, and the frequency curve like Michele showed. We've been adding some of the residual analysis that Michele presented such as the scatter plots and the gauge data. My biggest problem currently, is we're generating so many plots we're getting data overload making it

difficult to interpret. If half of these are good and half are bad, is that node good or bad? If you've got some nodes good, is the model good or bad?

DWR Goodness of Fit Measure

The other thing we've have done besides what would be the more standard approaches is DWR has created its goodness of fit measures. Since the statute requires us to look at yield, my approach to do this is through validation: engineers typically do a mass curve analysis at a point, which is what we use to determine the reservoir yields. I'm not proposing we're going to build a reservoir for each node but I can use that to look at various demands to bigger storages to see if we're getting similar yields out of it. We're not modeling groundwater directly but we are doing a base flow analysis here to compare base flows similar between the two for the historical data of the model. For lack of a better placeholder, I'm basically doing a 7Q10, I'm using that 7Q10 technique to plot out a 2-day to 100-year return period using 30-day long periods of pre low flow so we're doing the same thing there. Since we've got the drought plans of also checking to see if the amount of time you're in the various drought categories is defined by the drought monitoring the same or how they differ. It wouldn't make sense to be testing a drought plan you're never in the same level and never get to like a severe or extreme drought.

Publicly Available Data

We try to keep with the whole concept of publicly available data. We try to keep the tools available as open source. We've actually got one script now, actually of those examples I'm showing you. For the time, this is just the hydrograph so on one page now we can show you the daily, the monthly and the annual comparison. You can see how well it's matching up.

Exceedance and Non-Exceedance

Of course, we zoom in on areas of critical periods. The frequency curve that Michele showed, she showed exceedance. I usually use non-exceedance. I usually look at the full range but then the one at the right over here is the low flow and a low tail at the end of the curve. We took 30% because that's what the drought monitor classifies the low flow starting at the 30th percentile. Looking at residuals, this is a busy plot. This is basically the time series of all the residuals. You've got the box and whisker plot and histogram. We start with daily, monthly and annual. If you remember back on the annual, it looked like the lines are on top of each other. I know you can't read the scale but it does show we do have some deviation in there; it's pretty darn good. You're less than 3% on that or slight differences. It's just another way to help us look at the data. In later years where you got better data the model would have less residual, at least for this particular node that we're getting more residual in the later years than the earlier type years. It's just helping us look at the data and understand. Pretty standard scatter block.

Mass Curve Analysis

Need to explain the mass curve analysis a bit. We start with 10% of the median annual flow up to 90% of the median annual flow to figure out how much storage is needed if my demand was at 10% of the median annual flow.] Part of the reason I'm not looking at a single demand number is after having completed a number of these over the years, as your demand becomes higher, in terms of percent of the annual flow, your critical period will change. It won't always hold the same, especially when you're starting to get above the 50%, when demand is greater than 50% of the median annual flow, then you start to look at droughts that are longer than a year.

Around 30%, 35%, 40% they're usually the North Carolina droughts…you're looking at a critical period less than a year. So this lets me look at how well the system's responding for a short-term, long-term droughts and different critical periods all in one fly. This has been pretty typical of what we see. There's a pretty good match of the high and spreading out of the lower. This is the base flow analysis I'm using that was built into our

reprogramming and I just haven't had time to finish it. One of our graph-hydrologists worked along with this. He drafted a different base flow technique. These are basically different types of four-year analysis just to separate the base flow out. I have yet to figure out why we're seeing this spread where some of the other statistics are matching closer. Almost every one of these run has a spread in the base flow so we're still trying to figure out what's going on here mathematically and why we're getting that. If they keep up with the spread it maybe something that we'll have to say this isn't going to work and try to interpret base levels as part of the models. Something we're working on.

Pearson Analysis
This is the Pearson analysis. Most of you are familiar with the 7Q10 so all I'm doing over here is the seven-day low flow. The ten-year return period we're looking at from two years out to one hundred. I'm doing the same thing for these and this one surprised me. These matched up really good but the base flow didn't match up good at all. I'm still trying to figure out what the base flow is doing.

Compare Calibration Points with WaterFALL
We're still working with RTI to compare calibration points of WaterFALL. There's still a few more data points for me to look at. As Michele pointed out, I really think how we're going to use it is like the Tar example where we will use WaterFALL as an alternate inflow record to do the OASIS model. I think OASIS still has the strength. We're able to describe the operation of the system much better than I think we'll ever get with WaterFALL. I know the impairments have been added in terms of describing who's gonna use water, future demands, how that water's gonna get moved between the systems, drought plans, details of the reservoir, but I think OASIS is going to be the best tool for that.

With WaterFALL we will be able to see validity to look at climate change questions that OASIS cannot address. That's really where I see our use of WaterFALL going, although we're starting to see other alternatives for WaterFALL out there. And it seems like the universities are because of all the interest in water resources. Michele demonstrated she can take WaterFALL data and create an inflow output we need to run into OASIS to work. I've got one real practical question still to answer and that is how much it's gonna cost to continue working with RTI and whether our budget can handle it.

Questions of Clarification for Tom, Comments, and Responses:
Q: Your comment that you still think OASIS is a better predictive model perhaps for use than WaterFALL. What's your basis for that or why would you make that suggestion? Is it the lack variation or better prediction?
R: We've spent an awful lot of time working with power companies and water utilities to make sure we're getting their operations described well. The way I explained it in the previous presentation I provided is if you take a look, our modeling has evolved from the old style. For example some 20 years ago in the Roanoke, we had six or seven points all together. Now we're looking at literally hundreds of nodes; adding that level of detail helps spend additional time with the water system to help describe when withdrawing from this location exactly how much will be discharged. Many larger water systems may have multiple withdrawals and multiple discharges and we include sales to other systems.

What WaterFALL is doing is good; it's being done at a large scale but the model cannot focus on the individual river basin level to be able to incorporate and keep that level of detail. Since DWR consistently works with these systems for planning efforts, tweaks and updates are important working through that process. That's why I think there's collaboration between the two that will work but if you want to look at an individual river basin, use OASIS; if you want to look at a big regional question like the whole southeast, WaterFALL is definitely more appropriate. And if you're trying to address questions at a basin level, combining the two will work better.
Q: So to summarize you think it's the precision level is better?

R: Or the operational procedure at an individual river basin.

C: For WaterFALL, we can take any time series of alterations you give us. If you had a daily withdrawal from a certain operation we could put that in as our alteration for detailed data. WaterFALL cannot do the management and the switching of allocations that OASIS does, especially in the reservoirs but we could get down to a daily withdrawal or return for certain allocation if needed but we just haven't had data or a project to do that yet.

C: That probably will go back to the drought plans. The withdrawal was calculated on the fly based on the conditions of the triggers at ground level. It just depends and goes back to the question you're trying to ask. WaterFALL may be better for a certain applications where you may not need OASIS to address those questions. Or, you may need the combination of the two or just one. It's what are you trying to answer as to picking the model. Not one model will do everything.

C: Given that other states have gone down the road of some policy and regulation associated with their water resources and planning, do you think OASIS is up to the challenge if it were required to go in that direction?

R: Pretty close but I don't think an allocation should be based solely on a model number. A model is a tool that's part of the decision process and the earlier proposal for an allocation system basically made the model the determining factor -you ran the model and either you got an allocation or you didn't. To me, the model shouldn't go that far being the decision factor but rather part of the decision factor. Now, it's my understanding that South Carolina, where they've got the new water permitting coming online, will be using OASIS to model all eight of their basins as part of that permitting process. Right now we're just trying to get at the planning process.

Fred Tarver (NCDWR): Using WaterFALL to Test for Habitat Response Similarities with OASIS Model Flows

Fred presented briefly on his perspective of how WaterFALL might be used in habitat modeling. Particularly in terms of instream flow modeling, the use of WaterFALL on OASIS and the potential for utilization during instream flow studies and PHABSIM (Physical HABitat SIMulation) and the time series components of IFIM (Instream Flow Incremental Methodology).

Fred offered background information about how the Division of Water Resources (DWR) conducted instream flow modeling prior to the development of OASIS. Fred stated that DWR relied upon USGS gauges. If an instream flow study was being conducted in close proximity to a gauge, then this was convenient. But if a gauge was not proximal to the study site, the staff would look for another gauge hopefully in the same watershed and one that would match the characteristics of the study site. There is an expectation then that if the flow characteristics of an adjoining gauge (whether in the same or another watershed) meet the same characteristics there's going to be a match of the flow record for the site being reviewed.

With OASIS, there is the capability to actually generate these flow records at specific sites where an instream flow study is being conducted. Jim Mead's (ex-DWR) efforts at re-running time series involved nine of the existing 30-plus IFIM study sites across the state. Mead picked these studies because they modeled well and were also in basins with OASIS models, which was restrictive. The idea was to create a flow record from OASIS and run these instream flow studies to produce habitat response curves associated with various hypothetical environmental flow regimes. The resulting bar charts were presented to the EFSAB to review at earlier meetings and are still available at DWR's EFlow Website

Presented at the September, 2012, meeting was a timeline for the development of the OASIS models in the various basins that extended out to 2015 or 2018. If DWR stays on schedule with the development of the OASIS models for the 12 other basins, and the EFSAB wants to look at habitat responses at IFIM study sites in these 12 basins using the OASIS flow records, then the EFSAB will have to wait for the development of these OASIS models to create the flow records.

The benefit of the availability of WaterFALL is that the flow records can be created without having to wait for the development of the OASIS basin model of interest. In addition, the nine existing instream flow study sites rerun with an OASIS-generated flow record can be run again with a WaterFALL-generated flow record.. Thus a test of WaterFALL and OASIS flow record interchangeability is possible by comparing the resulting habitat response curves. Fred would like to pursue this analysis to review the comparison. Depending on how things proceed, there is also the possibility of reviewing the other 30-plus instream flow study sites, generate WaterFALL periods of record for those sites and, depending on the confidence of interchangeability, proceed with habitat responses in lieu of OASIS models.
Considering the use of the WaterFALL versus OASIS flow records in habitat modeling may also help in the development of the classification system. Given the timeline presented today on the development of the BEC classification, the question is are the nine updated instream flow studies enough to assist in decision-making? Might there be value in resurrecting those old instream flow study sites to have enough to actually compare to whatever classifications system is being developed. This could be an interesting comparison of the classifications that become evident and the habitat responses from the instream flow study sites.

Questions of Clarification for Fred, Comments, and Responses:

Q: What's the decision that will be informed by comparing the results of the two?

R: That was one of the things that Tom Reeder was talking about. Not necessarily how good is good enough but to obtain some level of confidence. The WaterFALL periods of record may provide some confidence that actual on-the-ground occurrences are being represented -what is seen if using USGS gauge data.

Q: You wouldn't necessarily be putting the comparison into a classification system at this juncture but to review whether the response looks the same?

R: Yes, this is what the Division was doing when Jim was comparing the EFS classification and habitat responses. In the future, the goal would be to see how these instream flow study sites match up with the new classification system, and compare those to see if any kind of responses fall out.

Q: You're talking about unregulated conditions?

R: Yes. Typically in our day-to-day work when we do instream flow studies we're looking at proposals so we can compare unaltered versus altered from water use or something like that. For this comparison I believe it would be better to look at the unaltered.

Q: So basically you're assessing how comparable the OASIS estimates of unregulated flows are?

Q: That's what I was going to say. So instead of spending all the time to run through a bunch of habitat models, is there another way to get at this information without the additional work? Especially since habitat models are essentially of monthly flow duration.

C: Because the flows, the sequences are the same then the results in the habitat model will most likely be the same if the comparison is simply flows.

C: Particularly if you're going to rely on OASIS and will just be using the WaterFALL as a front load. I just feel like that's time-consuming.

R: For me the PHABSIM models, the value in those is to actually make those changes in flow or potential alterations relevant to some species or group of species or habitats in the stream and not just an uplift on the hydrograph but something that means something to the critters, something measurable in the field.

Q: But if what you're talking about results in the same PHABSIM outputs with two different hydrology data sets, I think Brian and I are both saying that just compare the hydrology data sets. I mean what else would change?

R: The relationship between the preference curves, those flow to habitat curves created using PHABSIM – not sure if just looking at the flow statistics can necessarily predict what the rules will be after time series using two different flow records.
C: But if the flow sequences are identical, you're going to get the same answer. If they're not identical, and usually they won't be, then the drill is to find out whether they're different enough.
C: That's the thing, they aren't at first by looking at the flow.
C: The expectation is, from what I've seen so far, there's not a perfect overlap between the two.

C: Great minds think alike because Mark, Chris, and Brian pretty much said what I was going to say, that the first step is to compare WaterFALL with monthly flow duration to see how closely OASIS lines up. If there's something there that causes some concern then getting at what Fred proposes - does that difference make a difference for one or more of the guilds that are in a part of the PHABSIM analysis? It may be that the habitats versus flow relationships are shaped such that the differences you're seeing don't really matter. But the only way to tell that would be to actually rerun the PHABSIM and time series with OASIS water quantity. But as Chris pointed out, there is a fair amount of work involved in that. Hence, just compare the flows and if they're really close then don't go through the extra work of doing that time series habitat map.
Q: How close is close?
C: You know when you see it.
C: I would tend to think you would want to examine the WaterFALL more closely if it doesn't match up before you start spending the time to plug it all into PHABSIM because if there's actually something in the WaterFALL that's not allowing it to match up to your expectations based on OASIS and based on actual gauge data, doesn't it seem like that you would want to examine the WaterFALL more closely and find that explanation for that divergence before you use it?
R: Well what I was thinking hypothetically, let's say the disagreement is mostly at the high flow. Maybe the high flows aren't really significant and maybe you can't do anything about 'em anyway so you can apply some judgment as you go forward and do a smart analysis.

Overall Discussion of the WaterFALL and OASIS Panel (Facilitator –F:)

F: How could possibly WaterFALL be used either with or without OASIS? Brian mentioned to use it for the habitat response?
C: Yes, the habitat response curves like the nine sites that Jim produced. This gets back to what the previous discussion about comparing flow records, how well the flow records produced by OASIS and WaterFALL match up. So it's more of a test though to actually use the WaterFALL will allow us…if we wanted to…either in this effort or in DWR's efforts outside this effort we could rely upon WaterFALL to do instream flow studies and use a flow record generated by WaterFALL where we didn't have USGS gauge records proximal to the study sites. So that could be a benefit to us in terms of the work being done here and perhaps beyond.
F: So use where USGS gauges don't exist/ are not proximal.
C: Just a bit of clarification. If you didn't have WaterFALL, what would you do?
C: As I mentioned for the good old days we would look for a gauge nearby that matched the flow statistics of the site that we're working on. We would also continuously record in a stream recorded area.
C: Is the division proposing that WaterFALL is a better option than that?
C: There is a hierarchy of options and obviously we rely on USGS gauge if proximal, then from there, we have WaterFALL, a proximal gauge that matches flow statistics. As you go down from USGS you sort of have the random forced approach.
C: I was going to answer the question, what would be done if we didn't have WaterFALL and if what we've done elsewhere required adjustments using OASIS. This can be done, it's not perfect, and WaterFALL can probably do it better. WaterFALL can certainly do it better upstream of any USGS gauge but there are ways to make estimates. That's what it's all about. But this seems to me just another variation on the same question. It's

how good are these two models at replicating this USGS gauges and then it's a question of how your portion of flows in between those gauges or being estimated for a discontinued gauge.

C: Just to reiterate, I think what you're saying is in addition to the nine sites that went into these charts, there's a bunch more but they're in basins where no OASIS model exists yet and they are in basins where there is not going to be an OASIS model before the end of 2013 either. So if there's interest in using the PHABSIM sites in addition to these first 9 to try to inform whatever report this group puts together before the end of 2013, then hopefully WaterFALL will work because WaterFALL offers a way to use that PHABSIM data in other cases that the OASIS models in a shorter timeframe than waiting for the OASIS models. For example, there is a lot of PHABSIM sites in the Little Tennessee/French Broad Basins. The OASIS model there is used for PHABSIM ecological flows investigations.

C: Another thing is, the initial reason Jim did/reran the entry flow study sites is because they were associated with the EFS classification system so another component might be using water quality when we have a classification system in North Carolina, to use some of those other instream flow study sites and perhaps use WaterFALL data to look at habitat responses. Well you'd be looking at habitat responses at those instream flow study sites in relationship to what the class…what new classification says that the site is, whether you can say anything statistically or not.

F: So classification methods?

C: Yes, you can look at habitat responses for some of the other PHABSIM sites in relation to whatever classification system is coming down the road. Not necessarily to create that classification but maybe on the back end to look at how our habitat responses compare to the classes.

C: I have been thinking about WaterFALL as if it were a useful tool for simulating upstream inflows where we do have OASIS models and for simulating gauges where we don't have OASIS models. In both cases understanding that as time goes by either WaterFALL will become progressively more accurate as we learn more how to use it and/or OASIS will become progressively more comprehensive and WaterFALL will be gradually crowded away. Either of those is an acceptable solution because what we really need is to be able to model flows with some degree of consistency and an acceptable level of accuracy everywhere in the state. Right now we can't do that so it's essential to keep OASIS and WaterFALL both on the table, and at some point, see if there is some sort of symbiosis between them and then perhaps at some point one of them will come to dominate.

OASIS typically has a pretty goodness of fit score with gauges for which it has corresponded nodes. There's a little bit of circular thinking here in that the OASIS nodes are calibrated to those gauges but we have no clue about how much OASIS and WaterFALL differ for any given gauge and whether that difference is random or whether there is some sort of consistent pattern of difference between WaterFALL and OASIS as we look at them gauge by gauge. If the difference is small and random then having both of them on the table for the conceivable future is not a bad plan at all. If the difference is large and/or if it tends to show up in certain consistent ways then there are problems to solve and it make sense to work with the modelers and to come up with a way to solve those problems. Right now, there is not a definition of a problem; we do not know how much WaterFALL and OASIS differ from each other nor if we can use WaterFALL as a way to model gauges that OASIS can't be used to model.

C: I have this mental image that for a given gauge, there is a little triangle in which the legs of the triangle are measures of difference between WaterFALL, OASIS and the gauge itself. What I'd like to know is if those triangles tend to be the same shape and the same size for lots of gauges or if they tend to vary wildly in terms of their sizes and shapes across the state and if they vary wildly, we're in significant trouble. If they vary consistently then there's a problem that can be solved and we'll have a pretty good definition of what it is.

Goodness of Fit Aspect of OASIS

F: Chris has been in the queue for awhile so please keep this in mind.

C: I just have a thought. I was thinking about the goodness to fit aspect of OASIS. As Sam mentioned, there's a little bit of circular verification when you're testing OASIS against the USGS gauge and that gauge was used to develop the unaltered low flow record. Do we believe the USGS gauge data is good enough to answer the questions? Here's my other thought, is there a place where there is a USGS gauge that for whatever reason was not used to develop the OASIS model and it was too small or too short? And preferably, relatively unauthored but you've got a record of quote/unquote real flows from USGS gauges. Put in a node in the OASIS model at the same drainage area, same place as that USGS gauge, see what OASIS gives you for that same for that same period of record.

C: OASIS has to have unregulated inflow stipulated.

C: But do you typically find that you just prorate it by drainage area to the nearest portion of that stream.

C: If you were using the OASIS model to simulate the flows for a fish monitoring station or for a PHABSIM site, a place where there's no USGS gauge, that's what the OASIS model would be doing. So you've got quote/unquote real USGS gauge data that was not used to build the model and thus do not have the circular thinking anymore. You've got OASIS doing what you would do, whether or not there was a gauge there but you needed to know flows because that was one of your 858 fish stations or one of however many PHABSIM sites. You could also generate a record of flows for WaterFALL to see how the three do or don't hopefully line up. And maybe it might be that OASIS and WaterFALL are really close but they're not very close to the gauge.

C: For the universe of gauges, I'd like to conduct a comparison between three things: WaterFALL, OASIS and the gauge, and have the legs of those little triangles calibrated to those steps so that basically we're taking into account both the magnitude, the distance and randomness of the difference and then you could look at a metadata analysis and tell me whether there's a trend. It seems to me that at that point we can analyze the difference between the gauges and see if there's a pattern of difference between either model or the gauge, and between the models themselves.

F: Do you all want to put closure to this piece?

C: I don't know if this is a better idea but I was going to ask before Jim's suggestion - how many gauges to compare would you need? Would you just run them side by side and do it and you could have some that were used to develop the model and some that weren't. Are you talking hundreds of them? That's a fair amount of work. But if it's 10 or 20, or 30….?

C: I'm not clear where we are with this discussion. It seems like this whole issue is this validation of and comparison of these two models…Michele and others mentioned several things in their presentations that pulled the stuff out. You could color in the state but that's how WaterFALL could be used. Once you have a classification system it could be used to generate classes for each stream.

C: It seems to me that the question is not what are all the ways that *WaterFALL can be used either with or without OASIS?* But rather, what is the best strategy to use gauge data, OASIS technology and WaterFALL technology to answer the one question that we really are trying to answer, which is for each class of rivers and streams in North Carolina what really matters about flow in terms of ecological integrity? We've seen various strategies for plugging model data into that sort of larger model for ecological baselines and my question is, is there some consistent and strategically contemplative way for using the models available and the gauge data that we have?

Q: Aren't we going on the assumption right now that we don't feel like OASIS is adequate, that calculating from the existing gauge may not be satisfactory for predicting? Isn't that why we want to use WaterFALL? We thought that is going to give us an added benefit to try to know what the actual flow is at non-gauged locations?

C: WaterFALL covers the whole state and it covers it at the finest hydrological grain that's available; that's something that nothing else does. OASIS has extraordinary power in terms of its ability to forecast what will happen based on the period of record and in terms of its ability to simulate essentially any management strategy you can think of. So you can take an OASIS model when you've got one and do amazing things in

terms of simulating management strategies and predicting outcomes. These two things impress me as both essential.

The day will eventually come when OASIS covers the whole state and OASIS's current approach to moving up the watershed is to do special adjustments as you go up watershed so that you can simulate gauges. What we don't know is that a better strategy than the WaterFALL strategy which also simulates what happens upstream. We need to figure this out whether those two strategies for moving upstream into the watersheds beyond gauges or beyond gauges that are nodes and OASIS models, whether those two strategies differ from each other very much in terms of results and if they do, how consistently? Do they differ from each other in consistent ways or is the difference random? We do not have the option of waiting until there's an OASIS model in place for every watershed in North Carolina. This group has to produce a strategy by the end of 2013.

C: Let's say we do have a strategy. It won't be implemented in the OASIS until that basin's OASIS model is completed- correct? Let's say the mountain area is not completed until 2015, even if we have ecological flows and we think that it's appropriate for the little Tennessee that there's not a Little T OASIS model, the division is not going to be able to plug that in for planning purposes until the OASIS model is done – correct.

C: Yes and no. Implementation of our strategy doesn't have to happen right away and it may never happen. On the other hand, developing our strategy requires that we know something about all the different classes, rivers and streams in North Carolina and develop some sort of way to deal with ecological integrity in each of those classes. If we're simply unable to model whole classes of rivers and streams then we're toast. I think the best strategy here is for us to know the difference between OASIS and WaterFALL so that when we start moving upstream we recognize whether they produce significant differences from each other and from gauges that are not calibrated with OASIS.

C: We may be losing focus with Tom's slides about different ways that these different models can be used for the different reasons that DWR wants to use 'em for planning and so on and so forth. That's one pile of stuff. We've got something we've got to do in the next twelve months. That's another pile of stuff. We can talk about all the hundred different things that might be used some time or another, which is great but doesn't help us move this ball forward. In order to move forward we've got a couple of critical questions to address; we're not here to bury either one of these models. It's just that we've got to know what we're working with to move forward. We're not going to have the perfect answer in twelve months regardless of what we do but we've got to get a few things out of the way in order to get to that point of producing some kind of document.

F: And those two critical questions being?

C: Do the models differ from each other in consistent ways or are there random differences?

C: The company needs to define whether the selection of gauges we're looking at includes some that OASIS used or is it gauges that are outside of the proximal area, and which ones can we do side by side. Remember that WaterFALL is ultimately based on the same units as USGS Gauge. So the question really is, what are the differences in the prediction?

R: WaterFALL is not calculated from gauge data; it's calculated from rainfall.

C: But your goodness of fit measure is back to the gauge.

C: True; similar to the analogy earlier of the triangle. You've got goodness of fit between WaterFALL and the gauge, goodness of fit between OASIS and the gauge and goodness of fit between WaterFALL and OASIS. What would be helpful to see is whether the legs of those triangles vary from gauge to gauge.

F: Anyone who has not spoken yet want to engage in this discussion? Tom, did you have your hand up?

C: I want to urge a little bit of caution here. What I'm hearing is that these things are really easy, that we need to do this and that. You need to be very, very careful about the question you're asking, the design, the blocking of it because if you wind up saying that WaterFALL does not match OASIS and you throw out WaterFALL, you've got nothing to stand on anymore because you don't have OASIS where you need it, you're really kind of locked into having WaterFALL at this point. It's the only game you've got. So be real careful.

I'm very interested to see how these things line up too but be very careful on how you decide you're going to judge whether it matches or not because it's quite possible that these things differ in the headwaters or in the large rivers or the coastal plain or the mountains. So you've really got to think about if you've got a small set and they're all from the Piedmont and they don't match, do you throw it all out? It may be that they match elsewhere. So there needs to be a lot of thought and effort put into designing what types of sites you need, what type of criteria you need from those sites, and even the things like the period of record. We've heard all sorts of things about how that could mess up statistics. This is a huge statistical problem, both in terms of the analysis and the design of it.

C: What I'm really trying to figure out is whether WaterFALL consistently over or underestimates data in some consistent way that is predictable so that if we then go on to use WaterFALL, which is the only statewide coverage currently available.

C: Perhaps if we say let's move forward with WaterFALL, with the plan to compare it to OASIS and make adjustments in the move forward rather than pitching them against each other. Take an iterative approach.

F: Any other reactions to what's been brought up?

C: Back to my original question: what are the other options? It sounds like we need WaterFALL to fill the gaps where OASIS isn't present, otherwise there are going to be some perhaps old classifications of streams that cannot be included in the analysis.

C: There have been a lot of less sophisticated models through the years, these statistical models that deal with the whole state can treat a range of sizes of streams from very small to very large. But the variation and the courser models, those are still there, just that we've come down to something with more accuracy and resolution here that we're wrestling with.

C: There are iteration models that give me flow data for any stream in North Carolina?

R: Sure. And it goes back to USGS that developed those illustrations and maps and relationships through the years and updated them.

C: Are those flow models or are those watershed production models? Can I pencil them on the map and say what's the flow here?

R: It gives you statistical numbers but it doesn't give you time series. It says the mean annual flow is this or the 7Q10 is this or pick some statistical way you want to represent it. It gives you those things. So if you want to know the whatever, the 7Q2 of some month, it will spit it out. But that's not useful for doing analysis of what if scenarios. That's really the difference.

R: Just adding to the conversation on WaterFALL model, that we're doing work right now for USGS and their Water Smart program where they're comparing a bunch of statistical models on their PR Best model, which is another very sophisticated rainfall runoff model. And then also the WaterFALL data from Little Tennessee, French Broad and a few of the western basins where they're doing a whole comparison for the southeast. We should know in a little while about 20-25 different sites. So that's something, but again, like Chris was saying, those statistical models are more on the daily time step but they're based on a drainage area and in fact several, or at least one relates to a surrounding gauge site so ultimately it comes back to gauge data.

F: Can you present on this information in Feb? (Yes from Michele C.Eddy, RTI).

How Good is Good Enough?

C: Getting back to the question about how good is good enough? Before OASIS and before WaterFALL, DWR did do time series analyses for specific projects like the early hydropower projects. For example if there was a study site where there was not a USGS gauge nearby on that same stream, we'd look for the nearest gauge of

a similar drainage area, preferably not less than half a mile and no more than one and a half miles or which the drainage area and size, and then you'd compare the average flow per square mile, the 30Q2 or September median per square mile, and the 7Q10 per square mile at that gauge to the estimate from those USGS maps discussed earlier. This provided a feel for what was the runoff yield at a really low flow, the 7Q10 in a moderate low flow, September median and the average position 'cause that's typically what those investigations were focusing on, the water removal or water flow, and lower flows. If you found a gauge that was fairly close in terms of those three statistics per square mile to the site you were working at you used that gauge or you used Nolan Creek and Bryson City many times. Never had a single study site on Nolan Creek but did in the Little Tennessee, it had similar elevations, several sites and similar radiant per square mile. We used it because it was the only thing similar in two square mile drainage area. There are not many USGS gauges on streams that small. This is a crude comparison, but still it was considered good enough then, providing a representative flow record over time, not a replication.

Rationale for Three-Way Comparison

C: The reason for the three-way pairwise comparison is because the most important thing is not whether we model dead on accurately. What matters most is to model consistently in space and time so that as we compare various management regimes or various climate input variations we get differences that are useful, we can learn from the differences we detect. This is why I'd like to do this three-way pairwise comparisons to see if these models vary from each other, and from the gauge and in consistent ways. Spatial and temporal consistencies within any given strategy are essential.

F: Are there any reactions to Sam's proposal to do the three-way pairwise analysis? We heard from Tom earlier about being careful in how the design is set up and analyzed, the questions that area raised,…any other reactions or other proposals?

Prioritization/Justification of sites for three-way comparison and Going Upstream

C: One of my questions is where are we prioritizing where this is done? So like at which locations or which basins? What's the prioritization and where are choices being made to choose the records for comparison? What is the justification for selecting sites? Trying to predict what the long-term effects are or are we trying to look at completely unaltered locations? What's the goal of each location that we're looking at this comparison for?

If you want to get upstream, I'm unclear if that means to move upstream in your basin toward some of the smaller headwaters to compare this. Mentioned there were some of these withdrawals and some of the implications for a planning tool might actually occur on the more moderate medium and water size components of waters of rivers. So I'm wondering how we prioritize where these comparisons would take place?

C: My interest in going upstream is based on three things: 1) as you go upstream, you move upstream of the nodes that are highly correlated between OASIS and Gauge. That is, you're going to find more nodes and more gauges that would not have been correlated with OASIS nodes; 2) that's where WaterFALL perennial area is most powerful; and 3) that's where streams are the most sensitive to manipulation. The OASIS models only exist for a handful of basins in the Piedmont, not the mountains.

F: If we have an OASIS model in place already like the Piedmont, do we anticipate using WaterFALL in basins like Cape Fear, Neuse, Tar? Or do we use WaterFALL in these areas where we know we won't have an OASIS model?

C: For now if we're going to do something statewide in terms of habitat modeling like the project Jim submitted, we pretty much have to use WaterFALL as it's a consistent strategy that works from border to border.

WaterFALL for Other Uses Besides Classifications

C: So are we talking about using WaterFALL for any other piece besides just classifications?

C: No idea; that goes back to the comment made earlier, the model may be used for a lot of things once we hand all the stuff off to the department to figure out how they're actually gonna implement it. That's up to ERC and the department to figure out how they might use it five years from now. Think we have enough on our plates trying to figure out this whole classification bio fidelity kind of issue and if there's a way to use it.

C: If we use the WaterFALL border to border with the project that Jim described this morning, don't think we have a choice in terms of what simulation for flows we use in that project. But I'd like to know if WaterFALL is varying inconsistently or consistently and significantly or insignificantly from either gauge data or OASIS data.

WaterFALL Variation

C: Seems months ago when first introduced to WaterFALL there was some understanding that there was a variation to capture…to get to the gauge data – perhaps in the Piedmont? There was some spatial difference in the ability of WaterFALL.

R: For reference, WaterFALL introduced months ago wasn't the final model.

C: And you've not seen any regional variation in your ability?

R: We definitely have less consistency with the gauges in the more altered areas and there's a good chance that that could be the alteration data that we're using on that. We don't see any consistency to the model errors across the full range of sites and conditions in NC, for everything that we've looked at so far. I think doing the three-way comparison would be a good way to quantify those general findings that we have at this point.

More on the 3-Way Comparison

C: I'd just like to make a pitch to do a side-by-side comparison and conduct it statewide on all the different sizes of rivers rather than just the headwaters. There are lots of potential uses of all of these models and we need to know how they compare. It will take statisticians a lot smarter than I to design that study so it may take larger sample sizes.

C: One aspect of the comparison is to use gauges that are in basins modeled by OASIS that OASIS is not calibrated to.

C: There are lots of basins where there isn't an OASIS model and there are lots of downstream gauges that haven't been used in the OASIS input. Another point that hasn't been made is that when we're doing this comparison WaterFALL starts in 1960 so it's got to be gauges close to 1960.

C: I'm personally fine if you've got some gauges out there with 18 years; do that 18 years and see how they line up.

C: We also have the 2006 land use and the 1970 land use data so we need to focus on the most further period because land use is driving our models. So if you want to focus on a gauge from 1960 but use our 2006 findings we can already tell you there's going to be a mismatch so we need to focus on what our inputs are and try to do it as close as apples to apples comparison.

C: I think since we're doing this with estimates of unaltered flows you ought to use the earlier land data.

C: Our classification right now, as we're going forward, is going to be through WaterFALL, is it not? I mean the only classifications that we have on the table that's being developed will use WaterFALL? Is that true?

C: The project that Jen is doing is using biological data and WaterFALL for the metrics flow alterations.

C: I think it would be helpful to come up with a smaller group for the 3-way comparison. Question: how bad does WaterFALL have to be before we walk away from it as the basis of our classification?

C: If it's not a good fit.

C: Certainly don't have the luxury of waiting on this decision to decide whether we're going to use it for the classification.

Proposal Discussion:

C: Here's a proposal: 1) We are gonna use WaterFALL in the RTI project over the coming year because it is the only finely grained, statewide modeling strategy that we have; 1) Seems we want to know whether WaterFALL varies in any consistent way and by what order of magnitude from the other strategies that are

available for portions of the state. And thus how WaterFALL varies from OASIS and/or Gauges and whether that variation is consistent or random. If we can respond to the later quest (#2), it will be easier to understand the results of #1.

C: I wonder if I would feel more uncomfortable with random deviation versus a predictable variation.

C: If the variation is small and random I'm a happy man.

C: I said that there's always some error on it to be random. You want it to be random. You don't want it to be something specific . You want it to be random error. That's the ultimate goal.

C: If for example you're unable to adequately model Piedmont urban streams, we could take and use that knowledge during an assessment of the classification; it would be easier than understanding a large random variation.

C: From the state's perspective, when this rolls out, what are you going to use to model those flows? That ultimately is the question. Are you gonna use OASIS or are you gonna use WaterFALL or are you gonna use both?

C: I can say use this for both. We've been using OASIS for our basis models up to now and assume we're going to be using OASIS for some period of time in the future to model future basins so we'll be using OASIS. And I see us using WaterFALL, like I mentioned previously, in other aspects of our duties outside of this arena here in terms of other flow studies.

C: For me to get to where Sam's talking, we need to know how it is to compare because one's going to be used to kind of define the flow methods and the other going to be used to model the flows at the site so we need both pieces.

C: My personal definition of the ideal outcome is WaterFALL is so good that it's fine granular serves as a front end loader for OASIS which gives us the forecasting and management power that it brings to the table.

C: The statute talks about the models being approved by the ERC. I keep reminding people it's not a single model. I mean even things like the forecast or demands that go in it. It's not a model to figure out what the water demands are gonna be 10, 20, 30, 40 years down the road. I see them potentially working together to help get all these pieces to work together to identify where e-flows could be adversely affected. Which do we use at this point: WaterFALL? OASIS? It seems we'll probably use a combination of the two.

OASIS is Here to Stay

F: Amy and then Chris.

C: I think that the approval of Environmental Management Commission (EMC) for the OASIS model invariably says it's unlikely that OASIS is going away, that the State is going to continue the process of creating and developing OASIS models for every river basin in the state and for the EMC's approval. That's what they've committed to do and they're not going to move from an OASIS model to a WaterFALL model. ***Now whether or not WaterFALL provides some kind of input model for the kind of post-processing or whether or not you do work with the data that's provided, the fundamental mass balance work that OASIS does is going to be a black box in the process for every river basin state.*** So I think it's important to keep that in our minds that we're not talking about discounting or throwing out one model versus the other because that OASIS model and the path that this state is on is like a lot of things, it's not…probably not carved in stone but it's carved in something close to it. This is where we're going to go. If you use WaterFALL to create a classification system that is then not applicable within the OASIS framework or provides data points that are logical or not utilized by OASIS as variability between WaterFALL and OASIS – this to me is a legitimate question.

C: So with that said, it would be great to answer all these things up front but some of these things are gonna be answered down the road when more is known. If you can review some things up front, great, but if not, you're still gonna go through with this process. It might be that these models in this kind of stream classification on this physiographic region or whatever are…differ in this way. It's like adding a correcting factor after the fact. We don't have to have perfect knowledge up front or going forward; the question is, if we want to know it now, who's gonna do it, how and when? Would it detract from something else that could

be done or is being done? If it isn't gonna be done in the next few months, then maybe we've talked about it enough.

Support for Three-Way Comparison

C: I don't think it's gonna cost a lot of money nor take a lot of time to do a three-way pairwise comparison. With your permission and consent, I'll meet with the principals and see if we can't figure out some way to get that done.

C: I can tell you from my perspective [Brian], if somebody can design the study, which I think is the most time consuming part of this to figure out what gauges we're doing, if somebody can tell me the gauges we can turn the crank almost overnight.

F: Do you think a three-way comparison study could be accomplished by the February meeting? The April meeting?

R: Having spoken to none of the people that might support the study…it's unknown but thought I'd speak to Brian, Michele, and Tom. The results will not change anything unless the EFSAB wants it to.

F: Let's test the EFSAB for their level of support for the proposal of a 3-way comparison using a small group (perhaps with Brian, Sam, Tom, Michele, (and later Kimberly). Are there any downsides to this group moving forward and conducting this analysis? Please weigh-in with your level of support by the show of fingers: one finger "I am fully in support," two fingers, "I'm not fully in support but I'm okay with it," three fingers, "I have some reservations," 4 fingers, "I have serious reservations…",and 5 fingers, I cannot support it at all [Mostly ones and several twos were put forth with the understanding that the results will not change anything unless the EFSAB supports this].

Lastly, we heard there is support for Fred to table running the nine PHABSIM sites of WaterFALL data.

C: Before we start playing with comparisons of WaterFALL and OASIS in places where we don't have gauges, let's compare WaterFALL and OASIS where we do have gauges.

C: One thing that would be good in the analysis is not simply to look at patterns but tell us what the variation is.

C: The hope would be able to describe not just the amount of variation but its direction and any emerging patterns and seasonality.

C: Sorry to reiterate another big point but there will be USGS gauges that are not part of calibration in either OASIS or WaterFALL?

M: I would ask that maybe you give us a little latitude there. Thinking back on what I said, I think there are probably not too many large river gauges, and some have only been there a short enough time that they weren't used in OASIS so maybe we ought to do one set of ones that were and one set where they weren't used.

C: I'm trying to get clarification because it just seems like either way of the analysis, if those gauges were used in any part of calibration for either of those models then you're going to have linearity in those results. I have questions about the methodology for the analysis because it seems like the gauge selection is a really important part of this and what those gauges are to each of those models.

F: In an effort to be mindful of time, Kimberly can you join Brian, Tom, Michele, and Sam as a small group to look at the three-way comparison and deliberate the design considerations such a gauge locations. We have a couple of other agenda items.

C: Sam agreed to follow up with an email about the kinds of gauges that should be incorporated into this equation, project design, and money to pay for the operation.

Summary of Uses for the WaterFALL Model

- Habitat responses curves for 9 sites compared using WaterFALL.
- Instream flow where USGS gauges are not proximal

- Use PHABSIM sites in basins where OASIS is not ready for Eflows investigation
- Look at habitat responses for other PHABSIM sites compared for classes
- Need both WaterFALL and OASIS on table for symbiosis
- OASIS is here to stay
- How different are the models at the gauges, random or not? what is the pattern of difference?
- Generate classes for each stream after classification is completed
- Difference between the two models when moving upstream? consider a 3-way pairwise analysis
  - Exercise caution with a 3-way pairwise comparison: with the way the questions are asked, the study design and if you say WaterFALL doesn't match OASIS - how do you judge? By what criteria? Where to prioritize criteria for selection? What sites are used? Goal for each location? Upstream? This is a large statistical process - let it be iterative to check and review assumptions.

VI. Revisit Proposed Consensus Principle: % inflow and Concept Paper Discussed in October (for use in proposing future scenarios for EFSAB Feedback)

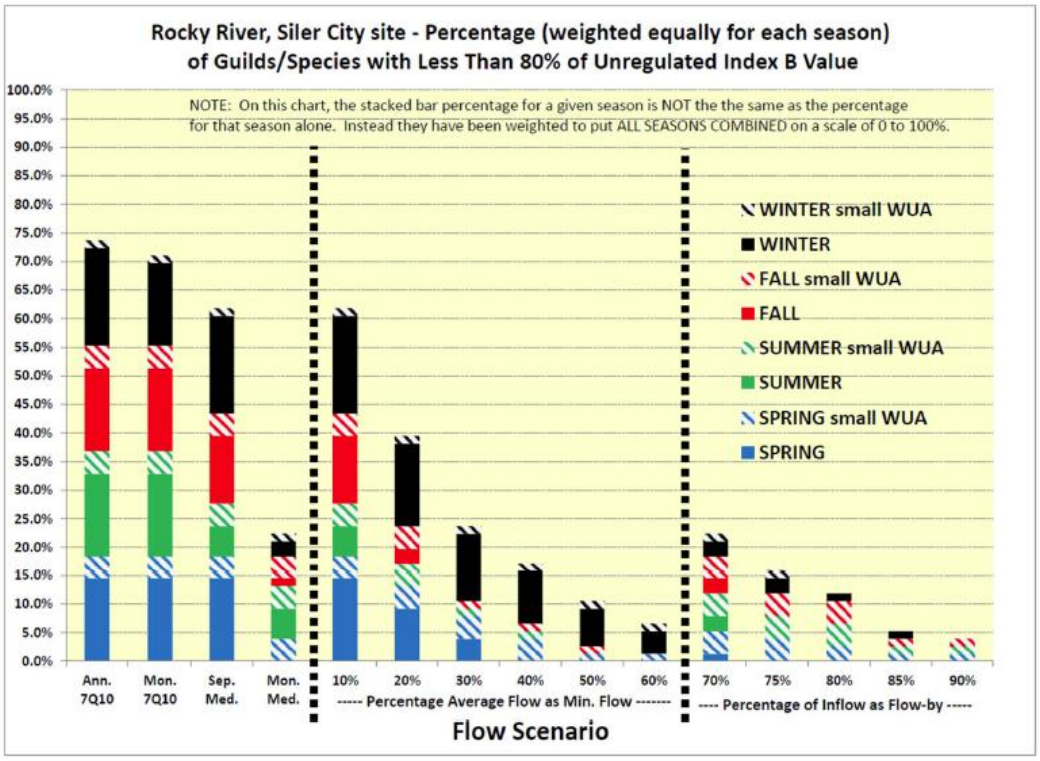
Links to Fred's Presentations: Rocky River Presenation and Big River Presentation

Facilitator: At the October, 2012 meeting, 3 consensus principles were proposed. Two were approved, but consensus was not achieved on the principle of using percent of inflow as flow-by as the preferred family of strategies for defining environmental flows (e-flows). The need for greater clarity on what the principle means and why it is being proposed was expressed. Fred Tarver will present on why DWR had expounded on the benefits of using percent of inflow as the preferred family of strategies.

Fred reminded the group that this relates back to the discussion of DWR's concept paper, presented at the October meeting, in which DWR suggested that one type of ecological flow regime being considered by DWR is the "percentage of inflow" approach to be considered as an environmental flow planning tool, based on the study sites that Jim Mead ran using the OASIS flow records. This was the right-hand grouping on the bar chart displays produced for the SAB, comparing the various e-flow approaches. There was some discussion at the October meeting asking DWR to provide additional information about what some of these flow-by scenarios might look like in terms of real-world flow records. Jim Mead put together some information using the Rocky River (Cape Fear Basin) looking at natural flows using OASIS-generated flow record. The criteria used are as follows:

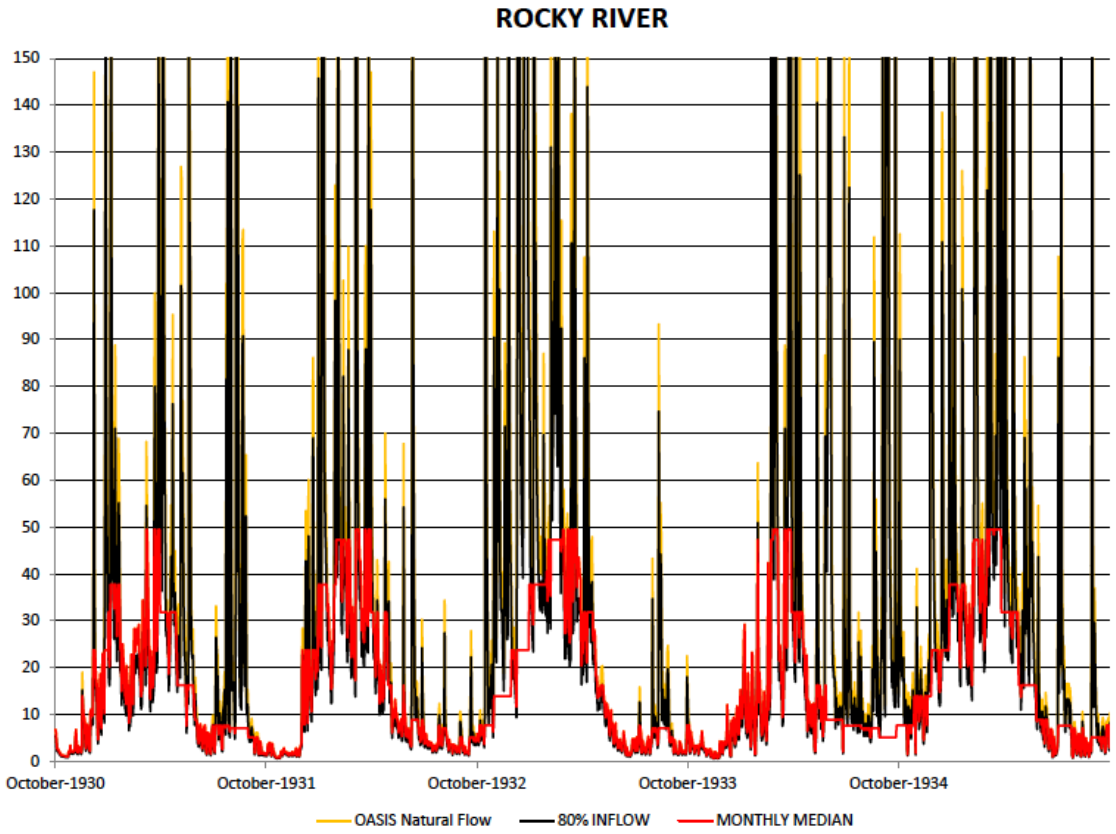
Period of Record 10/1/1930 – 9/30/2011

- Time series plots of flows in 5-year increments
- Three flows overlaid
  – Unregulated, natural flows from OASIS
  – 80% of inflow flow-by approach
  – Historic unregulated monthly median flow as the minimum flow, or inflow, whichever is less - on a daily basis
- Last 5 slides are various views of the 2000's: by 5-year increment; the entire decade with arithmetic and log scales; and only 2001 to 2003 - allowing greater resolution from 3 recent years with a variety of flow conditions.

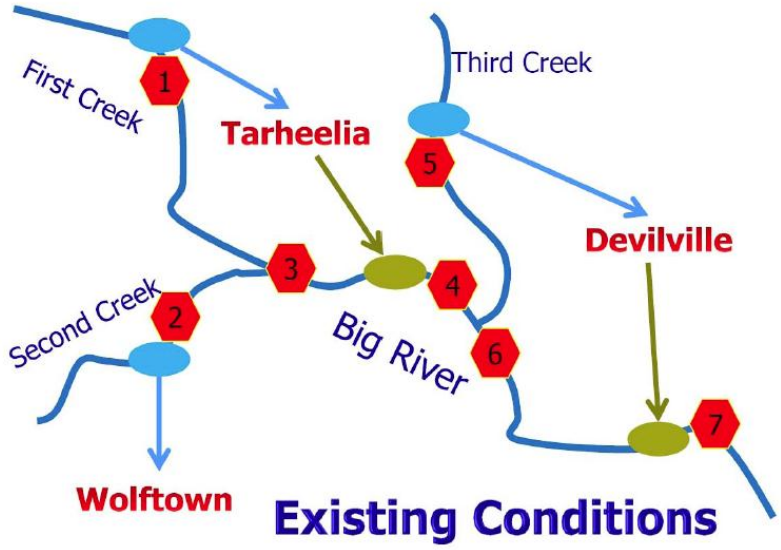


Fred first had the EFSAB look at a graph showing OASIS-generated natural flow (in orange), 80% flow by (in black), where the flow for the day is 0.8 times in-flow over flow for the day. It also shows historic unregulated monthly median or inflow (in red), whichever is less.

Q: So the red line is the monthly median? Is that a monthly level or is it a daily?
R: That means that each day, there's a monthly median for the whole period of record. There's one value used for September, for example. And so on day one, is the inflow less than that monthly median? If so, the flow is inflow; you are not augmenting flow. If the flow is at or above the median, then the flow is equal to what I am calling "historic median value" for that month.
Q: So the red line then is the monthly median or inflow?
R: On a daily basis. Correct.
R: Daily. Okay, so that's why it is flat in some places and then it is moving daily above that flat line
R: Yes, well actually it's moving below the flat line is what it is. It's not moving above it. It's the lesser of the monthly median or inflow, each day and model. And you've got twelve different values it could be, depending on which month it is. And so, you know, in a nutshell, basically, you lose the higher flow variability.



Fred wanted to present a pseudo real-world scenario. He wanted to take a hypothetical watershed with some hypothetical water systems under hypothetical e-flow scenarios and look at how the hypothetical hydrographs respond to the e-flow scenarios and the water withdrawal scenarios and return scenarios. Steve Reed did his presentation back in November, 2011 showing his perception of how environmental flows are going to be used in OASIS modeling. He came up with a hypothetical watershed (Big River) with three water systems with their various water withdrawals and water returns and also the position of these nodes in the watershed.



Fred used this hypothetical watershed. He set 20% 7Q10 as the initial present demand for these three water systems. Then

he projected it out ten years, just hypothetically, then also looked at present wastewater return and also future wastewater return. The initial present demand (20% 7Q10) is based on real gage data, but the future demands are hypothetical. He used 86% of demand as return for wastewater because EPA has reported that as the national average for the amount of return for an average wastewater system. Wolftown has a basin transfer where the water withdrawal doesn't return to the basin. Node 1 is associated with Tarheelia. Node 2 is with Second Creek down at Wolftown. Node 5 is for Devilville, Third Creek. Nodes 1, 2 and 5 are based on real-world gage data. The drainage areas are correct for Nodes 1, 2 and 5, but the drainage areas for the other nodes are hypothetical. To reflect Jim's bar charts, Fred selected the following e-flow scenarios to look at: monthly median, percent of the annual average flow as the flow-by, and 70, 75, 80, 85 % of inflow as flow-by. Given the property of the calculations, the monthly median and the percent of annual average e-flows were the calculated value or inflow, whichever is less, since the natural system is not expected to augment flows.

Looking at Node 1 (see Figure 4 of Fred's presentation) [Facilitator's note: to best see the hydrographs see the presentation on ncwater.org, which the link will take you to] the red line represents the 20% 7Q10; the green line represents the environmental flow, which in this case is the monthly median, or inflow, whichever is less. Due to the properties of the calculation, there are some times that the 20% 7Q10 withdrawal falls below the e-flow regime, and Fred is assuming that in the planning that DWR does, a lot of water systems are at or below the 20% 7Q10 thresh hold due to limited demand or to meet the minimum criteria under SEPA. The expectation is that even though you might see some red below the e-flow, the expectation is that's a—it falls below the standard, but it's—I guess it's considered an acceptable breach of the e-flow. Now, when you're projecting 50 years out, the question is with all those instances of where the 50-year projections fell below the environmental flow threshold, would you have a red flag every time that came up? Or would it be some sort of other criteria, like duration, frequency, timing, percent of flow below the threshold—those kinds of things.

Q: So, what's the yellow and the blue and the—
R: The yellow is the 50-year, down at the ones that really fall out below the straight line 7Q10. These are all log scale. This is one, ten, 100, 1,000, 10,000. So that's on log scale. And this is water years 2000-2009. This is the 50-year projection and the red that you can barely see—that's the current 20% 7Q10 withdrawal. The blue is the natural, unaltered flow. And then you have the environmental flow, which in this scenario is the monthly median, or inflow, whichever's less.
Q: That's the green?
R: Well it changes color—but the magenta behind here and then when the e-flow falls below the monthly median, that's where it falls out to this green down here, but then it kicks up in these wet years—you have the monthly median as your threshold.

The next graph is for Wolf Town (see Figure 6 in Fred's presentation). This scenario uses 60% of yearly average or inflow, whichever's less. The 50-year demand projection, which is 12 CFS or about 8NDD and the red line, which you can barely see, that's 20% 7Q10 values. This is the 60% of yearly average or inflow so, the green is in the wet years, when it becomes a threshold, and in drier periods you have the inflow as the threshold. So you do see some times where you actually have 50-year projections of reaching the threshold of the environmental flow regime, and a few times where you actually have 20% 7Q10. Not very often.

Next is moving downstream to Node 3 (see Figure 8 in Fred's presentation). This is on the Big River below Nodes 1 and 2 moving downstream, so you catch the drainage areas of those two streams. This is under the e-flow regime of 75% of inflow. I don't think there's any red (20% 7Q10 withdrawal) that actually violates the e-flow regime. With the additional drainage area, you do get a little additional flow in the system so it helps attenuate the alteration. And you do maintain the natural hydrograph to a great extent.

Moving downstream, at Node 4 you're going to be downstream of the wastewater discharge of Tarheelia, so you

do get some return into the system with the wastewater discharge; it's not a full return, but with the additional drainage plus with return, you see the mimicking of natural hydrograph (see Figure 10 in Fred's presentation) and you don't see the 50-year or the 20% 7Q10 withdrawal creeping through the e-flow threshold under this regime.

Next, look up on Third Creek, Node 5, which is for Devilville (see Figure 12 in Fred's presentation). The e-flow regime here is 70% of inflow, which once again, will mimic a natural hydrograph . I think there was beaver activity in the stream for the anomaly episode. Once again, you see mimicking of the natural hydrograph and there are a few occasions where the 50-year withdrawal projection reaches the environmental flow, but the 20% 7Q10 withdrawal does not. This is for Devilville, where the 20% 7Q10 is only 2 CFS so it's pretty small and in the 50-year projection is 6 CFS, so it's pretty small as well. It's kind of a low yielding watershed.

But moving on, Node 6 is down on the Big River again, so you have additional intervening drainage. This is under an e-flow regime of the lesser of 50% of the annual average or inflow, whichever's less, so you have somewhat of a natural hydrograph (see Figure 14 in Fred's presentation) in the lower—in the drier components of the year, but in terms of the e-flow, it flattens out to this 50% of annual average inflow.
But given the demands of the water system, they don't really get down to the point where they're actually reaching the e-flow threshold. And there are a few times down here during the dry seasons, where the 50-year projection does reach it—and I think there's a time or two where the 20% 7Q10 withdrawal does as well. So even though you have additional intervening drainage, it doesn't really help offset some of the alterations associated with the water systems.

Lastly, go down to Node 7, which is down below the other wastewater discharge. This e-flow scenario is 85% of inflow. Once again, this maintains a natural hydrograph (see Figure 16 in Fred's presentation).
I don't think any of the 20% 7Q10, the present demand or the future demand violates the threshold there, and this is the lowest node. It factors in all the intervening drainage and all the contributions of all the wastewater systems.

Finally, Fred presented a slide of points to ponder (last slide in Fred's presentation). He recommended that the EFSAB keep in mind, both in terms of modeling and in terms of these different e-flow regimes, when you're modeling, it's necessary to put nodes on unaltered or protected watersheds. As Brian pointed out earlier, if you don't have a node somewhere, then you really don't know what's going on in the watershed. So, if you—I guess the question is—if it is a protected watershed or an undeveloped watershed with no water demands, is it necessary to maintain nodes on those types of streams or watersheds? As we saw, the alterations in the upper watershed are continued as you move into the lower watershed. So if you didn't have those upper nodes, then you might not see those impacts of some of those upstream uses. If you were on those lower nodes, you might not see any kind of red flags popping up because you don't have those nodes in the upper watershed. Of course, if we did have water systems up in those upper watersheds, I think the expectation is you would have nodes there to track those demands and get the impacts on flows. Talking about the red flags raised, when you raise those red flags, is it every time you have a breach of the e-flow regime, or is it based on some other criteria? Is it frequency, duration, percent of flow-by that—you know the, reduction in flows? Or is it a seasonal component? And secondary cumulative impacts, the development in the watershed, the impacts that development of watersheds have on a natural hydrograph—the unregulated withdrawals, in terms of irrigation—could have a seasonal component to it. Land use, like I mentioned, could change the natural hydrograph. Also, like I mentioned, the middle criteria ("unregulated withdrawals") is, as you can see, 20% 7Q10 (unregulated in terms of being below SEPA minimum critera).

If it was a water system, then we would know about those kinds of things in a watershed so those water systems with 20% 7Q10 are easily identifiable; it's those other ones, like the unregulated withdrawals that are

sometimes hard to find and some of those do have to register if they withdraw certain volumes, but there are those occasionally that you don't know about. So you want to make sure that when you're establishing your nodes, you are trying to capture those water uses.
And then the high-flow skimming—some of those percent flow-by's, it does allow a lot of water out there during high-flow events, that if somebody wanted to stick a big pipe in the water, they could take out a lot of the flow and still not reach the e-flow regime threshold, and that could impact the natural hydrograph. We talked before about tidal waters and how do you handle that. Does anybody have any questions regarding this?

Q: What is a protected watershed?
R: A state park, national park—
Q: They're not eligible for withdrawals?
R: Typically, I don't think they would—well, I can't say for certain—I don't know if they would allow water supply withdrawals in state or national parks. I know there are public water withdrawals in national forests. They have permits for that.
R: I was just curious. I've never heard of it.

Q: Clarification question. So for those different nodes, you ran a different e-flow for each one?
R: Yes. And that's not to say that under any future classification system or e-flow regime that we're going to have a different—we probably won't—have a different e-flow regime at different nodes, I was just using that for illustrative purposes.
R: Okay. That's what I wanted to know—that it was just for illustrative purposes.
I wish I had a really big watershed. I mean, you're talking about the Cape Fear…

Q: So that wasn't the same e-flow that's down through the watershed?
R: No, I was just trying to show different ones, just to kind of show how they would look against a hydrograph.
R: Okay. Because I was trying to trace some of the points as I came downstream and wondered where some of them attenuated out of—out of the picture.
R: I was debating about should I use the same one—to kind of show the same flow regime going down the watershed or—
R: You could have done all seven for all seven--Thank you for only doing seven.

Facilitator: So what drove this presentation's being on the agenda today was that it was suggested as a consensus principle at the last meeting that the Board use percent inflow, as the preferred strategy for defining e-flow.

C: Friendly amendment: Percent of inflow is the preferred family of strategies.
Q: Strategies, for what?
R: Well, that's a good question.
Facilitator: That's what I was trying to get to. I wrote this, because what was written initially was percent inflow should be used as preferred flow metric running forward. And so, part of what I'm trying to get to is not even necessarily try to reach consensus on this today, but clarity on what was the proposal and then what are the implications, et cetera.

C: I'm the one who made the proposal, and I did not make it in the form of an absolute. I did not suggest that this family of strategies was the family of strategies that we should adopt. I was just trying to move the cart down the road a little and say that of the three families of strategies that DENR had presented to us, this one produced most consistently the highest quality of results in terms of habitat conservation. I believe that that's empirically true. And what I was basically trying to do was to get this group to just sort of drop the hammer on it and move on. That does not mean that in the end we won't have other strategies on the table that we like

better, it does not mean that we won't have customized strategies for each of the classes; we might have that. I just was trying to—of the three families of strategies that DENR had presented to us, I think, scientifically, that the third family consistently produced the most habitat conservation. I was basically hoping we would recognize that as a group and put that on our list of things that we had decided.

R: Well, I think maybe this is where it got folks hung up. It was said, even when you said that just now, two different ways. To say that it retains the most habitat, is different from saying that it's a preferred strategy. And so whenever we get to honing this thing, I think we need to figure out what it is we're agreeing to. I think that's what got some folks questioning what it was that they were voting on.
R: Well the concern was, was it going to be a regulatory question, and I was basically just trying to confirm that we agreed that the science showed us something.
R: Yes, so I think we need to be more clear. The word preferred in there, I think has baggage with it. Unless you define it with more clarity.
R: Rephrase that as this is the family of strategies that consistently produces the best habitat results.
R: I'll object to the term best in that it; it produces the most habitat. It retains the most habitat, but whether or not that's the best or not is getting more into the policy mode of things. Frankly I don't know what we're trying to accomplish here other than—are we trying to make the modeling job easier? I mean, what are we trying to do in this—making this statement? I don't disagree with it, I'm just wanting to know what we're trying to accomplish.

R: I think at the last meeting what I was trying to accomplish was a decision about just anything.
R: Just start narrowing down is how I understood it.
R: Yes.
Q: So—so does this—is the target here the strategies? Or is it the metric? Or is this the strategy that retains the habitat? Or the greatest potential for ecological processes that will maintain the habitat? Because the habitat is all over the place—it's up and down, back and forth, but it's the ecological processes that will be maintained with this sort of hydrograph.
C: Basically the assumption is that habitat availability or habitat quantity is the one and only acceptable substitute or surrogate for ecological services or environmental flows or whatever.
R: It's a general assembly—basically, they just want us tell them the number--what's the number? Is it 4,000 CFS? Or is it 400 CFS? Well, no, it's 400 and it's 4,000 and it's some things in between, and it's the magnitudes and frequencies and durations of all those sorts of things, but it's the sort of regime that will maintain the ecological processes. So it's the redistribution of sediments and spawning cues for fish or mussels.

C: Two things: One is the—as you saw this morning, what we're eventually—I hope—going to show you as the result of the RTI work is that for each class there are different flow variables that are most critical to the responses of species/guilds/communities and we'll see what those are. And, like I said, what I was doing last time was grasping for—is just to see this group to make a few decisions and perhaps the best way to have phrased it would have been that we agree that the percent of inflow strategy produces the least impact on the variance in the hydrograph, which is what Fred just showed us. All we would have been doing was agreeing with the science, but the truth is that if we agree that that's what the science shows us, then we're going to have some reason to prefer that family of strategies when we start looking at the range of strategies available for conserving ecological integrity in each class. That will be where the science takes us.
I don't think we need to have another vote on this thing, I don't even think we need to—

Facilitator: I agree, and I was not planning to. I was just wanting to, first, clarify what was proposed and then bring out the implications because we didn't have agreement, and then we didn't have time to really discuss why we didn't, why there was not agreement. And we thought it was important to have an opportunity to discuss where the concerns were about that potential proposal.

C: I think the concern was that this third category of strategies looked dangerous as a regulatory strategy—in the context of regulation—but that was not on the table.
C: Right.
C: From a long range planning perspective, looking at percent flow-by in terms of providing a cushion for long-term planning, picking something like that I think would be preferable to taking the most drastic other point of view of 7Q10 because if you use that as your threshold to get your long range planning, by the time you reach that threshold, then the water has been allocated, and you don't have much cushion with which to negotiate all the various demands whether it's in-stream or off-stream. So I think it does provide you a cushion for that long range planning perspective.
C: Well, and it sounds like to me, you're not going to vote on it and it—whatever—I was just going to suggest that we not miss every opportunity to reinforce the idea that like Tom Reeder said this morning this is for planning. It's not heading towards policy or, you know—certainly not towards regulation without any action by the people whose pay scales are higher than ours. But—and to do that, you might want to re-word that one word there and say for defining ecological planning flows—or just put that word in there somewhere, just so that other people who aren't as involved as all of us are, are continuously reminded that this is not standard setting for "No you can't have that water."
C: I think that's important because all of this is out and it's in full view, right?
C: It could give people a misperception so I think clarity is important.
C: We don't need to vote on this.

Facilitator: No, we weren't going to. We just want to get out the reasons that that's being proposed and the concerns about it, and then we can move forward, but…
C: So, I think it's even more basic to what percent of inflow means is that it's—it's the natural hydrograph, that it's directly related to this natural hydrograph feature that we do—I mean, that we maybe need to vote on whether we think that that's what it was presented to us scientifically that maintaining a natural hydrograph with the duration and frequency and these pieces tends toward maintaining ecological integrity and the 7Q10 and even mean annual or mean monthly flows, as demonstrated by Fred's illustrations, cuts that off. It cuts our understanding in the planning process off if we model that versus percent of flow-by. And so the benefit of using percent flow allows us to retain that understanding of how it is, how it looks in relation to the natural flow regime, that you're closer to maintaining frequencies and durations by using that. That's the stronger argument in favor of it preserving ecological integrity.

C: So it seems like we're saying two things here. One is that based on the hydrographs, percent flow-by retains the most, of these various families of the natural hydrograph, shape and variability and so on. This stuff is something else. This is saying—and that translates into retaining the most habitat as your analysis tool.

Facilitator: Any other points that people would like to make and then what I'd like to do is ask people their concerns. Again, my thinking here is we're not going to vote on this today, but this is a decision or related to a decision, which this Board is going to be making at some point, perhaps, and to bring out the thinking behind it so that something can be proposed for a final decision down the road.
C: I guess that, Sam, I'm kind of interested in the—all the work that RTI is doing, getting down to the final part relating hydrology to biological responses. Percent inflow is not one of the variables that they're using down here, is that correct? So, I think that to link the percent inflow into the variables that they come up with as being important in distinguishing the classes.
R: I don't think we should try to jump off this bridge until we get to it.
R: What I mean is that, if percent inflow is going to be kind of what we're recommending, it seems to be what we're doing, this is the hydrologic graph that preserves a lot of things. And then you've got all of this other stuff going on with RTI, and they come up with a bunch of hydrologic parameters that are important for different clusters. It seems somehow you need to link those and maybe the PHabSim is the way to do it, except the

PHabSim we have is not all inclusive. It seems to be an area that we haven't given any thought to.
R: I agree. I think that there's a real chance that we will arrive at the Step Three of the RTI work and recognize that we've come up with some variables that are themselves not actually manageable by the Division of Water Resources or plannable by the DWR. But that percent of inflow family of strategies, by maintaining the shape of the hydrograph more perfectly than other strategies may actually give us an approximate tool for handling the variables that we actually come up with. But we won't know that until we get there, so I'm inclined just to think that—I'm inclined to apologize for proposing this—for consensus at the last meeting and I don't think we need to pursue it any further.
R: But it certainly is—even though it may not be one of the variables out in the model, it's one that's easily measured in the field by anyone upstream or downstream, at any time, instantaneously or over a longer period of time--And then having something that an operator can measure—
R: Right. Operators, regulators, whomever can do it.

C: I'm just going to complicate things. I just want—and I guess it will help get off the point of using percentages of inflow, but I think you run into a lot of danger because of accumulation of impacts and translating that to how does that reflect what the percentage of inflow is? And where within a river system is that point-based percentage defined? So, percentage of inflow at X location, if you have a withdrawal there, then that percentage downstream is going to be affected by what was extracted upstream, so what's your baseline for your percentage of inflow? And you're going to have changes in flow through the system just, on account of accumulation, so I think that it sets up just sort of a challenging guideline to follow. I mean it sounds simple at the onset, but I think actually implementing something like that could potentially be much more challenging.
R: But it's riparian water rights, though. It's just entirely riparian water rights of the eastern province anyway. It's going to take part of what's coming in to you and you have to leave some in the river for those downstream. So, it has a lot of basis in that water doctrine.
R: Right. And isn't it something that—it's a model, the planning part of it is—is the model, so it's something that can be demonstrated in the model, not necessarily as far as like a point in time or point location. It's just hypothetically—or, in the model this is where we are with percentage inflow.
R: Right. That percent depending on what's extracted at different points and inflow is what that percentage is—so it's not, so your percent of in-flow it has—
Q: Are you basically saying that if there's somebody downstream and now there's somebody upstream who wants to take out more water, that person downstream, their percent inflow is now less than—
R: Less than that person upstream, right. You can accumulate the—run yourself out of water by using that.
R: Right. Right. Exactly.
C: It's the drainage.
R: That's true of any scenario we use, right? Actually cumulative withdrawal—
And that goes back to his—to that point there—
R: Percentage of inflow is a meaningless concept unless it's tied to a particular size of watershed, in which case you're saying in this particular watershed, we're going to take this percentage of water out based on how much water flows into the watershed. So it's a catchment by catchment or stream segment by stream segment strategy but we shouldn't get too deep into the ways of how to implement it since we have absolutely no idea whether we're going to implement it or not—
C: Right.
C: And since it's only a family of strategies and it may turn out to be the best surrogate for the hydrograph and it may not.

Facilitator: Lots of good points have been made, and I think there's been some perhaps useful discussion that will go into decision-making down the road. I don't want to beat this horse to death, so what I'd like to do is just give everybody an opportunity, if you have anything else that you'd like to comment on—the thinking that this has brought up for you that will inform your decision-making down the road. Okay. So I think we will leave that

for now and move on to—
C: I just got—I'm just scratching my head—the choice of words, it's not a dead horse, it's the whole reason we're here.
Facilitator: Exactly. Right. But we're not ready to do it yet, is what--
And I'm sorry for the word choice, because I agree. I think this is actually really important, and there were valuable points brought out. We're just not at a point to make a decision at this point. But I think that's why if there are further thoughts on it, bring them out because it informs the thinking as we move forward. So if there are not further comments at this point, let's move on to discussing the water coordination group. Who they are, what they do, and how their work relates to the EFSAB.

VII. Water Coordination Group: Who They Are, What They Do, and How Their Work Relates to EFSAB.

Sam Pearsall informed the EFSAB about the Water Coordination Group, a group of researchers who meet periodically to discuss water-related research. It is an ad hoc group that Sam convened after the first EFSAB meeting because at that meeting he learned about a lot of research that various parties were doing on either prioritizing streams of North Carolina for conservation or defining ecological flows or, in the case of Environmental Defemse Fund, attempting to classify streams. Sam had asked all the parties who were engaged in those research projects to come together to make sure they weren't tripping over each other. He wanted to avoid conflict and duplication of effort, and he was hoping to develop as much synergy between and among those projects as possible. He feels that they have had great success in both departments.

As a result of this coordination they are using common data sets, they are using common baselines and time series boundaries. They have a mutual Gantt chart that these various research projects can march down together. That way they can avoid hanging each other up, and they are now using common guild definitions as developed by Chris Goudreau and others [that was presented to the EFSAB] at the August 2012 EFSAB meeting. The attendees at that Water Coordination Group's meetings are State of North Carolina, EDF, RTI, and the Nature Conservancy. I think the Nature Conservancy is on its third independent project since they started coordinating this process. SALCC (the South Atlantic Landscape Conservation Cooperative) has just launched a new program, and USGS Conferencing Committee. So basically, it's people with irons in the research fire coming together to coordinate data, timelines, baselines, and that sort of thing.
The group meets monthly, sometimes at EDF, sometimes at RTI. That decision is made on the basis of who has the available conference room and what technology is required—whether they need to bring people in from outside by video conference. About 25 percent of the research that that group attempts to coordinate is relevant—or immediately relevant—to the EFSAB's work. The other 75 percent is not really. The other 75 percent is SALCC's southeast wide stuff, or the Nature Conservancy's institution specific stuff. However, the Water Coordination Group members on the EFSAB have made a point of making sure that everything that goes through the Water Coordination Group is recounted to the EFSAB, so that the Nature Conservancy's work has been consistently reported here and the SALCC work has been reported here, and so on.

Sam indicated that he had wanted to make sure the EFSAB knew about the group so that when the EFSAB hears some of the Coordinating Group's members talking about this, or you heard that some of us had worked on a database in that way, you would know what the context was. He clarified again that it is an ad hoc coordinating committee that does not coordinate water; it coordinates research.

VIII. Decommissioning of Gages on Tar-Pam River: Proposal and Discussion

Judy brought to the attention of the EFSAB the decommissioning of some USGS gages on the TarPam. In October, The Natural Heritage Program was contacted by Heather Jack at [?] Haw River about 8 gauges on the

TarPam that were being decommissioned and would no longer be collecting data. Heather Jack was seeking possible funding to put some of those back online. Judy indicated that the USGS gages are typically funded more or less cooperatively between USGS, municipalities, state agencies, some universities, and Fish and Wildlife service. Judy indicated that this is relevant to the EFSAB because the gages are at the core of the understanding of flows in the state. Judy thinks there are over 200 USGS gages in the state, but 68 of those are being supported by the state of North Carolina. Judy suggested that perhaps the EFSAB might want to have a statement of consensus on the significance of maintaining gages over time to the state of North Carolina because the gages provide information necessary for understanding e-flows. She noted that a lot of public entities and private entities use this information and that support from the state may not necessarily always be there over time. She asked if the EFSAB might want to reiterate as a group how significant that funding is. She noted that one of the challenges the EFSAB has faced in their analysis has been that the distribution of gauges is insufficient and so, in one sense, there's no time like the present to start establishing a period of record. Even if there were not a historic record, we should consider establishing gauges. She suggested that the EFSAB might be able to contribute in a strategic way to where new gages should be located. Judy indicated that she feels that strategic placement of gages is a necessity and that we shouldn't just restrict ourselves to where existing gauges are.
Q: Are these the only gauges at risk or are there other gauges in other watersheds?
R: I think there are gages in every basin that are at risk. There's actually a website.
C: 18 gauges discontinued this year for lack of funding.
C: And that's the case every year.
C: Every year.
C: A lot of them were stage gages used for flood plain mapping. The state has decided to take those over because they don't want to pay the Survey to do it. They think they can do it cheaper.
C: No, but we can.
C: without the quality.
C: I think Judy's right. We've been able to use freely—free being the choice words—the data collected over the past hundred years or more at gages across the state, and those data were served up by USGS for anyone to use once somebody does fund it. But once they're lost, then you have those incomplete years of data. Unless you can pony up money for it, then the gages certainly won't be reestablished. Having a really neat model is not going to provide real-time data, nor future data to look back on later. And some of the gages that I've been involved with establishing, I was told, you know, "You need to have at least ten years of data before you can make any good predictions." Well, ten years starts now and if you need data, then you need to start collecting it now. Ten years from now, you're going to look back for—as we're doing in some cases, 16-18 years of data, and say yeah, well, we're learning a lot more over the hydrologic cycle about what's going on with—I think it's a good idea for us to make that statement as a group about the value to our work to date as well as in the future.
R: Someone asked Tom, with the Water Smart Water Census Initiative at the Federal level—and that's largely unfunded [?]—how is that—or do you see that playing into how this, how to integrate filling data gaps and so on that Judy's talking about with that effort at a national scale?
Q: You mean, that as establishing any new gauges?
R: Yes, or I guess I may be more specifically asking—what specifically in that larger effort is expected to come out in terms of looking at reestablishing gages or putting new gages in North Carolina, specifically?
R: I don't see Water Smart as putting in any new gages unless there is cooperation or going to at least match some of the money. That's the only way gages really get installed; they don't get installed—very few gages get installed on federal money. There has to be a customer who wants it and is willing to pay some of the money, the payment on it. My involvement—what I've been involved with with Water Smart is primarily analyzing existing data. There may be a phase later on where they come back and say, based on what we've done, this is what we need to have. But unless somebody comes forward and says, "I agree with you and we're going to put up money" there aren't going to be any new gages.

C:The cost of a gage—a stage only gage—is $6,000 according to this e-mail and a stage/precipitation is $9,200 per year.
C: That's for non-federal.
C: That's the match—
C: The match is $9,200 a year.
C: A stage/precipitation is $9,200.
Q: Can you repeat that?
R: So if it is a stage-only gauge, it's $6,000 per year and a stage and precipitation gauge is $9,200.
Q: As matching?
R: Right.
Q: Total?
Q: Total or matching?
R: Matching.
C: Of match to federal—
R: It doesn't say explicitly here that that's the match, it just says cost. So I'm not actually sure if that's a match or the full fit.
R: That's a match.
Q: You're pretty sure? That's a match?
R: Yes.

Facilitator: So, I just want to make sure—are there any other questions of clarification for Judy and what she's presented? [silence] It seems to me that there are sort of two issues that Judy brought up. One, as a general proposal, is the importance of gages. The other is location of gages; clearly that would require some additional work in sorting that out. What are people's reactions to the idea of, as I suppose part of the final report, including a statement about the importance of the gages for the future. We'll start with that. Reactions to that proposal?
R: Oh, I'm in favor.
Q: Do a consensus on that? Show in favor of a proposal that a statement—
R: I guess it would be—I don't know if it belongs in the report out, you know, at the end of this entire process or where—or if it would be something separate, but I think as a scientific advisory board it seems like, rather than—it would be relevant for us to have a position on the maintenance of gages over time, and it may be that we only want to speak about once. We want to be specific and look at it strategically. I mean, is it something that DWR would do? Are there mission-critical gages, or as we go forward with WaterFALL assessment and OASIS assessment, can we identify mission critical gauges? I think that probably has already been done just by the fact that I think DWR is a funding partner already. So, make sure we support the mission critical gauges and also, to take it a step further would just be to say there are places—I would just guess that there are places across the landscape where it would be beneficial for us to establish a gage, and it would become a mission-critical gage so that we have a better understanding in our modeling with OASIS over time, given the fact, you know, that we may have climatic changes or there may be influential land use changes over time that we would want to capture with a period of record.

Facilitator: So, reactions to that second part, about a statement about critical areas for additional work on maintaining or adding gages? Anything?

R: I have two reservations. Reservation number one is that I'm not sure it's in our brief to provide advice to the state about whether or not it should have gages or not. As much as I personally think gages are powerfully, powerfully important, I'm just not sure it's in our brief. And I—we need advice from the department about what we do. My second concern is that in a time of constrained budgets, asking the department to pony up for more gages is asking the department to pony up for less people. And I'm not sure that this group should come down

on the side of more gages and fewer staff instead of letting the department figure out where that balance ought to be. Both of my reservations are tentative and uncertain but I just—I'm tentative and uncertain about it.

Facilitator: Other reactions? So, I'm wondering if maybe the way to go with this, since there is some interest, would be to put together a proposal, Judy?
R: I'd be happy to do that—
C: Although, I kind of would like to get—I really would rather know going forward if this is beyond the EFSAB. I can somewhat understand that position. I feel like, though, we are talking about science. We are talking about—and one of the sources, one of the fundamental sources, you know, going forward in our ability to use these models are these particular gages. They're foundational to this process, and our understanding of flows in-state and so, it does seem relevant, I mean it seems, to me, to be very relevant.
R: As far as asking the department to pony up more money, I don't think at all the SAB should be going there. But also, some kind of statement that gaging—that there are un-gaged systems. There are systems that we don't have adequate information for. I don't think that is going too far.
C: I think one way to deal with this—I could see that as part of a final report that says we've developed this recommendation, it's based on these models and so on which use gages to create them and from a scientific standpoint, it's in the best interest of the department and state to have a plan. I don't think we have to get into you want to do XYZ, but that gaging stations—adequate gaging stations need to be maintained going forward in order to keep the science relevant and advance the science. Something like that I could see as a recommendation that goes along with--
R: I think that fits our brief pretty well.
R: That's what—that's really more, I think what I was shooting for.
R: When we do it, we should stipulate not only that we see an urgent need for maintaining gages, not just in the Tar-Pam but wherever we need to maintain gages. But we should also stipulate that we need to have excellent models and good biological monitoring data. I mean, I don't want to pick gages out of the pile of foundational data that our recommendations will require and make them a separate issue, or do I? I mean, I'm just applying—
C: I think acknowledging what we need for robust analysis is appropriate. How robust is the science? And within that discussion, say the model relies so heavily [on gages]—that's, I think, very apparent, and I think making a statement about the validity and the necessity of the level of gage data that we have is what has allowed us to have this scientific discussion. Going into a conversation about what is in the best interest overall of the state, I think puts us squarely in a policy arena that probably goes beyond the basic charge. I don't know whether or not we would have consensus over those kinds of—with those kinds of statements. But I think dissecting and providing policymakers with a clear understanding about what we need in order to make that decision, both gaging, biology—there's a lot of information that we need in order to make the best decisions possible. But I think calling out as specifically as possible would be a critical part of the final report and I don't see how we get around that—sort of, this is our best scientific advice and having some way of explaining uncertainty and how robust is this really need—or how robust is the science already. What we are relying on, where do we get our information and getting so comfortable with whatever science we'd recommend, probably has a strong tie-back to the gaging data. I just would caution folks in getting into value judgments about balancing out gage versus people, or best interest of the state, or do we—how many gages do we really need, that kind of—where do we need them, I think we're probably getting far afield.
R: I agree. I think our final report would say here's what we think ecological flows look like and here's what you need to know to develop them.

Facilitator: Additional comments, reactions? [silence] What I'm thinking is the best way to handle this from here is that we as facilitators will start establishing a list of some of these statements that you might want to make in the final report and then when we get to the point of the final report, we can work on the actual crafting of those statements. Let's just start keeping a list, a tally of what things people feel need to go in the

report rather than trying to make any kind of decisions about that today. Does that work?
R: Sounds reasonable.

IX. Next Meeting: Agenda Topics & Meeting Location/Directions

Facilitator: That actually segues nicely into our next item on the agenda, which is sorting out our agenda, or getting suggestions for the next meeting. I want to preface that with letting you know that one of the things that we facilitators will be doing between now and the February meeting is going back through all the meeting summaries. For the first year or so there were not executive summaries, and the summaries have been very long. There have been decisions made or things pointed out that needed to be brought up in the future. One of the things we're going to do is create an index. And so for each meeting, we would first do executive summaries, so that every summary has an executive summary so that you can go back and look at what was discussed at that meeting or if you were looking for a particular topic, you can go through and find it in the executive summary without having to look through the whole summary. Also, for our index we would include what the purpose was for each meeting, the presentations, the presenters, the literature, and the references for each meeting, the substantive questions that were raised, the substantive discussions, the substantive decisions that were made—which would include micro-decisions like who you want to have as presenter, mezzo-decisions like methods of studies, conversions, along with methods, etc. And then macro-decisions like consensus principles, elements of planning tool. And then we will definitely do an acronyms list. Then what we were hoping to do is put this together so that you can cross-reference so that you have a tool for making decisions providing an index of what's been discussed over the course of two and a half years as you're facing a particular decision.
C: And then also serves to fit into that final report if necessary.
R: Right. So we'll be picking out things like this that have been mentioned that should go into a final report, a summary of remaining questions, and one of the things we wanted to get from you today is what else would be useful for you for us to include in that. This is what we're going to be doing between now and February so that we can have this—a tool for decision making-- as we head into this next year.
Q: Any additional suggestions?
R: Index, you can include like, presentations that you got on websites or something like that that might be useful.
R: Yes, I think those are mostly what were at the meetings, so, right.
R: But I mean, just that—if they're actually posted somewhere.
R: Exactly.
R: With a link on there.

Facilitator: Right. Okay. Thank you. Other suggestions? [silence]Okay. And then so finally, what would you like to talk about at the next meeting, which won't be until February? That is in part to give time for the development of the things that we've already talked about having to do in February. We've already discussed having RTI report on the recent development project status and the TNC report out. Kimberly indicated she would be prepared to do that in February, right?
R: Right. I won't be providing a report, but I will provide a—I can provide a sort of a progress presentation—More of the analysis—--the analysis will be done but I won't have a report.
R: Okay. Alright, great. We had discussed at one point, possibly doing a map day, sort of overlays—I don't know if February is a good time to do that. Something else that came up today was the USGS classification. And then of course, at some point we need a further comprehensive discussion about the coastal issues, again I don't know if that's what we want to do in February—it's your input on what you—in addition to the RTI status report and the TNC, what would you like to do in February?
R: I would like to be able to report back to you on the three-way comparison of the two models and gauges. I don't promise that I will be able to, but that's the goal.

R: Okay.

C: I'm not sure exactly how to cast a February agenda, but just want to—I've been, in my mind, running over Tom Reeder's presentation about his conversation with the ERC. Having done a number of this kind of panel before, I'm doing a little back counting. We have a final report due at the end of the year, which means the meeting before that we need a final draft, which means at the meeting before that, we need a rough final draft. If we meet basically every other month that puts us at needing a rough final draft, through robust conversation, 6 months from now.
R: Well, we're meeting more than every other month--
R: I think we're going to have—
R: Well, you need to do that.
R: I mean that division of who's drafting, that division of what goes in it, how do we characterize it, getting to some final conclusions, and recommendations, hashing out all that language takes time and I'm a little—Tom put a little bit of the fear in my heart about our ability to get there. I want to have a process for getting there. I want us to have some agreement about some milestones and some division of responsibility and some agreement about what that might look like. I'm worried that if we don't have that conversation in February, we're never going to meet a 2013 deadline. So I'm not proposing that we resolve that timeline, or any of those other issues right now, but we have to have that conversation, right? Otherwise we're not—
R: That's the suggestion I was going to make for the agenda. Based on what Tom had said, is there something that he suggested that, besides our meeting minutes and the reports that have come out so far, is there some kind of interim report where we can say here's what we do know after we've been here so far? Is there something we can just, even as a one-pager, some bullets, establish as a very interim report about where we've gone and where we plan to go? We certainly have to then start looking at that and taking stock of how we're going to get to that end point of a final draft.
R: I won't speak for Tom, but maybe a little bit. Except to say my sense from what he said is that our—this Board's relevance to the overall establishment of ecological flows is waning, from a legislative prospective, and that if we want to have the science that we have been considering—by we, I mean y'all—have been considering for the past couple of years and all of the good work that has gone into where we've gotten so far, into that legislative and that policy development, we need to have more than a one-pager. And that's not to say that we might not be able to explain to folks where we've been and where we might go, but the sense that I got from Tom today is that sending him something about this is where we might be at the end of 2014, it's not going to be—is likely not to be sufficient depending on what the 2013 legislature says.
R: I was suggesting a one-pager as a February thing.
R: Oh, oh.
R: Not as a November-December, but what can we do next. But we do need to have that conversation towards the report that would depend on modeling and other big things, but what can we do in the very short-term that shows value of keeping the lights on and the conference room scheduled.

Facilitator: And it may be that the work that we're getting ready to do, to hone down and drill down and give you a synthesis of that and then that might make it easier for this one-pager thing you're talking about.
Q: As you guys are going all through that, can you flag pieces of those documents?
R: Yes.
Q: Like, meaning, useful paragraphs?
R: In fact, how about we even go a little step further—we're going to send you out what our proposed kind of overview of what we're going to tackle and you guys can add to it, you can say you're missing this piece, we really want you to focus in when you're through these minutes and do this overview, this is the other stuff you need to be thinking about and capturing—we think we've got everything, but we could be missing it so our idea was that we were going to send it out after this meeting and give you guys a couple weeks to look at it and then just kind of tell us if we're on the right track, but yes that was the plan. And so that--

C: I figured you probably were.
R: And hopefully that would help get out what you are talking about in preparation for February and kind of supporting the idea of the one-pager.

Facilitator: Other thoughts? Either about what's been proposed or on other agenda items?
These [on the screen] are the ones that we started with and we are recording your ideas to add. Is there anything else on the agenda that we need?
Q: What about the RTI research and development project?
R: Right. I did mention that and the TNC and then the—what we'll do is sort of map out how those things will work time-wise and see where we might be able to fit the others in. The other thing that we had talked about—
Q: Do you have the dates to put in on here?
R: Yes. We're actually proposing nine meetings, so there's a lot of month to month to month, so not just every other month.
C: I'm actually counting ten.
R: Well, we were thinking that March would not be on the table, but it's up to y'all.
R: We'd better meet as many times as we can—I just—

Facilitator: So meet 10?
R: I'm not—I'm wondering if we could meet 20 times –maybe in part as subcommittees.
R: What we might do is look at where we get in February as far as our process plan.
I'm a bit concerned about getting product out. I think we need to be concerned that the legislature may check in on us in the Spring to see how we're doing.
Q: So are you really advocating meeting more than ten times?
R: I'm advocating that when we meet in February, we be as realistic and hardcore as we have to be about getting a product done in a timely fashion by the end of the year. And if it takes more than ten meetings to do it, we should have more than ten meetings- some in subcommittees.
R: And one of those could be a two-day meeting.
R: I don't want to get into what that means. I just think that we need to sit down in February and be very hardcore, iron-gutted about this thing and get it—and try and get it done.
Q: What's our February meeting date?
R: It's February 19th.

Facilitator: So these are the proposed meeting dates:
February 19, March 19, April 16, May 14, June 18, July 16, August 20, September 24, October 22, December 3.
C: They're all on the bottom of today's agenda.
Anything else anybody wants to bring up today?
Q: How many meetings have we had so far?
R: This was our 16th meeting.

R: I said hopefully at the February meeting, RTI and TNC will just blow you all away with our analyses and it will just be the spark that we need to get to the report at the end of the year.
C: We are adjourned.

Next EFSAB Meeting and Agenda Topics:
The next meeting of the EFSAB is scheduled for Feb 19, 2013 at the Stan Adams Educational Center from 9:15amuntil 4:15pm.

The discussion items for the agenda include:

- Facilitators Present Meeting Index and Results of Assessment (Survey of EFSAB members)

- Outline What Needs to Go into Final Report and Develop Time Line From Now to Final Report
- One-page Interim Report
- RTI Update Including Time-line
- TNC Progress Report
- Three-way Comparison of WaterFALL and OASIS and Gages (or time-line report if not yet complete)
- Presentation(s) on Classification Approaches?

Please remember to bring lunch and refreshments with you. Coffee will be available on site and soft drinks are ($1).

The meeting location is the Stanford M. Adams Training Facility at Jordan Lake Educational State Forest. Directions are:

2832 Big Woods Road, Chapel Hill, NC 27517
Map link: http://go.ncsu.edu/stanadams
From Rt 64 and Big Woods Road, it will be the first Forest Service sign on the right. Pass the office building and continue on through the gate to the education center.