Ecological Flows Science Advisory Board (EFSAB)
Meeting Summary
October 23, 2012
Stan Adams Center at Jordan Lake, NC

X **APPROVED for distribution**

Attendance

Members

Hugh Barwick, Duke Energy
Bob Christian, East Carolina University
Tom Cuffney, US Geological Survey
Linda Diebolt, Local Governments
Chris Goudreau, NC Wildlife Resources Commission
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
Fred Tarver, NC Division of Water Resources

Division of Water Resources

Ian McMillan
Don Rayno

Alternates

Rebecca Benner, The Nature Conservancy
Peter Caldwell, USDA Forest Service
Vernon Cox, NC Department of Agriculture
Sarah McRae, US Fish & Wildlife
Vann Stancil, NC Wildlife Resources Commission

Guests:

Ed Bruce, Duke Energy
Mary Davis, SALCC
Kyle Hall, unknown
Jim Mead, Environmental Defense Fund
Kimberly Meitzen, The Nature Conservancy
Lauren Patterson, RTI
Thomas Payne, Normandeau Assoc.
Jennifer Phelan, RTI
Haywood Phthisic, LNBA
Robert Varney, Normandeau Assoc.

NCSU Cooperative Extension 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 EF SAB will meet Nov. 27, 2012, 9:30 am- 4:30 pm at the Archdale Building Ground Floor Hearing Room, located at 512 North Salisbury Street in Raleigh. Public parking is at: www.ncwater.org/Data_and_Modeling/eflows/sab/visitorparking.jpg
(see last two pages for meeting agenda topics and location).

OCTOBER 23, 2012 QUICK SUMMARY OF DECISIONS MADE AND PROPOSED ACTIONS:

Decisions and Recommendations

A. Working Consensus Principles for Water Resources Planning of E-Flows (note from faciliators- working consensus principles are intermediary agreements of the EFSAB. These set a foundation of agreements for now as further analysis becomes available. They may be changed or new ones added)

1. Classification system of rivers and streams that incorporate geomorphology, hydrology, and biological characteristics **(full support)**
2. % of inflow as the preferred family of strategies **(lack of base support; some require additional time to process and to review some selected information)**
3. pure hydrology based classification does not work **(full support)**

Item 2: – % of inflow as the preferred family of strategies requires additional exploration and discussion. Currently there are concerns about this adopting B as a consensus principle for Water Resources Planning of E-Flows

B. Proposed Actions

1. NCDWR should distribute Hatfield & Bruce meta-analysis to EFSAB as a follow-up from Payne's presentation.
2. Papers referenced in Coastal Waters presentation to be made available to EFSAB.
3. EFSAB to review last habitat modeling results and other materials to be sent by NCDWR, to prepare for a discussion about a 3rd proposed consensus principle, % inflow as a preferred family of approaches, in November.
4. Look more closely at that SALCC southeast classifications and its potential for North Carolina, specifically what Henriksen is proposing nationally that is: explainable, understandable, and makes sense (that leads with criteria of flow variables and ties in physiographic variables). This system is fairly flexible in terms of the amount of aggregation that each state could use with regard to that classification.
5. Follow up with Mary Davis on the timeline for completion of the SALCC classifications
6. Ensure all presenters and EFSAB members are clear that the end product is a planning tool for the NC Division of Water Resources – not a policy instrument.
7. Discuss section A of the DWR Concept Paper.

Contents of this meeting summary for OCTOBER 23, 2012

Contents

I. Executive Summary

PROS AND CONS OF HABITAT MODELING AS A PLANNING TOOL, WITH THOMAS PAYNE

Thomas Payne, Normandeau Associates, Inc., provided an overview of various types of habitat modeling, and shared pros and cons of using hydraulic habitat modeling to determine ecological flows in NC. Hydraulic habitat modeling results in a habitat index related to discharge. The method has been used for 30 years and has broad acceptance as a valid approach. Pros include longevity, popularity, defensibility, and reviewability. Cons included insufficient validation for many species, costly and time consuming nature, intensive field data requirements, and requires high technical knowledge to properly conduct and review studies. The major points of his presentation were:

- Proper understanding and use of habitat models is critical
- Habitat models are not fish position models, they are frequency analyses
- Habitat suitability criteria (HSC) drive the models
- Site-specific habitat suitability criteria are much better than generic HSC
- Validation procedures for HSC rarely work
- Professional judgment- HSC can work if done with expert knowledge
- Results must make sense!

Regarding NC's stream classification effort, he recommended continuing with a hydrologic classification process, and supplement it with the following physical characteristics: Channel width; Channel gradient; Channel elevation; Pool/riffle ratio; and Predominant substrate type. He commented that North Carolina has advanced the science of habitat modeling.

Questions, Comments, and Concerns Raised
Some questions from EFSAB included: can streams be classified based on physical characteristics with the assumption preserving geomorphology preserves species? (response (R)- it's important to incorporate species responses to hydraulics, since you can't assume the species will come). How site and/or species specific do the habitat suitability criteria need to be? (R- surrogates are okay, just look to see if results makes sense). For HSCs- species v guilds, and what about mussels? (R-it's case specific, no to mussels!). How to include a margin of safety? (R-there is no one "conservative" flow, as different species respond differently to flows).

Proposed Actions or Identified Decisions to be made: none

BIOFIDELITY ANALYSIS OF STREAM CLASSES IN NC: RESULTS & DISCUSSION with Jennifer Phelan

Jennifer provided an update on the biofidelity analysis of stream classes that RTI has conducted with funding support from Environmental Defense Fund (EDF). The objective of the presentation was to adopt a stream classification system that represents the distribution of aquatic biota in North Carolina. The two components of the presentation included:

1. Compare fidelities of aquatic biota in two different stream classification systems for development in the Southeast, with EFS being specific to North Carolina.
    a. Environmental Flow Specialists (EFS)
    b. McManamay et al., 2011 (McManamay)
2. Adopt the most suitable classification system and/or modify a system to reflect biological assemblages

Seven steps of the project were outlined with conclusions. The research team was able to conduct an analysis through Step 5, which resulted in a comparison of stream classes of EFS and McManamay using USGS gage and WaterFALL hydrology data based on 147 catchments. This step of the analysis resulted in the conclusion that the two classifications cannot be extrapolated beyond USGS gage data. The research team did not conduct Step 6, assign stream classes beyond the catchments with USGS gauges given limited confidence in being able to do so. Rather than pursue Step 6 and 7, one objective is to determine how the EFSAB wants to move forward.

Questions, Comments, and Concerns Raised

1. The good news is the state did not invest money in the experiment and that the experiment resulted in information for the scientific community, including the EFSAB. Knowing what is not going to work is informative and can help direct future studies, particularly the direction in which to invest resources. RTI has additional funds from EDF to advance the scientific understanding. Please give consideration in what direction the EFSAB would like to explore.

2. Explore the SALCC's work with Henricksen; he is attempting to create a classification system for the entire country –the 50 states and Puerto Rico. He is looking to develop something that can be explainable, understandable, and makes sense.

3. The EFSAB has received confirmation twice (tests conducted with Henriksen and now with RTI), that when two stream classes are similar (i.e., minor variations in the variables that distinguish them flip streams back and forth between the classes) then it doesn't make a whole lot of difference to worry about whether they show biological fidelity or not because it is extremely unlikely that they will. We're now at the point where we need to consider other options.

> Option 1: Proceed without classes and to see if we can come up with a way of developing ecological baselines across the whole state with a modest amount of data - without using classes.
>
> Option 2: If a new classification system can be tested, start with biota and then the other four sub bullets: avoiding classes that are not robust; avoiding classes that have edges that are easily cropped, that are based on sensitive thresholds; avoiding classes that use variables that models aren't any good at; models are for the most part not good at extreme and short-lived events in the life of a stream.
>
> A new classification needs to avoid variables that are difficult to explain, not simply difficult to model. And most difficult of all, this system needs to have application across the whole state, and we're not going to get out of the fact that it's hard to do it in the coastal plain. It will be difficult to come up with a strategy in the coastal plain because things there are so hydrologically and hydraulically black given the landscape is in such altered shape, and because of tidal influence in the outer coastal plain.

4. There's some backwater that needs to be saved out of this effort though. When you work down to the McManamay information and collapse the classifications, if there is stable base flow, a lot of the hydrology is going to be similar, and if the hydrology is runoff dependent, then the hydrology will be similar. Being able to discern those two features of a given stream segment I believe is very significant. Curious as to whether there is the ability to determine:

> a. stable base flow using USGS gauges.
>
> b. stable base flow or runoff dependent stream segment using WaterFALL because WaterFALL could be extremely powerful to be used all across the state to places where USGS gauges do not exist.

This could be a simple discernment whether it's perennial runoff or whether it's stable base flow. If we can just get that far accurately with WaterFALL, using USGS to test against it to make sure of accurate predictions, then let's maintain that aspect of classification.

Impacts of withdrawal on a system that has stable base flow is different than the impact of withdrawal on a system that's dependent primarily on runoff. If we can get better at making that discernment, whether that's ecological or based on what hydrologic features are retrieved from the gauges or what we can get from WaterFALL, that will enable us to discern between stable base flows and perennial runoff segments.

5. What we're trying to do is a categorical classification on continuous data and it seems to me there are two potential problems. One is that if the data did not dome inside each category, if there is not a distinct mean and variation within each category but rather it's spread out across categories and goes from a high to a low or a low to a high, then the chance of having these overlaps is really great.

The second thing is we're using hydrological data. It seems like where we have these crossovers are in the hydrological data. Perhaps if we go to the geomorphological categorization as Fred offered in his concept paper, which is position in the landscape geographically from mountains to the coast and maybe stream water or something like that? Much more stable characteristics.

6: Observation: looking at the gauge space of the Henriksen clusters, they were actually kind of tight. But they were based on variables that were very compounded and the compounded variables weren't tight so there was deterioration. This is my non-statistical understanding.

Proposed Actions or Identified Decisions to be made:
1. Visit the Instream Flow Network (SIFN) wiki space linking the South Atlantic LCC and the topic of classification. Very information rich site: www.southeastaquatics.net/programs/sifn

2. The results of the Biofidelity Analysis of the EFS and McManamay classification determined the need for a classification system with the following criteria:

- Not based on sensitive threshold values
- Consistent and reproducible using USGS stream gage and modeled data
- Easy to understand and implement
- Can be applied throughout state
- Captures the distribution of aquatic biota in North Carolina

It is important to choose a classification system that is not based upon sensitive threshold values that easily jump between stream classes based upon the years that the climate data is taken from, or whether one uses USGS to model hydrology data. The goal is ensure the classification system is consistent and reproducible using both USGS gauge data and end model hydrology data, that it's easy to understand the input from the state perspective, can be applied throughout the state in every single catchment, and captures the distribution consistently with the overall goal of the biofidelity analysis.

The NC Division of Water Resources is in the process of evaluating other potential approaches; one way to move forward is to use the balance of the fidelity project to pursue an alternative approach.

ENVIRONMENTAL FLOWS AND COASTAL WATERS with Fred Tarver

Fred Tarver provided a presentation following up on the discussion EFSAB had regarding coastal issues. After showing a map of where OASIS model's lowest nodes are, he reviewed literature and compiled

specific information regarding other states' approaches to estuarine inflow management. Examples included inflow-based (FL Water Management Districts, South Africa), condition-based (San Francisco Bay) and resource based (Texas). Some highlights included: Most of the FL WMDs tend to choose a 10-15% reduction as a tolerable limit for reduction in flow, targeted allowable reduction in habitat was typically 15% maximum change. FL WMDs had caveats to verify the model assumptions to see if they are meeting the standards. San Francisco Bay used "near-bottom isohaline position" as habitat indicator. Texas considered commercial fishery productivity.

Questions, Comments, and Concerns Raised
EFSAB members commented on level of subwatershed detail needed in the examples, the potential need to address basin by basin or species specific prescriptions for e-flows in coastal NC.

Proposed Actions or Identified Decisions to be made:

- Papers will be made available to EFSAB.

NCDWR CONCEPT PAPER & Discussion of EFSAB Path Forward paper presented by Fred Tarver

Fred shared a Concept Paper that he developed with Jim Mead to suggest a way to move forward with stream classification, given the issues identified with the biofidelity test. This included using physio-geographic locations and physical characteristics. The paper also suggested comparing habitat model results for OASIS and WaterFALL, and to consider focusing on percent inflow as a conservative and protective family of approaches for a planning tool.

The EFSAB used the concept paper discussion as a jumping off point to discuss how to move forward. They suggested testing for consensus on several "consensus principles" as way to assist the EFSAB in providing recommendations to the NC DWR. Three principles were developed: the EFSAB reached consensus on two of them and one will require more exploration and discussion. A graphic showing a possible way to move forward was developed and is included in the complete summary of this agenda item.

Questions, Comments, and Concerns Raised
Other comments and concerns included- Don't use "runoff coefficient" when referring to "yield per square mile", as that has a different meaning. EFSAB should make a statement that mimicking the natural hydrograph is important. Monthly median should be examined to ensure that the most conservative approach is chosen for the planning tool. The EFS and McManamay classification systems should not be used going forward. It was suggested that the language used for describing the purpose of developing e-flows should refer to a "planning tool" rather than a "screening tool".

Proposed actions:

- EFSAB to review last habitat modeling results and other materials to prepare for a discussion about one of the consensus principles: % inflow as a preferred family of approaches at the November 27 meeting.

II. Meeting Summary Review: August 28, 2012

The EFSAB approved the Aug 28, 2012 meeting summary.

III. Pros and Cons of Habitat Modeling As a Planning Tool

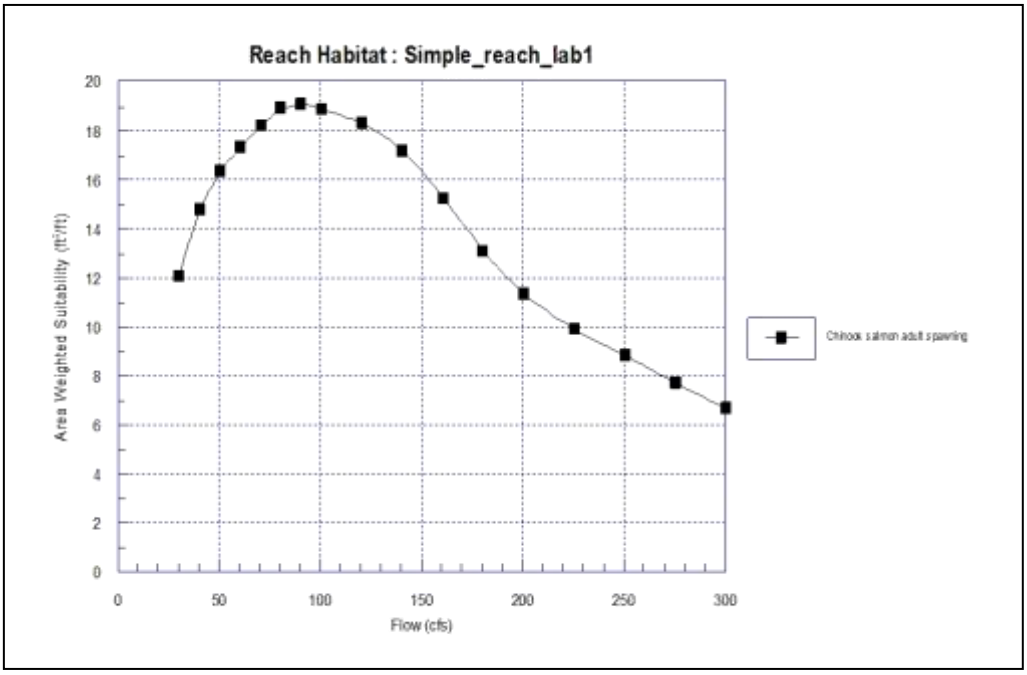
Presenter: **Thomas Payne, Certified Fisheries Scientist, Normandeau Associates, Inc.**
PPT link: www.ncwater.org/Data_and_Modeling/eflows/sab/presentations/20121023/

Thomas Payne has been developing aquatic habitat models for over 30 years. He was invited by the EFSAB to present on the pros and cons of aquatic habitat modeling. His presentation provided concepts rather than the nuts and bolts of modeling. He shared an overview of a number of tools available, the pros and cons of habitat modeling, along with qualifiers and recommendations. A summary of his presentation follows.

What is an aquatic habitat model?

> For the purpose of determining ecological flows is a tool that creates an index relationship between flow and some measure of hydraulic habitat.
>
> All aquatic habitat models assume a correlation between target species abundance or biomass and the hydraulic habitat index.
>
> Different models use different methods, variables, and degrees of complexity.

Very few, probably no, models that try to predict exactly where a fish should be. These are NOT fish position models, they are habitat indices models and those indices correlate with biomass or abundance.



Different models have methods and different degrees of complexity. You are trying to show a graph like this. Some relationship between an index (on y axis) and discharge (on x axis) - that is lower at some range of flows, higher, then lower. They don't always look like this sometimes they'll peak at lower flows for smaller fish, higher flows for larger fish, and you'll get a sense of the energetic capabilities of fish and life stages.

These are the primary tools out there:

- MesoHABSIM

- Expert Habitat Mapping
- Demonstration Flow Assessment

The first 3 are similar, essentially you are doing an empirical evaluation, the rest are hydraulic habitat modeling.

- Hydraulic Habitat Modeling
    - PHABSIM
    - RHABSIM- I wrote this
    - RHYHABSIM- out of New Zealand essentially same concept
    - CASiMiR- a German model being used extensively
    - River2D
    - EVHA
    - PHABSIM WIN 2002- there is a newer one out
    - RSS- River simulation system (from Norway)
    - SEFA- a new one I've developed that combines PHABSIM, RHYHABSIM, and adds dissolved oxygen, sediment transport, riparian, and other things elements that should be included in a riverine habitat assessment.

This is wide-spread- all around the world people have been working on this for over 30 years. Following is a description of these tools.

*MesoHABSIM(slides 5-6) (*Parasiewicz, 2001) a physical descriptor of different river reaches at different flows. You'll have a characterization of mesohabitat units. You'll walk over distances of a stream and characterize by different characteristics at different points of the river (pool, backwater, etc). You'll map it at several different flows. You'll link that with habitat suitability characteristics. All of these require assessing suitability of habitat types, hydraulic characteristics. So MesoHABSIM does longitudinal, and sometimes…it's an empirical evaluation of physical characteristics of flow. Then link that with habitat suitability criteria, and give percent of types at different flows, and calculate habitat suitability index.

Advantage: This is not abstract, you have to be physically on the river and see what is going on, see river at different flows. There is no substitute for going out and looking.

Major disadvantage: extrapolation is not possible, you don't know what happens under conditions you haven't observed.

Expert Habitat mapping

Similar, it tends to be on a smaller scale. You have to have landmarks to help you identify where your polygons are. Similar to MesoHABSIM as it's empirical.

*Demo Flow Assessment (*Railsback & Kadvany 2008)

This set up more formal approach for evaluation empirical flows and quality of habitat at different flows. He focuses most on just the aquatic hydraulic habitat, but the demonstration flow approach is also capable of evaluating aesthetics, fishability, water safety, wading, tubing-you can throw in more into a demonstration flow assessment than river hydraulics. Designed the same way- folks go out and physically ranking the stream at different flows. End up with same thing- habitat index relationship with discharge.

All 3- they are actually converging- their intention is to do empirical assessment. None of these methods get into predicting- that gets to be a problem when you try to evaluate conditions that don't currently

exist, such as really low flows or high flows. If you have a panel of people- for example the Australia EPAM requires consensus- it's hard to schedule people out there at the same time, especially in natural conditions.

***IFIM*- there is consistent, pervasive and pernicious conflation between IFIM and physical habitat modeling.**

See this flow chart called "Instream Flow Incremental Methodology" on slide 10. You start with proposed alternative, go into legislation and legal analysis, develop study objective, what are changes, geographic and temporal boundaries-all of the big things you try to look at when evaluating a particular project. IFIM tends to look at individual projects, not a basinwide planning tool- gets into nuts and bolts (read 3rd row, 4th row) it's very comprehensive.

Showed the piece of the complicated flow chart that is PHABSIM (small yellow boxes in the chart), which only included "Microhabitat suitability criteria, channel structure, hydraulics, and microhabitat area per unit length of stream". It's in the context of an overall IFIM. Determine what types of products you need- if you don't need a habitat index then you don't need to go into that, there are other ways of coming up with solutions.

There are a couple different ways to acquire the hydraulics:

1-D hydraulic habitat- creates confusion with people who think it's a formula.

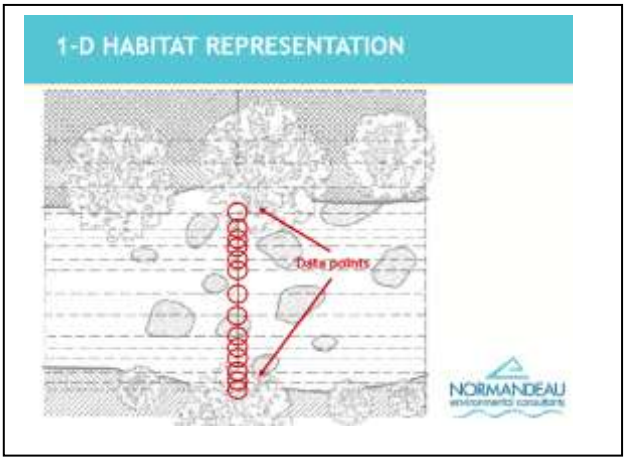
For any given vertical, it defines the bottom profile for 2 habitat types/transects located here, takes that data point and calculates V D and substrate or cover index. Every single point at every flow you want to simulate has those characteristics. The power of a hydraulic model is that you can simulate conditions you haven't observed- you can extrapolate upwards and downwards, interpolate, because it is a model and not empirical you can simulate. How does it do that? For every point at every flow you'll have Sv index from biological model, depth suitability, velocity, and substrate suitability. So you'll combine those suitabilities and give them weight based on representational characteristics of that data point…Representationally and not physically…this is a problem that how models are described in literature- you see stream channels described as trapezoids. That's not what happens- they are more complex. These are data individual points that then become a frequency analysis

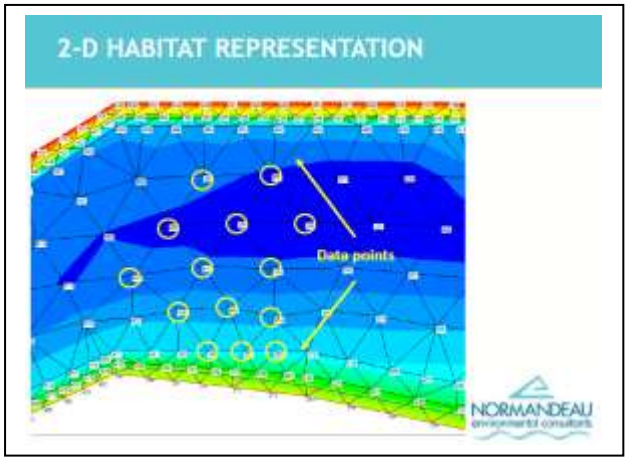
Then you generate a habitat hydraulic index, they come together with weighting to a value on the index….In SEFA we're not using weighted usable area anymore. It is not physical area, it has never been area…these are suitability weighted by the area that the point represents. We've changed the name- when you have a habitat index, the better name is *area weighted suitability*.

2-*D Hydraulic habitat*- based on complex grids, this model has rectangles and triangles- different models have different ways of representing hydraulic habitat. Every university's hydraulics engineer has different 2-D model. They all work the same, have topography, based on your boundary conditions of stage and discharge, it creates …simulate depths and velocities throughout study area. Results pretty pictures based on data points (often based on interpretation and not actual-simulated). There is no input for velocity in 2D model.

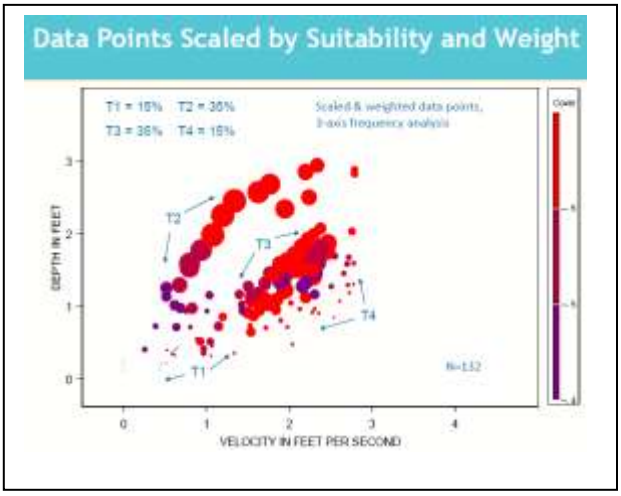
1-D habitat representation- look at the points and see the data points, nowhere else. In 2-D it's the same, every time you have a node where grid comes together, those are the data points. There are no other data points.

You get contour lines and pretty pictures and not real representations- they are interpretations between the data points. You don't know if there are actually fish there. 2-D has advantages but not the be all end all.





This is a major point- Frequency analysis of depth and velocity. Slide 16 (below) shows Frying Pan River in CO- it illustrates that it plots depth and velocity. Size of dot represents weight- bigger they are the more suitable they are. When shallow, low suitability- this species does not like it shallow, so these down here have low weight. Same for high velocity- data points get smaller. The bulk of habitat are in median depth and velocity. Color coded for different habitat sites- influences. Look at frequency analysis, then all these models work this way- this is a way of visualizing what you're getting. Good habitat is in this range on depth, this range on velocity (see the larger dots). Think of these models in this way as a frequency analysis.



All end up giving same type of result- a habitat index related to discharge.

What do you do with that?

So we have a curve…

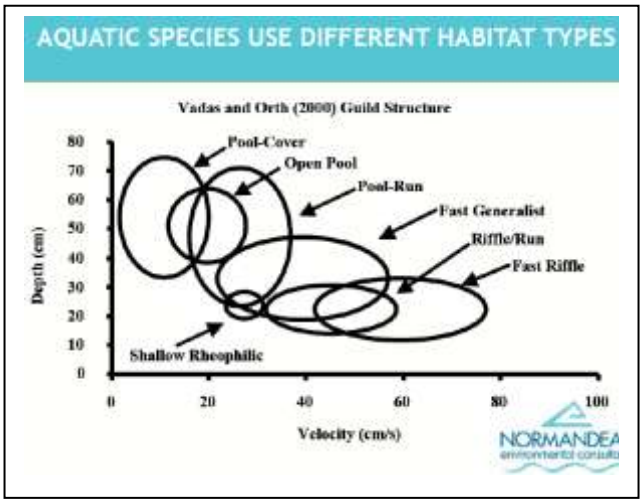
The Usual Options:

- Peak of the Curve
- Percentage of Peak of the Curve
- Habitat Time Series
- Habitat Duration
- Rule Making
- Negotiation
- Settlement/Order/Litigation(as last resort)

You get into problems of interpretation. When you run these models they are independent of hydrology. It doesn't give you availability of water, they give you instantaneous response of your hydraulics and suitability of fish, so you have to incorporate hydrology, it is a critical element. Some ignore it, there are lots of reason. There is a strong tendency to look at these indices and pick the peak of the curve, not a good idea as it doesn't go into availability of water, and you can't say if the habitat is there enough for

the species to respond to it. A lot of my work was in CA- Dept. of Fish and Game was recommending peak of curve, representing flows only there 5% of time. Their response was they were protecting for the good years.

FERC had policy of 80% of peak of curve, either way it doesn't incorporate availability of water. Where you get into the habitat time series. In NC thanks to smart people have been incorporating hydrology in interpretation. There are interpretive indices where you combine habitat and incorporate availability over time. There are several different indices have been used in NC for purpose of recommending in-stream flows. That is very positive in this region.



There are others to do it see bulleted list above.

Important questions: Do these habitat models have any validity?

What are the pros of habitat models?

What are the cons of habitat models?

Slide by Bob Vagas "Aquatic Species use different habitat types"

Describes well what we're looking for. This is a relationship between guild structure they identified and depth and velocity- they were finding different species that were occurring in different ranges of depths and velocity. It's obvious, you'll find different species in different conditions. You can see the influence of these guilds on these indices (see the red blot slide). The species tend to drop themselves out based on the hydraulic characteristics. But this one is independent of hydraulics. I'm disappointed they put a scale on the graph because its relative, to the condition of river and discharge. Keep that in mind that that's what you are looking at…there is a relationship between physical condition and habitat of fish, it is reflected in habitat models.

Validation studies- need to define because there is validation of suitability criteria and validation of habitat indices.

Positive evaluation of models (from slide 21)

- Most validation studies show that velocity, depth, and substrate or cover variables do correlate with biomass
- The existence of empirical models argues that habitat suitability varies with flow
- The common experience of practitioners is that habitat index curves do describe observed habitat conditions

There haven't been that many studies of habitat indices …because they are hard to do. It's been done for trout, smallmouth bass, benthic macroinvertebrates, but not many other species. Do you know of any others that have been tested where you get a biomass of the species for curve? Have to know the biomass of the species is as well, a drawback for instream flows in east is regarding complexity of species, how many, difficult to sample in big rivers. There are very few site specific habitat suitability criteria developed for even the most intensive in stream flow studies I've seen. It's all book curves, people get together determine what criteria should be, borrow from somewhere else, and people look

at the curves and say does this apply to our stream? It's a perfectly valid way but you have no data to support it. It 's a big drawback and means you can't really validate the studies. Without site specific criteria you can't get site specific biomass. Fact that empirical models exist is an argument that habitat suitability varies with flow. You can see when you look at it and the suitability changes. This is much more subjective. But I've seen it many times and people say why do you keep doing PHABSim studies- I've seen it many times, seen that the physical habitat and organisms out there are different amounts at different flows. I've seen it with small mouth bass in Susquehanna, in the northwest with salmon, tropical streams with gobies, tropical shrimp. Everyone I've talked to when a study is done well, these models are describing the physical conditions out there.

The pros of habitat models (from slide 22)

- Longevity
    - Still here after 35 years of experience
- Popularity
    - Most common method in U.S. and worldwide
- Defensibility
    - No court challenge has been successful (that I'm aware of)- there is enough support that it tends to be help up.
- Reviewability
    - Results can be independently reviewed – FERC makes big deal- they like them because they can see how study sites were selected, species used, model used. These models are capable of being reviewed. Can't do that with empirical models (the ones described above) you are dependent on the judgment of the people who did it at the time.

The cons of habitat models (slide 23)

- Insufficient validation for many species-
    - Only trout and smallmouth bass studied. Validity of habitat index curves is more intuitive than anything else, but if you have good criteria curves, and good representation of hydraulics on river, you'll have good models. But it's a judgment call.
- Costly and time consuming
    - Cost: $10K (if flow control and small stream)-500K+ Time: 1 month-2 years
    - Cost is largely due to field data requirements
    - Ex- Did one on Klamath River as part of relicensing- agencies required multiple habitat mapping at different flows, facilitated meetings. $1m spend on IF study. Agencies didn't like results and rejected them and went back to % inflow. Even though it correlated very strongly with habitat suitability. It was a high gradient energetic channel, not in equilibrium with natural flows, all you would get was few large fish. They wanted more fish-it was not the natural flow that was best for trout. They went with the natural flow.
- Intensive field data requirements
    - Channel topography, suitability criteria
- High technical knowledge
    - You need to know what you're doing- there are a lot of people who don't know what they are doing. If anyone pronounces it Fab-Sim they read it in a book and weren't trained in it. On the review side it's difficult.

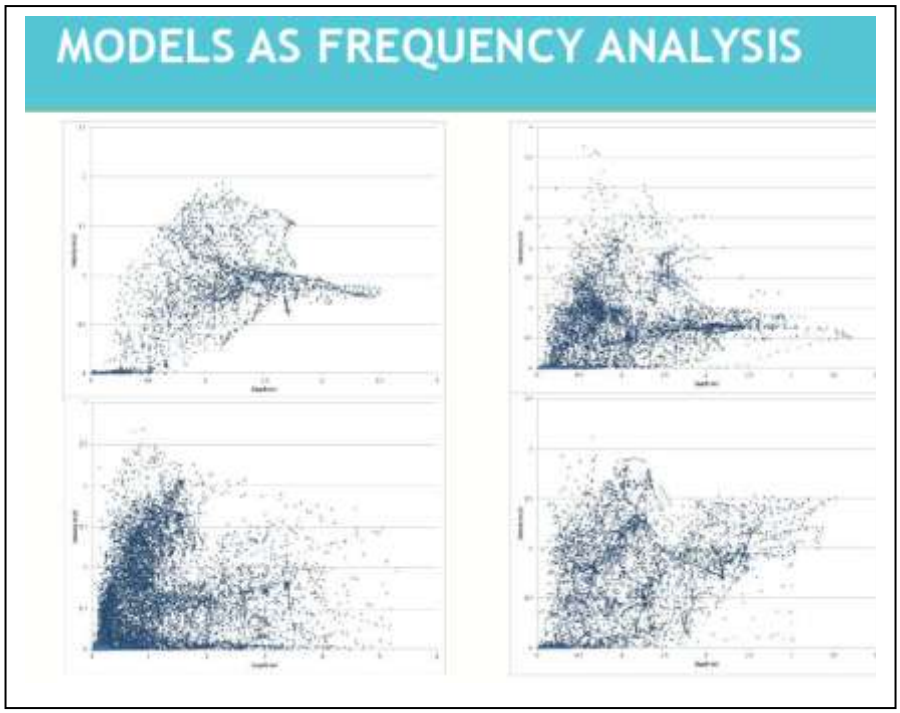
I wrote SEFA so that the method would be available on newer operating systems. SEFA It implements entire IFIM, including all the elements (legal, institutional analysis, etc) all the elements you should look at. If you want to PHABSim and go with top of curve, you can do that, but SEFA says you have to make that choice deliberately. This is not a simple thing.

Critiques are generally off-base

- Focus often on:
  - Lack of validation studies (this is legitimate)
  - Lack of instantaneous responses from organisms (takes time)
  - Non-statistical sampling strategies- just a sampling thing, the critic wants confidence levels
  - Details instead of big picture
- Few reviewers understand the models - Most reviewers have never done these studies, or understood the models. For somebody to review it who has never done it, it is troubling.
- No reviewer has ever said the resulting habitat indices are ecologically inaccurate- they may quibble with how they were obtained. It takes somebody who really knows the river to say they are inaccurate.

The Bottom Line

- **"There is a there there."**
- **Proper understanding and use of habitat models is critical.**
- **Habitat models are not fish position models, they are frequency analyses.**



What fish are sensing as to why they position themselves is much more complicated than what can be modeled. The more detailed you go, then the less likely you will be representative.

I think that's why TNC has gone to natural flow paradigm, they realize it's impossible to get to details for why fish are in certain places. Instead they said let's look at natural flow since that is what creates these populations. Flow is not the only thing, natural flow influences channel configuration, but the channel configuration is what determines habitat. Can't look at flow without channel configuration. That's what happened in Klamath- they were looking at natural flow and yet their objectives would not be met by natural flow. But the channel was too energetic to have too many fish in it.

It's *very* important to incorporate the influence of habitat models and habitat responses.

This particular plot, 2-d model shown (graphs have depth on x axis and velocity on y axis) for 4 study sites on lower Yuba River, CA. Frequency analysis, criteria curves, (this does not include transect weight).

On left top, this site has virtually no shallow habitat so will not be responsive to any of the shallow species. Lower left- you can see where this comes from. You can see that these are the physical conditions that occur at different flows, as flow changes those physical conditions changes you're your habitat suitability index will reflect that change.

Qualifiers

- *Suitability criteria (HSC) drive the models* – hydraulics are minor in comparison – you can screw up the hydraulics and you will end up with pretty much same results when you look at these frequency patterns. Much to my disappointment, studies were done using representative reach but proportion of habitats in reaches weren't representative of river as whole. I did studies and reweighted transects, but then got to habitat index and found no difference. Habitat suitability will come from those areas sampled. Total number of data points there only changes the magnitude it doesn't change the index. **Change your criteria you will change your results. Criteria are quite important.** Number of sites, sampling protocol are pretty irrelevant.
- *Site-specific HSC are much better than generic HSC*
- *Validation procedures for HSC rarely work*
- *Professional judgment HSC can work if done with expert knowledge*
- *Results must make sense!*

It's not easy to know they make sense. You can't do it unless you are very experienced biologist, or specialist…you have to know when you look at these indices and know they are describing the habitat. Example- someone put out suitability curves…I found that they kept moving up until it became white water. White water is not very fast…and the models showing it wasn't fast, and showed as suitable habitat. But fish can't see anything and don't feed there. So we went out and gathered data and showed a wonderful response. Adult curves went up and peaked, spawning curves peaked at higher flows, juveniles peaked at lower flows, fry peaked at low flow. Ah, small fish, low flow slow velocity. Juvenile bigger fish can use more area but are blown out at higher flows. With right criteria we came up with results that made perfect sense. Clearly it was a much improved knowledge. **If you come up with a habitat index, before going further make sure it makes sense. Habitat model is no good if results don't make any sense.**

Application to stream classification

- There is an additional relationship between habitat suitability and physical stream characteristics than only to hydrologic patterns or characteristics- you can have a certain pattern of hydrology, but if your stream channel is different, it will have a different habitat response that will require a different environmental flow. That's not a clear distinction because hydrology will influence stream channel. There is evidence of this.
- Evidence:
    - Washington Toe-of-Bank Method
    - Hatfield and Bruce Meta-Analysis
    - Payne AFS BioEngineering Meta-Analysis

Washington Toe of Bank Method- …they had a they regressed against several characteristics- TOB is where you drop off of floodplain, where stream channel is full they call it TOB, width of stream channel correlated with their habitat index. Method is still in use as a preliminary screening method for recommending instream flows in Washington.

Comment (C): they are trying to do more with it and tweak it some

Response (R): excellent. They can use updated methods. That is a physical characteristic that correlates with habitat suitability.

Hatfield and Bruce- in British Columbia (meta-analysis) they found strong correlation between channel characteristics. (Fred will distribute this study to EFSAB)

We found the same thing, in a couple of informal papers, if you run the same criteria through different rivers you find the same strong responses, it is a patterned response. In big rivers you'll have a peak at lower flows. Smaller rivers then that peak shifts- see strong pattern between river characteristics (I didn't tease out what the characteristic was, seemed consistent over high/low gradient, big/small rivers).

My recommendations to EFSAB/DWR:

- Continue with hydrologic classification process
- Supplement with physical characteristics
    - Channel width
    - Channel gradient
    - Channel elevation
    - Pool/riffle ratio
    - Predominant substrate type

Others? Doing hydrologic class is very important but not the whole story in protecting instream flows. Have to consider resulting physical characteristics. If stream channel is in balance with hydrology, which is more the case in alluvial systems, you're probably pretty good but you can't assume that all the time. I think there should be some other indicator that you can throw in to your classification process to supplement the hydrologic, that comes back to habitat response.

Not that many instream flow studies that are current in NC, but there are similar studies in piedmont area and different strata in nearby states. Just because there are lines drawn on a map I wouldn't worry about that. I've done studies in VA- there is a larger pool you can look at to come up with correlations. If you go by hydrology alone there will be more legitimate questioning of your relationships and e-flows. Look at physical response, which will take more research to do, I think it would strongly supplement your classification system and make your process much more defensible.

Questions of clarification:

Question (Q): Some people prefer more productive fishery as opposed to natural system: our legislation brings up many points. One of them is such things as eco flow, but in the same legislation it talks about goods and services. These are not necessarily the same thing, sounds like same kinds of concepts encountered in Klamath.

Response (R): They weren't explicit in what they were trying to accomplish. Go back to IFIM slide…very imp box is- what are you trying to accomplish? Happy fisherman, more fish, bigger fish? In Klamath

process it was never stated- I couldn't get their management objectives. I said they wanted more fish, that is typically the response. They didn't say what species or how many. The other part, this is a conundrum- you could not fish that reach at the flows they were recommending unless you were highly expert- it was hazardous. They weren't concerned about satisfying weekend fishermen. My experience is that it's very difficult to get people to say specifically what their objectives are. Major conflict was between what was showing as optimal flow for adult red band cutthroat trout- showed 700CFS was pretty good flow, above that it started dropping off. They wanted around 1500 CFS which was natural flow typical in summertime. I wish it had been more explicitly spelled out for goals and objectives. They put a rafting company out of business because the flows couldn't be provided for that long. Come back to IFIM process- if at beginning those things can be spelled out. With enabling legislation it is difficult to be so specific to guide you, you'll wind up with conflicts and you will have to define them.

CA- 5937 (A California law) says dam operators will keep fish in good condition below dam (huh- what fish, how many?). Nobody has dared litigate because they may get a definition and lose their flexibility.

Comment (C): What you've summarized to me is there is no way to escape user conflicts…

R: I was asked to recommend flows early in my career. People thought it was my opening position- you're working for a developer…it turned out to be unproductive. I've avoided making instream flow recommendations, decisions are political that are based on different objectives. It's fruitless to recommend eco flows because it is used in negotiation.

C: Does it mean we're done? It means we're no longer naïve.

Q: TNC work in NE, they made effort to class streams based on characteristics like slope, gradient, size, geology came up with color coded maps of types of classes.

R: Did it have habitat component? Only way to correlate and class back to basing on flow, need habitat…TNC what they have come up with is not an answer if not considering habitat effects, in my opinion. To set up eflow you need to know the **e**cological aspect- what are your management objectives? Species? What are you trying to accomplish? Until you know your effects on those, you are doing it without context, can't set threshold, if you don't know the response of your organism.

Q: I'm from TNC. We're doing similar study for SE for freshwater resilience. What assumption is wrong if you are preserving the stages of geomorphology, then we are preserving species/habitat?

R: The assumption has been if you build it they will come. The channels aren't the same, often the species are not the same as they used to be. So when you do it on that basis you can't assume you'll wind up with the species composition you had before. You might, but it depends on the extent of the alteration. You can do it but you are still missing the piece of response. You can do it readily with habitat model- there is a generic tool you can use- there is a strong response of species to physical hydraulics.

Q: We (TNC) want a basic model to help prioritize where to invest. When we try to do the strategies on the ground, then focus on hydraulics?

R: You can address degrees of hydraulic alterations, but that won't tell you the species that will be there. I'm not real familiar with NC, but you still have a lot of the native species, I don't think you have species brought in that are affecting the natives (C: yes, flat head). Everyone loves small mouth bass but they are an exotic predator that wipe out the natives. Theoretically you can provide what habitat used by natives, but if you have exotics… If you model habitat of target species then you will get responses based on the species. I sympathize with TNC because finding that isn't easy….I know it can be done because

I've seen too much consistency in habitat response over strata of rivers. (Showed Olympic ring slide) That's too real, that's what they use, different species respond different to different hydraulics. If you know your native and exotic species, and you know what you're changing, you're more likely to move in a way to favor one or the other. Too powerful too ignore, the tools are available. I grant you the habitat index functions aren't precise.

Q: How to do it on time scale that is meaningful. Habitat in a stream changes a lot, with storms…you would have to update habitat classification frequently-how often to sample it to know it?

R: That's why one of the components of IFIM has to do with channel structure, because there has always been an assessment you do, if channel is actively changing or evolving. If changing and in dynamic equilibrium, then the specific areas are moving around but proportions are the same and you don't have to update anything. But if you are below new reservoir and water is hungry and scouring, then it is actively changing, then you have to make prediction for it based on channel evolution. Only goes so far because nature sometimes hits reset. Ex- for my B.S. at Humboldt State, I looked at rivers, thought really nice, gravel bars, etc. Went back years later there was riparian vegetation covering everything. I first went there a couple years after 1,000 yr flood, which was a reset. It wasn't in the more stable condition. Ex- Platte River- water rights case- it is a constantly changing river. I looked at data and compared profiles- people who did studies combined results but I said you have to evaluate frequency of conditions for getting idea of channel over time. Critical element that has to be based on specifics of your system. Most of the time it is in dynamic equilibrium- pools move.

C: You hit nail on head about our purpose- we're coming off 30 years of frequent nature resets, we've doubled our population, record frequency of hurricanes and droughts, construction of large reservoirs, all of which has pointed to legislation that is trying to solve these issues. This is helpful.

C: Habitat suitability curves are critical to process, how important is it for them to be site specific and species specific. How much do you lose if you go from genus to species, or go to surrogate species?

R: If the surrogate species used has same size, feeding patterns, body shape, then you can use them. I've done studies that didn't have site specific curves- you can tell if they make sense when you look at them. An example I did work on behalf of First Nations, regarding oil sands… they used long nosed sucker as indicator- its big, lives in rivers and lakes. They said if deeper than that, they can use it. Criteria curves were broad. Habitat suitability response curves were the wetted area, it didn't drop until flood stage…so they used an indicator species that was not responsive to discharge. Stupid, predictable. I testified it wasn't a legitimate analysis. Oil talks…pipeline to bring down oil to U.S. will to continue to devastate Alberta. Results were contradictory to common sense. It's apparent when things go wrong. If you know the river and look at a habitat response curve and it makes sense, then use it. Don't ever trust model explicitly- if you can't tell if it is getting a good result, you shouldn't use it.

Q: We get them and ask what is going on- it is a transect thing? A curve thing?

R: I haven't heard any horror stories about NC. Owe it to you to have the ability and longevity to focus in on those issues. NC has advanced the science…willingness to do that is important. I've written articles, in other places you'll have a consultant doing study who has been indirectly trained and won't know what they're doing. They'll send it up to people not capable of reviewing it until it goes up to FERC or courts. Takes considerable knowledge to recognize those issues, mistakes. If you have good criteria and agreements on results, you're likely to have a good decision made.

Q: We'll wind up with classification system- what should we be looking for in terms of results of habitat sites. Within classes in order to establish whether classes are working…what criteria should we use?

R: Start with hydrologic class, then look at physical characteristics of streams that fall out into different classes, then use the other elements you're talking about, gradient, riffle, then see if they are consistent in the ones you've classed. If there are discernable patterns in same in class (in gradients like canyon and alluvial, which need different e-flows as a rule for ex because channels are not responding equally to the flow) then you may want to subdivide based on those characteristics. That would be an improvement in short term as it is readily available …wouldn't tell you the habitat response, that is a bigger task, hasn't been done yet, can be done, TNC may be one to pursue it. Seems their job is not complete unless they consider habitat responses. It will happen but not within your time frame. If you look at channel characteristics in your categories, and you can say- yes same watershed area, whatever physical parameters are- that would give you some idea as to whether physical habitat is responding in same way to the flow patterns you've used to classify streams.

Q: Can we take the sites we used to develop hydrologic classifications and try to get this information on variability?

R: Any time you start collecting data on habitat response and hydraulics of stream and assess habitat response you will be better off. That's why this process was developed and why it's been around for so long, it generates powerful info on a site specific basis but it's not cheap. It's getting better, especially with Doppler- very useful as a technological advance. Some of 2-D modeling can be used with LIDAR that can penetrate water to get depths. Getting more feasible to collect data but not cheap. I'd like to see more site specific criteria, but it's hard, visibility is crummy, rivers are big, there's no money. Habitat response is the missing piece in these types of analysis.

Q: Do you have preference for guild vs. individual species criteria? We're looking at broad brush to look across state. Are there any canaries in coal mine, stressed species to key in on?

R: It's too case specific. The general answer- if you have endangered species that will drive your system anyway so try to get data on that. You don't want to use generalists for indicator species (catfish, sturgeon). I like guilds, nothing wrong with guilds, they do fall out. You can say you will find certain species within those ranges of the Venn diagram (Olympic ring slide). It will happen. Look at the circle – looking at probability in the circle of the diagram- if you get out of the oval in depth or velocity you have declining availability. So the extent of your capabilities I don't have problem with guilds, especially if you have several, then you'll have some idea of what types of species will be responding to the change.

Q: What about mussels, more sedentary species?

R: I have done studies and have no faith. Mussel is there because that's where it settled out from host species. It stayed there because it could stay over the range of condition. Some mussels will move, but there is not enough of a direct correlation between location of mussel and hydraulics for me to be satisfied …need to have pretty strong correlation like those Venn diagrams. Hell benders, crayfish are similar- with benthic species it becomes different as they move around, they don't care about depth.

Q: Big picture question: one approach we're exploring is to pull in multiple site specific studies using guilds, generic HSCs, that would be same at all multiples sites, and seeing if there are common trends in way the pool of sites responds to particular flow (old school flow, % ambient,) then the whole idea behind class is to parse the pool into groups that have similar trend response to that set of e-flows. Are you aware of anyone else doing it? What do you think?

R: Good first step, only people before is me, and Hatfield and Bruce who did meta analysis. Be careful, you mentioned using same criteria across strata. Some species change their suitability and use of habitat based on characteristic of river. Ex - Snake River adjudication- lawsuit about instream flows on Idaho- (habitat suitability curves) used on all streams. So we looked at site specific criteria (60

streams)- 3 different criteria occurred- fish were using habitat different. In small rivers they were hiding behind boulders and moving laterally to feed. In big rivers they were hiding behind rocks deep enough so they'd feed vertically. Mean column velocity was lower in the bigger river. Have to be careful of that, not try to evaluate response of tiny brook vs major river with same criteria unless you know they will use the same type of habitat. It's relative to the conditions, it's not relevant to having values.

C: I tried to make the same point at our last meeting- we need to take values off and make it scalable.

Q: If you have perfect knowledge you have perfect accuracy, we're working with less than perfect knowledge. Is it a linear relationship or are there key thresholds as you move up that predictability that we have to watch for. Having less knowledge about HSCs is more critical than hydrology.

R: You never get perfect knowledge. I studied trout behavior for my M.S.- tried to get it down but still a probability of response- all trout don't respond same way to same circumstances. Even if you did you do with political interpretation, prioritizing species, getting objectives. We have computer capability to look at hydrology in great detail, hydraulics in great detail, we know enough about species response that we have a pretty good idea of that component. It's not completely predictive, there are always unknowns. I'd like to know more about the predictive response of organisms to different flow ranges. We don't know enough about that. We're at a plateau right now…adding the habitat response we have, that will be another threshold of knowledge, beyond that we need to know the time scale of response…I've worked in systems where in low flows- some the trout die, some they hang in pools together and survive... We need to know more about biological response and correlating to different flows. That will be another threshold. Beyond that I don't think we'll go very far, as it will fall on politics.

Q: What role will the meta analyses, instead of in supplement to flow alt biological response analysis, in supplement to the flow response…what do you think (couldn't hear question in recording)

R: it's always possible to know a lot about individual systems, especially if water quality is important. Can do a model of that and get better idea of flow response. If you're only changing flow and not other variables, I don't think you can do it without going to a habitat component of it. You can do it when looking at more than hydraulics….

Q: Appreciate you'll have changes in flow based on channel type….absent change in flow and express your predictive variable as a change in flow as opposed to CFS and link to biological response….

R: There are too many components of flow- 67 characteristics of flow. USGS has one >100 as well. There are different ways of characterizing flows. I have seen indicators of hydrologic alteration used…people end to say we're built into flood plains so we can ignore channel forming flows since we're not allowing them, but some can be critically important…ex- flows that go up onto hot rocks can warm water and kill fry. In different circumstances, different parameters become more important.

Q: IFIM is about your management objectives, species objectives. I don't see how those will be similar enough across geography and uses in NC that we'll be able to approach it without classifications, sub classifications, objectives, sub-objectives.

R: The coarser the classification, the more exceptions there will be within your categories.

Q: Where is your model SEFA available?

R: On SEFA.co.NZ it is hosted in NZ because I couldn't get the URL in U.S. It's available now, it's cheap, especially for multiple copies, I'm just trying to cover costs. I formed my own company, designed to

support and improve SEFA over time. It's not a fixed model. Plan is to have technical committee to decide if we should add an element or not. $295 for a copy.

Q: Getting in the weeds- the different indices, A, B, C- what's been your experience on advantages and disadvantages- what do you use?

R: I don't use them outside the Southeast, mostly because agencies don't accept them. 1) They didn't have advantage of Instream flow group coming to teach time series and interpretation. If you're not exposed they will get thrown out . In CA they didn't accept time series. And the indices are based on time series. My experience is from a review capacity, think what they do is evaluate persistence of habitat over time, good idea if there are not limiting events on either end. C is the lower half. They exclude the 10%- the 10% can override the other 90%…you can use to look at persistence of habitat but be careful you're not overlooking bottleneck events. If looking at a new dam, and using an index C you're not picking up on the fact that the high flows are happening and channel evolves- fish communities, water temperature will be different. Use indices contingent on context of your studies. As far as habitat index, generally those extremes won't change very much so I have no problem using them- they are valid, not used widely at all.

C: We use them here, we're using B.

R: Looking at habitat over time is a critical component. Why I haven't heard horror stories about NC.

Q: Is there way to build in margin of safety, like EPA and chemical criteria. We're trying to develop screening tool, with a well defined margin of safety. How to achieve that?

R: With a margin of safety you wouldn't get those extremes. If you take out channel forming events because of storage you have to put them back in, will get that margin of safety in response curves. More safety for one is a margin of disaster for others…I don't know what a conservative flow means. if you have habitat responses, and know what they are, it can be a negative to have a higher flow and call it a margin of safety, you can be doing worse things on either end. When EPA looks at those rules, they are looking at sensitivity, so they add margin of safety which can be more dilution (of pollution). With flows it gets much more difficult. The greatest failing in stream flow science has been (in not) following up after predictions. A lot of people don't want to know, in case they've been wrong. It's expensive, takes time. Licenses don't often have those provisions. We don't know our track record for making flow recommendations. I've only done a couple in my career.

Q: We've made all those mistakes in management of the Roanoke River- we have flushed out larval striped bass, took decades to work out flow regimes, we're still working them out.

R: You need to know what the biological responses are for the management objectives. I've done competing flow studies…in this country there are lots of lawsuits and money spent on that… but on monitoring? Never mind. Unless it is clear you are flushing things from system but then you need to monitor it to know it. Don't think you can put in margin of safety. You should do adaptive management where you do releases and then monitor response. That's difficult, because once you decide a flow they let you test a higher flow but not a lower flow.

Q: We have existing dams but are being asked to take them out of equation and consider impacts of withdrawals and volumes of withdrawals will have affect on system. Also directed not to think much about channel forming flows because we're talking about withdrawals.

R: Withdrawals are difficult especially if they're small in relation to the system. Also in-stream flows aren't compatible with rules that require rigid limits…that say this is your minimum flow…may or may not be supported over time…you can't be adaptive to that…

You don't know what the flow will be instantaneously….if you're flexible in measuring the inflow and doing it instantaneously, you can set a rule like that but generally water law is not compatible with that kind of flexibility, nor are operations. I don't have enough storage to supply the city, but you tell me I can't take any more water? There is a mix in how they are operating.

Q: Our synergistic regulation we're not protecting water quality below 7Q10, as we move we have competing rules as well.

Next June in collaboration with American WRA there is a conference on in-stream flows in CT- topics include 1) technological advances- what's new in data gathering and analysis 2) how are agencies dealing with things- rules, - maybe your experience would be good for presentation 3) industry- whether they can implement some of the regulatory responses coming down. We just talked about those examples- hydro dams- operator and infrastructure may not be there to respond to regulatory advance.

The facilitator asked members to write down their responses to questions on flipchart: *In hearing this pres, what is useful in helping us move forward with the screening tool? Reponses included:*

- importance of species/site specific HSC
- expanding hydrologic classification with habitat relevant parameters
- cost of site specific flow/habitat studies
- impact of legislative decision off science
- how reasonable is it to develop categorical classification on:
    a. hydrologic variables that do not "clone" (have distant means and variation) within categories?
    b. relatively short-term and variable attributes (i.e., hydrology)
- Maybe only geomorphology without hydrology should be used

IV. Biofidelity Analysis Of Stream Classes In NC: Results & Discussion

Presenter: Jennifer Phelan, Research Scientist, RTI
PPT is at: www.ncwater.org/Data_and_Modeling/eflows/sab/presentations/20121023

Objective: Provide update on the biofidelity analysis of stream classes (i.e., present the results comparing the EFS and McManamay stream classifications and classifications determined using USGS vs. WaterFALL data)

Jennifer began her presentation by reminding everyone about the objectives of the project which is to adopt a stream classification system that represents the distribution of aquatic biota in North Carolina.

There are two components to this work:

1. Compare the fidelities of the aquatic biota to two different classification systems:

   a. Environmental Flow Specialists (EFS)
   b. McManamay System (2011)
   for development in the Southeast, with EFS being specific to North Carolina.

2. Adopt the most suitable classification system and/or modify a system to better reflect the biological assemblages.

Jennifer outlined the seven main steps of the project, including the steps that are completed and those remaining to analyze.

Step 1: Determined the catchments that could be included in this analysis.

The focus was on the catchments that are minimally altered, with respect to water quality and flow condition. Given the variety of criteria, it was determined that 1,094 NHD+ catchments could be used in the analyses.

Step 2: Linked these catchments with aquatic biota data for the fidelity analyses and then link with benthos (1,094) and fish (416). Because one criterion used to determine water quality was linked to benthic site condition, there is a one-to-one match with catchments and benthic monitoring stations resulting in the ability to identify 416 fish monitoring stations in the 1,094 catchments. These are associated with different federal and state level monitoring programs.

Step 3: Conducted preliminary statistical analyses of biological fidelity to test analysis framework. This was done on subset catchments that included the EFS stream classes. A total of 106 of these catchments actually had benthos data associated with them; the analysis was conducted at the individual species and community levels. Credit is due to Tom Cuffney for his analysis and contributions (presented several months ago to the EFSAB).

Step 4: Compared the stream classification systems – EFS and McManamay.

An initial comparison of EFS and the McManamay Systems yielded that the two systems are quite similar. Both classification systems focused on flow metrics. The resulting assumption is that if these classification systems are similar, the fidelity analysis can be conducted on one system. If the two systems were distinct enough, it would make sense to conduct a fidelity analysis on each of them to determine if one resulted in a better fidelity than the other. The distinctions about the systems included:

- **EFS System** was developed in North Carolina to support environmental flow determinations. It was developed using USGS Gauge Data with strict locations with stable load conditions (meaning that the load conditions had not altered for an 18+ year period and this equated to 185 gauges). Hence, the classification system was based upon 22 ecologically –relevant flow metrics in North Carolina and resulted in 7 classes:
  - Small Stable Streams
  - Medium Stable Streams
  - Large Stable Streams
  - Coastal Streams
  - Large Piedmont Rivers
  - Small Flashy Streams
  - Small Seasonal Streams
- McManamay System was developed for the Southeastern U.S. by Ryan McManamay and others, and encompassed an eight state region in the Southeast. It was also developed using USGS gauge data restricted for minimally disturbed, unregulated stream conditions and

there are 292 gauges used in this classification system. It was also based upon 9 ecologically relevant flow metrics that were used within the higher logic classification tree. Originally, 66 metrics in a cluster analysis were used and later reduced to 9 predictive metrics using this classification tree. They were able to determine 8 different classes with 6 as the main ones.

- Intermediate flashy
- Coastal/Intermittent
- Stable High Base Flow 1
- Stable High Base Flow 2
- Perennial Runoff 1
- Perennial Runoff 2

Compare stream classification systems:

- EFS and McManamay
- classifications determined using USGS gage data
- 147 catchments (restricted to catchments with 15+ years of USGS records between 1960 – 2006)

The comparison of the two stream classification systems, EFS and McManamay, was completed using USGS gauge data. A total of 147 catchments were used within North Carolina (selection of the catchments was restricted to catchments with 15+ years of USGS records ranging between 1960 and 2006). Completing a cathostatistical analysis [Slide 8], the similarity in the e stream classes is evident but the findings were not significantly related, meaning the classification systems are not the same.

The cathostatistic was negative .145. When a cathostatistic value is one, it means it is a perfect match. A cathostatistic of zero means that there was not a significant match or the matches that would occur are due to random chance (a cathostatistic can be biased by zero values). However, a visual comparison of these different classes results in noticeable differences between the classification systems. The conclusion is the classifications are dissimilar enough that biological fidelity analyses should be conducted on both of these classification systems, meaning the classifications are independent enough that maybe there is a better fidelity for one of these systems over another.

Step 5: Compare stream classes of EFS and McManamay using USGS gage and WaterFALL hydrology data based on 147 catchments. CONCLUSION = can't extrapolate either classification beyond USGS gages

The initial idea was to compare the stream classes using USGS gauge data versus waterfall hydrology data. However, even though the EFS and the McManamay Systems are built using USGS Gauge data, this would have meant assigning stream classes to the 1,094 catchments and presumably all the catchments within North Carolina. Since the 1094 catchments do not have USGS Gauge data, it would be necessary to gain data from an alternate source, presumably model hydrology data. Before classifying every single catchment, the goal was to determine how well does the model hydrology data reproduce classifications based upon the USGS Gauge data? This comparison was completed for both EFS classifications and McManamay classifications using the 147 catchments used in the Step 4 analysis. [Reasoning: the restriction to the 147 catchments was to use catchments that had USGS reference between 1960 and 2006 because that is the data range that waterfall has data for, climate data flow for. This resulted in comparing apples to apples.)

For the EFS Classification, comparison based on USGS data and WaterFALL data:

- Only 49% match
- Stable streams (B, F and C) are sensitive to the median base flow metric
- Flashy streams (D and A) are sensitive to the Very High Flows (>90th percentile) metric

The table summarizes the results for all 7 classes and the percent of the match rates, ranging from

0-93%, with an overall total of 49%, which is very, very important and a concern. Some interesting results included:

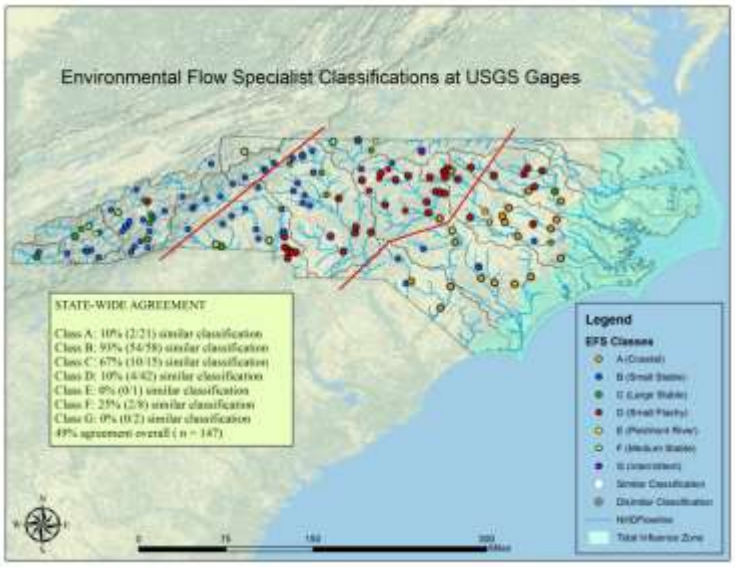
EFS Class	**% USGS – WaterFALL Match**
B - Small Stable	93% (54/58)
C - Large Stable	67% (10/15)
F - Medium Stable	25% (2/8)
D - Small Flashy	10% (4/42)
A - Coastal	10% (2/21)
G - Intermittent	0% (0/2)
E - Piedmont River	0% (0/1)
Total	**49% (72/147)**

- The general trends is there is a higher match with the stable streams and a much poorer match with the small, flashy, and coastal streams, and the Piedmont representations were not that high.

- There were some interesting trends in that there appeared to be some very, very sensitive flow metrics that would easily push over…you could baseline one stream class or another very easily because the data was quite clustered around that threshold, and we found this particularly for a couple of the metrics mainly for the stable streams classes E, C, and F. These were very sensitive to the median base flow metric and that shifted less than 10% of the data from the USGS and waterfall data points between stream classes. That is a very sensitive threshold that could easily cause a jump between the stream classes.

- Similarly with the flashy streams, classes D and A, there is a sensitivity to the very high flow, the 90 percentile metric. This was a concern, showing that even within USGS gauge data or waterfall data there are a couple of metrics that could easily fall on either side of the stream class. This is in line with some of the investigations conducted by Sam and Jim with EFS, looking at how stable the stream classes were in general.

So if you change the date range of your records, using USGS records, how stable were the stream classes, how repeatable were they? If we took a 80-year time period and varied the period of record that was used to determine stream classes and then used a 20-year period throughout that 80-year record, the finding was that in some cases, they jump classes and change classes. Increasing it to a 30-year record reduced the number of stream class jumps; increasing it to a 40 year record it was much stronger. Nevertheless, that basically also shows that this classification system was very sensitive to changing the period of record, further supporting the concern that there are these very sensitive thresholds which result in an inconsistent stream classification.



This slide [Slide 11] illustrates how the stream classes fell across the landscape. You can see here on the legend that the different dot colors represent the seven different stream types and it might not be very easy to see given the light and the resolution of how detailed the map is.

However, behind each colored dot is either a gray or a white background. The white background represents situations or locations where both USGS and the waterfall data result in the same stream class. The gray shows a similar classification where they were not the same. Moreover, you can see in general that there was a higher match in the mountains and then a decreasing frequency of match in the piedmont and the coastal plain.

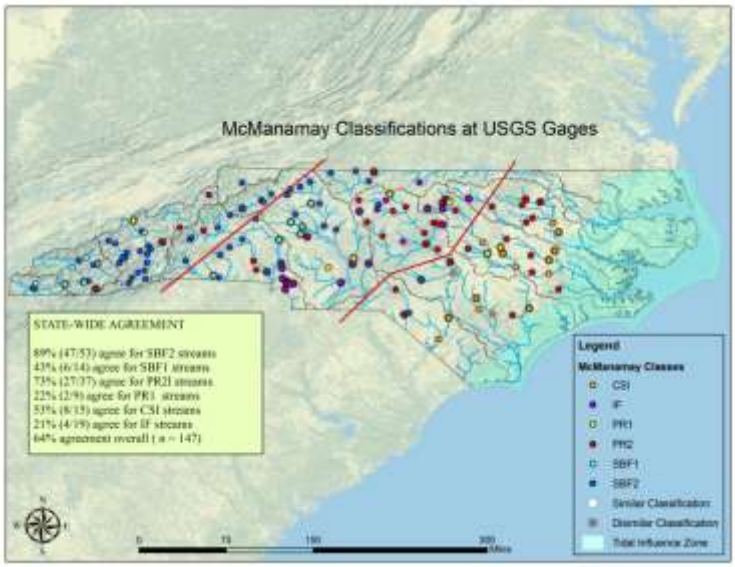
For the McManamay Classification system, once again looking at how well the classes could be determined using USGS versus WaterFALL data.

- Only 64% match
- Thresholds of classes sensitive
- McManamay found classification tree resulted in 66-80% accuracy in assigning USGS gages to classes

McManamay Class	**% USGS – WaterFALL Match**
SBF2	89% (47/53)
PR2	73% (27/37)
CSI	53% (8/15)
SBF1	43% (6/14)
PR1	22% (2/9)
IF	21% (4/19)
Total	**64% (94/147)**

Once again presenting the results in the tabular form, presented are the 6 main McManamay classes and the percentages of the matches. Here they were slightly better, ranging from 21% to 89%, with an overall total match of 64%. Certainly, not quite as good as one would prefer. Similar to the EFS classification system, there was a sensitivity right at the threshold value levels as a stream class jumped both for USGS gauge data and for waterfall data so it was consistently WaterFall or USGS. McManamay described in his paper that the classification tree and the nine ecological irrelevant flow metrics, had an accuracy that ranged from 66%-80% in assigning USGS gauges to classes; this is a level of error that's associated with the McManamay system in general.

The following slide [Slide 13] shows the physical distribution of the points across the landscape, and once again having a greater similarity in the USGS versus WaterFALL classifications in the mountains and less so in the Piedmont and the coast. That's consistent. In working with the classification a bit more, there was an effort made to improve the matches by grouping some of the



classes together. For example, what would occur if the stable base flow classes were grouped together with the perennial classes – would there be an improvement in the accuracy of the matches? There was an improvement; it improved the matches up to a level of 76%, ranging from 21-99. So the stable base flow really improved dramatically though still not very comfortable with that level of matching.

Q: Was that equally true with EFS? Were you able to combine small and large?

R: We did not pursue that as I recall. We completed that step and the conclusion from that is we can't confidently extract either of these classification systems beyond the USGS gauges. This adds problems and challenges to the remaining steps to this fidelity analysis.

Step 6: Assign stream classes to all 1,094 catchments

Step 7: Conduct biological fidelity analyses to determine fidelities of benthos and fish to the stream classes

The next step, Step 6, was to assign stream classes to all 1,094 catchments and then in Step 7, conduct these biological fidelity analyses. However, the research team did not actually assign stream classes beyond the catchments with USGS gauges given limited confidence in being able to do so. Rather than pursue these two steps, the objective is determined with the EFSAB, how to move forward.

There is a need for a classification system with the following criteria:

- Not based on sensitive threshold values
- Consistent and reproducible using USGS stream gage and modeled data
- Easy to understand and implement
- Can be applied throughout state
- Captures the distribution of aquatic biota in North Carolina

It is important to choose a classification system that is not based upon these sensitive threshold values that easily jumps between stream classes based upon the years that the climate data is taken from or whether one uses USGS to model hydrology data. The goal is ensure the classification system is consistent and reproducible using both USGS gauge data and end model hydrology data, that it's easy to understand the input from the state perspective, can be applied throughout the state in every single catchment, and captures the distribution consistently with the overall goal of the biofidelity analysis.

The NC Division of Water Resources is in the process of evaluating other potential approaches; one way to move forward is to use the balance of the fidelity project to pursue an alternative approach.

Question (Q): What is it about the mountain area? It appears to show the mountain systems have a better predictive power than in the Piedmont and the Coastal Plain. Is it geomorphology in the

mountains being more consistent and that may lead to better predictive capabilities? What is it about those systems?

Response (R):I can think of two things. First, I believe it's one predominant stream type, the small stable streams, as far as flow metrics are concerned in the model. Therefore, it is more consistent from that perspective. In addition, as you move down the Piedmont and the coast, you have a lot more instream flow alterations that are influencing the streams. Moreover, because we have to use estimates based upon monthly records, the daily accuracy might not be as good as the USGS daily records. Therefore, there is more of an influence on instream flow alterations in the Piedmont, the coast and your mainly small stable streams in the mountains that have easier to model flow metrics.

Q: Is that true for WaterFALL? Are you all able to model it? Is that what you're saying too?

R: Yes, that's my understanding.

Q: Were these sites chosen for their flow alteration or were these chosen for their representing natural flow?

R: These are all the USGS locations so they are everything that we could include within the 1960-2006 data. We have also included instream flow alterations from the daily state data for withdrawals and discharges.

Comment (C): I'm inclined to think that the further east you go, the more modified the streams are, and the more modified landscapes are around the streams which include impervious surface and agriculture. However, that is not going to be captured in withdrawal scenarios besides broad estimates, right? Do you include an agricultural estimate?

C: We are basically relying upon the equality of the instream flow withdrawals in the estimates that are included in the modeling and the accuracy of those.

R: Oh yes, definitely. Land cover is very well represented in the model.

Q: As far as the withdrawal?

R: Only in the state database, which is spotty; it's not consistent.

C: Thank you Jennifer for the presentation on classification and fidelity experiment. The good news is the state did not invest money in the experiment and that it was just that, an experiment to provide the scientific community, including the EFSAB, with additional information. Knowing what is not going to work is informative and can help direct future studies, particularly the direction in which to invest resources. RTI has additional funds from EDF to advance the scientific understanding. Please give consideration in what direction the EFSAB would like to explore.

C: During the call with the South Atlantic LCC (recall Mary Davis has presented to us and been on several webinars), we learned that there is a continual need to look at the classification system in a general sense. This group has gone back to Jim Henriksen and he is now trying to create a classification system for the entire country –the 50 states and Puerto Rico.

They are coming at this, in a different way. In North Carolina, one approach is to crank it through the computer and let it spit out classifications. Instead, the SALCC is determining criteria up front. Essentially what they are calling a size attribute of mean daily flow and then a couple of others – a variability attribute, is a mean daily variability flood frequency, and a flood timing attribute. There may be other details so this is a brief overview. They haven't put out a document yet but have started out with about 7,400 gauges. Most likely they may use a similar approach to TNC – the use

of overlays and other attributes like temperature and geomorphology. This study is going on as the EFSAB has its discussions. What this says is that everyone is trying to get at a classification system with similar criteria. Hence, the EFSAB is not alone in its deliberations and thus there may be additional resources that the EFSAB can tap into.

Questions of clarification for Jennifer on her presentation, what was accomplished, and the findings that resulted?

Q: Do you have any biological data- benthos or fish data that you can tie to the gauge data?

R: Yes, there was definitely benthos behind the six catchments.

Q: So could you use the biological data with the gauge data to see if there is any kind of relationship between the classification and the biology? Just using the gauge data versus the waterfall data?

R: So basically, identify the EFS classes and then how would we extrapolate them?

C: For instance, early on in your presentation you had a secondary objective list to determine whether there's a connection between the hydrological classifications and biological classifications. Right? So could you use the gauge data with the biology data with a smaller number but see if there's any kind of relationship?

C: The EFSAB did talk at one point about a working hypothesis: that the EFSAB did not expect to have a great matchup between the EFS classes and biotic distribution until the EFS classes were further manipulated. The EFSAB discussed the strategies for doing that manipulation, including subdividing them according to physiographic province or according to eco region. I believe we considered 6 options to use as topoedaphic variables on the landscape and subdivide these classes. We did not do that because the earlier tests failed and so it just did not make a whole lot of sense to carry on down that road.

R: And further, the 106 catchments used in that test were a combination of both altered catchments; the ones that did not meet the criteria for water quality or its flow alteration plus those that did. Recall, 58 of those 106 actually met those minimally altered criteria so it even further restricts the number of data that could be used to try to take out the other sources of variation.

C: Bottom line is the EFSAB has received confirmation twice (tests conducted with Henriksen and now with RTI), that when two stream classes are similar enough so that minor variations in the variables that distinguish them flip things back and forth between the classes, that if the classes are not distinct enough, then it doesn't make a whole lot of difference to worry about whether they show biological fidelity or not because it is extremely unlikely that they will. From my perspective (Fred Tarver), we're now at the point where we need to consider other options. One option is to proceed without classes and to see if we can come up with a way of developing ecological baselines across the whole state with a modest amount of data - without using classes. Another option, is if a new classification system can be tested, start with biota and then the other four sub bullets, avoiding classes that are not robust; avoiding classes that have edges that are easily cropped, that are based on sensitive thresholds; avoiding classes that use variables that models aren't any good at; models are for the most part not good at extreme and short-lived events in the life of a stream. That third bullet is easy to understand and implement.

I have gone through the McManamay classes and the EFS classes, and would be terrified to try to explain to a roomful of people as smart as you what some of those compound variables actually mean. Therefore, I think the new classification needs to avoid variables that are difficult to explain. Not only variables that are difficult to model but variables that are difficult to explain. And finally and most difficult of all, it needs to have application across the whole state, and we're not going to

get out of the fact that it's hard to do it in the coastal plain. I just don't think we're going to come up with a strategy that is easy to do in the coastal plain because things there are so hydrologically and hydraulically black given the landscape is in such altered shape, and because of tidal influence in the outer coastal plain. There are some distinct challenges ahead of us.

C: I think that there's some backwater that needs to be saved out of this effort though. When you work down to the McManamay information and collapse the classifications, if there is stable base flow, a lot of the hydrology is going to be similar, and if the hydrology is runoff dependent, then the hydrology will be similar. Being able to discern those two features of a given stream segment I believe is very significant. I'm curious as to whether there is the ability to determine a stable base flow using USGS gauges. I'm also curious whether we can make a simple discernment between stable base flow or runoff dependent stream segment using WaterFALL because WaterFALL could be extremely powerful to be used all across the state to places where USGS gauges do not exist. This could be a simple discernment whether it's perennial runoff or whether it's stable base flow. If we can just get that far accurately with WaterFALL, using USGS to test against it to make sure of accurate predictions, then let's maintain that aspect of classification. Impacts of withdrawal on a system that has stable base flow is different than the impact of withdrawal on a system that's dependent primarily on runoff. If we can get better at making that discernment, whether that's ecological or based on what hydrologic features are retrieved from the gauges or what we can get from WaterFALL, that will enable us to discern between stable base flows and perennial runoff segments.

C: So perhaps not necessarily using the exact same flow metrics here but using some other way to distinguish between those main stream types.

C: What we need is a system similar to what Henriksen is proposing for the entire country that can be explainable, understandable, and makes sense (similar to what they are trying to do; that leads first with criteria. The first two criteria are very doable with WaterFALL - mean daily flow and mean daily variability. So what is the range of variability of your mean daily flow across the year? So does it change a lot or a little? That's a central tendency metric if you're not dealing with whacky things on the end. Other things might be more difficult. Flood frequency would be more difficult but flood timing wouldn't be since it's a seasonal thing. I think it's worth pursuing.

R: I agree with you quite a bit. One of the strengths of the classification system that SALCC is proposing is leading with criteria of flow variables but they are also tying in physiographic variables as well. This could result in a strong classification. The other thing that I think that is really good about or that can be helpful is, is the system could be fairly flexible in terms of the amount of aggregation that each state could use with regard to that classification. This may result in more variables and fewer classes and/or subdivide it out and have fewer variables per classes and have a larger number of classes. It is a very flexible system and they are intentionally producing a flexible system so that individual states can use it to fit their needs. I believe it would benefit the group to look more closely at that SALCC southeast classifications and its potential for North Carolina.

Q: What's the ETA of it? How many months away are they from working on it?

C: Most of it's done though do not know the final ETA. The physiographic classification is largely done, the geologic subcomponent, and they are working on hydrologic classification. We could ask Mary Davis what she thinks that that might be. The classification for the TNC project that I'm working on should be available next spring.

C: In her talk or follow-up, Mary Davis mentioned one of the problems they were having was in terms of temperature. Guess she was using air temperature to get a handle on water temperature?

C: We took the Northeast temperature classifications and applied them in the southeast; essentially two-thirds or more of North Carolina ends up warm and so what Mary wanted to do was to see if we could further separate that out.

C: So with the SALCC Southeast classification what we're going to do is investigate whether splitting out the warm temperature a little bit finer. Does it make sense that everything essentially from Burke County all the way to the coast is essentially the same temperature?

R: It's a bit more like saying where the influence starts coming in.

C: They're going to look into that more and try to use the air temperature correlation. Note: the Upper Dan has trout water and that's been captured in the assessment.

R: They have also included drainage area or the size classes on it. For the geology component, they basically did the geology regionally by going to different states with different levels of scales of available geological data so they grouped the similar units as best they could to have a complete regional classification of that.

Q: In the use of WaterFALL and USGS gauge records, is there the ability to match waterfall gauge or pseudo gauge records to the USGS records? Is there some component of that that might influence the classifications and WaterFALL, its ability to actually get the USGS within a certain margin of error? Would that factor into the classification based on waterfalls?

R: If I understand you correctly, I think any classification system that's going to involve a hydrological component, where it occurs has the potential of being erroneously classified comparing USGS versus WaterFALL.

Q: So it should matter what records you use and they should all fall out?

R: I think so unfortunately, Michelle's not here to be able to add to that more completely. But my understanding based on what she's done with watersheds as far as how well the WaterFALL's hydrologic data matches the USGS gauge data, it does depend on the watershed locations and also the attributes of that particular watershed. Some match extremely well, some not as well and Michelle can provide a list of different reasons why that is the case. Main point – it will depend on the location. What these results have shown, is to move away from a classification system that's going to be so fixed on flow metrics, these sensitive flow metrics with these special values because it doesn't matter whether USGS gauge data or WaterFALL data is used. There will always be a chance of misclassification because of the period of record used or whether model data versus a measured data is used.

C: Those thresholds between classes, we trip over them all the time. McManamay and Hendrickson both used extremely sensitive measures of seasonality. Henriksen considered extreme to be Seasonal? Intermittent?, meaning if it had a single zero value in the period of analysis. So extreme that is normally intermittent and extreme that was once for a single record value intermittent may be very, very, very sensitive. Ditto for high end flows. Somehow or other, we need to look at that third sub bullet there that's easier to understand and implement and get to variables that are both explainable and cluster well so that we don't end up with these sensitive thresholds between classes.

R: I recognize this is not the answer some may have wanted.

C: We're further than we were when we started.

R: Before RTI joined the discussion, my understanding was that Tom was writing more of a biology based classification system right from the start so that could be part of the discussion this afternoon, if we want to pursue an entirely different approach as opposed to pursuing further analysis for existing classification systems like the [inaudible] And that can be part of the discussion this afternoon after Fred's presentation.

Q: Any other questions for Jennifer about what she talked about? If you would, please reflect for just a minute before Fred's presentation about:

1) What was useful about what you heard for moving forward?

2) What questions do you have from the presentation that need to be addressed?

Can I ask somebody who wrote something down to share their comments?

C: What we're trying to do is both a categorical classification on continuous data and it seems to me there are two potential problems. One is that if the data did not dome inside each category, if there is not a distinct mean and variation within each category but rather it's spread out across categories and goes from a high to a low or a low to a high, then the chance of having these overlaps is really great. The second thing is we're using hydrological data. It seems like where we have these crossovers are in the hydrological data. Perhaps if we go to the geomorphological categorization as Fred offered in his concept paper, which is position in the landscape geographically from mountains to the coast and maybe stream water or something like that? Much more stable characteristics and we may have a better chance.

C: Just an observation. I have never looked personally at the McManamay clusters and gauge space but I did look at the Henriksen clusters and they were actually kind of tight. But the problem is that they were based on variables that were very compounded and the compounded variables weren't tight so there was deterioration. That's my non-statistical understanding.

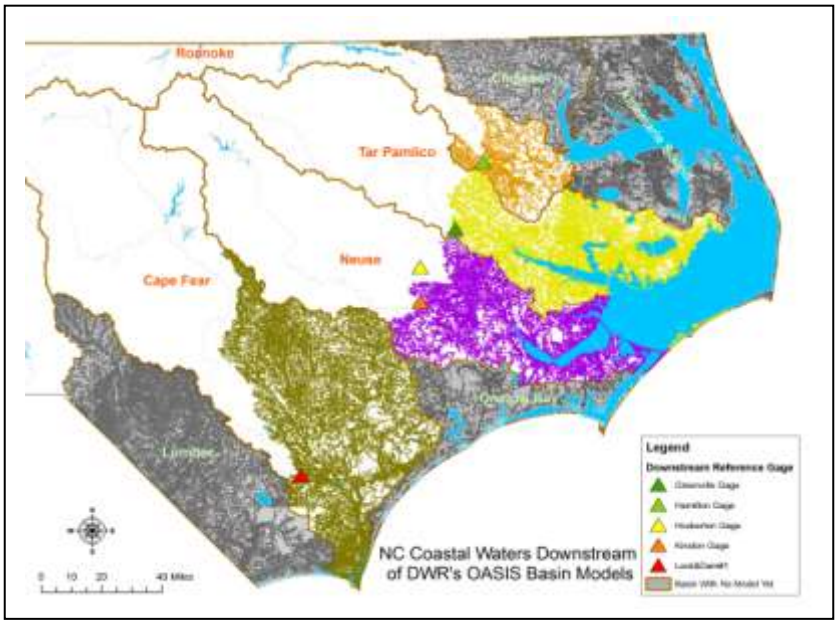
C: A resource we might find of value is the Southeast Instream Flow Network (SIFN). It has a wiki space, which conveys the number of different things this group is doing, how it links to the South Atlantic LCC and the topic of classification. Very information rich site: www.southeastaquatics.net/programs/sifn

V. Environmental Flows And Coastal Waters

Presenter: Fred Tarver, NCDENR Division of Water Resources
PPT is at: www.ncwater.org/Data_and_Modeling/eflows/sab/presentations/20121023/

Fred Tarver, NCDWR, provided a presentation following up on the discussion EFSAB had regarding coastal issues. He reviewed literature and compiled information regarding other states' efforts. References are included on the last slide of his presentation that is posted online.

This is following up with Bob Christian's presentation at a previous meeting, and discussion about coastal issues. I want to continue about how we're going to handle the coastal waters. At coast there have been perturbations, dewatering efforts (mining, ditching). May be reducing interface between groundwater and surface water.



I put together a map showing OASIS models (see below), OASIS doesn't work in coastal waters; took basins where we have tidal influence then (Cape Fear- there's quite a bit of area not covered because it stops at lock and dam 1, had a discussion with modelers to see if it could be rectified.)

OASIS model has terminal node upstream associated with a gauge. Other 4 basins have not been modeled yet. Lumber is probably not as associated with tidally influenced waters, Chowan may have areas not tidally influenced. We will need to discuss what sort of modeling is needed in these basins. If OASIS doesn't work the law requires some sort of model.

Q: Waccamaw is completely separate from Lumber so we may need two separate models, Waccamaw and Lumber models?

R: Good question, possibility we might work in cooperation with South Carolina. It's part of Pee Dee in SC, so may be incorporated into a greater Yadkin Pee Dee model.

C: Think it will be to a lesser degree because the Waccamaw winds around a lot.

C: Other modeling challenges- it's windy, swampy.

General Approaches to estuarine inflow management policies (Adams et al. 2002; Alber & Flory 2002).It was noted that Fred picked a good range of estuarine inflow management policies to share.

Inflow-based (Holistic):

- flow is kept within some prescribed bounds under the assumption that taking too much away is bad for the resources (allows certain % water to be withdrawn)
- also looks at ecosystem requirements
- Based on flow hydrograph (natural type of flow)
- Florida - Water Management Districts is an example
- South Africa is an example

Condition-based:

- one in which inflow standards are set in order to maintain a specified condition (e.g., salinity as a reference point) at a given point in the estuary.
- California – San Francisco Bay

Resource-based:

- inflow standards are set based on the requirements of specific resources (ex- economic catches for fisheries)
- Texas

First- Inflow-based (holistic) examples:

Florida- water management districts

Florida legislation (373.042 Minimum flows and levels) focuses mostly on estuarine waters, includes the following:

- …calculated by the department and the governing board using the best information available.
- …shall also consider, and at their discretion may provide for, the protection of nonconsumptive uses in the establishment of minimum flows and levels.
- …may be calculated to reflect seasonal variations.
- …subject to independent scientific peer review."

Non-consumptive uses- the discretionary part is the key on what they focus on for setting flow requirements. Those most greatly impacted by flow requirements include 5 different Management Districts in FL. Descriptions follow.

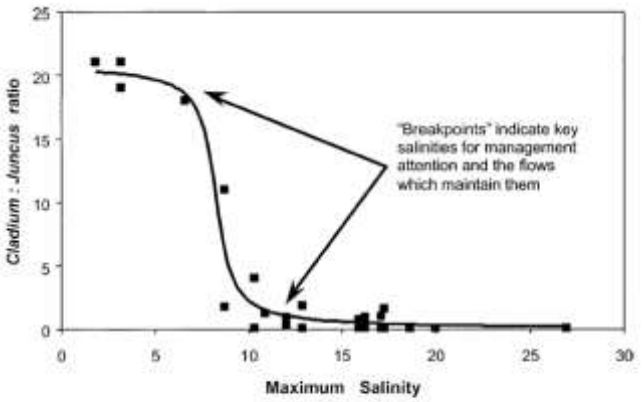


Fig. 2. Relationship between maximum salinity at a location in the Suwannee estuary and the ratio of sawgrass occurrence to black rush occurrence (after Clewell et al. 1999).

Lower Suwannee River:

- flow-associated risk estimates for each habitat type of interest;
- the weight of evidence for submerged aquatic vegetation (SAV) appears to be more robust and since SAV is known to be important habitat…this habitat is recommended to be the prime consideration for minimum flow level (MFL) establishment;
- recommended Minimum Flow of 6,600 cfs for warm period = averaging estimates of the average inflection point and the 3.5% risk estimate of SAV;
- recommended median flow of 7,600 cfs in the cold season will allow 5-foot passage requirement during the cold season for fully grown manatee to be met 85% of the time;
- a reduction of 12% over current conditions;
- throughout the year the historic flow regime will not be reduced by more than 10%;

A lot of these districts base studies on peer reviewed articles, some studies themselves but mostly rely upon journal articles. They post a lot of articles on research they've done themselves in some of these estuarine areas.

They chose a reduction of 12% over current. Most of the Water Districts seem to pick level between 10-15% reduction as tolerable limit for reduction in flow.

This graphs shows Breakpoints for making decisions in terms of salinity (see above Fig 2)

Typical relationships- yearly hydrograph or % exceedance graphs, they usually model the flow requirements, natural flow and reduction based on % removal of flow.

Waccasassa River

- Min. flow level (MFL)Flow Duration Curve be set at 87.5% of the Baseline Flow Duration Curve for the gage;
- 5 ppt surface water isohaline contributed most to the delineation of low salinity habitat nursery areas for nekton, habitat for benthic invertebrates, and maintenance of the vegetative communities;
- 15% "Relative Risk Increase" (RRI) to the estuarine habitat identified as maximum change that would prevent significant risk in estuary;
- reductions in flow that would allow no more than a 15% RRI would shift the frequency of incursions of the 5 ppt surface isohaline from it's baseline frequency of 31% to 36%;
- 15% RRI would result in a shift from 157 cfs median flow on the Baseline Flow Duration Curve to a 137 cfs median flow, or a 20 cfs reduction;

SW FWMD Lower Alafia River

- percent-of-flow method for determining minimum flows;
- percent-of-flow method determines what percentage of daily flow can be removed without causing significant harm to the ecology or biological productivity ;
- method is designed to protect the natural flow regime of a river to which the ecosystem has become adapted;
- highly nutrient enriched & associated problems with large phytoplankton blooms & most pronounced at low flows;
- comb-jelly is also most abundant in the river during low flows & is a predator of zooplankton and larval fish & flow reductions during low flows could act to increase their abundance;
- analyses indicated that recommended minimum flow rule of 19% reduction of daily inflows, combined with the 120 cfs low-flow threshold, would not reduce the median abundance—based on catch-per-unit-effort--of juvenile red drum by more than fifteen percent.

Regarding the 120 CFS low flow threshold- it's interesting that they have hard and fast threshold, occasionally during low flow periods, if water withdrawal gets below it you must have to turn off pump. Not sure how they do it, I've seen some studies that show how often you get below the MFL. I don't think we have that in place in NC- I think we have guaranteed amount allowed to withdraw if they have a drought policy in place. Not sure if this is true everywhere or just this district.

C: It forces them to have off-stream reservoirs.

Lower Myakka River

- used 15% reduction in resource indicators as a threshold for identifying significant harm in other minimum flow analyses;
- abnormal tree die-off has occurred in the upper reaches of the Myakka River watershed;

- cause of tree die-off was excess water that entered the system due to land-use changes and structural alterations within the watershed, no "drying out";
- the removal of excess flows will benefit restoration but will cause changes in the flow characteristics of the Lower Myakka River that will likely result in shifts in some ecological communities and reductions in the abundance of some key fish and invertebrates in the lower river;
- hydrodynamic salinity zone analysis indicated that 10% of the flow in addition to the excess flow could be removed and not exceed 15% habitat reductions relative to either existing or historical conditions;
- need for adaptive management strategy for the removal of excess flows and compliance with minimum flows for the Lower Myakka River;

They had additional inflow from upper in swamps because they don't have drying off period. Removing water to restore natural hydrograph, excess flows in lower watershed. In lower they are trying to anticipate future scenarios with the removals happening in upper watershed. Past gauge history will not match future.

Lower Peace River(LPR) and Shell Creek(SC)

- analysis goal was to regress organism abundance/distribution from a sampling trip, comprised of several individual seine or trawl samples, against the mean daily inflow that corresponded to the sampling trip;
- attempts were made to develop empirical models that relate flow to ecological criteria for the LPR in order to identify a low-flow threshold;

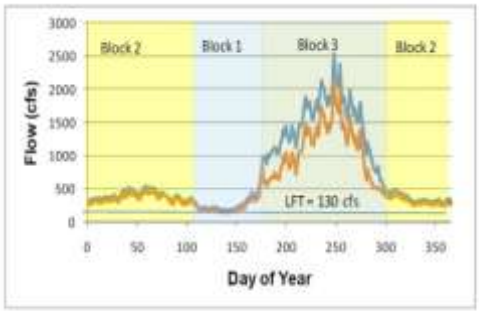


Figure 8-12. Hydrographs of the median daily Lower Peace River flows for the Baseline (blue line) and flow remaining after the maximum allowable withdrawals were taken (orange line).

- no defensible relationships were found between flow and DO or between flow and chlorophyll a in various segments or locations in the LPR - not possible to define a flow that would preclude low DO values or high chlorophyll a values.
- volume less than two ppt was the most sensitive metric - hydrodynamic model was to predict salinity in LPR as a function of flow and other variables;
- criteria for MFL development in LPR was maintenance of 85% of the combined (LPR plus SC) available habitat less than 2 ppt;
- committed to verifying the models and assumptions applied in the current determination / to conduct a re-evaluation in the future;

Sometimes they do seine hauls and associate sampling trips with flows in the rivers when doing sampling runs. It doesn't sound terribly rigorous but I guess it's enough for them to base decisions on.

A lot of these have a caveat about going back to verify model assumptions to see if they are meeting these standards- a good thing- they are trying to validate assumptions.

Slide with graphs- 3 blocks- seasonal blocks, with various % withdrawals within the blocks, some barely reach the low flow threshold. Shows what block you are in, threshold

South African National Water Act (1998)

- provision for a Reserve to be determined prior to the issuing of licenses for freshwater use;
- Reserve is the quantity and quality of freshwater required to satisfy basic human needs, considering both present and future requirements, and to protect aquatic ecosystems in order to secure sustainable development and use of the resource (MacKay 2000);
- task of Reserve assessment is to provide quantified information about the frequency, magnitude, and duration of particular flows and levels of water quality variables for the Ecological Reserve Category of a target water body.

The steps include delineate boundaries of estuary ,current state, identify, reference conditions, determine the Ecological Reserve Category based on the present health and the ecological importance score; set the Reserve for water quantity; design a monitoring program to improve the confidence in the Reserve assessment, to verify predictions, to audit whether the Reserve is being adhered to.

Mata Estuary (eastern South Africa)

Rainy season is during rainy summer month. A large dam messes up the hydrograph. They look at salinity and seasonality of flows.

The Dam has shaved off peaks and raised lower flows.

They came up with estuarine reserve category C . Flow scenario for level C- allow flows to go down low enough to allow salt to go up river system

Condition- approached example: California- SF Bay, simple approach to manage

- San Francisco Bay Estuary -a system where inflow has been extensively modified by humans - diversion of freshwater for irrigation & municipal use has frequently exceeded 50% of inflow estuary, especially during drought years (Jassby et al. 1995).
    - To regulate volumetric approach to flow seemed difficult
- Effective management of the estuary's biological resources requires a sensitive indicator of the response to freshwater inflow that has ecological significance, can be measured accurately & easily, & could be used as a "policy" variable to set standards for managing freshwater inflow.
- Positioning of the 2‰ (grams of salt per kilogram of seawater, denoted by X2) bottom salinity value along the axis of the estuary was examined for this purpose.
- Monitor the distance from the Golden Gate Bridge to the 2‰ isohaline, measured 1 m off the bottom and averaged over more than 1 day;
- The 2‰ bottom salinity position has simple and significant statistical relationships with annual measures of many estuarine resources(see slide for details)
- 2‰ marks the locations of an estuarine turbidity maximum and peaks in the abundance of several estuarine organisms

- The 2‰ value may not have special ecological significance for other estuaries, but the concept of using near-bottom isohaline position as a habitat indicator should be widely applicable.
- Complications caused by variables additional to X2

There were some complaints that it was too simple and there are other complicating factors that should be considered…example, larval striped bass didn't have correlation with 2% salinity and one of the hypothesis was larval fish were getting entrained resulting in larval mortality…things to consider when setting condition-based criteria.

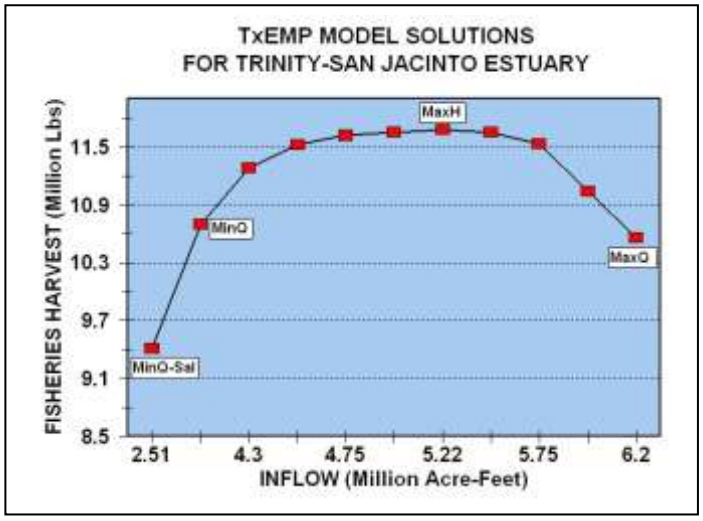
Texas

There were water user conflicts.

- 1975 legislative mandate to perform studies on the needs of bays and estuaries;
- "Beneficial inflows" - salinity, nutrient, and sediment loading regime…economically important and ecologically characteristic sport or commercial fish and shellfish species…and estuarine life they are dependent;
- 2007 Environmental Flows legislation shifted focus from beneficial inflows necessary to support a sound ecological environment to determining a comprehensive freshwater inflow regime which provides for geographic, seasonal, and inter-annual variation of recommended inflows.

State Methodology:

1. Data collection/hydrographic surveys (ungaged watersheds – Rainfall-Runoff (TxRR) model;
2. Hydrodynamic and salinity transport modeling - (2-d (TxBLEND) & 3-d (SELFE));
3. Sediment analyses;
4. Nutrient analyses;
5. Fisheries analyses;
6. Freshwater inflow optimization -Texas Estuarine Mathematical Programming Model (TxEMP);
7. Verification;



MinQ-Sal – flow at which only the salinity constraints of the esutary are met;
MinQ – minimum inflow that meets the salinity & biological constraints of TxEMP;
MaxQ – maximum inflow that satisfies all the salinity & biological constraints of TxEMP;
MaxH – harvest - between MinQ & MaxQ & maximizes fisheries productivity w/i the range of possible inflows considered;
MaxC – biological-sampling catch- '' ;Some people had issue of using commercial catch as rate of success. Some thought it better to base on biological sampling. Sometimes catch techniques have certain biases.

Showed the TxEMP Model Solutions (graph from slide 22). They picked somewhere between Min Q and Max H, falls between 10th and 50th percentile.

In terms of our coast, they might be worth a look where we can't use OASIS. Looking around to see what other techniques may be used. Found RENCI@ ECU (Renaissance computer institute- UNC-CH has one, ECU does too), which is hydrologically- based. We can look into them.

Also, Neuse River Estuary Modeling and monitoring project (ModMon)- creates interesting salinity profiles.

C: I don't know if we can get to something like TX where we can set 2 ppt in Neuse.

Lastly looking at floodplain mapping, coast has been done by LIDAR and…HEC-RAS has to be used for delineating river channels. Maintaining connectivity between flows and wetland, maybe some elevation model could be used to make sure that at some time of year connectivity with flood plain is maintained.

Facilitator asked what questions of clarification people have for this presentation?

C: Concern about level of detail that is needed at subwatershed level, even in FL , each District is broken into sub watersheds with detailed prescriptions. For biological standpoint it is probably necessary, but we are light years away from that. We'll be considering tolerance level for some kind of screening instrument. Seems like we're far away from that landscape level…do we have anyone (Div Marine Fisheries) saying that flow is an issue in our estuaries? Do we know we have water level rises we're anticipating? Is there perception of insufficient flows?

C: Some of the fishery management plans for key species have flow requirements in them. Requirements are there or in process of getting there for some of the species (striped bass, shad).

R: We have impoundments on the four main stems, Cape Fear, Tar, Neuse , Roanoke. The Roanoke probably sees the most impacts, from Kerr Lake. Not sure of impacts from others.

C: Cape Fear gets minimal impact from Jordan as it's such a tidally influenced system, flushed twice a day. For estuarine species flow is not an issue, for shad and bass going upstream it is.

R: If you monitor the OASIS models and verify that flows going through model are mimicking preexisting conditions, the assumption is that you're not seeing significant impacts …when you start seeing shifts in that then you need to address that. Doesn't cover tributaries.

C: that's the important things, Cape Fear example- if model is going down to some point, and in 50% of watershed we don't know what is going on there could be impacts but you don't pick it up in model.

C: Also other groups are looking at a basin by basin situation- if sturgeon were issue in Cape Fear we'd want to focus on sturgeon. Prescriptions are driven by basin issues itself rather than class. (where there are) pertinent species …we maybe can't make statewide prescriptions. May need to look at least on basin scale.

C: The Cape Fear Partnership has a plan (Black and NE Cape Fear)- aimed at diadromous fish, maybe we can look at flows to see if it's sufficient. Is that in the action plan, to look at flows?

C: I don't think they were looking at flows. Nutrient contributions, but not flows.

Any other questions?

C: will the papers you referenced be archived on the web?

R: If I can get permission. FL, TX does good job of posting articles.

The EFSAB were asked to write any response they may have to the question: In hearing this presentation, do you have any remaining questions, and/or what is useful in helping us move forward with the screening tool?

One response received:

- good group of examples of how a different approach might be used on the coast

VI. NCDWR Concept Paper & Discussion of EFSAB Path Forward

Presenter: Fred Tarver, Division of Water Resources
Paper: *Thoughts on Stream Classification and EFlows (Tarver and Mead*)
Lou provided an overview of DWR's concept paper. The paper is presented in four parts:

1. The overall concept
2. Section A: recommend postponing until the November discussion about WaterFALL & Oasis
3. Section B and C, proposal is to discuss today.

Main points of the concept paper are listed below in italics- the complete paper is online for viewing:

A useful classification system should be:

1. Meaningful - groups streams according to discernible key characteristics producing an algorithm(s) for determining the EFlows. One would expect the groupings to correspond to different assemblages of organisms that respond differently to changes in flow, or have different flow needs;
2. Reliable – produces consistent results;
3. Relatively simple and explainable; and
4. Applied using desktop information for a given stream, not requiring field investigations each time a classification is needed.

We suggest an alternative approach to stream classification for determining EFlows for streams in North Carolina. This approach would rely heavily on the following map layers:

1. Physio- or geographic Location – using traditional boundaries, for example: mountains, foothills, piedmont, sandhills, inner coastal plain, outer coastal plain, or using an alternative approach.
2. Drainage Area – divide streams into 2- or 3-size groupings.
3. Elevation – a surrogate for temperature to subdivide mountain and foothill streams into cold and cool water ecosystems.
4. Gradient – The Division of Water Resources' (DWR) habitat modeling work indicates this has a significant influence on the physical habitat conditions and how a stream responds to changes in flow.

Some other points we considered during our deliberations that we wanted to note:
A. Obtain WaterFALL output for the nine habitat model sites DWR has evaluated to date – the full, unregulated flow record with 1970 land cover, then compare habitat model results for OASIS and WaterFALL.

B. Given the uncertainties that we are dealing with – uncertainties about hydrologic simulation models, stream classification, and ecological response to flow changes – the percent of inflow approach is desirable from the standpoint of being more conservative and protective. Taking a conservative approach is an appropriate screening tool for planning purposes because it prevents overestimating water availability for offstream users during the basinwide planning process. ..By being conservative, a percentage of inflow approach might also help address uncertainties about how coastal stream ecosystems respond to changes in flow.
C. Lastly, the SAB has focused on water removals accomplished by simple withdrawals, not large reservoirs that alter a large portion of the downstream hydrograph. This is justified by the extensive project-specific studies required of large reservoir projects, and the fact that each reservoir operation is unique and does not lend itself to a generic ecological flow algorithm. That said, there is a possibility that a percentage of inflow approach for determining ecological flows could be applied to potential reservoirs for basinwide planning purposes, not just to simple water withdrawals.

Fred Tarver explained how they came up with the Concept paper. Tom Reeder was talking before with the Environmental Review Commission (ERC) about Falls Lake and repartitioning storage. The topic of Eflows came up- the ERC requested a presentation in November and discussed having something from EFSAB by end of 2013.

Jim and I spoke, and brainstormed a potential path forward if the EFS classification wasn't working as envisioned.

Show some of background info about what we used to come to agreement with our concepts proposed- from presentation by TNC. Four points at top are self evident: criteria for classification. About class system, I was thinking we need to further partition it using other physiographic geographic characteristics. You may remember the talk from Feb about TNC's work in NE was a good fit. In their NE approach, they looked at various factors assoc with river networks in NE, weren't trying to override state classes but come up with way to complement them. They're doing this in NC too.

Some of variables they used- see slide from their presentation (initial classification variables). May not be simple mountain coastal, piedmont, could also be inner coastal, outer coastal, sandhills. For geological overlays.

Talk about complexity of "set of types", some may not be agreeable to water managers, understandable and easy to apply- not. Need to keep relatively simple but maintain level of detail that it's accurate to some extent. Here's what I envision we may do (listed above).

What to do with EFS class- if we decide to revisit and tweak- is it worthy of an effort? Or adopt new type of Henriksen system. We can discuss it.

Doesn't mean we can't do both at once. These folks are doing SE- it would be nice to take advantage of their good works (TNC).

As you read down through paper, it talks about work RTI did on validation using gauges. Also talked about how we came up with gauges, Jim was primarily one who worked with picking gauges for gauge records to run through EFS program. In retrospect, maybe we could have picked better gauges or looked at different periods of records. Hard to know how to game the system, and anticipate results based on gauges and results.

Jim Mead: up against wall trying to find as many gauges possible, why we went to 18 years, to find set of gauges with same overlapping record. If you only use reference gauges with no alterations, drastic reduction in available gauges. Had to pick some with some degree of alteration.

Page 2 –using some sort of runoff coefficients- (Curtis Weaver, USGS) low flow characteristics, a few places show mean annual runoff- not geospatially located (problem), and from 90's so doesn't take into account changes. Can talk about updating it. Would be good to incorporate runoff coefficient.

Q: Runoff coefficient on second page? Where?

R: 30Q2 is a runoff coefficient, 7Q10 per square mile. (7Q10/square mile ratio)

C: That's not what I think about when I think of a runoff coefficient. I think of a runoff coefficient for land uses, which is not what you are talking about.

C: It's a flow per area (not a surface runoff), not a yield.

C: **Call it yield per square mile** rather than runoff coefficient.

C: Confinement to USGS will be a constraint

C: They also used partial record stations..they are snapshots where they go out at low flows for a handful of measurements. Use those to determine low flow 7Q10 per square mile.

C: Those will be important to understand. The current threshold we have for site specific is used for 7Q10. It would be helpful to know, the streams with 7Q10 of 0 or less than 5. Those probably wouldn't be candidates for withdrawals, it would narrow the world of streams geospatially, that we need to be concerned about with this screening tools. Which streams are eligible for withdrawal, would help us frame our work moving forward.

Facilitator: Reactions to this comment?

C: I like the idea. Some systems will be so small withdrawal will not be an issue. Is it 20% of our stream?? 50%? Anyone have a guess?

C: Looked at this paper, not willing to guess, but one of the descriptors they have for each of geographical areas, they produce a formula, they list square miles of drainage needed to produce 7Q10 greater than 0. Many do not have a formula. But minimum drainage areas seems to be in all of them.

Fred: interesting to see what WaterFALL could yield…could WaterFALL do this for watersheds?

R: Yes

C: It is really important. What if all small flashy streams were not important? Why worry that class system doesn't do small flashy streams well? It would save us time.

Q: Where would people request permits? Any stream that passes through landowners property is eligible for agricultural withdrawal, but that's not in DWR authority. But within DWR authority, would help us narrow our area of concern.

Q: With current state law, you can have withdrawal anywhere that is not in a capacity use area.

R: Yes, but there needs to be water there if water is to be withdrawn. If there's conflict, its up to landowners to settle or take to court.

Facilitator: back to the point, you brought up runoff coefficient. Jim suggested replace with yield per square mile, ok?

R: yes.

Fred continued: High flows are impacted by large projects- that would fall under requirement for specific in-stream flow. Usually associate large impoundments, hydropower, those that capture high flow events, that would trigger selection of e-flows there. When looking at flow records its more important to look at low to mid flows than high flows for classification system.

Q: High flows, you mean storm event flows? Is that the case if there's off line storage- they're trying to take those high flows?

R: That's coming down the road. Those would probably require studies too, impacted reach for project like that, open to debate. There are those high flow "skimming" situations becoming more frequent. Those are restricted to size of pipe they are utilizing, so far haven't seen huge capacity intakes.

Q: But we're not going down EFS road anymore?

R: that hasn't been decided.

Q: We're not pursuing biofidelity? Thought that meant we wouldn't continue to use that class.

C: That's not my recommendation. We're abandoning EFS and McManamay because they don't produce replicable results, so think the challenge is still to come up with some sort of class system, meeting Fred's criteria.

Facilitator- Let's test for understanding- what was everyone's understanding. Should we test that about EFS?

R: It's important to have hydrologically based as classification, if not EFS then some other means of labeling hydrologic characteristics?

C: My faith in a hydrologically founded class system has been shaken. It may be we'll come up with a different kind of hydrologic based system with replicable results and meet the other criteria. The alternatives are to come up with some sort of size, gradient, geology, temperature, some of above approach, or start with biology and do biota based class. We should set aside time to talk about and resolve that. I don't' think it will be possible for managers to take % inflow or other basic strategy for defining ecological baselines, and not say how are we going to do it for different kinds of streams? Somehow it will have to be divided up by kinds of streams and times of year to make sense. My recommendation is to deep six EFS, and probably McManamay. Decide today if we want to go with hydrology based or physical variable based, biology based, or combo.

Several comments from group: Not either or, but both. If not doing hydrological variable now then later.

C: I second that, if we move forward with mainly on hydrology, we'll still see these (situations) …where classes jump back and forth based on hydrological variables.

Facilitator: Let's test this "deep sixing". First, are there any other concerns, comments about this? We want to make sure we're settled with concerns before testing consensus. Proposal is to not use EFS or McManamay specifically for classification.

C: It may be more accurate to say we'll base classification system on broader range of variable including hydrology…add the other things we talked about, then weed that down until we get …optimization question, to get maximum agreement on classification.

C: The whole group needs to understand and support that we're abandoning those 2 classifications. We're not abandoning hydrology as a feature of classification. Either we agree or maybe we're not there yet.

C: Until we find another way to do it, should we abandon them completely?

Facilitator: Fred, have you completed your presentation? If not, let's allow you to complete your presentation and then come back to the discussion. It may help to frame the discussion a bit more.

Fred: I'm pretty much done. SALCC has provided the overlay for us; we can do some of our own if we choose to but it won't be quite as rigorous as their technique. I'm not sure of their timeline. Sections A-B-C raised different thoughts in the concept paper.

A. For section A, the suggestion was raised to table discussion until November's discussion about Oasis and WaterFALL. Our interest was to gain some confidence in the use of WaterFALL, mainly curious to see if you took WaterFALL. Remember Jim's efforts to come up with these graphs, looked at flow scenarios based on instream flow studies we did that used USGS flow records. Our thoughts were to produce WaterFALL flow record and compare results to see how the two compared in terms of habitat responses. Might be informative.

Jim: The Time series analysis in this graph used gauge data in OASIS. Think about doing Water FALL Data to see if they are close.

Q: I don't see why you'd expend the energy. You're trying to see difference in 2 data sets. Is there some other way to compare them?

R: this may be more of a question for next month's meeting, r.e. Water FALL. See how they work together.

Q: Are Bob and Tom and Brian preparing for that?

Facilitator: if there is a question that they need to address at next meeting?

C: Is there another way to compare them? Run IHA or something? Other ways to look at it

Fred: Tom Fransen ran it through a statistical package and found discrepancies. This is an attempt to address the discrepancies.

C: If we don't go forward with using a habitat based decision tool, than it doesn't matter. Whatever tool you're going to use you want to know how tool's output will be affected by WaterFALL.

C: As Fred alluded to, Tom Fransen's statistical package showing some discrepancies. If there is a concern about using WaterFALL data in one way doesn't mean the difficulties cause another application to have problems. If habitat modeling approach does continue to be pursued, advantage of WaterFALL data is it's schedule is WAY ahead of OASIS basinwide models. We'll be lucky to get one or two OASIS models per year. It will be way down the road to get flow data for some basins. This is more pertinent to November's discussion.

C: Talking about #2 criteria- reliable and repeatable- has to be some way to compare them.

C: It is laborious way, but simple index of hydrologic alterations method, (Fransen's statistical analysis) if it raises some doubts, it may be good to test it.

C: There are differences in scale with the models; their granularity and methodology are different.

C: It's the criticality of HSCs vs hydraulics…

C: Remember the difference between hydraulics- and..hydrology. hydraulics is micro-velocity and depth simulation….(this conversation is inaudible in the recording)

C: This information generated (habitat modeling) is still useful even if you remove the class. We shouldn't abandon this analysis. We were trying to interpret it related to classification, but in of itself it has important data for analysis that can be interpreted regardless of which class is used. Predictive ability of WaterFALL may be tested with more simple way. Would be time saver not to have to redo analysis.

C: I agree, those are 2 different things (the habitat modeling analyses and testing WaterFALL data)

Fred back to presentation:

B. Section B talks about the conservative approach. Flow by approach allows a little more conservative approach, modeling is for long range planning . Allows enough lead time to deal with concerns. (see the slide titled "Spring", % inflow scenarios are on the right)

C: I agree with preference for % of inflow. Did we not vote on that in a previous meeting?

R: We had a trial balloon where we narrowed it down for the habitat analyses. We agreed to run them all but not include 7Q10 in reporting until ready to report externally.

Facilitator: there was a general agreement about those.

Q: Referencing Thomas Payne's discussion to be aware of issues of being conservative- is a margin of safety relevant here?

C: His point was if you're looking at habitat in a study, you can't define conservative in way you're talking here. What is conservative for species x is not conservative for species y. If talking about habitat, talk about habitat. As opposed to approach that raises red flags sooner than later, which I think you're talking about here.

C: It would be helpful to me to to understand philosophy behind this…minimal impact on species for % inflow, monthly median is similar. Could DWR flesh out pros and cons of % inflow vs monthly median. These 2 seem most relevant.

R: Like the FL examples, % flow tends to mimic hydrograph.

C: Monthly median would be a single number per month- 12 flows per year.

Q: But they would be thresholds in a screening tool. You're not prescribing a flow in these plans. Do more red flags get thrown with monthly median or % flow by? If you're talking about a site specific release schedule, you want to mimic the hydrograph. But for developing a screening tool, I'm curious to compare monthly median and % inflow.

Q: On these suggestions, you're not going down a particular path- it's hypothetical?

R: Yes, its hypothetical, and we're not suggesting a particular percentage.

C: This is dependent on PHABSim approach? Ability to do this will depend on ability to develop number of classes. From funding standpoint, 94 classes is not going to work right? What range are we talking about- under 10 classes? We have to deal with fact that you will have to do this.

R: It would be informative if you did have a site specific study in each class to get an idea of response, more than one would be great but probably not possible. In lieu of site specific study, use a classification system we can come up with.

R: Trying to figure out what relationship between this and classification system.

R: We originally picked the original site specific studies in what we thought were going to be classifications.

C: My understanding that the whole question of classification is still separate than the approach for determining an ecologocial flow, whether habitat based or biological data based. Degree hydrologic alteration vs degree of biotic integrity. Those 2 paths go back to blue box and green box diagram. Determine how many buckets you have for each approach. Each bucket has an ecological response curve, that comes back to class system- whether you have one, three or 94.

C: The goal is to have as few buckets possible and not leak.

C: And to each be distinctive and unambiguous. The question of how you classify streams is separate for how you come up with eflows for each class. They can inform- there could be feedback loop from either of those methods (habitat based or hydrologically based)- if we rearrange buckets, it could be that the spread of blue and red box on whisker plots gets tighter- if you subdivide streams as suggested by habitat model approach results, or biological response results.

Facilitator: Are there clarification questions on point B? Pros or cons? Does the way it is framed seem like doable approach, with a couple tweaks as an option for moving forward?

Q: I'm not sure what you're asking. Are you asking us to follow B and go along with % inflow? (yes) Then my reaction is to desire evaluating monthly median as well.

Q: In terms of screening tool? We're not talking about actual flow recommendations.

Q: How tightly will this be tied to future regulations? If so, we need to make a statement that mimicking natural hydrograph is extremely important.

Q: I need a little clarification about screening for what? I hear about it for a screening tool, not as basis for regulatory, not for an e-flow as a number. If you take 80% flow as threshold, what happens to those that are in the bucket?

R: My interpretation as a screening tool, in the basin models, if you plug the e-flow in the model and use it as a screening tool, if you had it in the nodes and run the model for current demand and future projected uses, and you get red flags when you're are violating e-flows.

C: A post-processor to add onto OASIS. If somebody says they want to increase withdrawal by x% you run it through OASIS and add ecological flows as post-processor, then if it goes below 80% it flags it? (the 80% is an example)

R: Not for a specific project proposal, but all municipalities' projected uses, to see which ones go below e-flows, at 20 year point, 50 year point. If somebody has a specific project- for example if in 5 years, we want x amount of water from that stream, that is a permitting decision not a planning decision.

C: Even with planning, a local watershed supply plan is not regulatory, it is planning. You still have somebody saying they will court a user like Pepsi, you still have those case by case instances in the planning process that are in the dialogue between states and local governments.

Q: I like % inflow. % average flow we can probably never see that again. If I'm setting up a program to screen, I want to see where the system breaks. Annual 7Q10 helps to show- is the system ultimately going to break or not? If you go below 70% on percent inflow down to 10%, or down to 70, 60%, then jump over to something that sets system on its ear?

Q: Aren't we trying to never get there?

C: Right. If you set it at 70%, you can think that you can take 30% out of river and only see a 10% change…is there a non-linearity we have to watch out for. (where does the system break, or does it break at all?). Where is the area where we say "we don't want to see it there".

C: I agree with Bob. It gets pretty complicated pretty quick. This whole thing, do we base it on guilds, species, have we agreed on the habitat issues- the things we'll use to evaluate what type of scenario should be used for ecological flow (% inflow or other)? I would prefer not to make blanket statements - I'm not there yet.

C: I remember- I'm looking to draw from resources of group to understand how these percentages have been tied to habitat modification, overall class system. I'm understanding we are still mimicking overall hydrology. Basic understanding of robustness of % back to either biota or habitat or physical characteristic or some way of evaluating beyond this single graph, or have you had that conversation already?

C: You may be suffering from not being here during first 2 years of EFSAB, but…I'd suggest that a lot of what we're doing is thinking like a paramecium in a Petri dish- brainstorming and coming to walls, a hodge-podge of discussions going on at same time based on 2 year knowledge curve of learning. I'd like to get to thoughts from the last meeting- build consensus principles to funnel concepts, thoughts, ideas to narrower discussion such that at end of meetings we'll arrive at point where we can communicate in way to folks who haven't been at table.

C: Great point. B in particular is a concept that relates to planning screening thing but how it may be implemented in regulatory sense. You're right, we need to put things in pigeon holes to have discussion that is appropriate.

C: Early on, we discussed that the regulatory component was outside the scope of our work and thus it is easy to get distracted from the recommendations we need to be working on.

C: It's been awhile since we discussed focusing our discussions and presentations on a planning tool. Some people think of e-flows as a much more regulatory perspective. Folks get nervous about talking about how much water can be used. As screening tool it is important. For example, Pepsi may want to ask DWR to find out where they may not run into water issues- what are the best economic development locations. Regulatory implications may complicate our recommendations.

Facilitator: We've also heard that from some of the presenters thus we are ensuring that their presentations are tailored toward a screening tool for planning as opposed to a regulatory instrument. This was discussed at the first session in Nov 2010 and again in Nov 2011; it has also been brought up several times through Jim's presentations.

C: That is not clear in the legislation, it could be more clear.

Facilitator: Fred described at the last session some of things he would be looking for during his description of a conceptual framework.

R: Let's call it a **planning tool rather than a screening tool for planning.**

C: A reminder, we're asked to provide recommendations on how much water needs to be left in stream to maintain ecological integrity. That's the question we need to be responsive toward; how the Division uses our recommendations is not the EFSABs responsibility. We are leaning toward one set of strategies, as opposed to the others in the chart, but we've not arrived at consensus yet. I also think we'll have to answer that question for different kinds of streams, we're not going to be able to answer it holistically for all streams.

Facilitator- Jay, you said you would like to see principles of consensus as a way to operate?

C: We need to set a foundation of some things we can agree to such as do we need a classification system, is so, let's decide on that and not continue to debate it. Let's put it in as one of our principles. Examples: we'll be basing recommendations and further evaluations on fish habitat, whether or not we choose to do that. To incorporate benthic macro invertebrate habitat. Until we build on things we can agree on, we'll be brainstorming without funneling down our thoughts. If we have a year to go, I'm a little concerned how we can share 2-3 years of work with people who haven't been at the table.

C: Would this address Vernon's questions, are we going with benthic guilds? Are we doing a habitat analysis? Is habitat the question we are trying to answer? We keep sliding back into the small picture and set a foundation from which to work from.

Facilitator: What is the list of proposed consensus principles?

C: I propose these three principles:

1. (We need a classification system) Classification system of rivers and streams that incorporate geomorphology, hydrology, and biological characteristics
2. % of inflow as the flow by strategy looks like a superior strategy
3. pure hydrology based classification does not appear to work

Q: When you say % inflow- are you are proposing 20% as a number? Or the concept of % inflow? I'm having trouble understanding how 20% number ties to classification. If basic % is consistent for every stream in state, if you don't have problems until you remove 20% inflow, that's the conservative amount, then why do we need a classification system? Are we agreeing to a % or a concept?

C: Take the language "you can take out" out. Ask yourself instead, what % of inflow at top needs to exit at bottom of catchment to maintain ecological integrity within the catchment. As a strategy, is that superior to other 2 families of strategies? I think it is. Other question- does that strategy use the same number at all times of year for all streams? I think not. For smallest streams you need to leave larger percent than others. This is a working hypothesis we need to spend time on. My gut tells me you can't apply a single number to all kinds of streams in all times of years.

C: I accept your reformulation. My gut tells me the same thing, I just wanted to test.

C: (Cuffney draws a diagram on the newsprint) This is NC- all our streams. We made classes. Now we're trying to adding other variables (geology, habitat). Reason is to divide these into discrete units, further classes to make classes more distinct. My question is- is this were PHABsim sets the flows?

Q: If that's the teeny stream that is only perennial runoff, should it get to keep 90% flow by because we think it's more sensitive, then should we run habitat based analysis to determine if it is more sensitive? Do you run everything through PHABsim?

R: Can do biology, there are number of different things. Let's focus on whether to do process for classifications, then have to set flows for each of different classes. The advantage of the classifications is we'll set different flows for each of these, because we're assuming the classes have more similar characteristics than all streams in NC.

C: I want to know how we are going to …we haven't…there's a slight difference in my perception. we've been trying to sort biology into predetermined buckets. My current recommendation is to do what you told us a long time ago, and incorporate biology into determination of buckets in the first place (bring an arrow to biology)

C: That is one route, not the only route? Is it a multiplier?

C: There is another parallel track, to build ecological response curves using biological monitoring data and water FALL to calculate degree of hydro alt, then plot the points (1,000+), then you have subsets of them. Some would be class A, B, etc. If you take that route, then the classification which is somewhat biological (been through biofidelity) is closely related to biological data approach to get eco flows.

C: There are two possibilities. May be that one reinforces the other.

C: (first part of comment was inaudible) With changes in flow, how does your biology respond. You can establish relationships for each of the classes, since they will incorporate biological assemblages in the classification.

Diagram 1: Cuffney's Diagram

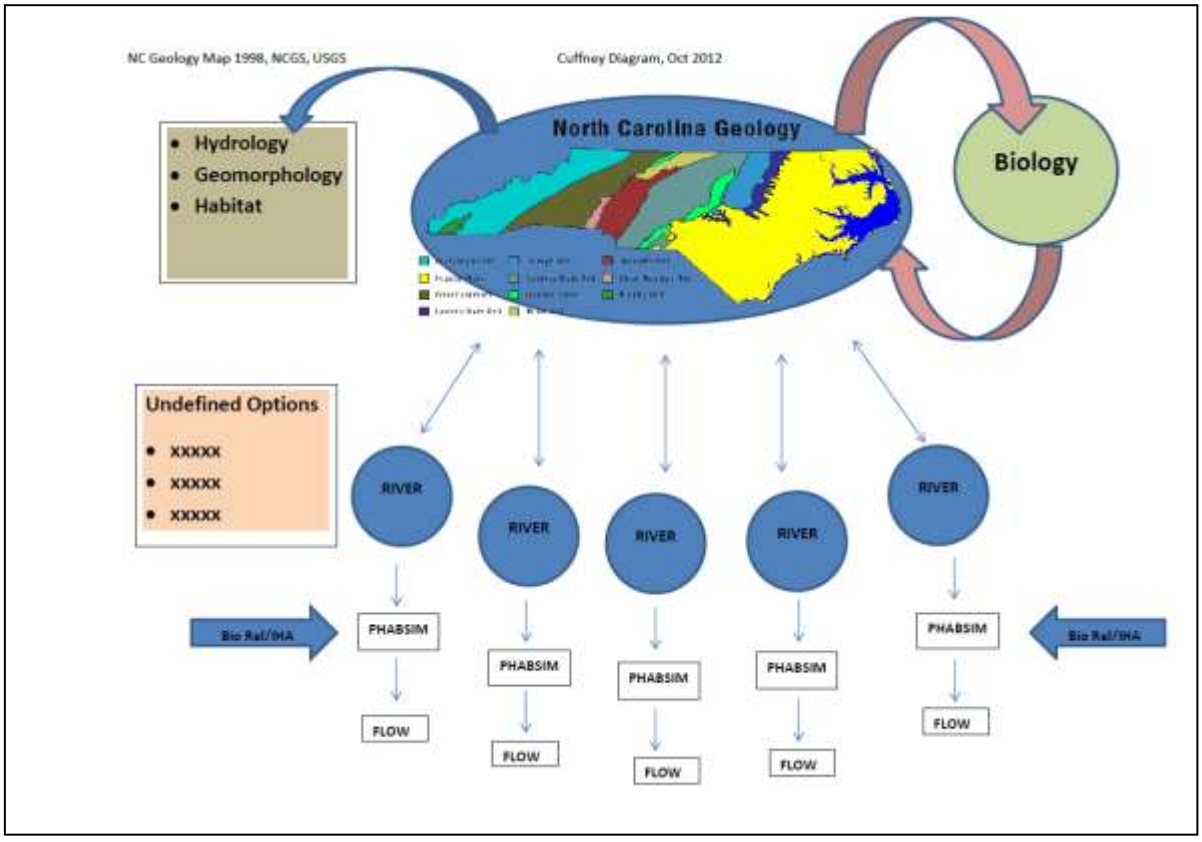
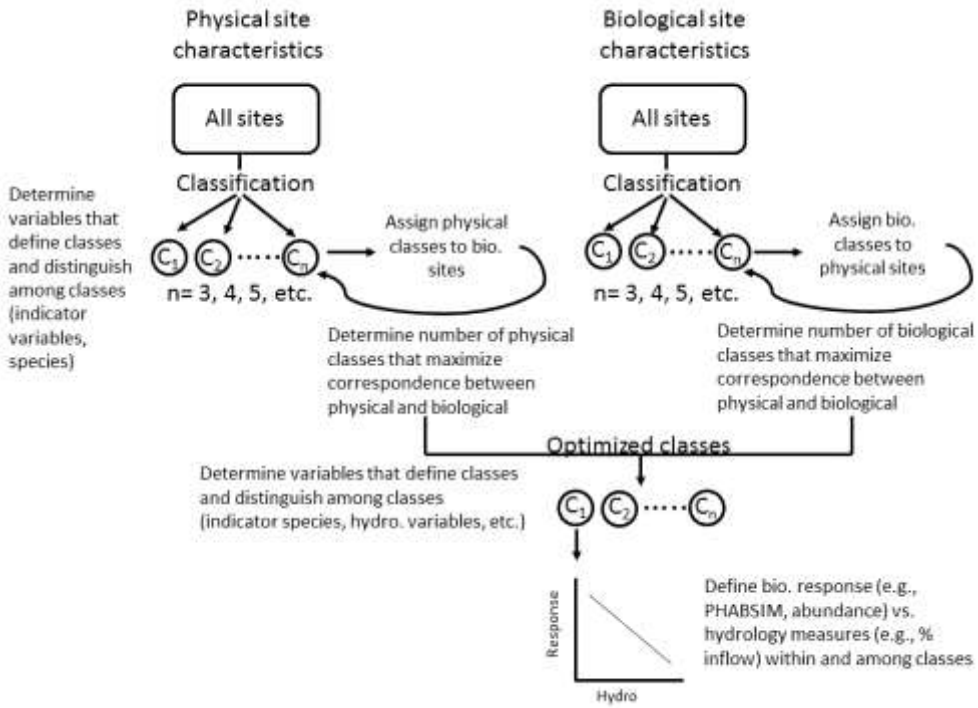


Diagram 2: Additional Details of the Cuffney's Diagram



C: Advantages of each of those approaches, PHABSim approach (Payne's approach) gets to habitat and flow, and flow alone. The biological monitoring data approach does a couple things. It expands your number of data points, gets at actual organisms, though I still like usable area, but it gets at numbers or diversity of organisms. Question with biological database approach- is flow the only variable? By having the habitat model, flow is only variable, why I'm seeing how the two can complement each other.

C: you can also see how much of biology changes as your flow changes- what that slope looks like.

C: And you can have representation of biology in each of the classes

C: Look at these graphs, can give indication of some kind of trend in various flow scenarios, you may gain confidence about what response will be in general, maybe transferability from site we have to site we don't have. At least you have something to gauge your confidence level.

Q: I didn't know what component of biofidelity is going forward? If EFS and McManamy is not going forward, what is of biofidelity is going forward?

C: Look at… what is on the flipchart.

C: You've got your variables to make your classes. You can run cluster analyses and come up with some. (who is doing that? We don't know yet) Can relate to biology and see what variables maximizes correlation with biology. Kind of an optimization. Other way is to start with biological class and do same thing with other parameters. Can do both ways until you get to an optimization. That gets you your classes, one way to get down to a meaningful amount of classes. Once you get

that begin looking at your other process to see if it's doable. If not doable, you may have to combine more classes.

C: I agree. Once those buckets exist, identifying the canaries in each buckets and determining how they respond to flow becomes a less challenging task.

C: We need to keep these principles moving forward, they need to go into final report. I'd like to see Tom's bucket picture fleshed out.

Facilitator: We've identified a key term to frame our discussion is "planning tool".

C: How does this group go about deciding these principles?

Facilitator: First was the term of "planning tool". Let's test these: (numbers reflect order they were written on the flipchart)

1. (We need a classification system) Classification system of rivers and streams that incorporate geomorphology, hydrology, and biological characteristics
2. % of inflow as the preferred family of strategies
3. A purely hydrology, by itself, based classification does not work

Facilitator: I heard other principles mentioned, were those examples or did you want them up here? That these serve as the foundation for the final report.

C: They were examples, but most important is we do not lose these principals so they don't get rehashed. As we add more to them, these principles as we agree to them, they will be the foundation of our final report. I got ~80% of the dialog around the bucket picture. I would like to see this diagram and discussion more developed so we can reacquaint ourselves about it at next meeting.

Facilitator: Do any of these need to be reframed? Is there anything else to add to the principles? (no responses- looks good)

C: Monthly median and way to show system will break.

Q: You want to show a range of possibilities, where it breaks. (yes, how bad can it get)

C: That's a different point than saying %inflow is a preferred strategy, it's not saying either/or.

Q: Monthly median usually came out as 10% or between 10-20% change, not as drastic as the others- seemed conservative approach of these habitat guilds, it seems like an equally useful scenario to go forward with. I'm not sure how to include, though if everyone else votes to use % inflow I'm okay with that**.** Test monthly median as an analysis? We already agreed to continue to analyze these as we move forward.

Facilitator: Is there something else to add?

C: I don't know how to change the principle to reflect this. We need it to be continued to be analyzed- it was already agreed to continue with it at a previous meeting. Just carry on. Jay may want to add one.

C: One thing that's missing is the biology, haven't decided the scope of it – whether its fish?bugs?.

C: We don't need to complete this list today, as long as we don't lose anything.

Facilitator: does anything else need to be added up here?

C: We should add that the Classification system should incorporate hydrology, geomorphic characteristics, and biology.

C: Regarding principle 3, is it explicitly saying we are not pursuing the McManamay system?

C: It's more diplomatically said.

Facilitator: Let's go around the room and see how you weigh in using the 5 finger scale, for the three principles. There are 3 principles and there's a map up here Tom introduced. (one at a time)

> **Principle 1: Classification system needed that includes** hydrology, geomorphic characteristics, and biology: Mostly 1s, a couple 2s
>
> **Principle 2: % inflow as preferred family of strategies:** Are there 4 or 5? (Two 5s were raised)

Discussion about Principle 2:

C: Yes; I don't understand why % inflow is preferable over all the others.

C: The information in the chart is providing the information.

C: [talking about graphs/charts] There's spring guilds, less than of unregulated B,….I'm sorry, but don't even remember what unregulated means B means. We looked at a great number of charts.

C: Agreed, we have looked at a great number of charts.

C: I think the point in Fred's paper- was that this family of approaches does what the other ones don't, is that it retains variability in flows , so % flow by is not a static number as opposed with the ones on the left. To me, that statement, all its saying is- of those 3 groups of strategies, the ones on right are preferred because of that retaining variability.

C: But you're suggesting if somebody chooses annual 7Q10 there won't be any variability in flows, that's not true because there is inherent variability in the system.

C: But that leaves an extremely small amount of water in the stream.

C: I'm not suggesting that's the one I'm picking, I just don't see why % inflow is preferred.

C: Compared to ones on right, the other ones have much less variability in the hydrograph than the ones on the right, that's all I'm saying.

C: If you select 7Q10 as your environmental flow and use it in your models, you would model out almost all the volume of water in stream before you see red flags. As a long range planning tool, that side on the right allows you a little more flexibility in long-range forecasting.

Facilitator: Let's hear some more from others and more so we can understand the rationale of the 5. Then I want to make sure there were no more 4s, and 5s, and move forward to #3, we can go back and discuss it.

C: The question is, not how much water you leave in, how much needs to be in river to maintain integrity. That graph and 20 others like it, are all shaped like that. You get much more likely to retain significant portion of habitat, and therefore ecological integrity, using that family of tools than the other 2 family of tools. This is not speculative this is graphed.

C: As presently said, that's a false comparison. If you go down to 70% which flipped around would be 30% removal, in the highest retention is 60%, and that's a 40% removal. You can't look at those points on right hand side and extrapolate them over to be equal to the points in the middle, because you're talking about 2 different regimes and amount of water removed. In one case you're removing only 30% and the other you're removing 40%. those in middles since you're… you're only looking at beginning of curve on right and you've gone half of the curve over in the other case.

C: I'll interject, because we have a 5 we really need to pick up at another meeting and make sure we're on the same page.

Facilitator: Exactly, which is why we want to go back and ensure we heard his rationale about the 5, and we need to check-in with others who have not weighed in their support on the list of principles. Is there anything else you need to say to make sure everyone understands where you're at?

C: I'm just not comfortable looking at this chart today and saying this is where we need to go. There wasn't any other discussion today about this topic. Perhaps, but if we want to discuss it at next meeting, put in on the agenda and give us more time to think about implications. If there are previous presentations that relate to this decision- need the link/date/ etc. rather than try to go through the summaries.

C: Facilitator: Is anyone else at 4-5? (No.)

C: Suggest we put this discussion earlier in the agenda for Nov. rather than end of day.

> Facilitator: Testing for the **Principle 3: A purely hydrologically based classification does not work-** any 4s or 5s? Everyone is happy with it (yes- 1's)

Discussion about Cuffney's Diagrams

Facilitator: We can set aside time at beginning of meeting, though depends on when presenters can come. (follow-up: presenters need the morning, so this will be in the afternoon). As you move forward, you may add additional principles or revise the ones listed.

Q: Do we need to talk about Tom's diagram?

C: There are least still 2 paths, and both are on table: Biological species response curves and habitat modeling (PHABSIM) .

Q: Are we pursing biofidelity? R: No

C: Biofidelity is not an official activity of the EFSAB; it is something that EDF is doing. TNC is also conducting research, all research will potentially useful applications to the EFSAB and others as a whole. EDF has stopped its biofidelity test. At this point we're struggling with what to do with rest of our commitment to it, resources. We're asking ourselves now: what can we do to inform the establishment of buckets using biological data instead of pure hydrological data that would be useful?

C: What's critical- we have the biology in useful form. We have hydrology, possibly with EFS and WaterFALL. It's the other elements we need are geology, if we can get it assembled all of the data can model it. Once you have the data,

C: TNC is doing it.

C: There are definitely classes that fall out of it (geology data)

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

Next EFSAB Meeting and Agenda Topics:
The next meeting of the EFSAB is scheduled for Nov 27, 2012 at the Archdale Building Hearing Room from 9:30 until 4:30pm. The first meeting in 2013 will be on February 19. Parking passes that apply to the state parking decks are available at the meeting for EFSAB members/alternates and guest speakers- please carpool if you can!

Map to Archdale Building

The discussion items for the November's EFSAB meeting includes:

- Overview of a proposal for proceeding with stream classification (RTI)
- Panel discussion of WaterFALL and OASIS models (brief presentations by Hydrologix, RTI, DWR followed by discussion among EFSAB and speakers)
- Revisit the consensus principle proposed at Oct. meeting: % inflow should be used as preferred flow metric moving forward
- An overview of the Water Coordination Group- who they are, what they do, how their work relates to EFSAB
- Decommission of Gauges on Tar-PamRiver
- Proposed new meeting dates for 2013