Yadkin Project Relicensing (FERC No. 2197)
Water Quality Issue Advisory Group
April 6, 2005

Alcoa Conference Center
Badin, North Carolina

Final Meeting Summary

Meeting Agenda

See Attachment 1.

Meeting Participants

See Attachment 2.

Welcome and Introductions

Wendy Bley, Long View Associates, opened the meeting with a review of the agenda and introductions. She explained that Don Kretchmer, Normandeau Associates, would review the results of the Water Quality Monitoring Study and the Sediment Fate and Transport Study. She reminded the Issue Advisory Group (IAG) that Don had met with the IAG previously to present a lot of the monitoring data. Wendy also stated that since the Sediment Fate and Transport Study was distributed in December 2004 Yadkin had received comments on the draft report from the City of Salisbury and High Rock Lake Association.

Water Quality Monitoring Study Draft Report

Don Kretchmer reviewed the study objectives: 1) characterize baseline water quality in reservoirs and tailwaters, 2) evaluate effects of Project operations on reservoir water quality, and 3) evaluate effects of Project operations on tailwater water quality (see Attachment 3 – Meeting Presentation). Don also described the characteristics (e.g. surface area, depth, elevations etc.) of the four developments. He highlighted the residence times for each of the Project reservoirs: High Rock = 20 days, Tuckertown = 22 hours, Narrows = 2 days, and Falls = 2 hours. Larry Jones, High Rock Lake Association, said that he had asked once before for a review of the High Rock and Narrows residence times because a 10:1 ratio between the two does not seem right. Wendy explained that Normandeau had reviewed the residence times after the last IAG meeting. She said that the important thing to understand is that it takes a long time for water to pass through High Rock relative to the other reservoirs. Next, Don discussed inflow into the system and showed how inflows impacted water levels and influenced water quality.

Review of Monthly Data

Don said that Normandeau collected monthly data at 20 stations throughout the system from 1999 through 2003 for multiple parameters at multiple depths. Don made the following general comments about the water quality parameters monitored (see Attachment 3):

- Total suspended solids (TSS) vary markedly from upstream to downstream.
- Surface and bottom water comparisons show that TSS travel at a depth in High Rock (i.e. solids are settling deep in the water column); as a result there are much less TSS in Narrows and Falls.
- Total phosphorus (TP) is directly related to TSS concentrations, which drop off from upstream to downstream. There is plenty of TP in High Rock and Tuckertown to fuel algal blooms. In Narrows, there is some TP released from lower sediments.
- Total nitrogen: there are intense algal blooms in High Rock Reservoir and there is less productivity in the downstream reservoirs.
- Temperature and dissolved oxygen: there is little thermal stratification in High Rock Reservoir, but there are times during the summer when oxygen goes to zero in High Rock; there is little thermal stratification in Tuckertown Reservoir; there is strong thermal stratification in Narrows Reservoir (10-20°C), but the intakes at Narrows Dam are high and the low dissolved oxygen water is not exposed to the intakes all summer long (i.e. there is limited column mixing); there is no thermal stratification at Falls Reservoir.
- At full pond, during summer, intakes may entrain cooler water with low dissolved oxygen content and at lower water levels, intakes may entrain warmer water with somewhat higher dissolved oxygen content.
- Chlorophyll a: the highest concentrations are in lower High Rock Reservoir; upper High Rock is much more turbid (i.e. it has a light limitation factor) and therefore has lower concentrations; Narrows has lower concentrations
- Ammonia nitrogen: there a spikes of ammonia particularly in Narrows where there is a big anoxic zone.

Continuous Tailwater Data

Don discussed the continuous tailwater data that Normandeau collected. He explained that the state standard for dissolved oxygen is 5.0 mg/l daily average and 4.0 mg/l instantaneous. He described the number of monitored days when dissolved oxygen did not meet the state standards. Generally, there are a substantial number of days when dissolved oxygen is below the standards.

Relationship of Water Level and Water Quality

To determine the influence of water level on water quality, Normandeau ran a Kendall tau correlation. Don concluded that there is no correlation between water level and water quality at Tuckertown and Narrows reservoir because there is little reservoir elevation fluctuation. At High Rock and Narrows as water levels decrease, concentrations increase. The strongest relationships in the reservoirs were for TDS and TP in High Rock and nitrate and temperature in Narrows (all negative). In the tailraces concentrations are generally related to biology (chlorophyll a, BOD, and TDS) and are likely confounded by seasonal effects.

Relationship of Flow and Water Quality

Don briefly explained the methodology he used to examine the relationship of flow and water quality. Don said that in the reservoirs, higher flows are associated with lower biologically related parameter (chlorophyll a, TDS, BOD, TOC) (i.e. there is a flushing effect – the reservoirs act like rivers during periods of high flows). He noted that the strongest biological relationships are in the High Rock arms, lower High Rock Reservoir, and Tuckertown Reservoir. The High Rock arms and lower High Rock Reservoir are most closely correlated with flow. TP and TSS showed weak negative relationships with flow in High Rock and week positive relationships downstream.

Don said that in the tailraces, the one day results were similar but with weaker concentrations and the results were similar to the upstream impoundment stations. Generally, tailwater is directly related to water quality in the reservoir. Don stated that flows can increase or decrease, but if there is good water quality upstream in the reservoir then there will be good water quality downstream in the tailwater.

Effect of Project Operations on Tailwater Dissolved Oxygen Concentrations

Continuing, Don discussed how generation and air injection at Narrows Dam affects tailwater dissolved oxygen. Don noted that Narrows Reservoir is the deepest impoundment and has the greatest dissolved oxygen deficit. Don reviewed the results of the dissolved oxygen testing in 2001. He said that there is about a 2-3 ppm (parts per million) increase when Unit 4 is run with aeration. When the other three units are turned on, there is a dilution effect and there is not as big an increase in dissolved oxygen.

Don explained that Normandeau also conducted testing at Narrows and High Rock in 2004. The purpose of this testing was to 1) further evaluate the effectiveness of the air injection valves at Narrows Unit 4 to increase tailwater dissolved oxygen levels, 2) to determine how increases in dissolved oxygen concentrations in the Narrows tailwater impacts the dissolved oxygen concentrations in the Falls tailwater, and 3) to determine if an increase in dissolved oxygen concentrations in the High Rock tailwater impacts the dissolved oxygen concentrations in Tuckertown Reservoir (the High Rock units were run at 30 percent of full power, which provides some air injection through the bearing risers – High Rock could not be operated this way for the long-term).

Don reviewed the test results. The largest improvement in dissolved oxygen at Narrows (+1.75 mg/l) occurred after the first aeration valve at Narrows Unit 4 was opened. Opening the second value at Narrows Unit only provided an additional 0.25 mg/l increase in dissolved oxygen. With all four units at Narrows running and both valves open at Unit 4 there is a big dilution effect (DO = 3.50 mg/l).

Don concluded that air injection at Narrows improves tailwater dissolved oxygen. The improvements to dissolved oxygen at Narrows were also documented at Falls. Conversely, there was no improvement in dissolved oxygen in the High Rock tailwater (Tuckertown Reservoir) after air was drawn through the bearing risers.

Randy Tinsley, City of Salisbury, asked why High Rock could not be operated at 30 percent of full power for the long-term. Paul Shiers, PB Power, likened operating the units at 30 percent capacity for a long time to driving a car in first gear for a year – it can be done for a day or two, but not all year. Larry Jones asked if air injection is an effective option for improving dissolved oxygen. Paul responded yes. He explained that at High Rock it was not possible to get enough air injected with the existing equipment to see an improvement in dissolved oxygen. Larry questioned whether or not there will be major structural issues with getting air injected into the turbines at High Rock. Paul said that APGI is considering the options.

Darlene Kucken, NC Division of Water Quality, asked if Normandeau had data to support the conclusion that improvements in dissolved oxygen at Narrows would also be seen in the Falls tailwater. Don said yes and explained that Normandeau had monitored Falls during the test and documented similar improvements in water quality.

Lateral and Longitudinal Distribution of Dissolved Oxygen Near Dams

With regard to the lateral and longitudinal distribution of dissolved oxygen near the dams, Don concluded that the time of travel through the system makes synoptic data difficult to interpret. Don said that a better way to study the interaction between each reservoir and tailwater would be to look at upstream/downstream relationships.

Don briefly discussed the methodology for examining the lateral and longitudinal variability of dissolved oxygen and temperature in the vicinity of the dams under two different operating scenarios: full generation for six hours and no generation for six hours. The results were as follows:

	Reservoir	**Tailrace**
High Rock	- minimal thermal stratification under both generation and non generation - generation increases depleted oxygen zone at the transect closest to the dam	- temperatures 1-2 degrees C lower during generation - dissolved oxygen 1 mg/l lower during generation
Tuckertown	- evidence of algal bloom during generation survey - minimal thermal stratification under both scenarios - generation decreases depleted oxygen zone at the transect closes to the dam (deeper intake than High Rock) - effect still present but less pronounced at transect 2	- generation dissolved oxygen 4.2-4.6 mg/l - non generation dissolved oxygen 8.7-9.6 mg/l - likely that algal cells from the reservoir continued to produce oxygen in the tailrace
Narrows	- strong thermal stratification (10-20°C) - generation decreases depleted oxygen zone at the transect closest to the dam - effect still present but less pronounced at transect 2	- generation dissolved oxygen 4.1-6.2 mg/l - non generation dissolved oxygen 6.5-7.1 mg/l - highest generation readings near Unit 4, lowest readings away from Unit 4
Falls	- no thermal stratification - non generating dissolved oxygen readings lower	- dissolved oxygen concentrations approximately 1

	than generating probably due to timing of surveys	mg/l lower during non-generation

Total Suspended Solids

After a review of the TSS data, Don stated that the average TSS concentrations change both spatially and temporally. He said that High Rock has the highest average TSS concentrations, which reflects input from the Yadkin River and Falls has the lowest, which reflects the retention of solids in the upper reservoirs. The average decrease in TSS concentration from High Rock through Falls is 94 percent (i.e. the Yadkin Project reservoirs act as sediment traps). Don noted that the highest average TSS values were in higher flow years (2000 and 2003).

Jeff Jones, City of Salisbury, asked why there were no monitoring locations above the Interstate bridge when the Project boundary extends a couple of miles above the bridge. Jeff said that the uppermost monitoring station (H1) is below the City's intake. Wendy Bley explained that the monitoring locations were chosen many years ago; she thought to mirror the NC Division of Water Quality (NC DWQ) stations. Randy Tinsley said that the NC DWQ has monitoring stations above the bridge. Don Kretchmer noted that there is other historic data discussed in the report.

Biological Issues

Don explained that the Water Quality Monitoring Study also examined two biological issues raised by the IAG: mercury and fecal coliform levels. He explained that Normandeau collected 10 largemouth bass, 10 black crappie, and 10 channel catfish from the Tuckertown tailwater (upper Narrows Reservoir) to test for the presence of mercury. He said that all the samples were below 0.15 mg/kg (the FDA action level is 1 mg/kg). All the fish sampled were well below the FDA action limit.

Don explained that Normandeau reviewed fecal coliform data collected by the state from 55 mid-lake samples in High Rock, 6 in Tuckertown, and 10 in Narrows between 1999 and 2001. He said that all of the samples were below the state standard of 200 per 100 ml. Additionally, Stanly, Rowan, and Davidson counties received no complaints requiring fecal coliform monitoring during this same time period.

Robert Petree, SaveHighRockLake.org, stated that there is long history of spills in Abbots Creek that samples taken from the middle portion of the reservoir would not show. Don explained that there are no changes in Project operation what would influence spills in Abbots Creek. Pete explained that Abbots Creek is one of the largest tributary arms to High Rock and because High Rock has such a long retention time, the coliforms are in the creek longer. Specific to this issue, Don agreed to review the data again.

Robert Petree also asked that data in the final report be presented in feet instead of meters (especially when referring to reservoir elevations). Don said that because he was dealing with state water quality standards that are expressed in the metric system he expressed all the data in the metric system. Larry Jones asked that at a minimum all dimensional data be presented in the English system. Don agreed to use both the English system and the metric system in the final report. Robert also asked that Normandeau check the accuracy of the normal hydraulic capacity numbers for High Rock provided in Table 1.0-1 on page two of the report. He thought that there might be some confusion between licensed capacity and normal operating capacity.

Ben West, US Environmental Protection Agency, asked about next steps. Specifically, he asked if the Water Quality IAG would be responsible for developing recommendations or if recommendations would be discussed in the context of the settlement negotiations. Gene Ellis said that the issue of how the work of the IAGs relates to the settlement negotiations is a process question. He thought that there would have to be some opportunity for the Authorized Representatives participating in the settlement negotiations to review and digest the study results.

Sediment Fate and Transport Study Draft Report

Don explained that the Sediment Fate and Transport Study Draft Report was prepared by Al Larson, Normandeau Associates, and Shirley Williamson, PB Power. Don explained that the objectives of the "desktop study" were to: 1) estimate the current sediment load to the Yadkin Project reservoirs and identify the sources of sediment, 2) estimate the sediment load being retained within the Yadkin Project reservoirs and identify patterns of sedimentation with High Rock and the impacts of sediment deposition on aquatic habitats and municipal water supply intakes, 3) characterize the physical characteristics of the sediments, and 4) evaluate sediment fate and transport qualitatively under existing and potential future operating scenarios. Don then reviewed the results of the literature search. He offered the following thoughts on the previous investigations of erosion and sedimentation in the Yadkin River basin (see Attachment 4 – Meeting Presentation):

- The region has some of the highest erosion rates and sediment yields in the United States and the Piedmont region of North Carolina has the highest sediment yields in the state.
- Although agricultural use has declined (once counties having the highest concentration of croplands had the highest estimated erosion rates), land development is increasing in urban and suburban areas, which may result in an increase in sediment yields.
- The highest concentrations of suspended sediment are found on the Yadkin River at Yadkin College. There is a significant decrease in suspended sediment concentrations below this point because much of the sediment is deposited in the six impoundments.
- The highest concentration of suspended sediment occur during high flow events. The bulk of sediment transported by the Yadkin River occurs over short periods of time in response to storm events.
- There is a documented reduction in sediment transport over time (estimated to be 30 percent).

Don also reviewed the various estimates of reservoir sedimentation. The 1979 study reported an input of 870 ac-ft/yr and an output of 42 ac-ft/yr – a 95 percent reduction. A 1993 study reported an input of 628 ac-ft/yr and an output of 138 ac-ft/yr – a 78 percent reduction. Larry Jones questioned the difference between these two reports. Don explained that the 1979 USDA study estimated input and output based on predicted erosion rates. The 1993 Fisher study is based on measured suspended sediment concentrations.

Shirley Williamson explained that PB Power had compared maps of the bathymetry of the upper portion of High Rock Reservoir from 1917 and 1997 to better understand that accumulation of sediments in the reservoir. She said that they found that sediment had accumulated in the upstream area of the reservoir between the I-85 bridge and Crane Creek. She estimated that 80 years of sediment accumulation has resulted in a reduction of total usable storage capacity in the upper 12 ft of the reservoir by six percent. Larry Jones commented that High Rock Reservoir was originally about 35-ft deep and now it is only 20 to 22-ft deep. Shirley said that the focus had been on the impact to usable storage (i.e. within the upper 12-ft of the reservoir). Randy Tinsley asked about the 1917 contours. Shirley was uncertain, but thought that they 1917 contours might be 5 or 10 ft. [Shirley later confirmed that the contours are available from elevation 660 ft (Yadkin datum) down to the original river surface; the contours are at 5 ft intervals in the area of the confluence of the Yadkin and South Yadkin rivers.]

Don Kretchmer described the effects of sedimentation on habitat. He said that there is very little quality habitat on High Rock Reservoir because it has all filled in. He briefly discussed the delta in upper High Rock and the wetlands present there.

Continuing, Shirley explained that there are four municipal water supply intakes located within the Project. Of these four, only the Salisbury-Rowan Utility intake on High Rock appears to be impacted by sedimentation.

Shirley summarized the overall findings of the study:

- There is a lot of available information on soil erosion and sediment transport in the Yadkin River basin.
- Sediment is one of the principal water quality problems in the Yadkin-Pee Dee River Basin.
- Sources of sediment have changed over time. Stormwater runoff in urban and suburban areas is now the major contributor of sediment to the Yadkin River.
- TSS concentrations have declined over the long-term, but may begin to increase with increased land development.
- The dams along the Yadkin-Pee Dee River are acting as sediment traps. Estimates are that from 78 to 95 percent of the sediment transported into these impoundments is retained.
- Deposition of sediment in High Rock Reservoir is reflected in changes in bathymetry.

Randy Tinsley asked if the source of sedimentation had shifted from agricultural to urban land development or if agricultural land use is still a big contributor. Al Larson said that with the introduction of Best Management Practices the impacts of agricultural land use on sedimentation have decreased. He noted that disturbed lands and associated runoff in general are big contributors to sedimentation.

Donley Hill, US Forest Service, recalled a 1968 EPA publication that cited road construction as the single largest source of sedimentation. He asked why road construction was not specifically discussed. Larry Jones agreed that he believes that road construction is the biggest problem. Al

Larson said that the 1979 Soil Conservation Service study indicated that the number of unpaved roads (not necessarily road construction) was a major contributor to sedimentation.
Randy Tinsley assumed that even if contributions of sediment from upstream sources were effectively managed there would still be a problem of bed load extending upstream from the Project. Al Larson stated that the studies reviewed included very little information on bed load transport because it is such a difficult thing to measure.

Robert Petree said that there was a study on dredging and sediment removal conducted in the late 1990s. He asked why the results of this study were not included in the draft report. Gene Ellis commented that APGI was one of the sponsors of the study. He said that the much of the information included in this late 1990s study was derived from previous studies (the same studies reviewed as part of the Sediment Fate and Transport Study). Robert said that the late 1990s study included several recommendations that should probably be considered by the IAG. Robert said that the results of the Sediment Fate and Transport Study, conducted as part of the Yadkin relicensing, offered no new information. He said that he, and others, already knew that High Rock has a huge sedimentation problem.

Ben West said that he too was having difficulty pulling all of the information together, not only from this study but from others as well, to draw conclusions and make recommendations. Wendy Bley explained that the results of this study together with the results of the water quality monitoring study, habitat assessment, and wetlands assessment present a very complex picture of the issue. She said that sedimentation has both negative and positive impacts on the resources. She noted that the entire Yadkin-Pee Dee River Basin below the Yadkin Project is benefited by sediments being captured by the Yadkin Project reservoirs. Meanwhile, there are associated impacts to other resources, such as habitat. John Ellis, US Fish and Wildlife Service, asked if there had been any studies conducted that concluded that the lower river is sediment starved. Wendy was not aware of any. She thought that the Yadkin Project reservoirs provide a benefit in that they trap sediments. She acknowledged that some sediment is a good thing and too much sediment is a bad thing. Al Larson added that there is a general reduction in sedimentation from the piedmont to the coastal plain.

Larry Jones questioned whether the study evaluated sediment fate and transport qualitatively under existing and potential future operating scenarios (a stated objective of the study). Wendy noted the difficulty in addressing this objective. She said that the report clearly states that most of the sediment entering the Project reservoirs comes in during high flow events. She said that APGI could, on a conceptual level, evaluate what would happen with regard to sediment transport if High Rock was operated to pass the inflow events. She said that she could ask Normandeau to make an assumption about the sediment concentration per volume of water during a high flow event and then use the OASIS model to do some comparative runs between the base case and an alternative operating scenario (e.g. operating High Rock at near full pool) to determine how much more sediment would be passed downstream. Larry Jones stated that there had been ample opportunities during the past two years collect actual data (i.e. to take grab samples during storm events) rather than relying on a computer model. He commented that when High Rock Reservoir is full there are no visible signs of a rain event (e.g. trash, logs etc.) in the tributary arms because this debris passes on downstream. Alternatively, when the reservoir is drawn down debris from rain events backs up into the tributary arms. He suggested that sediment would behave similarly. Wendy said that sedimentation is a very dynamic situation and for this reason, APGI had committed to evaluating sediment fate and transport qualitatively. She added that the OASIS model is the tool that APGI is using to evaluate alternative operating scenarios. There was additional discussion about velocity and changes in velocity being a driver in sedimentation. Don Kretchmer commented that there is probably not the force/velocity to move sediments through High Rock Reservoir. He was doubtful that enough sediment could be passed through High Rock Reservoir to make a difference. Wendy and Paul Shiers agreed with Don that there probably would not be a big difference in sedimentation between the base case and alternative operating scenario. Larry commented that when High Rock is down 5 to 10-ft there is a huge difference in velocity in the tailwaters as opposed to when the reservoir is full.

There was discussion about the use of HEC RAS as a better tool to compute sediment transport. Randy Tinsley assumed that HEC RAS had been used because the draft study report said that changes in reservoir elevation do not have an impact on flooding upstream of I-85. Paul Shiers explained that HEC RAS was used previously to study Project effects on flooding upstream of I-85. Randy asked if the study report could be used to predict sedimentation effects during the new license term. Jeff Jones said that a six percent loss in usable storage over 50 years does not sound like a lot. However, he recognized that sedimentation is having a very localized impact in upper High Rock. He said that the City of Salisbury needs to understand if sediment deposition is going to increase or decrease in this area over the term of the new license. Ben West added that it would be useful to understand the loss in capacity from a volumetric standpoint over the next 30-50 years. Ben suggested that APGI take recent estimates of sediment load coming into the Project and project them out over the next 30-50 years to determine any changes in the stage storage curves and changes under alternative operating scenarios. Chris Goudreau, NC Wildlife Resources Commission, said that even changing the stage storage curve would require assumptions about how areas are filled in. Wendy agreed and suggested a simple assumption that the sediments would spread evenly across the bottom of the reservoir.

Larry Jones stated that the High Rock tributary arms are flat from the siltation whereas the tributaries to Narrows Reservoir are not because the sediments move through the mainstem of the reservoir. He suggested a comparison of the original contours of the tributary arms to the present day contours. Al Larson said that High Rock Reservoir has a much larger drainage area carrying higher volumes of sediment than Narrows Reservoir. He said that over time, sediment deposits at the confluence and in the tributary arms have built up and have begun moving towards the mainstem reservoir. John Ellis added that a large percentage of the sediment is settling out before it even gets to Narrows Reservoir so Narrows Reservoir is not filling in as quickly.

Before breaking for lunch, Darlene Kucken took the opportunity to speak about the upcoming TMDL (Total Maximum Daily Load) planning process for High Rock Reservoir. She said that the first public meeting, scheduled for May 24, 2005, will be a meeting to present the goals and objectives of the TMDL as well as a schedule. A subsequent meeting will be held in late July. She stated that it would be a long process. She also noted that this TMDL would be the first watershed wide TMDL in North Carolina. Darlene explained that it is possible that turbidity in the watershed would have to be reduced 70 to 80 percent, which may be very challenging due to the erodibility of the soils in the piedmont. Darlene suggested that APGI be an active participant in the process.

After lunch, Wendy Bley agreed to doing some additional work on the Sediment Fate and Transport Study to better evaluate sediment fate and transport qualitatively under existing and potential future operating scenarios: 1) estimate the volume of sediment transported downstream as a result of changes in Project operations and 2) estimate the total volume of sediment coming into the reservoir and describe the changes in the stage-storage curves and changes under alternative operating scenarios. Chris Goudreau also suggested adding a qualitative matrix to the final report that describes the various pros and cons associated with sedimentation.

Randy Tinsley said that if the City of Salisbury is given access to the 1917 High Rock bathymetry data the City could evaluate the anticipated effects of future operations on its intakes and other infrastructure. Randy also asked for the HEC RAS modeling results that are summarized in the Sediment Fate and Transport Study. Chris Goudreau asked what type of evaluation the City would do with these data. Don Cordell, City of Salisbury, said that the 1917 1977 comparison indicated that there was substantial sedimentation that materially reduced the cross section of the river and caused localized flooding impacts. Don said that once he has the data he could complete the evaluation in about 10 days. Gene Ellis said that APGI understood the request and asked that Paul Shiers and Don Cordell talk more specifically about the HEC RAS model and the available data.

At the conclusion of the meeting, the IAG revisited the issue of upgrades to the Project developments to improve dissolved oxygen. John Ellis asked if alternatives to air injection were being considered (e.g. an underwater weir). Gene Ellis stated that APGI is considering options that will remedy the dissolved oxygen problem and that make the most financial sense. Larry Jones asked about the cost of upgrading a unit and adding air injection capabilities. Paul Shiers estimated that the air injection at Narrows Unit 4 cost about $250,000 because it was done concurrently with the upgrades. If the air injection was added independent of the upgrades, it would have been more expensive – probably $350,000.

Darlene Kucken said that the 401 water quality certificate would include a reopener should the planned upgrades fail to improve dissolved oxygen to or above the state standards.

Wrap-up and Next Steps

Wendy Bley said that APGI would accept additional comments on the draft study reports through May 6, 2005. The meeting adjourned at about 2:00 p.m.

Attachment 1 – Meeting Agenda

Yadkin Project
(FERC No. 2197)
Communications Enhanced Three-Stage Relicensing Process

Water Quality Issue Advisory Group Meeting

Wednesday, April 6, 2005
Alcoa Conference Center
Badin, North Carolina

9:00 AM – 4:00 PM

Preliminary Agenda

1. Introductions, Review Agenda
2. Review and Discuss Water Quality Monitoring Study Draft Report
3. Review and Discuss Sediment Fate and Transport Study Draft Report
4. Wrap-up and Next Steps

Attachment 2 – Meeting Participants

Name	Agency/Organization
Ben West	US Environmental Protection Agency
Darlene Kucken	NC Division of Water Quality
Don Kretchmer	Normandeau Associates
Donley Hill	US Forest Service
Donna Davis	Stanly County
Gene Ellis	APGI, Yadkin Division
Jeff Jones	Salisbury Rowan Utilities
Jody Cason	Long View Associates
John Ellis	US Fish and Wildlife Service
Larry Jones	High Rock Lake Association
Paul Shiers	PB Power
Randy Tinsley	City of Salisbury (counsel)
Rick Simmons	Normandeau Associates
Robert Petree	SaveHighRockLake.org
Shirley Williamson	PB Power
Steve Padula	Long View Associates
Steve Reed	NC Division of Water Resources
Todd Ewing	NC Wildlife Resources Commission
Wendy Bley	Long View Associates

Attachment 3 – Meeting Presentation

Yadkin Project
Water Quality
1999-2004

April 6, 2005

Normandeau Associates

Water Quality Study Objectives

- Characterize baseline water quality in reservoirs and tailwaters
- Evaluate effects of project operations on reservoir water quality
- Evaluate effects of project operations on tailwater water quality

Background Information

Characteristics of Yadkin System

High Rock
Area: 15,180 acres
Max depth: 19 m
Mean depth: 5 m
Pond elev: 190.2 m
Top of intake: 184 m
Bottom intake:173.4m
3 generating units
Ave. res. time: 20 days

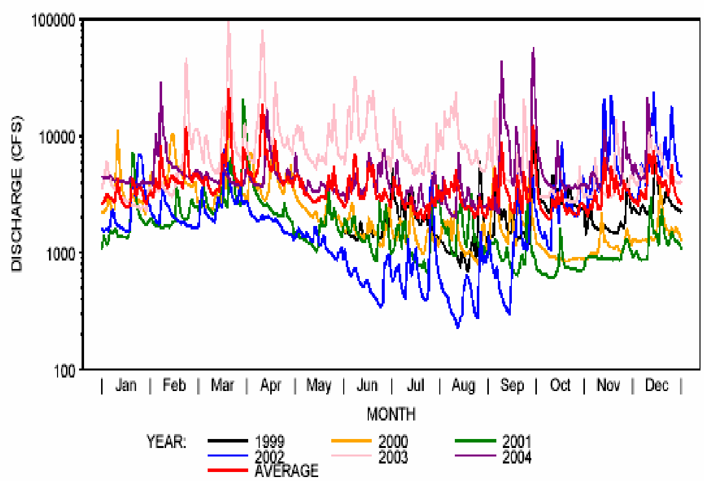
Tuckertown
Area: 2,560 acres
Max depth:17 m
Mean depth: 5 m
Pond elev: 172.2 m
Top of intake: 162.3 m
Bottom intake:154 m
3 generating units
Ave. res. time: 22 hours

Characteristics of Yadkin System

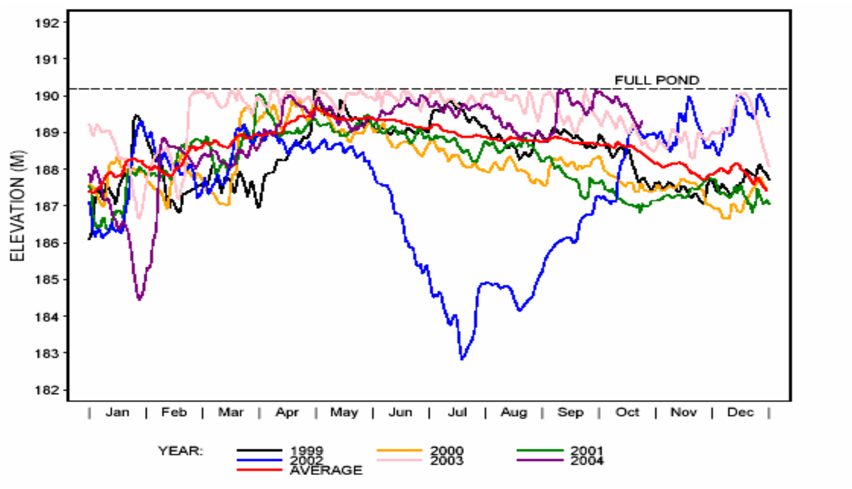
Narrows
Area: 5,355 acres
Max depth: 53 m
Mean depth: 14 m
Pond elev: 155.4 m
Top of intake: 146 m
Bottom intake:140.6 m
4 generating units
Ave res. time: 2 days

Falls
Area: 204 acres
Max depth:16 m
Mean depth: 8 m
Pond elev: 101.5 m
Top of intake: 99.3 m
Bottom intake:89.6 m
3 generating units
Ave res. time: 2 hours

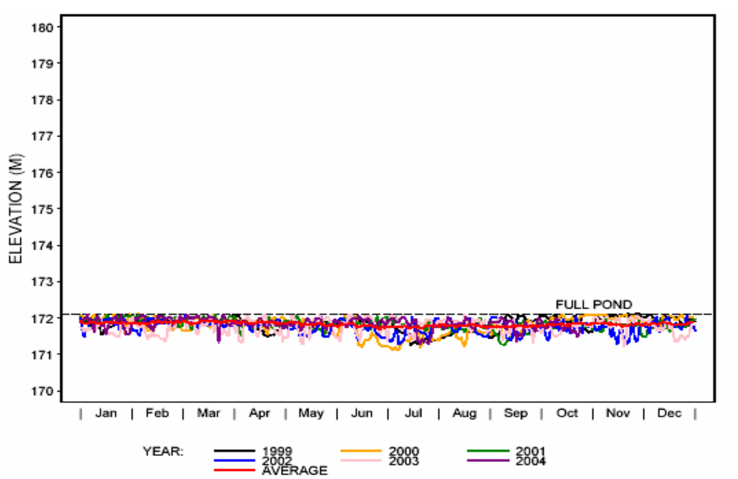
Inflow to system (cfs)



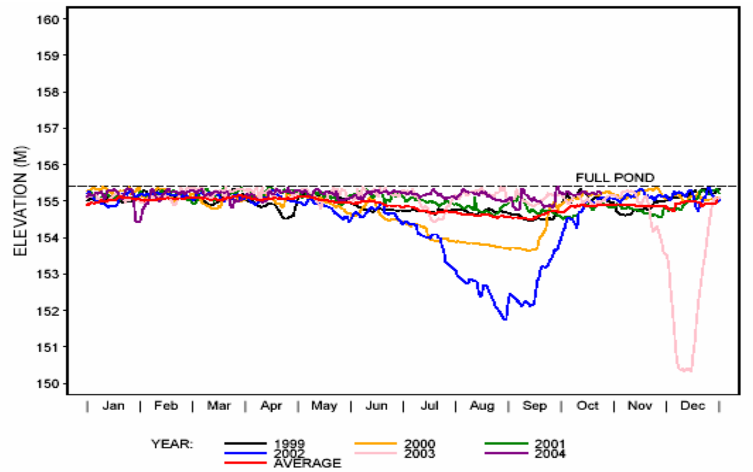
High Rock Water Level



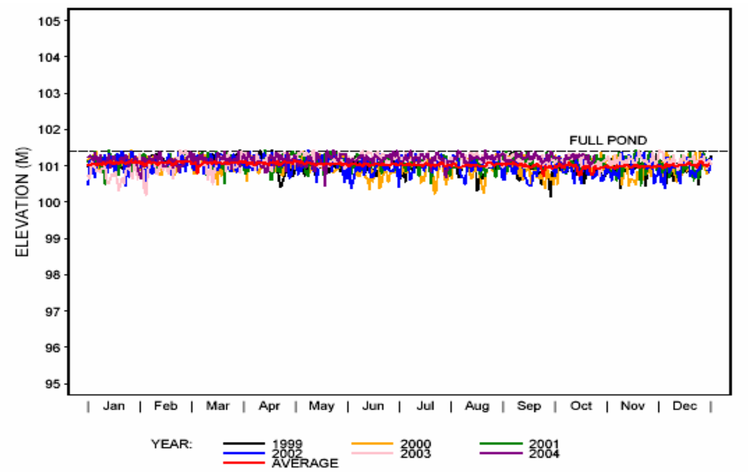
Tuckertown Water Level



Narrows Water Level

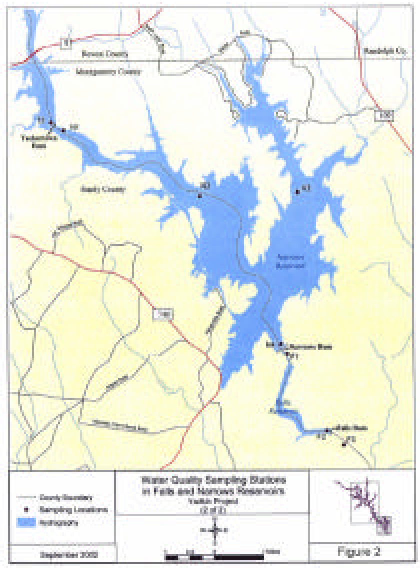


Falls Water Level



Today's Discussion

- Review of monthly data
- Review of continuous tailwater data
- Relationship of water level and water quality
- Relationship of flow and water quality
- Effect of project operations on tailwater dissolved oxygen concentrations.
- Lateral and longitudinal distribution of DO near dams.
- Total Suspended Solids
- Biological Issues

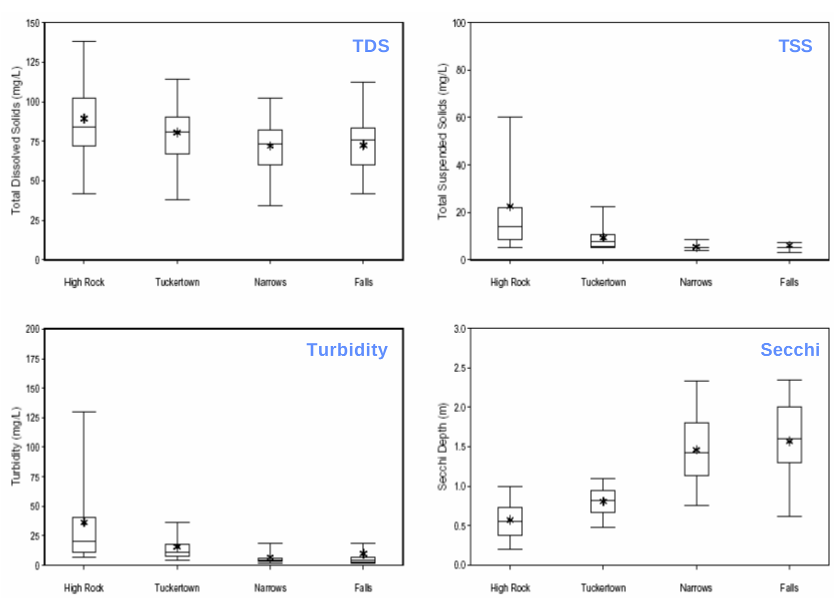


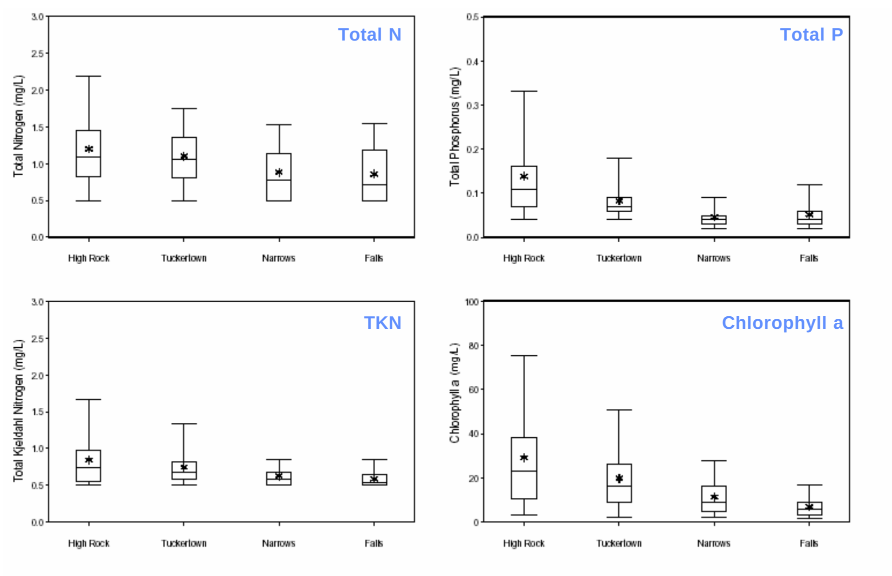
Monthly Water Quality Monitoring Program

- 20 stations throughout system
- Monthly data collected from 1999 through 2003
- Multiple parameters at multiple depths

Monthly water quality parameters

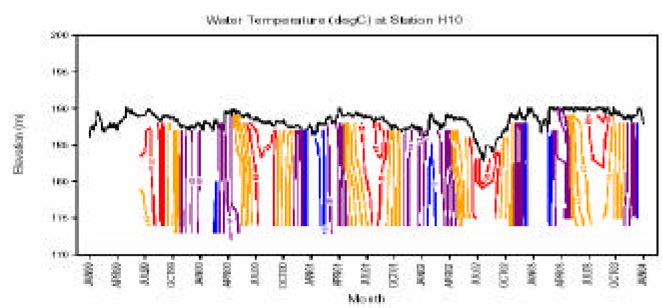
- Chlorophyll *a*
- Alkalinity, Total
- Biological Oxygen Demand
- Cadmium
- Carbon, Total Organic
- Chemical Oxygen Demand
- Copper
- Cyanide, Total
- Lead
- Mercury
- Phosphorus, Total
- Nitrogen, Ammonia
- Nitrogen, NO3+NO2(as N)
- Nitrogen, Total Kjeldahl
- Residue, Total (TS)
- Residue, Filterable (TSS)
- Residue, Nonfilterable (TDS)
- Turbidity
- Dissolved Oxygen
- Temperature
- Secchi Transparency
- pH
- Conductivity



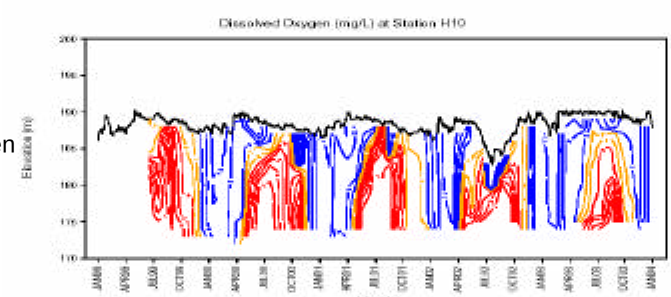


High Rock
Station H10

Temperature



Dissolved Oxygen



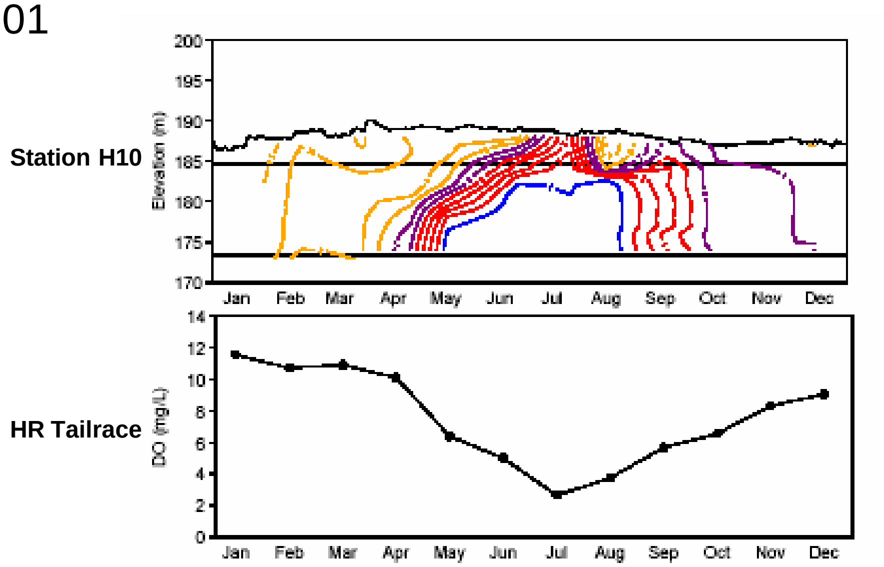
Dissolved oxygen characteristics of stations in High Rock Reservoir.

Station	Number of sampling dates where:[a] Anoxia (<1 mg/l) in deeper water	Low DO (<5 mg/l) in surface 2 meters
Arms		
H2	4	17
H4	3	12
H5	10	5
H6	18	3
H8	9	7
H9	10	2
Mainstem		
H1	0	0
H3	0	2
H7	3	2
H10	16	5

[a] Total number of sampling dates varies from 53 to 55.

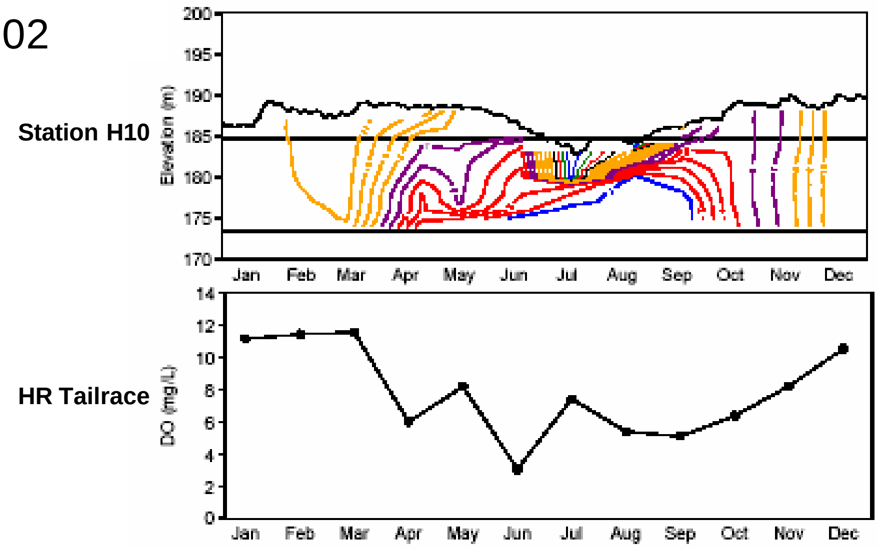
High Rock

2001



High Rock

2002

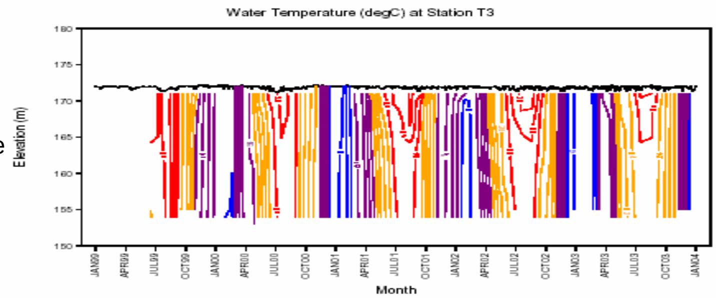


Relationship between reservoirs and tailraces

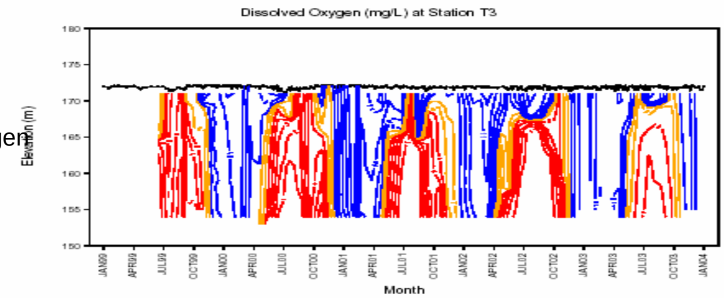
- At full pond, during summer, intakes may entrain cooler water with low dissolved oxygen content
- At lower water levels, intakes may entrain warmer water with somewhat higher dissolved oxygen content

Tuckertown 1999-2004 Station T3

Temperature

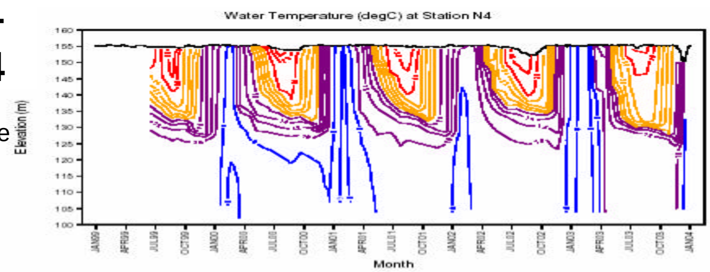


Dissolved Oxygen

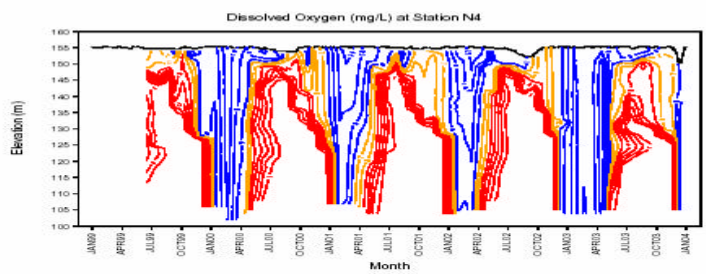


Narrows 1999-2004 Station N4

Temperature

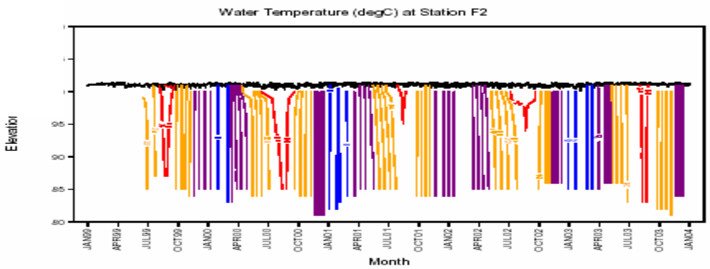


Dissolved Oxygen

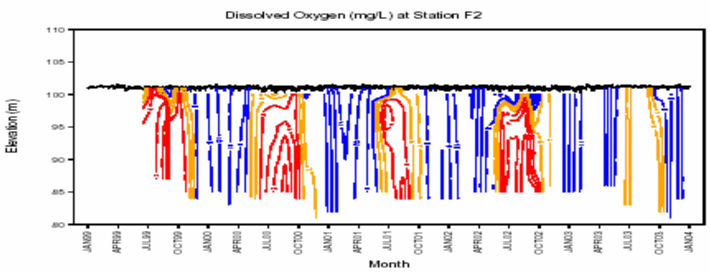


Falls
1999-2004
Station F2

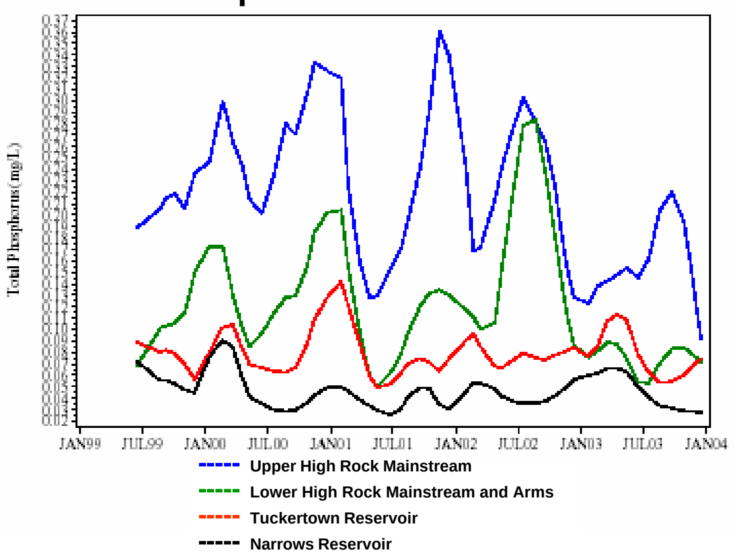
Temperature



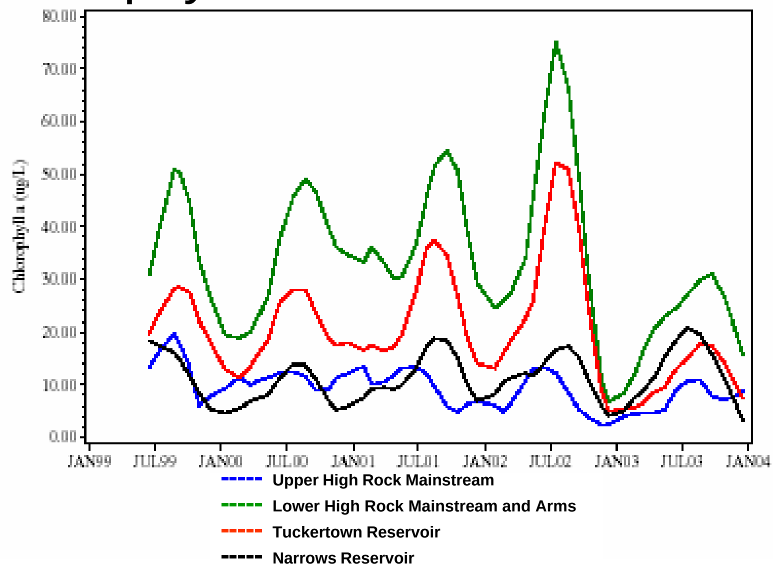
Dissolved Oxygen



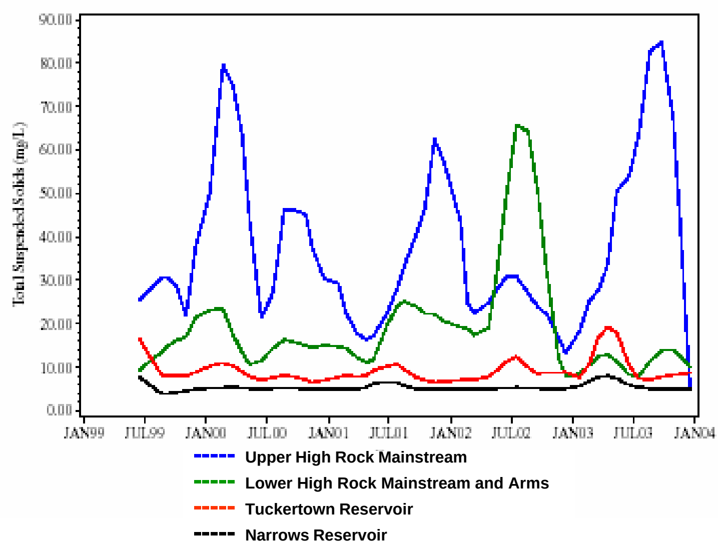
Total Phosphorus



Chlorophyll a

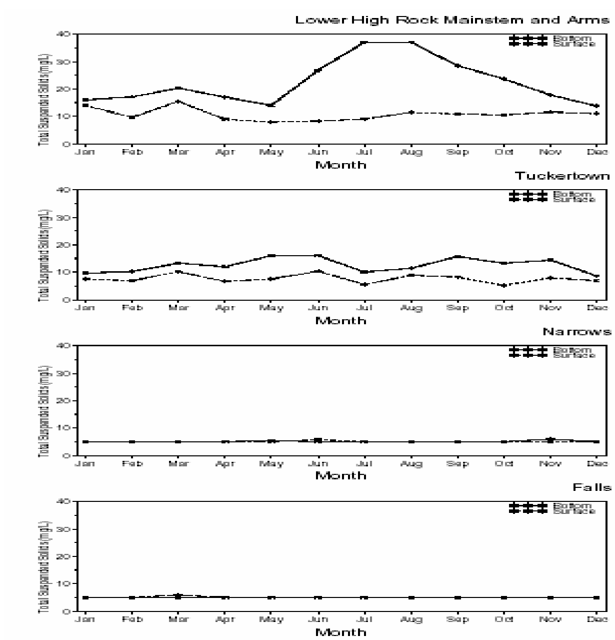


Total Suspended Solids

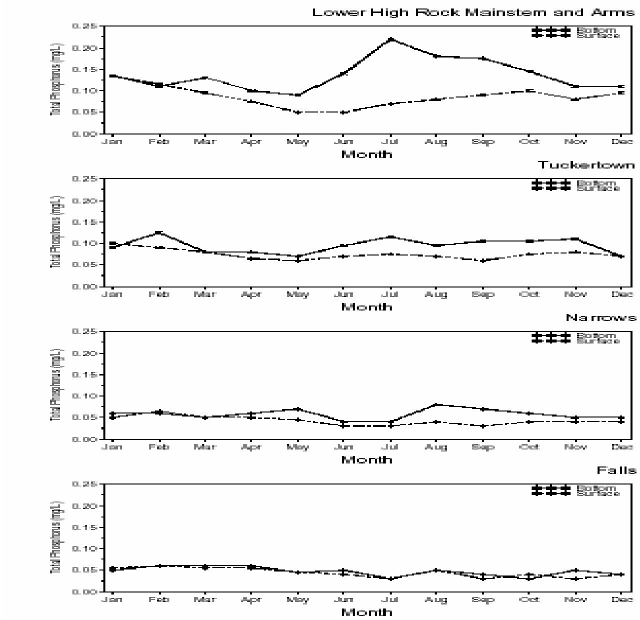


Surface and bottom water comparisons

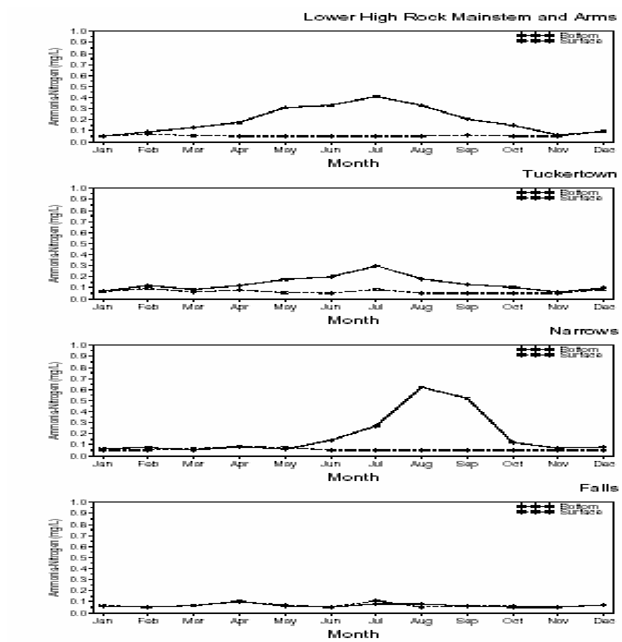
Total Suspended Solids (TSS)



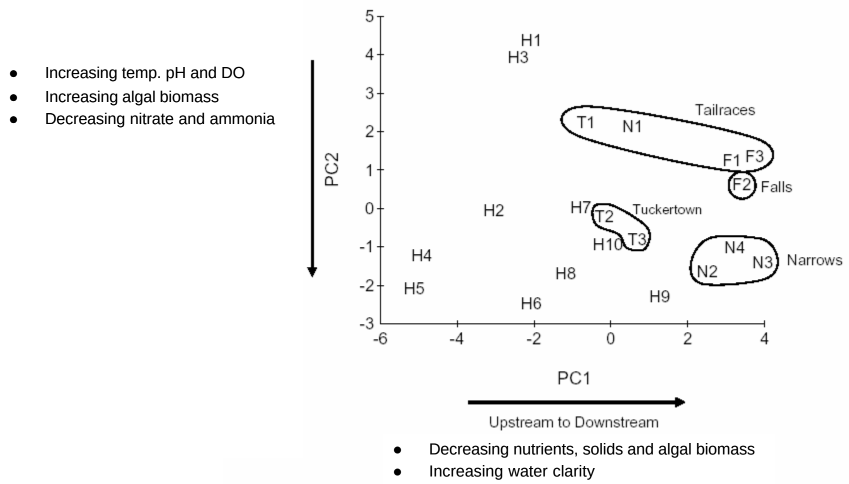
Total Phosphorus (TP)



Ammonia Nitrogen



Principal Components Analysis



Today's Discussion

- Review of monthly data
- Review of continuous tailwater data
- Relationship of water level and water quality
- Relationship of flow and water quality
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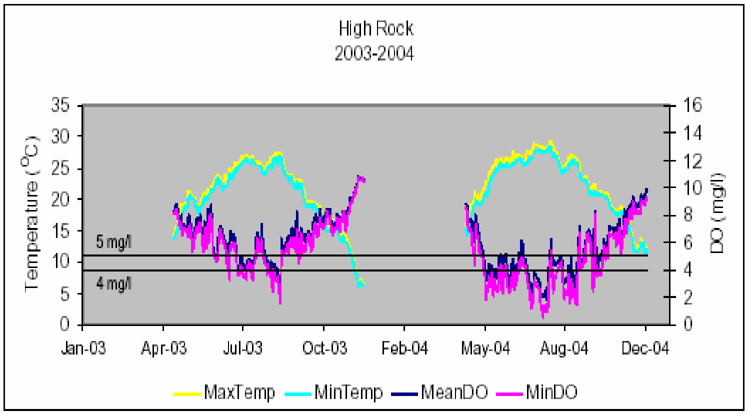
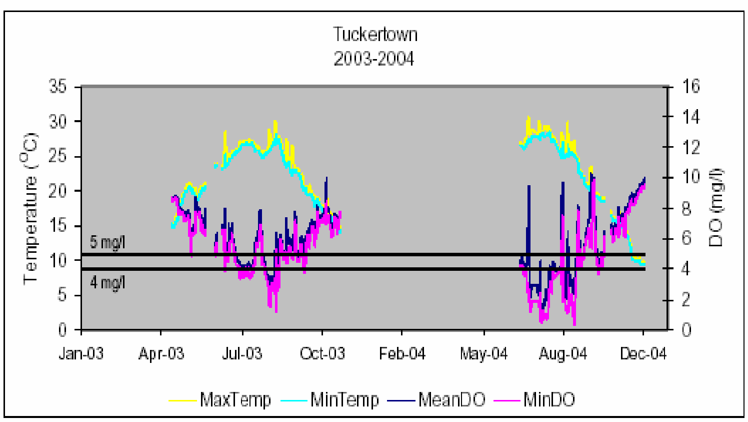
- Total Suspended Solids
- Biological Issues

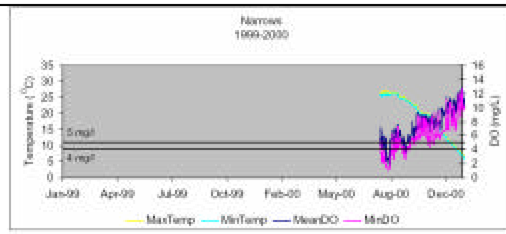
High Rock 2003-2004

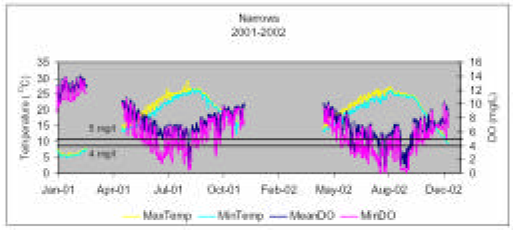


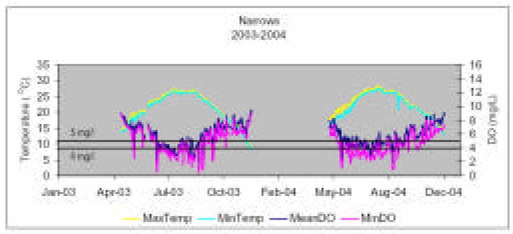
Tuckertown 2003-2004



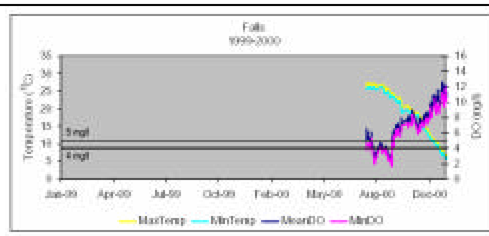
Narrows
1999-2004

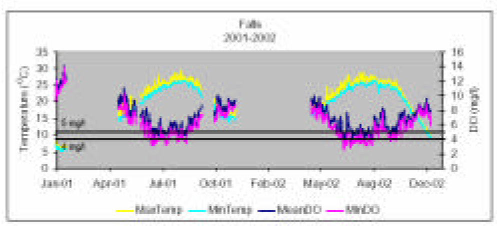


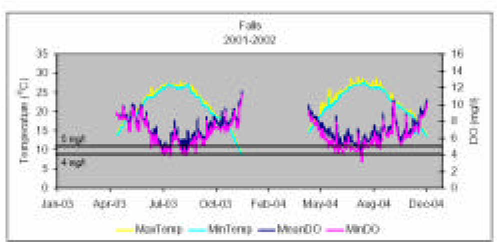




Falls
1999-2004







Number of monitored days below specific DO concentrations

		2000	2001	2002	2003	2004
High Rock	<5 mg/l[1]	NS[4]	NS	NS	49	107
	<4 mg/l[2]	NS	NS	NS	33	96
Tuckertown	<5 mg/l[1]	NS	NS	NS	48	62
	<4 mg/l[2]	NS	NS	NS	36	55
Narrows	<5 mg/l[1]	23	11	54	79	75
	<4 mg/l[2]	34	57	95	78	91
Falls	<5 mg/l[1]	35	35	48	19	4
	<4 mg/l[2]	32	35	46	9	5

[1] based on daily average concentration.
[2] based on at least one 15 minute reading below 4 mg/l per day.
[3] continous monitoring initiated 08/03/00.
[4] NS – not sampled.

Today's Discussion

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Influence of Water Level on Water Quality – Methods.

- Kendall tau correlation (95%, $p<.05$)
- Water level vs surface concentrations
  - BOD
  - Chlorophyll a
  - Ammonia
  - Nitrate
  - TDS
  - TOC
  - Total Phosphorus
  - TSS
  - DO
  - Temp

Water Level Correlation Summary

- Tuckertown and Narrows - essentially no correlation in due to little level fluctuation.
- High Rock and Narrows
  - Most sig. correlations negative (as water levels decrease, concentrations increase)
  - Reservoirs - Strongest relationships were for TDS and TP in High Rock and nitrate and temp in Narrows (all negative)
  - Tailraces - concentrations are generally related to biology (chl a, BOD, TDS). Likely confounded by seasonal effects.

Today's Discussion

- Review of monthly data
- Review of continuous tailwater data
- Relationship of water level and water quality
- Relationship of flow and water quality
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- Biological Issues

Influence of Flow on Water Quality – Methods.

- Kendall tau correlation (95%, p<.05)
- Flow through dams vs surface concentrations
  - BOD
  - Chlorophyll a
  - Ammonia
  - Nitrate
  - TDS
  - TOC
  - Total Phosphorus
  - TSS
  - DO
  - Temp
- 7 day average flow used in analysis
- 1 day average flow also calculated for tailraces

Flow correlation summary

- Reservoirs
  - Higher flows associated with lower biologically related parameter (chl a, TDS, BOD, TOC).
  - Strongest "biological" relationships in HR Arms, HR lower stations and Tuckertown.
  - TP and TSS show weak negative relationship with flow in HR and weak positive relationship downstream.
  - HR Arms and lower mainstem stations are most closely correlated with flow.
- Tailraces
  - 1 day results similar but weaker correlations
  - Results similar to upstream impoundment stations

Today's Discussion

- Review of monthly data
- Review of continuous tailwater data
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Question: How do generation and air injection affect tailwater dissolved oxygen?

2001 Narrows Survey

- Air injection only at Narrows
- Narrows is deepest impoundment and has the greatest dissolved oxygen deficit

Narrows operations results 2001, DO (mg/l) (change from previous setting in brackets)

Status	No air	1 valve	2 valves
No units	4.6 (- 2.0)		
Unit 4	2.6 (- 5.0)	5.5 (+3.0)	6.0 (+ 0.5)
All units	2.6 (- 2.0)		4.7 (+1.5)

Purpose of 2004 Testing

- To further evaluate the effectiveness of the air injection valves at Narrows Unit 4 to increase tailwater dissolved oxygen levels
- To determine how increases in dissolved oxygen concentrations in the Narrows tailwater impacts the dissolved oxygen concentrations in the Falls tailwater; and
- To determine if an increase in dissolved oxygen concentrations in the High Rock tailwater impacts the dissolved oxygen concentrations in the Tuckertown tailwater.

2004 Operations Test Results at Narrows

Test	Unit	Unit Configuration	Air Valves	Total Discharge (cfs)	DO Change (mg/l)	DO (mg/l)
Baseline	U4	@ 20% gate or 4 MW		350		5.25
Test 6	U4	@ BE or 28 MW	0	2240	-2.00	3.25
Test 7	U4	@ BE or 28 MW	1	2240	1.75	5.00
Test 8	U4	@ BE or 28 MW	2	2240	0.25	5.25
Test 9	U4 U1	@ BE or 27 MW @ 30% gate or 5 MW	2	2580	0.25	5.50
Test 4	U4 U1,U2	@ BE or 25 MW @ 30% gate or 8.8 MW	2	3420	0.25	5.50
Test 5	U4 U1,U2, U3	@ BE or 25 MW @ 30% or 8, 8.7 MW	2	4625	0.25	5.50
Test 1	U4 U1, U2,U3	@ BE or 23 MW @ BE or 23 MW @ 30 % or 8, 8 MW	2	4885	-1.50	4.00
Test 2	U4 U1,U2, U3	@ BE or 25 MW @ BE or 24, 24 MW @ 30% gate or 8 MW	2	6440	-0.50	3.50
Test 3	U4 U1,U2, U3	@ BE or 29 MW 26,28 MW @ BE or 28 MW	2	9170	0.00	3.50

Operation Analysis Conclusions

- **Air injection at Narrows improves tailrace DO**
  - **Unit 4 alone improves DO from 1 mg/l in reservoir to 5-6 in tailrace**
  - **Other units run with Unit 4 dilute this effect**
  - **Air injection at all four units would likely maintain DO >5 when running**
  - **Improvements at Narrows would be seen at Falls**
- **No improvement in tailrace concentrations were observed in High Rock or Tuckertown in response to drawing air through the bearing risers**

Today's Discussion

- Review of monthly data
- Review of continuous tailwater data
- Relationship of water level and water quality
- Relationship of flow and water quality
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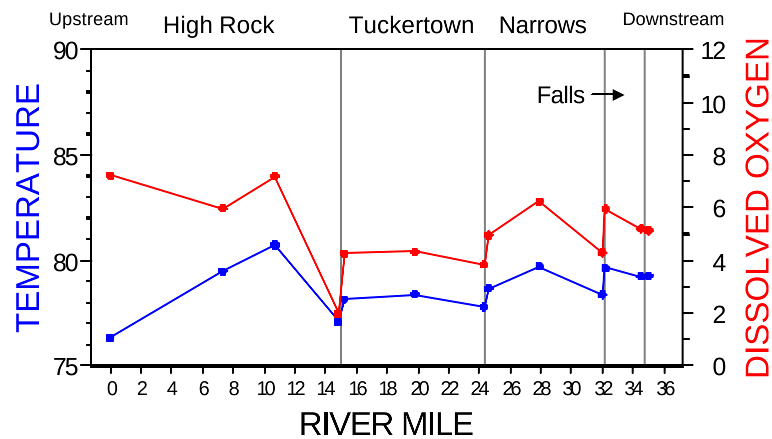
August 19-20, 2002 Temperature (°F) and DO (mg/L) by River Mile



Longitudinal Variability

- Time of travel through system makes synoptic data difficult to interpret.
- The interaction between each reservoir and tailwater may be a better way to look at upstream/downstream relationships.

What is the lateral and longitudinal variability of dissolved oxygen and temperature in the vicinity of the four dams under different operating scenarios?

Methods for lat/long study

- Profiles at quarter point of river
- Transects ¼ mile apart
- Temperature and DO
- All 4 reservoirs and tailraces
- Scenarios
  - Full generation for 6 hours
  - No generation for 6 hours

High Rock

High Rock Results

- Reservoir
  - Minimal thermal stratification under both generation and non generation
  - Generation increases depleted oxygen zone at the transect closest to the dam.
- Tailrace
  - Temperatures 1-2 degrees C lower during generation
  - Dissolved oxygen 1 mg/l lower during generation

Tuckertown Results

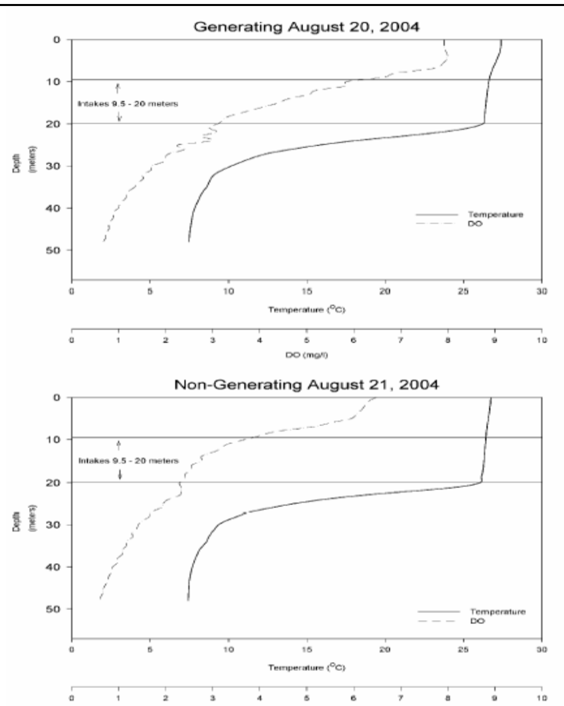
- Reservoir
  - Evidence of algal bloom during generation survey
  - Minimal thermal stratification under both scenarios
  - Generation decreases depleted oxygen zone at the transect closest to the dam (deeper intake than High Rock).
  - effect still present but less pronounced at transect 2
- Tailrace
  - Generation DO 4.2-4.6 mg/l
  - Non-generation DO 8.7-9.6 mg/l
  - Likely that algal cells from reservoir continued to produce oxygen in tailrace.

Narrows Results

- Reservoir
  - Strong thermal stratification (10-20 ºC)
  - Generation decreases depleted oxygen zone at the transect closest to the dam.
  - effect still present but less pronounced at transect 2
- Tailrace
  - Generation DO 4.1-6.2 mg/l
  - Non-generation DO 6.5-7.1 mg/l
  - Highest generation readings near Unit 4, lowest readings away from Unit 4.

Narrows Evaluation

Temperature and DO



Falls Results

- Reservoir
  - No thermal stratification
  - Non-generating DO readings lower than generating probably due to timing of surveys
- Tailrace
  - DO concentrations approximately 1 mg/l lower during non-generation.

Today's Discussion

- Review of monthly data
- Review of continuous tailwater data
- Relationship of water level and water quality
- Relationship of flow and water quality
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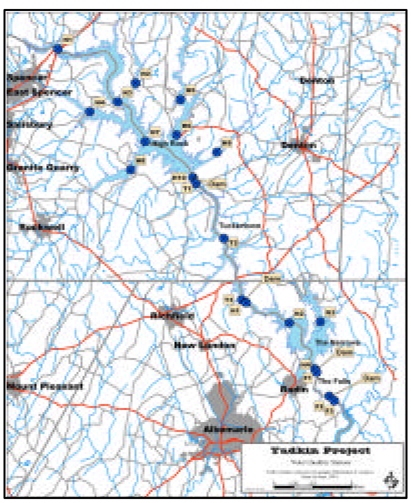
- Total Suspended Solids
- Biological Issues

Total Suspended Solids

DATA COLLECTION

- **Water quality samples collected by Normandeau on a monthly basis from June 1999 through December 2003.**
- **Samples collected from 20 stations located throughout the reservoirs in the Yadkin Project.**
- **At each station a sample was collected near the water surface and at a depth below the photic zone.**
- **Samples analyzed for Total Suspended Solids (TSS) along with Total Solids, Total Dissolved Solids (TDS) and other organic and inorganic parameters.**

Sampling Station Location Map



Total Suspended Solids

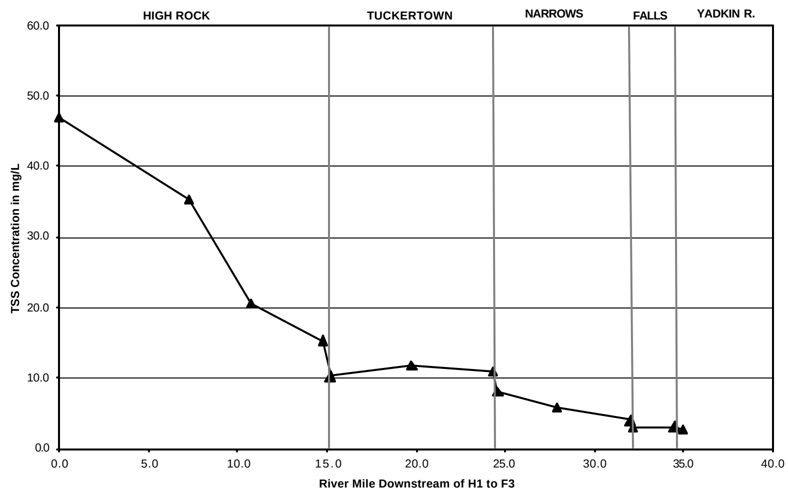
DATA ANALYSIS

- Data available from June 1999 through 2003.
- Monthly sampling results from each station (shallow and deep averaged) along the river's thalweg used in the analysis: H1, H3, H7, H10, T1, T2, T3, N1, N2, N4, F1, F2 and F3.
- For samples with no detectable TSS, assumed concentration equal to one half detection limit.
- Data summarized in tables and graphs and results reported in the January 2005 Yadkin Water Quality Report prepared by Normandeau Associates.

Average TSS Concentrations and Concentration Change

Station	1999	2000	2001	2002	2003	MEAN
H1 (High Rock)	26.8	75.3	28.8	25.7	77.7	46.9
H3	30.4	42.7	47.0	25.2	31.1	35.3
H7	21.0	26.4	20.5	18.2	16.6	20.5
H10	15.7	18.3	14.1	16.2	11.8	15.2
T1 (Tuckertown)	10.8	11.6	10.3	9.4	8.9	10.2
T2	13.2	11.8	12.4	10.7	10.9	11.8
T3	12.2	12.2	11.2	10.7	8.2	10.9
N1 (Narrows)	10.6	8.6	6.8	11.0	7.4	8.0
N2	5.8	5.9	5.7	4.9	7.3	5.9
N4	2.8	3.0	3.3	3.0	8.0	4.0
F1 (Falls)	1.8	4.0	2.5	2.9	3.6	2.9
F2	3.0	3.1	3.1	2.6	3.5	3.1
F3	2.0	2.7	2.7	2.7	3.8	2.8
Total Decrease (mg/L)	24.8	72.5	26.1	23.0	74.0	44.1
Percent Decrease	92.5	96.4	90.6	89.4	95.2	94.0

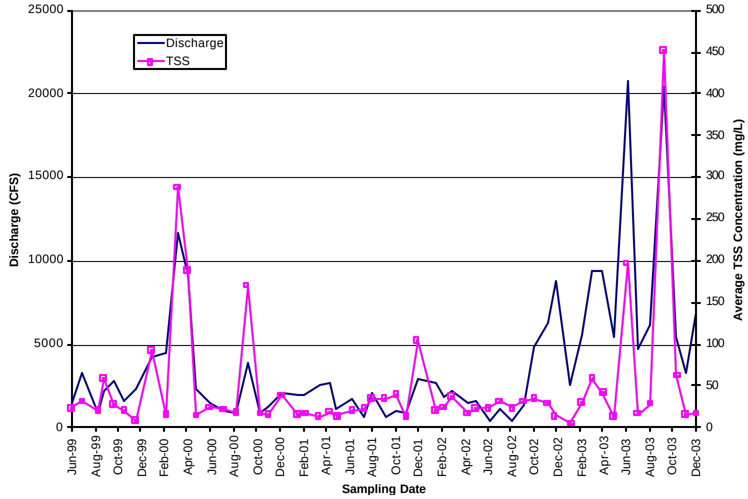
Average TSS Concentration vs. Distance Downstream of H1 (1999-2003)



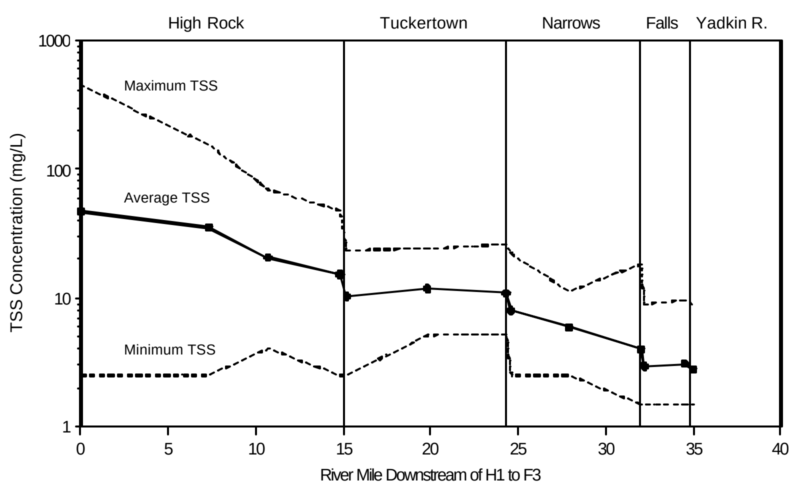
Average TSS Concentrations and Concentration Change (1999-2003)

- **Average TSS concentrations change both spatially and temporally.**
- **Highest average TSS concentrations in High Rock Reservoir and lowest in Falls Reservoir.**
- **Highest average TSS experienced during higher flow years (2000 and 2003) lower average TSS in low flow years (1999, 2001 and 2002).**

Yadkin River Flow into High Rock Reservoir and Average TSS Concentration at H1 (1999-2003)



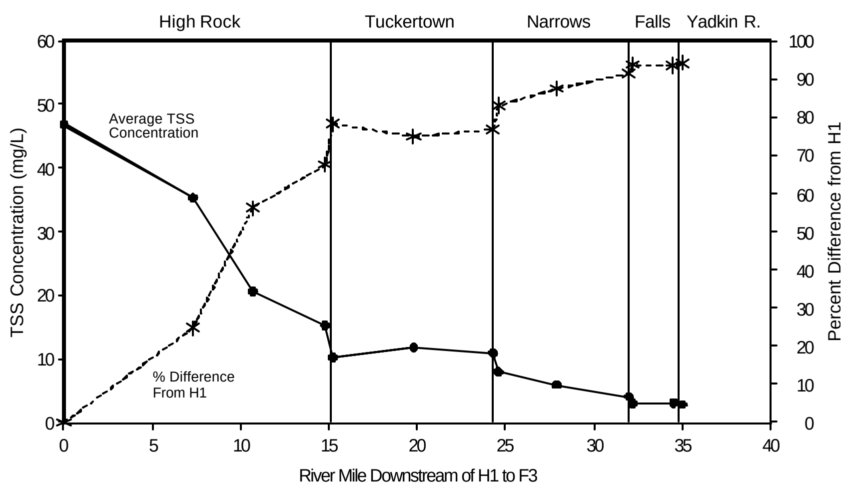
Average, Maximum and Minimum TSS Concentrations vs. River Mile (1999-2003)



Average, Maximum and Minimum TSS Concentrations vs. River Mile (1999-2003)

- **Highest average TSS concentrations and greatest range in TSS values recorded in High Rock Reservoir which reflects input from Yadkin River.**
- **Lowest average TSS concentrations and lowest range in TSS values recorded in Falls Reservoir reflecting retention of solids in upper reservoirs.**
- **Average TSS concentration consistently decreases through High Rock and Narrows, slight increase in average concentration in portion of Tuckertown and Falls reflecting trbutary input.**

Average TSS Concentration and Percent Change vs. River Mile (1999-2003)



Findings of TSS Monitoring

- Based on data collected from June1999 through 2003 average TSS concentrations decline from the High Rock Reservoir downstream to the Falls Reservoir.
- Decrease in TSS concentrations have ranged from 74 mg/L (2003) to 23 mg/L (2002) with an average decrease of 44.1 mg/L.
- Percentage decrease in TSS concentrations have ranged from 96.4 % (2000) to 89.4 % (2002) from High Rock (Station H1) to downstream of the Falls (Station F3). The average decrease in TSS concentration from High Rock through Falls is 94%.

Findings of TSS Monitoring

- Greatest decrease in TSS concentrations occurs in High Rock Reservoir (46.9 mg/L to 15.2 mg/L or 58%) indicating the deposition of sediment. Slight increase in TSS concentration in portion of Tuckertown suggesting tributary input. Decrease in Narrows and slight reduction in Falls due to low overall concentrations.
- Highest average TSS concentrations associated with high discharge events that occur in response to high rainfall storms in late winter/early spring and summer/late fall.
- Yadkin Project reservoirs are acting as sediment traps reducing TSS concentrations, on average, by 94 percent (46.9 mg/L to 2.8 mg/L).

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Samples where mercury (Hg) above detection limit in water samples

	Parameter (detection limit)	Mercury[c] (<0.2 • g/l)
Reservoir	**Station**	
High Rock Arms	H2	4
	H4	2
	H5	1
	H6	2
	H8	1
	H9	
High Rock Mainstem	H1	6
	H3	1
	H7	
	H10	1
Tuckertown	T1	
	T2	
	T3	
Narrows	N1	
	N2	
	N3	
	N4	23
Falls	F1	1
	F2	1
	F3	1

Mercury in Fish

- 10 largemouth bass, 10 black crappie and 10 channel catfish collected in Tuckertown tailrace (upper Narrows)
- All samples below 0.15 mg/kg
- FDA action level is 1 mg/kg

Fecal coliform monitoring

- State collected 55 mid-lake samples in High Rock, 6 in Tuckertown and 10 in Narrows between 1999 and 2001.
- All samples were below state standards of 200 per 100 ml.
- Stanley, Davidson and Rowan counties logged no complaints requiring fecal coliform monitoring during this time.

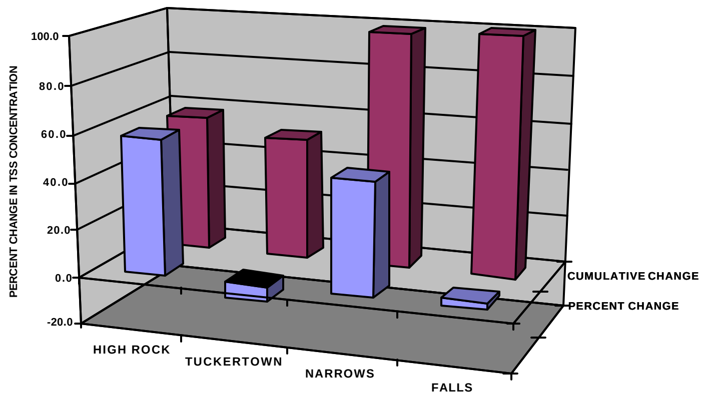
- end

Percent Decrease in TSS Concentration by Reservoir and Cumulatively

RESERVOIR	1999	2000	2001	2002	2003	MEAN	CUMULATIVE CHANGE
High Rock	42	76	51	37	85	58	58
Tuckertown	-14	-5.1	-8.3	-13	8.2	-6.5	51.5
Narrows	74	66	52	54	-8.0	47	98.5
Falls	-12	32	-9	7.7	-5.6	2.6	~100

Note: negative values indicate increase in concentration

Average Percent Change in TSS Concentration by Impoundment and Cumulatively (1999–2003)



Attachment 4 – Meeting Presentation

Sediment Fate and Transport

Review of Existing Literature Including Reports From:

- **Duke University**

  Norwood – 2001, Changes in Land Use and Water Quality in the Yadkin River Basin

  Henkels – 2000, Water Quality and Quantity Trends in Three Sub-basins of the Yadkin River Basin

  Krishnaswamy and others – 2000, Dynamic Modeling of Long-Term Sedimentation in the Yadkin River Basin

Sediment Fate and Transport

Review of Existing Literature Including Reports From:

- **Duke University (cont.)**

  Richter and others – 1995, Decreases in Yadkin River basin Sedimentation: Statistical and Geographic Time-Trend Analyses

  Fischer – 1993, A Suspended Sediment Budget for Six River Impoundments on the Yadkin-Pee Dee River.

- **North Carolina DENR – 2003, Yadkin-Pee Dee River Basinwide Water Quality Plan.**

Sediment Fate and Transport

Review of Existing Literature Including Reports From:

- **Soil Conservation Service – 1979, Special Report: Erosion and Sediment Inventory, Yadkin-Pee Dee River basin, North Carolina and South Carolina.**
- **United States Geological Survey**

  Harned and Myer – 1983, Water Quality of the Yadkin-Pee Dee River System, North Carolina: Variability, Pollution Loads, and Long Term Trends.

Sediment Fate and Transport

Review of Existing Literature Including Reports From:

- **United States Geological Survey (cont.)**

  Simmons – 1993, Sediment Characteristics of North Carolina Streams.
  1979, Water-Quality Characteristics of Streams in Forested and Rural Areas of North Carolina.

- **Robert Meade – 1982, Sources, Sinks and Storage of River Sediment in the Atlantic Drainage of the United States.**

Sediment Fate and Transport

Synthesis of Previous Investigations: Erosion

- **Inputs of sediment to the Yadkin-Pee Dee River include:**

  Upstream Soil Erosion
  Streambank and Channel Erosion
  Urban Runoff

  The principal source of sediment is upstream soil erosion.

Sediment Fate and Transport

Synthesis of Previous Investigations: Erosion

- **Rates of erosion in the basin vary in response to type of soil material and land use. Due to the fine grained nature of the soils in the basin, its humid climate, topographic relief and land use, this region has some the highest erosion rates and sediment yields in the United States.**

- **USDA (1979) estimated that average annual soil erosion is 3.9 tons/acres or 2,500 mi^2/yr. Counties having the highest concentration of croplands had the highest estimated erosion rates.**

Sediment Fate and Transport

Synthesis of Previous Investigations: Erosion

- **Simmons (1993) found that based on an analysis of suspended sediment data the drainages in the Piedmont region of North Carolina have the highest sediment yields in the state.**

  Based on land use, highest sediment yield (527 tons/mi^2) associated with urbanized basins followed by agricultural basins (302 tons/mi^2). These values are less than USDA (1979) because they are based on measured sediment data, not predicted soil erosion values.

Sediment Fate and Transport

Synthesis of Previous Investigations: Erosion

- **Duke University (Richter, Henkels and Norwood) examined the impact of land use on sediment production over time. Overall these studies have shown that as the amount of land use for agricultural purposes has decreased the estimated gross erosion in the basin may have decreased by at least 17 percent since the 1950s.**
- **Although agricultural use has declined, land development in suburban and urban areas is increasing which may ultimately result in an increase in sediment yields in the basin.**

Sediment Fate and Transport

Synthesis of Previous Investigations: Sediment Transport

- **Harned and Meyers (1983) documented that the highest concentrations of suspended sediment (158 mg/L) are found on the Yadkin River at Yadkin College, with slightly lower concentrations (149 mg/L) in the Rocky River at Norwood. Lowest concentrations (33 mg/L) observed on the Pee Dee River near Rockingham. Reason for significant decrease in suspended sediment concentrations is the deposition of sediment in the six impoundments located between these stations.**

Sediment Fate and Transport

Synthesis of Previous Investigations: Sediment Transport

- **Harned and Meyers (1983) and Simmons (1979 and 1993) evaluated relationship of discharge and suspended sediment transport. They found that the highest concentrations of suspended sediment occur during high flow events.**

- **Simmons (1979) and Richter (1995) also found that the bulk of sediment transported by the Yadkin River occurs over short periods of time in response to storm events and that the bulk of this material was silt/clay sized particles.**

Sediment Fate and Transport

Synthesis of Previous Investigations: Sediment Transport

- **Richter (1995) documented the reduction in sediment transport over time. Based on 40 year record (1951-1990) the transport of suspended sediment has decreased by approximately 30 percent.**
- **Norwood (2001) updated this analysis and confirmed the continued decline in suspended sediment concentrations to 2000 in response to the continued decline in cropland.**

Sediment Fate and Transport

Synthesis of Previous Investigations: Sedimentation

Estimates of reservoir sedimentation include:

USDA SCS (1979)

Input to Reservoirs	870 ac-ft/yr
Output from Reservoirs	42 ac-ft/yr
Reduction	95 %

Fischer (1993)

Input to Reservoirs	628 ac-ft/yr
Output from Reservoirs	138 ac-ft/yr
Reduction	78 %

Sediment Fate and Transport

Synthesis of Previous Investigations: Sedimentation

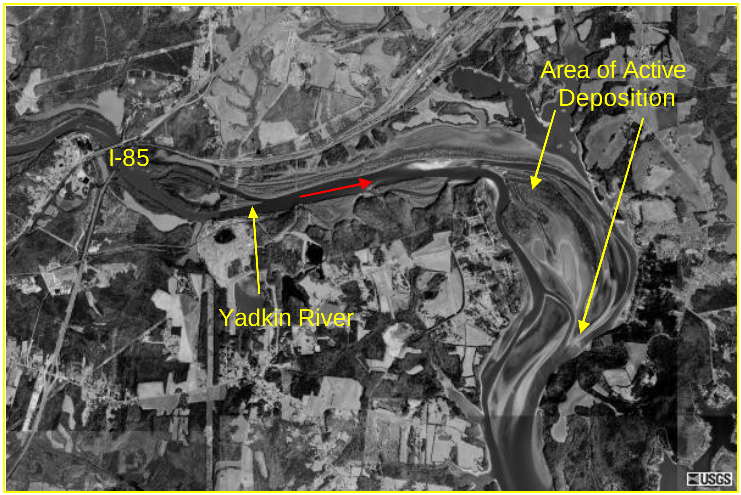
- **The SCS (1979) and Fischer's (1993) estimates are for suspended sediment. SCS (1979) estimates based on predicted erosion rates and not measured values while Fischer's (1995) estimates are based on measured suspended sediment concentrations.**
- **The accumulation of sediment in the reservoirs should be reflected by changes in their bathymetry volume. The greatest changes would be expected to occur where the Yadkin River and its tributaries discharge into the reservoirs.**

Sediment Fate and Transport

Findings of Recent Investigations: Sedimentation

- **PB Power compared maps of the bathymetry of the upper portion of High Rock Lake from 1917 and 1997. They found that sediment had accumulated in the upstream area of the reservoir between the I-85 bridge and Crane Creek. They estimate that 80 years of sediment accumulation has resulted in a reduction of approximately 6 percent of total usable storage capacity in the upper 12 feet of the reservoir.**
- **Impacts of sedimentation on habitat being evaluated by Normandeau Associates.**

Sediment Fate and Transport



Sediment Fate and Transport

Findings of Recent Investigations: Sedimentation

- **There are four municipal water supply intakes located within the Yadkin Project:**

  <u>Salisbury-Rowan</u> on the Yadkin River upstream of High Rock Reservoir
  <u>City of Albemarle</u> on Tuckertown and Narrows Reservoirs
  <u>City of Denton</u> on Tuckertown Reservoir

  The report acknowledges SRU's concerns relative to the impact of sediment on their intake and pump station. The water supply intakes located on Tuckertown and Narrows are generally much less affected by sedimentation.

Sediment Fate and Transport

Overall Findings:

1. A significant wealth of information on soil erosion and sediment transport in Yadkin River Basin is readily available with major studies having been performed by the Soil Conservation Service (now NRCS), the United States Geological Survey (USGS) and researchers at Duke University.

2. As noted by the North Carolina Department of Environment and Natural Resources, Clean Water for North Carolina and the USGS suspended sediment is one of the principal water quality problems in the Yadkin-Pee Dee River Basin.

Sediment Fate and Transport

Overall Findings:

3. The sources of sediment have changed over time. In the past the major source of sediment was agricultural land use (1800s to early 1900s). Agricultural land use has declined in the 1900s while land development in urban and suburban areas has been increasing. Stormwater runoff from these areas is now seen as a major contributor of sediment to the Yadkin River.

Sediment Fate and Transport

Overall Findings:

4. **Total suspended sediment (TSS) concentrations in the Yadkin River have declined over the long term due to decreasing agricultural land use and the implementation of best management practices (BMPs). TSS concentrations may begin to increase due to increased land development, construction and urbanization.**

5. **The dams along the Yadkin-Pee Dee River are acting as sediment traps. Estimates are that from 78 to 95 percent of the sediment transported into these impoundments is retained.**

Sediment Fate and Transport

Overall Findings:

6. **Deposition of sediment in High Rock Reservoir is reflected in changes in lake bathymetry. Active deposition occurring at confluence of Yadkin River with High Rock in the area between I-85 and Crane Creek.**

7. **Impacts of sedimentation on habitat being assessed by Normandeau Associates.**

Sediment Fate and Transport

End of presentation

Attachment 4 – Meeting Presentation