

Yadkin Project Relicensing (FERC No. 2197)
Yadkin Project 2004 Tailwater Dissolved Oxygen Testing
Final Study Plan
August 2004

Background

Alcoa Power Generating Inc. (APGI) is the licensee for the Yadkin Hydroelectric Project. The Yadkin Project is currently licensed by the Federal Energy Regulatory Commission (FERC) as Project No. 2197. This license expires in 2008 and APGI must file a new license application with FERC on or before April 30, 2006 to continue operation of the Project.

The Yadkin Project consists of four reservoirs, dams, and powerhouses (High Rock, Tuckertown, Narrows, and Falls) located on a 38-mile stretch of the Yadkin River in central North Carolina. The Project generates electricity to support the power needs of Alcoa's Badin Works, to support its other aluminum operations, or is sold on the open market.

APGI prepared and distributed an Initial Consultation Document (ICD), which provides a general overview of the Project as part of the relicensing process in September 2002. Agencies, municipalities, non-governmental organizations and members of the public were given an opportunity to review the ICD and identify information and studies that are needed to address relicensing issues. To further assist in the identification of issues and data/study needs, APGI has formed several Issue Advisory Groups (IAGs) to advise APGI on resource issues throughout the relicensing process. A Draft Study Plan for this study was developed by APGI based on discussions with the Water Quality IAG and was distributed to the IAG for comment in July 2004. APGI received comments on the Draft Study Plan from the High Rock Lake Association (Larry Jones) the North Carolina Wildlife Resources Commission (Todd Ewing), U.S. Fish and Wildlife Service (John Ellis) and High Rock Lake Business Owners (Mark Oden). All comments on the draft study plan were considered, and this Final Study Plan was revised to address the comments accordingly.

Organization of the Study Plan

The Study Plan for the Project tailwater DO test begins with a description of the regulatory setting in which the study takes place and a summary of the issues to be addressed. Next, the Study Plan specifies the objectives of the Study and presents the planned Methodology for analyzing each of the issue areas. Finally, the Study Plan describes the plan for reporting the Study findings to APGI and the IAG and presents the Study schedule.

Overview

Yadkin has been conducting water quality monitoring at the Project since 1999. As part of that monitoring program Yadkin collected water quality data on a monthly basis from stations located in all four Project reservoirs through 2003. Yadkin also installed and operated continuous dissolved oxygen (DO) and temperature monitors in the Narrows and Falls tailwaters seasonally (May-November) since 1999. Similar DO/temperature monitors were installed and operated in the Tuckertown and High Rock tailwaters in 2003, and are being operated again in 2004. DO and temperature data from the tailwaters, confirms that DO conditions in the tailwaters are sometimes at or below state standards (4.0 mg/l minimum and 5.0 mg/l daily average) in all four tailwaters. Analysis of the data indicates that of the four tailwaters, the most serious DO degradation is observed in the tailwaters below the Narrows and High Rock developments. Data collected to date further suggests that while DO concentrations in the Tuckertown and Falls reservoirs are often below standards, they are related to concentrations observed in

water passed through High Rock and Narrows dams, respectively. This suggests that improvement in DO conditions in the High Rock and Narrows tailwaters may result in improvement in the Tuckertown and Falls tailwaters as well due to the relatively short travel times through these impoundments.

In December, 1999, Yadkin filed an application for amendment of license to upgrade¹ units at three of the Yadkin Project developments. In that application, Yadkin proposed upgrading Units 1 through 4 at Narrows, Units 1 through 3 at High Rock and Unit 2 at Falls. As part of the upgrade program, Yadkin examined opportunities to increase the DO concentration in downstream waters by utilizing air injection through the draft tube cone of Narrows Unit 4. In August 2000, FERC approved Yadkin's application and issued a license amendment. Article 39 of the amended license required Yadkin to consult with state and federal resource agencies on the development of a dissolved oxygen plan for the Project. The purpose of the plan was to "assess the effect of the turbine upgrades on DO concentrations below the Project developments, and, if necessary for compliance with state water quality standards, to develop and implement measures to improve DO, either through structural or operational modifications at the Project." Yadkin prepared the required DO plan which was filed with FERC in August 2001.

In 2001, Yadkin completed the planned upgrades on Unit 4 of the Narrows development including the addition of two air injection ports with valves that could be opened during unit operation to increase the oxygen concentration of water passing through the Unit 4 turbine. In August 2001, Yadkin's consultant, Normandeau Associates (NAI), completed a survey in the Narrows tailwater designed to evaluate the influence of the two air injection ports that were installed in Unit 4. Results of that survey were included in an overall water quality report that was submitted to FERC in June 2002. Results of the survey demonstrated that the air injection at Unit 4 can increase DO concentrations in the tailwater of the Narrows development. Survey results showed that the aeration valves increased DO concentrations in the tailwaters by approximately 2 mg/l when only Unit 4 was operated and one valve is open, by approximately 2.5 mg/l when only Unit 4 is running and both valves are open, and by 1.5 mg/l when all four units are running and both valves are open.

Overall, the upgrade of Narrows Unit 4 with installation of air injection valves demonstrated that air injection holds promise as a relatively efficient means of increasing DO concentrations in the Narrows tailwater. However, due to changes in economic conditions, the upgrade program for the Yadkin Project was curtailed in 2002, and no additional upgrades have been undertaken at the Project. Nonetheless, based on the work done at Narrows Unit 4, it is possible that eventual installation of similar air injection valves at some or all of the remaining units, will allow waters leaving the Narrows powerhouse to meet state DO standards. Moreover, if Narrows tailwater DO concentrations are raised to above state standards, it is believed that DO standards may also be met in the Falls tailwater, due to the short retention time in Falls Reservoir.

Based on the work done to date on Narrows Unit 4, and discussions with the Water Quality IAG, it appeared there were several areas in which further investigation was warranted and these areas are the subject of this Study Plan. First, at their May 4, 2004 meeting, the WQ IAG suggested some additional investigation of the aeration capability provided by the Unit 4 air injection valves to better understand the effect of air injection through Unit 4 on Narrows tailwater DO concentrations, particularly under various combinations of unit operating configurations. Second, through discussions with the IAG, it became clear that it would be very useful to understand the effect on DO concentrations in the Falls tailwaters given an increase in DO concentrations in the Narrows tailwaters. Similarly, the relationship between DO concentrations in the High Rock tailwater and DO concentrations in the Tuckertown tailwater were also deemed to be worth investigating and this issue is an additional focus area of this Study Plan.

¹ The upgrades proposed by Yadkin involved replacing the turbine runners and rewinding the generators. The upgrades were determined to be prudent to increase the life and the efficiency of the old units.

Issues

As outlined above, water quality issues at the Yadkin Project are being addressed as part of the FERC relicensing process. One of the issues that has been raised by the North Carolina Division of Water Quality (NCDWQ) is tailwater DO conditions. More specifically NCDWQ, along with several other state and federal agencies, asked Yadkin to conduct studies to investigate the degree of DO degradation in the Project tailwaters and to conduct studies to evaluate what measures could be undertaken by Yadkin to ensure that tailwater DO concentrations meet state standards in the future. Earlier work done by Yadkin to increase and study tailwater DO concentrations suggests that air injection technology added to the High Rock and Narrows developments may be a successful means of bringing tailwater DO concentrations up to state standards at all four Project developments. However, further study is necessary to demonstrate this potential more clearly.

Objectives

The primary objectives of this study are three-fold. The first objective of the study is to further evaluate the effectiveness of the air injection valves at Narrows Unit 4 to increase tailwater DO levels. The second objective is to determine to what extent an increase in DO concentrations in the Narrows tailwater impacts the DO concentrations in the Falls tailwater. The third and final objective is to determine to what extent an increase in DO concentrations in the High Rock tailwater impacts the DO concentrations in the Tuckertown tailwater.

Methodology

Narrows

At Narrows, a follow-up to the 2001 DO testing will be performed. The purpose of this test will be two-fold to meet the first and second study objectives outlined above. Overall, the test will be designed to utilize existing equipment, on a temporary basis, to increase Narrows tailwater DO conditions to above the state standard, and to investigate how and to what degree this translates into DO increases downstream through the Falls tailwater. To do this, the turbines at Narrows powerhouse will be used to introduce air into the water stream in the draft tubes through two sources. An aeration system was installed on the draft tube at Narrows Unit 4 as part of the turbine refurbishment and upgrade. In addition, the Narrows Units 1 through 3 naturally aspirates air through the water wheel cone in the range of 20 % to 35 % wicket gate opening. The valves that open while the turbine is operating at this small wicket gate opening allow air to enter the draft tube to stabilize the turbulence that is inherent in this operating range. This air serves to reduce vibration and damage to the equipment during loading and unloading of the generating unit. It must be emphasized that this mode of operation will allow Yadkin to conduct a test on a short-term basis, but is not suitable for continuous operation due to the very low efficiency and the potential for damage to the turbines.

For purposes of the test, the Narrows turbines will be started individually beginning with Unit 4 with both air valves open. The other three turbines will be started sequentially and operated at 30% wicket gate opening to allow air to enter the draft tube. In addition, a similar testing sequence will be run starting with Unit 4 at best efficiency followed by the sequential startup of each of the four remaining units at best efficiency. There will be a delay between starting each turbine to allow DO to reach equilibrium in the tailwater and the two test sequences will be run on successive days. The results from these tests will be compared to the August 2001 tests to determine the variability of response.

The operation of the Narrows turbines in this mode will continue a sufficient length of time to evaluate the effect of increased DO at Narrows on DO in the Falls tailwater. The required time will be estimated

based upon expected travel time of the oxygenated water from Narrows to Falls and confirmed by observations during the testing. The DO in the Falls tailwater will be monitored using the currently installed continuous DO monitors throughout the testing at Narrows.

The turbines at Falls powerhouse will be started and operated at power output necessary to pass the flow coming from Narrows powerhouse with a minimum of reservoir fluctuation (i.e., typical operation).

The target timing for these investigations will be during a period of low river flow coupled with high water temperatures. Such conditions have historically resulted in low tailwater DO concentrations and are typically encountered between August 1 and September 30 in the Yadkin system. The testing is currently scheduled to be completed on September 8, 9 and 10, 2004. The proposed schedule is contingent upon water availability and weather conditions.

Dissolved oxygen and temperature will be continuously monitored in the tailwaters of the developments scheduled for testing throughout each test. The continuous monitors placed in each of the tailwaters will be the primary point of measurement of tailwater conditions. NAI has previously demonstrated, as a part of the routine tailwater monitoring as well as during previous aeration tests at Narrows, that there is little lateral or longitudinal variability in DO concentrations in the tailwaters. This is particularly true during operating conditions when there is substantial water movement through the tailwater. This previous work has confirmed that the continuous monitoring locations are representative of tailwater conditions.

During the test, DO and temperature readings will be continuously logged and reviewed in the field in "real time". DO concentrations will be recorded and plotted throughout the test period or until such time that a clear equilibrium in DO concentrations has been reached. Equilibrium will be considered to have been reached when the DO concentrations of 3 successive readings are within 0.5 mg/l of each other. Each reading for this test will be a 5 minute average concentration. Short term variations of < 0.5 mg/l are typical in the tailwaters due to water turbulence. Once equilibrium is reached in the Narrows tailwater under each operating scenario, real time monitoring will continue for at least 2 hours below Narrows. At the end of each day's testing at Narrows, all data from Narrows as well as data from the Falls monitor will be downloaded and evaluated. This will help guide the following day's testing and shed light on the persistence of changes in Narrows tailwater DO concentrations downstream at Falls. Continuous DO monitors will be serviced and calibrated prior to testing and after testing and will be checked for calibration with an independent meter at the beginning and end of each test scenario below Narrows and each time the meter is downloaded at Falls.

High Rock and Tuckertown

A similar set of information is desired at High Rock and Tuckertown, to address the third objective of this study. Though no air injection system is currently installed at this development, as part of this study Yadkin will use existing piping and valves at High Rock to inject air through the bearing riser to the top of the runner, on a short term basis, as a way of increasing High Rock tailwater DO concentrations. If Yadkin determines that existing piping and valves at High Rock can be used to increase tailwater DO concentrations, Yadkin will conduct a test similar to that done at Narrows/Falls. While this method of injecting air can only be used for short term test purposes due to the low efficiency and potential damage to the turbine, it will be used to evaluate on an order-of magnitude basis, whether increasing High Rock DO concentrations results in a measurable improvement in DO concentrations in the Tuckertown tailwater. The testing program below High Rock and Tuckertown will be conducted in a manner similar to that proposed for Narrows and Falls as described above.

During this test, the Tuckertown turbines will be started and operated at power output necessary to pass the flow coming from High Rock powerhouse with a minimum of reservoir fluctuation (i.e., typical operation).

Similar data will be required for both the Narrows and High Rock DO testing. The data type and source are as follows:

- DO and Temperature - The existing continuous DO/temperature monitors in the High Rock, Tuckertown, Narrows and Falls tailwaters will be used to measure DO and water temperature. Currently the DO monitors record DO and temperature over a period of time and NAI periodically removes them from the water, downloads the data, does a quality check on the data and then enters the data in the Yadkin water quality database. For purposes of these tests, DO values will be observed in the field on a real-time basis and recorded as well as being continuously logged.
- Turbine Power Output - The turbine power output for all powerhouses will be measured using existing metering equipment and recorded in the APCI Operating Center.
- Turbine Discharge - Water flow through all turbines will be calculated from power output.

Reporting

A Draft Study Report will be prepared and distributed to the Water Quality IAG for review and comment. After meeting with the IAG to review and discuss the Draft Report a Final Study Report will be prepared.

Schedule

It is anticipated that the Draft Study Report will be completed in the 4th quarter of 2004.