Water Quality Design Requirements for a Line Diffuser Oxygen Injection System at J. Percy Priest Reservoir

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This abstract is a summary of the water quality assessment portions of a study conducted by the authors for the Nashville District of the US Army Corps of Engineers.

Existing Conditions

The existing conditions at J. Percy Priest were evaluated as a part of this study using available water quality data. Hydropower releases from J. Percy Priest are typically below the Tennessee minimum dissolved oxygen (DO) standard of 5 mg/L from mid-May to November. The data indicate that releases from the turbine have shown periods of about 90 days each year where the dissolved oxygen (DO) concentration is approximately 2 mg/L and frequently contain the anoxic products ammonia, iron, manganese, and hydrogen sulfide. Reservoir conditions include high oxygen demands in the lower levels of the hypolimnion that is built up by long periods of infrequent turbine operation each summer in combination with high nutrient loads from the watershed.

The poor water quality conditions in the releases are due to the conditions in the hypolimnion of the J. Percy Priest Reservoir. Thermal stratification and high hypolimnetic oxygen depletion rates result in a seasonal decline of DO in the hypolimnion so that it typically reaches anoxic conditions (less than 1 mg/L) in the bottom-most water during late June. Once anoxic conditions develop in the hypolimnion, iron, manganese, phosphorus, and hydrogen sulfide concentrations increase at the sediment interface and are mixed into the hypolimnion. These materials build up in the reservoir hypolimnion during periods of no generation and are released downstream during any turbine operations until the reservoir mixes in late fall. The mixing of phosphorus into the epilimnion can also lead to nuisance algal blooms following this mixing period.

Objectives

The Nashville District of the U.S. Army Corps of Engineers (LRN) water quality objectives for the oxygenation of the releases from J. Percy Priest are: to meet the 5 mg/L State standard for DO in the turbine discharges, reduce the release of dissolved iron and

manganese to prevent impacts to downstream water treatment plants, and eliminate the hydrogen sulfide odor.

Diffuser Design Requirements

Unlike previous porous hose diffuser applications, the high oxygen demands, mid-level intakes, and long periods of no turbine operation at J. Percy Priest require a significant departure from a straightforward hydropower oxygenation design. The conditions at J. Percy Priest require an oxygenation system that is capable of meeting the oxygen demands of high water flow rates during consecutive days of turbine operation, as well as maintaining oxygenated forebay conditions during long periods of no turbine operation. In addition, the system must distribute the oxygen well upstream of the dam to obtain the retention times necessary to impact the anoxic products in the reservoir. The conceptual design of the oxygenation system in this presentation is the result of the application of the expertise obtained designing, installing and operating eleven line diffuser systems for TVA and other utilities.