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Rapidan Dam Hydroelectric Research Project Director
Professor Henry W. Quade

Note: For a more detailed presentation of the Water Chemistry and Macroinvertebrates refer to:

1.) Ruff, Greg. 1987. The Impact of A Non-Stratifying Reservoir and it's Small, Low-Head, Peaking Hydroelectric Dam on the Water Quality and POM Transport of the Blue Earth River, South central Minnesota, M.A. Thesis, Mankato State University, Mankato, Minnesota, 293 pp.
2.) Danks, Marilyn. 1991. Macroinvertebrate Co mmunity Response to Flow Fluctuations Causedly by a Peak-Operated Hydroelectric Dam. M.A. Thesis, Mankato State University, Mankato, Minnesota, 102 pp.

For reports on the fisheries component of the Rapidan Dam stipulation agreement contact Dirk Peterson, Minnesota Department of Natural Resources.

This report is dedicated to Paul Fasching, a friend, colleague, and a valued team member who died in January of 1987. He was dedicated to the task of completing his thesis, which he was unable to do and to which I have attempted to the best of my ability.

The full Research Project Report and the Executive Summary are available on the Minnesota River Basin Data Center: Water Resources Center, Minnesota State University Mankato. http://mrbdc.mnsu.edu

INTRODUCTION

Background

At the turn of the 20th century, hydropower met 60% of the nation's electrical power demand. Thirty years later, its role had diminished as inexpensive oil and coal dominated as major energy sources. With the election of President Roosevelt in 1932, the United States embarked on an ambitious program of building the large hydroelectric dams on the Columbia and Colorado Rivers. By 1976, more than 2,000 megawatts of electrical power were being generated from the Columbia basin dams, while 3,200 megawatts were being produced in the Colorado basin (Reisner, 1985).

By the late 1960's, with nearly all the prime hydro sites occupied or found in national parks, with inexpensive oil and vast reserves of coal available, and with the increased use of nuclear power, hydropower's role in the nations economy diminished once again.

The OPEC oil crisis of 1973 spurred a flurry of interest in hydropower. Since most of the available prime hydropower sites were developed earlier in the 20th century, attention was focused on the smaller hydroelectric producers. In 1978, the U.S. Congress passed the Public Utilities Regulatory Policies Act (PURPA), which required both private and public utilities to purchase the electric power produced by small private producers at a per-kilowatt cost. This cost would be equal to what the utility would have to spend to produce the power itself. PURPA, along with other new laws which provided small energy producers with investment tax credits and accelerated depreciation schedules, made small hydropower projects (less than 5 megawatts of potential output) like the Rapidan Dam economically feasible.

In 1864, with a change from subsistence to commercial grain farming in southern Minnesota, the first Rapidan Mill for grinding grain was built. The town of Rapids was built around the mill. An eight foot high, 260 foot long dam was built upstream from the mill with an 800 foot diversion tunnel, seven feet in diameter constructed from the pond to the mill to power the mill. The construction of a large iron bridge in 1878 connecting Rapids to the other side of the river, allowed easy transportation to Mankato. However, the railroad went four miles east of Rapids and the town of Rapidan grew rather than Rapids. With the construction of the hydroelectric dam, the town of Rapids would be underwater and therefore the power company bought 913 acres as far as five miles upstream (Pfaender, J. 1969).

Construction of the Rapidan Dam began in 1910 by the Ambursen Company under supervision of the H.M. Billesby Company of Chicago. Ambursen type dams are hollow-reinforced concrete buttress and slab dams. Construction of the dam lasted 11 months with a total cost of $500,000 for the Consumer Power Company. Consumer Power eventually became Northern States Power Company (NSP). The power house consisted of two 1250 horsepower horizontal Francis-type turbines manufactured by the Pelton Water Wheel Company, each driving a General Electric 750 Kw generator. The maximum potential output of the hydroelectric facility was 1500 Kw. The dam went into operation on March 11, 1911, and supplied power to the towns of Rapidan, Mankato, Lake Crystal, and Kasota. This doubled the existing capacity of Mankato's power supply and was the first electricity brought in from outside of the city (Tim Krohn, 2002).

The Rapidan Dam consisted of an 82-foot high structure extending 435 feet between rocky abutments. It also includes a 252-foot hollow concrete overflow spillway, a 90 foot powerhouse and inclined concrete decks slabs supported on reinforced concrete buttresses founded in sandstone bedrock. Sluice gates were installed to allow silt and sediments to be removed periodically from the upstream base of the dam. The gates failed to operate when first attempted due to sediment accumulation. The sediment then built up quickly to present level. Had the gates functioned, we probably would have had a thermally stratified reservoir.

Over the last 90 years, a series of repairs have been made to the dam. In 1916 and 1920 extensive repair work was needed on the concrete spillway apron due to a large hole scoured in the downstream apron of gate #4. The original apron of 50 feet was extended downstream to its present length of 300 feet. In 1937, concrete repair work was needed on the east bank retaining walls and during the 1950's the spillway pier noses were repaired.

In April of 1965, abnormal early ice break-up and greater than normal rainfall produced a peak flow of 43,100 cfs. The dam was left inoperable due to extensive damage to the dam's tainter gates and powerhouse caused by the record flow of the Blue Earth River. As stated earlier, the status of hydropower in the U.S. during the 1960's was considered bleak, therefore NSP decided against repairing the dam, and eventually presented ownership of the dam to Blue Earth County in 1975. The dam remained abandoned for 18 years until the rehabilitation project began in 1983. During this time the river was unregulated and discharges from the dam were run-of-the-river. The dam began producing electricity in the fall of 1984 after a rehabilitation project, which included the following:

-Reinforcement of the dam itself.
-Installation of new tainter gates.
-Upgrading of the powerhouse with new equipment that would produce a maximum potential output of 5 megawatts.
-Dredging of reservoir sediment immediately upstream of the turbine intakes.
-Doubling the surface area of the reservoir to 168 hectares (145 acres).

Rapidan Dam was the first hydroelectric plant in the state to be resurrected (Tim Krohn, 2002). In order to achieve maximum output of electricity, and economic gain, the developer of the dam requested a store and release mode of operation. This required storing water in the reservoir during periods of low electrical demand and the releasing it through the turbines during periods of high electrical demand. This operational scheme of store-and-release is termed "peaking."

The relicensing of the Rapidan Dam provided an opportunity to study the effects of manipulated flows and its unstratified reservoir on the physical, chemical and biological aspects of the river.

Purpose and Study Components

As part of the relicensing of the Rapidan Dam Hydroelectric Facility, the Blue Earth County Board of Commissioners contracted Professor Henry Quade and his students at Mankato State University to determine "the effects of converting a run-of-the-river, unstratified reservoir, hydroelectric dam into a peaking operation."

The Rapidan Dam Research Project investigated four river components potentially impacted by the conversion to a peaking operation of the hydroelectric dam during the years of 1983 to 1985. The four components include: water quality, sediment transport, synthetic organics, and aquatic macroinvertebrates.

The Minnesota Department of Natural Resources conducted a separate study pertaining to the affect of the peaking on the downstream fishery.

In order to assess and quantify the potential impacts identified above, the following research was conducted:

1) The establishment of a spring to fall baseline set of data (run-of-the-river) for eleven water quality parameters and four size classifications of particulate organic material in transport within the water column. Three peak power generations in August 1985 were sampled with the data being compared to the baseline data set as well as historic data, impacts down stream, and effects of differences in peaks.
2) The establishment of a peaking season baseline set of data (run-of-the-river) for five sediment in transport parameters. Three peak power generations were sampled and compared to the seasonal baseline data.
3) The characterization of the surficial reservoir sediment by grain size and percent organic. This component also included an initial bed load study and post peaking reservoir sediment grain size comparison.
4) A survey of waters, baseline and peaks, for chlorinated hydrocarbons.
5) The permit for relicensing of the dam specifically required a study of the impact of fluctuating flows on the aquatic invertebrates of the Blue Earth River. Samples were collected over a three-year period beginning in 1983, the year before dam operation, and during dam operation from late 1984 through 1985.

The information gained from this study is intended to identify parameters impacted by the peaking versus "run-of-the-river" operation. The impacts identified, and their magnitude, can be utilized as a component in the decision making process of whether to remove, restore, or modify the dam. The results can further be utilized as input for future research and model development concerning the physical, chemical and biological impacts of small peaking hydroelectric dams on riverine systems.