EFFECTS OF A HEATED DISCHARGE ON THE ECOLOGY OF THE MISSISSIPPI RIVER

316(a) Type I Demonstration on the Monticello Nuclear Generating Plant, Monticello, Minnesota

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INTRODUCTION

The following summary and conclusions are based on the extensive physical, chemical and ecological studies conducted at the Monticello Site from 1968-1974. Rather than cite each study in the summary, pages of the main text of the 316(a) Type 1 demonstration are referenced, should more detailed information be desired.

ENGINEERING AND HYDROLOGIC DATA

The Monticello Nuclear Generating Plant is a base load facility with a design generating capacity of 545 MWe. The cooling system of the Monticello Plant is constructed to operate in open cycle, helper cycle, partial recirculation and closed cycle modes. Normally, the open cycle mode is used during periods when the ambient river temperature is less than 68°F (20°C) and the helper cycle mode is used when temperatures exceed 68°F (20°C). The plant is operated at essentially full capacity at all times. Significant variability in heat rejection rates occur only during shut-down and start-up periods.

Thermal plume mapping surveys have been conducted 34 times during the 1971-1973 period. Of these, eight surveys have been selected to define variations in plume configuration under various seasonal, hydrologic and plant (cooling system) operating conditions. Compliance with applicable regulations was evaluated using the draft NPDES permit restrictions and Minnesota water quality standards.

River discharge and cooling system mode are the major factors influencing the spatial extent of the thermal plume generated by the Monticello Plant. Under extreme summer low flow conditions, non-compliance with the draft NPDES permit requirements and state water quality standards is indicated both with and without the use of cooling towers. With high flows, compliance with state water quality standards is achieved both with and without cooling towers. However, non-compliance with the draft NPDES permit is indicated. Under "normal" summer operations (near median river discharge

ith cooling towers operated in the helper mode), compliance with
standards may be indicated. Occasional non-compliance with
standards is indicated for winter and seasonal transition
ods. In some cases, non-compliance with the restrictions of
raft NPDES Permit is possible without violation of the state
quality standards.

w of thermal survey results and historical discharge data
cated that during 70 percent of the period from June through
mber, the immediate discharge zone (the +90°F [+5°C] isotherm)
ded over less than half of the river width and less than
eet below the plant outfall.

quality (other than temperature) in the Mississippi River is
ppreciably affected by the operation of the Monticello Plant.

3. ECOLOGICAL DATA

3.1 PRIMARY PRODUCERS

Periphyton, phytoplankton and macrophyton are the three potential sources of primary production in the Mississippi River at the Monticello Site. Phytoplankton was not extensively investigated at the site but is assumed to have a minor role in river trophics as compared to periphyton.

Phytoplankton at the Monticello Site is dominated all year by diatoms (see p. 69), although green and blue-green algae become important in summer. Moyle (1940) indicated that blue-greens dominated some of the summer communities of the upper Mississippi River during his studies (see p. 70).

Periphyton was studied extensively at the Monticello Site. Studies were based on the algae that colonized artificial substrates. From 1968 through 1974, 134 taxa of algae were identified, the majority of which were diatoms.

Spring periphyton was dominated by diatoms, mainly Gomphonema olivaceum, Diatoma vulgare, Synedra ulna and Navicula gracilis. Peak production occurred in the summer when both diatoms and blue-greens were abundant. Chroococcus minimus was the major summer alga. Diatoms dominated in the fall when species of Cocconeis were very common.

Species composition of periphyton communities did not differ significantly between the intermediate discharge zone and the "ambient zone" (see p. 73). However, within the immediate discharge zone there was a shift in species dominance. Stigeoclonium nanum, Characium pringsheimii and Achnanthes exigua were more abundant in the immediate discharge than in other zones (see p. 73).

Species diversity was greatest in the immediate discharge in the spring (see p. 75) but no trends were discernible during other seasons. Similarly, chlorophyll a and total algae densities failed to show major differences among areas. The cumulative effects of the Monticello Plant discharges do not affect the overall balance of the periphyton communities of this region of the Mississippi River.

Few data exist on the macrophyton of the Mississippi River in the Monticello Plant area. Major taxa present include Fontinalis antipyretica, two Potamogeton species and Cladophora glomerata. These plants are assumed to play a minor role in river trophics as compared to periphyton.

3.2 ZOOPLANKTON

Zooplankton of the Monticello Site has not been investigated recently. Past studies show that few crustaceans inhabit the region. However, protozoans and rotifers may be common in the area (see p. 103). The trophic importance of zooplankton is considered to be limited in this portion of the Mississippi due to the small

number of organisms that feed on zooplankton and due to the paucity of crustaceans in the zooplankton communities.

3.3 MACROINVERTEBRATES

Macroinvertebrate studies were initiated on a five-mile stretch of the Mississippi River in 1968 to gather baseline information before the construction of the Monticello Plant. Preoperational data include the results of investigations from the summer of 1968 to the end of 1970. Operational information has been collected since the plant start-up in 1971.

Two major types of habitat have been described from the survey area. In one habitat type, the backwater areas and protected shoreline areas where grasses and sedges grow, the water is usually less than two feet deep and the substrate is silt and mud. Current velocity in this habitat may fluctuate greatly throughout the year. Random qualitative collections were made along the shorelines and backwaters with invertebrate sweeping nets. In this habitat, the diverse fauna consisted of 11 orders, 32 families and 66 genera (see p. 164). Coleoptera, Ephemeroptera and Hemiptera were the dominant orders.

The main channel represents the other major type of habitat. Substrates are primarily gravel, rubble and boulders with some sand. Current velocity is substantial but fairly consistent. Qualitative analysis of four artificial substrate samplers placed in the central channel during 1968 produced representives of eight

orders, 15 families, and 25 genera (see p. 167). Caddisflies and mayflies were the major components of the benthic fauna in the main channel, although five genera of stoneflies were also represented. Presence of these three orders is indicative of good water quality in this part of the Mississippi River.

In an extensive quantitative program from 1969 through 1972, concrete blocks (artificial substrates) were placed at two control stations above the intake and at six experimental stations below the proposed discharge (see p. 136). In operational years (1971 and 1972), 9 stations were in the outer discharge zones, although 3 of these were, at times, at ambient temperatures, and 4 stations wer in the intermediate discharge zone. None of the stations were in the immediate discharge zone.

Although major taxa composition remained the same (see pp. 169 to 175) in all stations, the percent contribution of dominant groups changed during operational years with a substantial percentage increase of caddisflies, particularly in 1972 (see p. 176).

A recolonization study in 1973 monitored one control station and one experimental station between July 1971 and July 1972 (see pp. 142-158). The experimental station was in the defined outer discharge zone, although over 50 percent of the time it fell within the +3°F (+2°C) isotherm (see p. 179). Caddisfly larvae reached higher population levels in the experimental station, while mayfly and dipteran numbers were reduced (see p. 181).

This increase of caddisflies was statistically significant in three of the eight sampling cycles (see p. 182). While increases and decreases in major taxa occurred in the thermal discharge zone, none of the major taxa were excluded. In 1972, maximum standing crop was reached one month earlier in the experimental station than in the control station, probably due to the constant elevated temperatures at the experimental station. Macroinvertebrate growth rates showed no significant differences between the heated water and control stations.

In a drift study, the experimental station was located in the intermediate discharge zone (see p. 140). Drift compositions at the experimental and control stations were not significantly different at the order level nor was the relative magnitude of the major taxa within each order significantly different. Elevated temperatures in the intermediate discharge zone (see p. 184) produced no measurable change in drift density as compared to the control station.

The adult light trap study provided a species list of the major taxa near the Monticello Site. There did not appear to be a significant change in the emergence periods of the

major taxa, with the possible exception of Macronemum zebratum. Macronemum zebratum emerged two weeks earlier at the light trap near the thermal plume area than it did at the control light trap above the intake.

3.4 FISH

Various sampling gear and analytical methods were employed to examine the impact of the Monticello Plant on the balanced, indigenous fish populations of the Mississippi River. Sampling techniques included electrofishing, seining, trap nets, creel census and tagging (see pp. 189-192). Catch data were transformed to catch-per-unit-effort (catch per electro-fishing-hour, catch per trap net set, catch per seine haul). Spawning sites and time of spawning were determined by examination of fish condition (state of maturity and condition factors).

Carp and shorthead redhorse were the most abundant species captured during pre-operational studies. Game fish were restricted to microhabitats within each sector, which limited their overall abundance (see p. 214).

After the plant went into operation, fish were found in the immediate discharge area regardless of whether or not the

plant was generating. Rough fish species continued to dominate the catch in all areas (see p. 197), a reflection of the relative abundance seen during pre-operational studies. In 1973, rough fish were most abundant in the outer discharge area. The intermediate discharge area yielded greater catches than the immediate discharge area (see pp. 237, 255, 263). In 1974, rough fish were still least abundant in the immediate discharge area but were more abundant in the intermediate discharge area as compared to the outer discharge area, at least through June (see pp. 245, 259, 267). Game species were caught most frequently in the immediate discharge area in 1973; distribution was about even in the other areas (see pp. 239, 257, 265). In 1974, game fish were abundant in the intermediate discharge (see p. 261). In all cases, the catch of game fish was much lower than that of rough fish.

Seining studies were conducted both before and after plant operation. Stations in the adjacent water body segment and the intermediate discharge area were compared by rank correlation (see p. 203). The results indicated that species composition changes were minor. The immediate and outer discharge areas were not sampled in both years, therefore, no comparison could be made. Seining studies

of young-of-the-year smallmouth bass and white sucker indicated that differences in abundance between the intermediate discharge area and ambient control stations were not statistically significant (see p. 204). It was speculated that there may have been some inhibitory action on spawning and/or egg incubation in the intermediate discharge area but that heat could not be singled out as the causative agent. Growth of young-of-the-year smallmouth bass and white suckers was significantly faster in the heated water (see pp. 204, 216).

Spawning studies were conducted for the dominant species in the area: shorthead redhorse, silver redhorse, white sucker and carp (see p. 204). Since the plant was down during most of the spawning periods of white sucker, shorthead redhorse and silver redhorse, anticipated impact must be inferred from the existing data. Carp preferred flooded areas off the main river, so the plant is not anticipated to have any impact on their spawning success. Spawning beds of other species were located in many areas around the plant site (see p. 271). Some of these beds are expected to be in the heated effluent. The impact is anticipated to be minimal because most spawning takes place in the spring and early summer when flows are high and heat should be rapidly

dissipated. Also, most spawning areas likely to be in the heated effluent are in the intermediate discharge area, further reducing heat levels. Yellow perch and walleye overwintering in the discharge canal are expected to experience reduced spawning success (see p. 219).

A small sport fishery was found to exist in the immediate discharge area in the fall. High catches of smallmouth bass and walleye were noted (see p. 210). The occurrence of these fish in the fall is expected to establish a new fishery in the Monticello area for highly desired game species. A creel census of other areas near the plant indicated that a rather unsophisticated and under-utilized fishery existed.

Fish were attracted to the immediate discharge area during the winter months. The standing crop of fish in this area did not appear to be in excess of the carrying capacity as condition factors of these overwintering fish are comparable to published data for the species (see p. 340). Winter shutdowns are expected to result in fish kills due to cold shock. Winter cold shock mortality has not adversely affected fish populations in the river, based on catch-per-unit-effort data.

The major components of the balanced, indigenous population of fish inhabiting the area of the power plant have been minimally affected by plant operation. Rough fish dominated the catches of large species in operational years as in pre-operational years. Forage fish species composition was virtually unaffected. Fish frequenting the immediate discharge area included: smallmouth bass, black crappie, walleye, northern pike, carp, shorthead redhorse, silver redhorse and white sucker. Spawning of some species is expected to be inhibited by the heated discharge, but rapid dissipation of prohibitively high temperature water is expected to minimize impact. Fish kills are probable during the winter, however, the low standing crop in the immediate discharge area is expected to reduce impact. A potential sport fishery in the discharge canal is anticipated.

In summary, the balanced, indigenous population of fish at the Monticello Site is expected to be maintained with a minimum of impact.

4. CONCLUSIONS

Although there have been periods of non-compliance with thermal regulations (both state and NPDES permit), there is no indication of prior appreciable harm to the biota of the Mississippi River within the area of influence of the Monticello Nuclear Generating Plant.

- Water quality parameters measured (other than temperature) were not affected by the operation of the Monticello Plant.

- Primary producers displayed some shifts in periphyton species composition in the immediate discharge while maintaining a balanced community. Intermediate and outer discharge area periphyton communities were indistinguisable from those of the control area.

- Macroinvertebrates were dominated by caddisflies and the benthos standing crop maximum was one month earlier in the area immediately downstream from the discharge. Community stability was not measurably affected in discharge zones.

- Fish populations have not been noticeably altered in composition in the affected areas since the Monticello Plant started operation. Rough fish predominate but game fish are, at times, abundant in the immediate discharge. Minimal impact on spawning of local fishes is predicted.

The evidence presented in this demonstration indicates that the operation of the Monticello Nuclear Generating Plant has not produced appreciable harm and has not interfered with the maintenance of balanced indigenous populations at all trophic levels. Thus any effluent limitations would be "more stringent than necessary to assure the protection and propagation of a balanced indigenous population of shellfish, fish and wildlife" in the Mississippi River.