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- Letter re: Final Report
- Final Report

PGS - 38

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November 10, 1983

Municipal Building
Township of Bedminster
Hillside Avenue
Bedminster, New Jersey 07921

Attention: Mr. John Schoenberg

Re: Biological Survey of the North Branch of the Raritan River

Dear Mr. Schoenberg:

We are pleased to transmit the Final Report of Mr. Ken Wagner covering the two-phase biological survey of the North Branch of the Raritan River. As per your instructions, we enclose three copies for your use and distribution.

Mr. Wagner has offered to meet with you and other officials if the need arises.

Preparatory to the Stream Biological Survey, water quality standards for pollutant loads were presented as a part of the justification for proceeding with the survey. A review of the impacts to expand the Bedminster Treatment Plant from 200,000 gallons per day (gpd) to 400,000; 500,000, and 600,000 gpd was made for water quality parameters including ammonia, dissolved oxygen, total dissolved solids, and phosphates. The Allan Deane 850,000 gpd Facility was also considered. The review disclosed additional stress will occur, however, existing conditions may remain within the same relative level of overall water quality, suggesting the wisdom of performing a biological assessment.

With the completion of the Stream Biological Survey, a base line of quantative conditions has been established prior to the discharge of large flows from Allan-Deane and any increases in Bedminster flows. The stream was found to be experiencing suboptimal conditions throughout its passage in Bedminster, however, from a biological perspective, the stream was not of poor environmental quality. Ken Wagner recommends that Bedminster monitor stream quality to see if changes occur when wastewater discharges increase.

In summary, the present situation indicates that a modest Bedminster treatment plant expansion of 200,000 gpd can be undertaken. Futhermore, previous recommendations by Kupper Associates to install a Belt Filter press sludge processing system and establish a sludge land application system can move forward.

If we may be of further assistance, please call.

Very truly yours,

KUPPER ASSOCIATES

William F. Selders, P.E.

WFS/ib
Enclosures (3)

Biological Survey of the North Branch Raritan River, Bedminster, New Jersey

Survey conducted by
Kenneth J. Wagner
Marcia Grimshaw
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Report prepared by
Kenneth J. Wagner

for
Kupper Associates
Piscataway, N.J.

October 1983

Background Information

On May 22 and 23, 1983 the North Branch Raritan River between Peapack Rd. and Burnt Mill Rd. was surveyed. Four mainstem stations were quantitatively sampled:

- RR #1 Just below Peapack Rd. bridge above the confluence with Peapack Brook.
- RR #2 Approximately 100 meters downstream of the Bedminster sewage treatment plant discharge site.
- RR #3 Approximately 200 meters downstream of the Route 202-206 bridge, at the small island.
- RR #4 Just below the Burnt Mill Rd. bridge, above the confluence with the Lamington River.

Four stations on three tributaries were qualitatively sampled:

- RRT #1 Peapack Brook just above its confluence with the North Branch Raritan River.
- RRT #2 Unnamed tributary off Route 202-206 south of the Route 287 junction and north of "The Hills" development area, above its confluence with ditches draining The Hills.
- RRT #3 Just downstream of RRT #2, below the confluence with the drainage ditches, west of Route 202-206.
- RRT #4 Clucas Brook at River Rd., about one half mile west of Route 202-206.

Peapack Brook drains the Peapack area. The unnamed tributary drains a largely wooded section until its confluence with the ditches draining exposed areas of The Hills (construction in progress). Clucas Brook drains a mixture of woodland, farmland and low density residential area.

Periphyton (mainly algae attached to the substrate), macrophytes (large plants, usually of a vascular nature), macroinvertebrates (bottom dwelling animals with no backbone, larger than 0.5 mm in some dimension) and small fish were sampled at each station. Other data collected included stream width, depth, water velocity, substrate composition (as percent areal cover) and water temperature.

The stations were again sampled on August 25 and 26, 1983. Stations RRT #2-4 were omitted because of negligible flows. An additional mainstem station was designated and sampled:

RR #3A Approximately 50 meters above the Klines Mill Rd. bridge, between stations RR #3 and RR #4.

Data were collected for one additional parameter in August, dissolved oxygen concentration.

The surveyed area includes two sewage treatment plant discharges, those of the Bedminster and Allen-Deane sewage treatment facilities. The Bedminster plant is a tertiary treatment operation, although some of its effluent standards are apparently not being met. It has an average discharge of 0.14 mgd and a rated capacity of 0.2 mgd, but future expansion is anticipated. The Allan-Deane plant is not yet operating at full capacity, having only an intermittant discharge. This is also a tertiary treatment facility, but with some differences in effluent standards. At full capacity 0.85 mgd will be discharged.

The watershed in the Bedminster area is largely a mosiac of woodland, low density residential area and commercial zones. Runoff potential is high, but reasonable erosion control measures have been taken in the survey area. Rip-rap and hay bales were properly utilized in The Hills development area and vegetated buffer zones were maintained around several farm fields observed. Erosion is not prevented from occurring in these areas, but is probably greatly reduced. The river itself has open and canopied sections, with destabilized banks in some places facilitating erosion. In the survey area the North Branch Raritan River is a series of riffle zones and pools.

This survey was conducted to provide baseline biological data for the system, to act as a reference point for future evaluations, and to facilitate an assessment of present and potential environmental impacts on the Bedminster reach of the North Branch Raritan River.

Survey Results

Quantitative data are reported in Table 1. For a given parameter and station there is frequently considerable difference between values for the two sampling dates. Water flow and velocity values illustrate the contrast between wet spring and dry summer conditions. While the change in weather pattern between spring and summer 1983 was particularly striking, observed differences in physical and biological characteristics were not atypical of seasonal fluctuations.

Flow increased markedly between RR #1 and RR #2, then remained relatively stable through the survey area. Water velocity was variable over space and time, but showed a slight tendency to increase in the downstream direction, based on values at sampling sites. The important aspects of water velocity are its scouring and reoxygenation potential; both increase with increasing velocity and are moderate to high at all stations.

The substrate at the sampling stations is comprised mainly of cobble and gravel, with RR #2 also having large quantities of sand. Silt is generally a minor component, but even small amounts may have significant effects on stream organisms. The changes in substrate composition between sampling dates are partly due to errors of measurement, but are largely a function of changing river morphology (e.g. Only small channels at RR #3 were wet in August, while the entire riverbed was flooded in May). It is important to collect biological samples from regions of similar substrate if comparisons between stations are to be made; hence the stations were selected for their substrate similarity, among other factors.

Water temperature was similar at all stations on each sampling date. Slight increases in the downstream direction reflect the influence of sunlight on the river as it passes through regions of low canopy cover. August daytime dissolved oxygen levels were relatively high; percent saturation values ranged from almost 100% at RR #1 to over 170% at RR #3A.

Macrophyte and visible periphyton cover were generally low at the studied sites, except in August at RR #2 where an extensive loose mat (mainly diatoms) was observed. Unsampled pool areas may have contained greater macrophyte densities, but no profuse growths were observed during this survey. More extensive growths have been reported by observers in recent years.

While visible periphyton growths were not overly abundant, less noticible growths covered most suitable substrate. These growths can be characterized by their chlorophyll (pigment) or ash-free dry weight (organic matter) concentration per unit area. Dry weight per unit area includes periphyton biomass plus inorganic matter such as silt or sand which may coat or mix with the periphyton. Indicated periphyton biomasses were relatively high, except in August at RR #1. Dry weight concentrations included large portions of inorganic matter, mainly silt. Values for all periphyton biomass parameters tended to increase after RR #1 and then decrease by RR #4.

Macroinvertebrate dry weight reflects the biomass of benthic animals at each station. Values were highest at RR #1, but were relatively low overall. Statistical comparison of replicate samples from each station indicates that the biomass at RR #1 may be significantly higher ($P<0.05$) than that at any other station, depending upon the test used. The spring biomass at RR #4 may be significantly lower than those for other stations, using the same criterion and tests.

Periphyton and composition and relative abundance are tabulated in Table 2. No striking changes were observed among stations or between sampling dates. Diatoms and certain green algae were dominant. Macrophyte species composition and relative abundance are not reported in tabular form, since these plants were not abundant. Myriophyllum spicatum, Anacharis canadensis, Potamogeton crispus and an aquatic moss were observed. The moss achieved the highest densities at RR #1 and RR #3, coating rocks in an unobtrusive manner. Myriophyllum, Anacharis and Potamogeton formed sparse, trailing growths at RR #2-4 in August.

Macroinvertebrate composition, shown in Table 3, was also similar among stations, but differed somewhat between sampling dates. Differences in relative abundance are mostly non-significant when replicate samples are statistically compared. Total organisms per unit area varied within an order of magnitude, representing statistically non-significant differences in nearly all cases. Total taxa per station showed no striking variation among mainstem stations, but tributary stations had fewer taxa and some of these were different from the mainstem taxa. Overall, ephemeroptera (mayflies), trichoptera (caddisflies) and diptera (two-winged flies) were the most abundant orders of macroinvertebrates encountered.

The size distribution of macroinvertebrates is given in Table 4. Smaller organisms were prevalent, the median size being 3 to 5 mm for all samples. Few organisms were larger than 15 mm. The size distribution varied little over time or space. The organisms collected for this analysis provide an additional measure of macroinvertebrate density, with variation over time and space again having no statistical significance.

Hellgrammites (Megalopterans, specifically Corydalis) are large, predatory benthic invertebrates considered to be excellent food for larger predatory fish.

Assessing hellgrammite populations requires more intensive sampling, due to a normally low density of these insect larvae. The results of five minutes of D-net sampling at each mainstem station and RRT #1 in August are given in Table 5. Hellgrammites were found in roughly equal numbers and sizes at all stations sampled.

Very few fish were captured by seine in May. This was attributed partly to high water velocities and flows that hindered sampling. It was also early in the year relative to the hatching of fish eggs. The results of more successful seining in August are given in Table 6. Catches were highly variable, but the total haul per station followed much the same trend as the periphyton biomass; an increase after RR #1 with a decrease by RR #4. The catches were taxonomically similar. Larger fish were infrequently observed. Anglers interviewed gave conflicting reports of fishing quality in the survey area, but generally considered fishing to be better upstream of the survey area.

The gut contents of a total of 29 small fish, representing 7 species, were examined and are given in Table 7. Identifiable items were most frequently chironomids and few fish appeared satiated. Many fish guts contained unidentifiable matter which appeared to be a mixture of digested insects and detritus or algal matter consumed incidentally.

Data Interpretation

Biological data are interpreted on the basis of anticipated changes in response to environmental disturbances. Anticipated changes include taxonomic compositional shifts, increases or decreases in relative abundance or total biomass, and alteration of size distributions of organisms. Research into these effects was begun in the first quarter of this century (Kolkwitz and Marsson 1908, 1909, Turner 1918, Richardson 1921, 1928, Forbes 1928) and has been continuously refined up to the present (Goodnight 1973, Lowe 1974, Hart and Fuller 1974, Higler and Repko 1981, Hilsenhoff 1982).

Response to perturbations are to some extent site specific, due to the nearly unique nature of every aquatic system. Consequently, biological standards of a precise nature have not been formulated by regulatory agencies, leaving management organizations with the task of "preserving the biological integrity" of a system. The lack of universally applicable biological criteria renders any evaluation of biological data subject to interpretive controversy. Any distinct loss of taxa or deleterious change in biomass or relative abundance is regarded here as an impairment of biological integrity. "Distinct" is defined here as statistically significant at $P<0.05$ or obvious to the trained eye from inspection of the data. Evaluation of biological quality at any station is based on published pollution biology literature, New Jersey State reports and personal experience.

Taxonomic composition and relative abundance--

Very little difference was observed in the taxonomic composition of the periphyton over space or time (Table 2). Navicula spp. and Cladophora were the most abundant taxa encountered, with a variety of other diatoms and green algae observed. Cyanophyte skeins and large filamentous chlorophyte growths were generally absent, although Cladophora was occasionally present in visible quantities and diatoms formed loose benthic mats at RR #2. According to Lowe (1974) and Palmer (1959) the periphyton assemblages observed are tolerant of organic wastes and other pollutants, but are usually not associated with the worst of aquatic conditions. Most of the taxa encountered are considered to be readily available as food for grazers and would supply adequate nutrition for benthic herbivore populations.

The macrophyte species encountered were indicative of nutrient enriched waters below RR #2, and are known to form nuisance growths in New Jersey lakes and rivers. Excessive growths of these plants were not observed in this survey and the patches noticed provided valuable cover for fish.

There was also little difference in macroinvertebrate composition among the mainstem stations sampled (Table 3). Several genera of each of the orders ephemeroptera, trichoptera and diptera, one megalopteran and two coleopterans were consistently encountered and accounted for most of the benthic invertebrates collected. A variety of rarer taxa, spanning 17 orders of aquatic invertebrates (mostly insects), were also found at mainstem stations. According to Hart and Fuller (1974) the observed numbers of taxa are indicative of "damaged stations" (i.e. pollutionally impacted areas), which average 25 taxa per station with a range of 1 to 63 taxa. Undamaged stations average 72 taxa with a range of 37 to 101 taxa by the same scheme.

The dominant macroinvertebrate taxa appear on several of Hart and Fuller's (1974) extreme tolerance lists, most notably in association with high alkalinity and high B.O.D. levels, both typically associated with sewage discharges. This includes RR #1, however, upstream of the treatment facilities in the study area. Most recorded taxa are considered tolerant of periodic oxygen stress, but are not associated with extremely low dissolved oxygen concentrations.

Plecoptera (stoneflies) were abundant at several tributary stations, but not in the North Branch Raritan River. These insect larvae are considered to be largely intolerant of pollution, especially oxygen stress (<4 mg/l). This and other differences between tributary and mainstem station biology indicate environmental degradation in the mainstem, although physical differences (substrate, flow, temperature, etc.) could be the cause of observed discrepancies. There are also temporal differences in composition at mainstem stations, but these are probably the result of life cycle traits and not any marked change in aquatic conditions.

Overall, the taxonomic composition and relative abundance of macroinvertebrates indicate suboptimal but not poor environmental quality in the Bedminster reach of the North Branch Raritan River. Depressed species richness and the pollution tolerance of dominant species are consistent with nutrient enrichment and periodic oxygen stress in the survey area. Discharges of organic wastes frequently cause such effects. Hazardous levels of toxic substances are not indicated by the compositional data collected.

The observed fish species and their relative abundances (Table 6) were typical of lotic systems in the northeastern United States, but the species richness was somewhat low. Species richness and relative abundance are frequently determined by physical conditions (Sloane-Richey et al. 1981). Cover is not extensive in the study area and the summer temperature is too high for the long term maintenance of salmonid populations. Observed siltation from erosion of riverbanks and disturbed soils in the surrounding watershed appear sufficient to impair the reproductive success of many species (silt impairs oxygen transport across the membranes of most fish eggs).

Daytime oxygen levels appear quite sufficient, but periodic oxygen depression could be occurring and influencing fish species composition. The high percent saturation values recorded are indicative of photosynthetic oxygen input, which is minimal by day and can reverse itself at night by respiration (Rudolfs and Heukelekian 1931). Consequently, supersaturation of oxygen during the day suggests an oxygen deficit at night. The magnitude of the deficit is unknown.

Inadequate food supply can also affect species composition and relative abundance, and there is some indication that the fish food supply is relatively low in the study area. The fish, as the top of the energy pyramid in this system, may be affected by shifts anywhere below them in the hierarchical scheme.

Katz and Gaufin (1953) found that sewage discharges caused a depression of species richness immediately below the input point, but eventually the number of fish species increased to a level above that observed upstream of the sewage outfall. Distinct increases or decreased in species richness were not observed in the Bedminster reach of the North Branch Raritan River.

Biomass--

The trend exhibited by measures of periphyton biomass (Table 1) is consistent with nutrient enrichment at RR #2. The higher May values at certain stations (especially RR #1) probably reflect non-point source inputs during the rainy spring. The biomass at RR #1 and RR #4 are significantly smaller than at RR #2-3A for the August sampling, suggesting a finite impact by the Bedminster Plant's discharge within the study area.

Wilhm and colleagues (1978) report chlorophyll values of up to 50 mg/m^2 for Oklahoma streams with no immediate point sources of nutrients. Morton et al. (1981) give a mean value of about 28 mg/m^2 for the Lamington River upstream of the Roxbury sewage treatment plant and 117 mg/m^2 below it. Schiller et al. (1981) cite an average periphyton chlorophyll level of 60 mg/m^2 for the Musconetcong sewage treatment plant and 75 mg/m^2 below it. This represents only a small increase in periphyton, but macrophyte biomass increased greatly below the discharge. Immesberger et al. (1980) give a mean of 17 mg/m^2 of chlorophyll in relatively undamaged portions of Middle Brook. The elevated values at RR #2-3A are undoubtedly related to the nutrient enrichment from the Bedminster treatment facility.

A large portion of the dry weight of "periphyton" at each station is not periphyton at all, but rather inorganic matter. Considerable sand was associated with the periphyton in the August samples for RR #3, but in the other cases the inorganic matter was silt. The relatively large quantities of silt collected with the periphyton are likely to adversely affect the aquatic community. Silt may depress periphyton production by shading, but can also reduce grazer biomass and the reproductive success of fish by impairing oxygen transport across membranes. Excessive siltation may provide a nutrient rich substrate for periphyton and macrophyte growth.

Macroinvertebrate biomass, as dry weight and numbers of individuals (Tables 1, 3 and 4), does not exhibit a consistent trend. Dry weight values are highest at RR #1 and lowest at RR #4, while the density of organisms does not change appreciably among stations. Dry weights and organism densities, relative to those reported in the literature (Immesberger et al. 1980, Morton et al. 1981, Schiller et al. 1981, Simpson 1982), were moderate to low. There is little question that the periphyton could support a larger grazer biomass. Intense predation pressure, siltation, oxygen depletion or the presence of a toxic substance could be responsible for depressed invertebrate biomass. Considering the available data, siltation and periodic oxygen stress are the likely causes.

Small fish biomass, as numbers of fish per haul or station, appeared low. Measurement of fish populations can be difficult, and the recorded values could be misleading. However, the observed fish biomass trend follows that of certain other parameters; an increase after RR #1 followed by a decrease by RR #4. Katz and Gaufin (1953) noted a similar trend on a larger scale in response to organic enrichment. Brinley (1943) also noted a positive response of fish density to organic enrichment via food web effects, providing that oxygen levels remained high enough to support the elevated respiration of the biota. The sewage treatment plant discharges to the North Branch Raritan River therefore have the potential for a positive impact on the associated fishery. Few large gamefish were observed during this survey, however, suggesting that this potential is not realized. Fishing pressure could exert considerable influence on standing stocks of gamefish in the study area, but pollutional impacts are a more probable cause of observed trends.

Size distribution--

The lack of change in the size distribution of macroinvertebrates is consistent with the relative constancy of the taxonomic composition at the sampled stations. Discharge of treated sewage to the Musconetcong River causes changes in both composition and size distribution of invertebrates in that system (Schiller et al. 1981). Decreases in organism size affect the energetics of food consumption by predators, reducing their net gain per capture and often making prey more difficult to locate.

The size distribution of invertebrates in the study area has a moderate to small median but a fairly long "tail" in the large size direction, suggesting at least moderately favorable feeding energetics for predators. The guts of small fish examined contained mainly small prey items (Table 7), but the size of the fish may be responsible. If invertebrate size distributions have been altered by pollution, the pollution is not attributable to sewage discharges alone.

Influences on Biological Quality

Aside from temperature and stream morphology, over which relatively little control can be exerted in the bedminster reach of the North Branch Raritan River, three factors have considerable potential influence on biological quality in this area. The first is the quality of the water entering the study area, which is presumably also beyond the control of the people of Bedminster. Point source inputs in the study area comprise the second influence. Although there is presently only one major point source, the Bedminster sewage treatment facility, the Allan-Deane plant is now operational and will eventually be a more influential point source. The third factor is runoff entering the river in Bedminster. This runoff may include a variety of pollutants, but the one of greatest concern here is fine sediment.

Since temperature and stream morphology are similar at the mainstem stations, one is left with some initial set of conditions which may be changed by inputs in the study area. Analysis of spatial patterns of stream biology can give insight to the importance of those inputs and initial conditions.

Changes in taxonomic composition, relative abundance and size distribution in the study area are relatively small, as opposed to the marked changes associated with serious pollutional impacts. This suggests no obvious deleterious influence by the Bedminster treatment facility discharge or by runoff. Compositional aspects of the biota indicate suboptimal environmental quality throughout the study area, however, suggesting that deleterious influences do exist in the Bedminster reach.

Any environmental degradation at RR #1 must be related to water entering the study area, and related impacts occur for some distance downstream. Yet it is highly unlikely that organic wastes and sediment in the water at RR #1 would yield equal effects at RR #2-4, so it is concluded that negative influences (erosion, runoff, and/or organic wastes) exist within the study area. From a compositional viewpoint these influences merely sustain some level of degradation; they do not noticably degrade the system further.

Changes in the biomass of various biological components suggest more influence by runoff and sewage treatment plant discharges within Bedminster's borders. The pattern of periphyton biomass is consistent with nutrient enrichment at RR #2 with diminishing effects downstream. During the rainy spring non-point sources may contribute significantly to periphyton production, but there was little doubt that the Bedminster plant was the primary source of nutrients during the dry summer.

Invertebrate and small fish biomass did not track that of the periphyton. Invertebrate and fish biomass could be expected to respond positively to increased periphyton biomass, given unchanged algal quality. The standing crop of aquatic animals did not reflect the periphyton increase, however, suggesting that another factor is holding the animal populations in check.

The logical factor to consider is oxygen, which is critical to animal populations and subject to considerable fluctuation in nutrient enriched systems. The nutrients rarely affect animals directly, but stimulation of excessive primary production can lead to diurnal oscillations in oxygen concentration that drop below tolerable levels at night. Chronic severe oxygen depletion is not indicated by the data collected, but the existence of a nightime oxygen deficit downstream of RR #2 is postulated. The lack of a deficit at RR #1 could explain the slightly higher invertebrate biomasses at that station. A more detailed oxygen study is warranted.

Sedimentation could also create oxygen related problems for animal populations, even in the presence of adequate dissolved oxygen concentrations, by impeding oxygen transport across membranes. Such an effect would explain the generally low invertebrate and fish biomasses encountered throughout the study area. Silt may come from eroding river banks or the disturbed soils in the watershed.

Depression of invertebrate biomass by either a silt effect or oxygen deficit could lead to depressed fish biomass as a result of inadequate food supply. A combination of these factors is the postulated cause of the relatively low aquatic animal biomasses in the study area. Either alone may be sufficient to produce the observed results, but both are likely to have an influence in this system.

Potential Effects of the Allan-Deane Discharge

Given that biological quality in the Bedminster reach of the North Branch Raritan River is suboptimal but not poor, the possibility of further deterioration from increased inputs exists. Three responses are possible:

1) Conditions could get steadily worse to some maximally degraded state.
2) Conditions could remain unchanged up to some critical point at which deterioration would be rapid.
3) No response may be observed, especially if the new inputs are being added to already excessive levels of the same substances.

At this time the biological quality at the upstream border of Bedminster is somewhat better than that at the downstream border, with different biological components of the system displaying different trends over space. The Allan-Deane discharge will alter those trends so that biological quality is clearly inferior at the downstream border, but is only one of the forces responsible for the degradation. The effects of the discharge will be of the same type associated with the Bedminster plant, but may be more severe as a consequence of Allan-Deane's higher capacity.

It is expected that the additional nutrient inputs from the Allan-Deane plant will cause the periphyton biomass in the remaining portion of the Bedminster reach to rise to levels at least equal to those observed at RR #2 and RR #3. Algal biomass will exceed the levels at those stations if nutrient levels are not already excessive. Studies on the Lamington and Musconetcong Rivers (Morton et al. 1981, Schiller et al. 1981) and Stony and Bedens Brooks (Wagner 1978) suggest that phosphorus concentrations up to 0.2 mg/l can affect primary production in lotic systems. Since the Allan-Deane discharge is projected to raise the background phosphorus concentration from 0.10 to 0.15 mg/l during low flow periods, increased algal biomass could be expected.

Increased nutrient retention in pool areas could lead to greater macrophyte growth and abundance, as observed downstream of the Musconetcong sewage treatment plant (Schiller et al. 1981). This effect was not observed downstream of the Bedminster plant in this study, however.

Substantive changes in the taxonomic composition and relative abundance of the river biota are not expected as a direct result of nutrient inputs from the Allan-Deane facility. However, this plant has the potential to increase the B.O.D. load to the river by a factor of ten. Coupled with the oxygen fluctuations typically associated with plant growths supported by discharged nutrients, this could lead to periodic oxygen depletion and subsequent species changes.

Sections of the Musconetcong and Lamington Rivers have morphologies similar to that of the Bedminster reach of the North Branch Raritan River and receive high nutrient and B.O.D. effluents from 1 mgd sewage treatment plants. Yet the dissolved oxygen concentration in these sections was never less than 4 mg/l as a consequence of high reaeration potential (Morton et al. 1981, Schiller et al. 1981). This suggests that severe oxygen depletion will not occur in the Bedminster reach.

Another possible impact of the Allan-Deane discharge is toxicity due to chlorine. Such an effect was noted below the 1 mgd Musconetcong discharge

(Schiller et al. 1981). Chlorine toxicity was not noted below the Bedminster sewage treatment plant discharge, probably because of its relatively small size. The proposed dechlorination of the Allan-Deane effluent should prevent chlorine toxicity below its discharge point.

The lack of impoundments in the study area reduces the effects of most inputs to the system. However, an old diversion wall designed to power a defunct mill is still in place between RR #3 and RR #3A, possibly creating an impoundment effect. Also, volunteers with Trout Unlimited have been manipulating natural rocks to create pools in the river. This practice is considered to represent a physical habitat improvement for fish, but may foster macrophyte growths and oxygen fluctuations in this case.

Technical Summary

Physical and biological aspects of the Bedminster reach of the North Branch Raritan River were surveyed during two periods (May and August) in 1983. Chemical characteristics had been studied previously by other investigators. Based on the available data, the following observations are made:

1) The major factors controlling river biology are temperature, river morphology, water quality at the upstream border of Bedminster, runoff and erosion in Bedminster, and discharges from two sewage treatment facilities.

2) Few changes in the taxonomic composition of the periphyton, macroinvertebrate, and fish communities or the size distribution of invertebrates are observed. The noted composition of the biota is indicative of suboptimal but not poor environmental quality throughout the study area.

3) Nutrient enrichment, partly from runoff but largely from the Bedminster

sewage treatment plant, results in elevated periphyton biomass in the study area, particularly just downstream of the Bedminster discharge point. Dense macrophyte growths are possible but not observed in this study.

4) Expected increases in invertebrate and fish biomass in response to elevated periphyton abundance are not observed. Periodic depression of dissolved oxygen levels and/or the impairment of oxygen transport across biological membranes by silt could be holding aquatic animal populations in check. Both mechanisms are likely to be operating within the study area as a consequence of erosion, B.O.D. loadings and nightime respiration by large periphyton growths. Invertebrate food supply for fish may also be inadequate.

5) The riffle-pool morphology of the river in Bedminster, with the absence of impoundments, reduces the effects of discharges of B.O.D. and nutrients. Comparison with similar systems indicates that severe oxygen depletion is not likely to occur in this area, even with additional inputs from the Allan-Deane treatment facility.

6) The inputs from the Allan-Deane plant will cause periphyton biomass to rise to at least the level observed downstream of the Bedminster Plant. If all effluent standards are met, this should be the only noticable change in the study area. Under present conditions the increased primary production is not likely to stimulate increased invertebrate or fish production.

7) Overall biological quality declines slightly through the study area, with different biological components displaying different temporal and spatial trends. The Allan-Deane discharge will make the degradation more noticable, but is only one of several factors

contributing to the biological deterioration, which is evident even at the upstream boundary of Bedminster.

Non-Technical Summary

Information gathered from this survey and studies performed in the past indicate that the major factors affecting the biological components of the river include temperature, physical characteristics of the riverbed, the quality of water in the river as it enters the study area, runoff and erosion in Bedminster, and discharges from two sewage treatment facilities. The people of Bedminster can exercise control over only the last two factors.

The types and sizes of plants and animals found in the studied area do not change appreciably over space or time, which is generally a desirable trait. However, the types of organisms found are indicative of some intermediate level of environmental quality throughout the Bedminster reach of the North Branch Raritan River, suggesting that some degradation is occurring.

Excessive fertilization of the river, partly from runoff but largely from the Bedminster sewage treatment plant, causes excessive growth of attached algae in the study area, especially just below the discharge site. Growths of large aquatic plants were not observed in this study, but have been seen in the past and are consistent with the noted fertilization.

Despite the possibly unappealing appearance, algal growths can be a benefit to fish production by stimulating increased invertebrate production, thus providing food for fish. Such increases are not observed in the Bedminster reach, however, probably as a result of fluctuating oxygen levels and the adverse effects of silt on aquatic animals and their eggs. The silt comes from erosion in the watershed and the oxygen fluctuations are the combined effect of oxygen demanding inputs from the sewage treatment plants and respiration by the excessive algae growths at night. The result is that the river exhibits the negative aspects of fertilization but none of the positive ones. The presence of toxic substances is not indicated by any available information.

The physical nature of the riverbed and lack of large, still water areas mitigates the impact of river fertilization. This means that the situation would be worse if dams were built on the river in Bedminster, especially at the downstream end. The situation could be improved by stabilizing the river banks in areas prone to erosion.

The Allan-Deane discharge will cause additional increases in the abundance of attached algae, but is not likely to change the types of plants and animals found as long as all effluent standards are met. Alteration of fish production is not anticipated under current and projected conditions; an increase would be desirable.

The biological quality of the North Branch Raritan River in Bedminster declines slightly in the downstream direction. This decline will become more obvious as the Allan-Deane discharge approaches its maximum level, but it should be remembered that this discharge is only one of several factors responsible for the degradation, which begins above the upstream border of Bedminster.

Recommendations

A review of available data on the North Branch Raritan River reveals two areas which are in need of assessment if the impact of environmental disturbances is to be more accurately assessed. The first is a quantification of diurnal dissolved oxygen patterns in the Bedminster reach. There is no record of any 24 hour oxygen monitoring for this area, but the N.J. State Department of Environmental Protection (Division of Water Resources) has performed such surveys in the past and is well equipped to do so (expensive equipment is involved). Knowledge of the nighttime oxygen levels in the Bedminster reach would be useful in assessing the impact of B.O.D. inputs and increased algal biomass.

The second area in need of study is the state of gamefish populations in the Bedminster reach. An assessment of population sizes and growth rates would allow an evaluation of the relative importance of siltation, oxygen stress and angling pressure. The N.J. State Department of Environmental Protection (Division of Fish, Game and Wildlife or Division of Water Resources) is also equipped to handle this type of assessment.

Aside from gathering information on parameters for which little data has been collected, it would be advisable to monitor the biology of the river at two or three strategic sites as the Allan-Deane discharge is increased. Simple analyses with samples from stations RR #1, RR #2 and RR #3A would allow biological changes to be detected rapidly and associated with upstream water quality, the Bedminster or Allan-Deane discharges, or runoff. Measurement of periphyton and invertebrates species composition and biomass would be very useful, but a simple photographic analysis of benthic organisms and general conditions at each station would be adequate and could be performed by almost anyone with a minimum of training.

Therefore, the following recommendations are made:

1) The N.J. Department of Environmental Protection should be contacted and persuaded to perform brief assessments of diurnal dissolved oxygen concentrations and gamefish populations. Oxygen patterns over a 24 hr. period should be quantified, and the population size and growth rates of gamefish species should be measured. Summer would be the best season for these assessments.

2) The Bedminster environmental commission or appointed representatives should undertake a small scale monitoring program to assess aquatic conditions as the Allan-Deane discharge increases.

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Table 1. General Survey Data

Parameter	RR #1		RR #2		RR #3		RR #3A		RR #4	
	5/23	8/25	5/23	8/25	5/23	8/25	5/23	8/25	5/23	8/25
Mean water velocity (ft/sec)	1.9	0.5	2.5	0.7	1.6	1.4	NO SAMPLES COLLECTED	1.5	3.3	2.2
Water flow (ft^3/sec)	71	7.6	166	18.4	146	17.6		26.6	152	26.6
Substrate										
% cobble	70	80	45	45	10	30		50	50	60
% gravel	20	10	10	10	50	30		35	20	20
% sand	9	9	40	40	20	35		14	10	15
% silt	1	1	5	5	20	5		1	20	5
Water Temp. (°C)	14.3	21.9	15.0	22.4	15.0	22.2		23.6	15.2	25.1
Dissolved Oxygen (mg/l)	-	8.6	-	13.7	-	14.3		14.6	-	11.3
% Macrophyte Cover	0	0	0	2	1	10		5	2	10
% Periphyton Cover (visible)	21	9	13	80	5	31		27	5	6
Mean periphyton										
Chlorophyll a (mg/m^2)	111	7	167	114	109	81		115	38	38
Dry weight (g/m^2)	24.6	8.2	28.3	85.3	61.2	911		24.5	62.0	24.0
Ash-free dry weight (g/m^2)	8.9	4.4	10.2	23.4	16.2	117		14.6	8.2	12.5
Mean macroinvertebrate dry weight (g/m^2)*	1.63	1.71	0.48	0.73	0.69	1.17		0.77	0.17	0.50

Station/date

* 8/25 values calculated from abundance and size distribution data

Table 2. Periphyton Composition and Relative Abundance

X = present
XX = common
XXX = abundant

Station/date

Taxon	RR #1 5/23	RR #1 8/26	RR #2 5/23	RR #2 8/26	RR #3 5/23	RR #3 8/26	RR #3A 5/23	RR #3A 8/26	RR #4 5/23	RR #4 8/26	RRT #1 5/23	RRT #1 8/26	RRT #2 5/23	RRT #3 5/23	RRT #4 5/23
Bacillariophyta							No Samples Collected								
Achnanthes	X	X	X	X	X	X		X	X	X		X			
Cocconeis		X		X	X	X		X		X		X			X
Cyclotella															X
Cymbella	X	X	X	X	X	X		X	X	X	X	X	X	X	
Diatoma	XX		X		X				X		X	X			X
Epithemia	X				X										
Fragilaria			X												
Frustulia												X			
Gomphonema		X		X				X							X
Gyrosigma	X														
Melosira			X		X				X		X				X
Meridion													X	X	
Navicula	XXX	XXX	XXX	XXX	XXX	XXX		XXX	XXX	XXX	XXX	XXX	X	X	X
Nitzschia			X	X	X	X		X	X			X	X	X	X
Rhoicosphenia		X	X	X	X						X			X	
Surirella	X	X		X	X							X	X		X
Synedra	X		X	XX	X	X					X		X	X	X
Chlorophyta															
Ankistrodesmus						X		X							
Cladophora	XX		XX	X	X	XX		X	X	X		X			XXX
Closterium				X		X		X							
Coelastrum		X		X		X		X							
Cosmarium	X			X		X		X		X		X			X
Oedogonium				X											
Pediastrum		X		X		X		X		X					
Scenedesmus		X		X		X		X		X					
Sphaerocystis				X				X							
Staurastrum	X														
Stigeoclonium			XX		X				X		X			XX	
Tetraedron		X		X											
Ulothrix			X		X				XX		X			X	
Cyanophyta															
Chroococcus				X											
Oscillatoria	X	X	X	X	X				X	X	X		XXX		
Euglenophyta															
Trachelomonas			X		X										
Total Genera	12	12	14	20	16	13		14	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 3. Macroinvertebrates per m^2

	Station/date																
	RR #1		RR #2		RR #3		RR #3A		RR #4		RRT #1		RRT #2	RRT #3	RRT #4
Taxon	5/23	8/26	5/23	8/26	5/23	8/26	5/23	8/26	5/23	8/26	5/23	8/26	5/23	5/23	5/23
Ephemeroptera							NO SAMPLES COLLECTED								
Baetidae															
Baetis	15	4	15		6	161		183	9	71		P			
Pseudocleon	4								2		P				
Caenidae															
Caenis			2		4										P
Ephemerellidae															
Danella	2		4												
Ephemerella	105		112		43	6		24	17	26	P				
Eurylophella									6						P
Heptageniidae															
Cingymula	2														
Macdonnoa										4					
Stenonema	34	19	9	11	4	2				13	P	P			
Leptophlebiidae															
Paraleptophlebia					4									P	
Oligoneuridae															
Isonychia		9				4		120		28					
Siphlonuridae															
Ameletus		39		4				11		2		P			
Siphlonurus					P										
Unidentifiable forms	13		11		2				4		P				
Plecoptera													P	P	
Chloroperlidae															
Rasvena													P		P
Nemouridae															
Amphinemoura															
Perlidae															
Acroneuria			2												
Neoperla									2						
Paragnetina	2		2		9	2		4		4					
Megloptera															
Corydalidae															
Corydalis	6	4	P	P	P	4		4		2	P	P			
Nigronia											P				

Table 3.

Taxon	RR #1 5/23	RR #1 8/26	RR #2 5/23	RR #2 8/26	RR #3 5/23	RR #3 8/26	RR #3A 5/23	RR #3A 8/26	RR #4 5/23	RR #4 8/26	RRT #1 5/23	RRT #1 8/26	RRT #2 5/23	RRT #3 5/23	RRT #4 5/23
Trichoptera							NO SAMPLES COLLECTED								
Hydropsychidae															
Cheumatopsyche		183	13	24	2	97		520		329	P	P			
Macronema	2	26	2	4		22		28		45		P			
Potamyia					2										
Symphitopsyche	6	28	52	11	11	52		101		56	P				
Lepidostomatidae															
Lepidostoma	6	2	4												
Leptoceridae															
Ceraclea	2														
Limnophilidae															
Pseudostenophylax					2										
Philoptamidae															
Chimarra	2	13	2		2	2		183		32					
Wormaldia			2												
Polycentropodidae															
Cernotina				4		2									
Neureclipsis					2										
Rhyacophilidae															
Rhyacophila		11								2					
Unidentifiable forms			4												
Diptera															
Athericidae															
Atherix				2						2					
Chironomidae															
Chironominae		2		176		202		71		22		P			
Orthocladinae	129		140		232				39		P				
Tanypodinae				45		43									
Simuliidae															
Cnephia		4				338		108		52					
Simulium									2		P				
Stratiomyiidae															
Euparyphus					2										
Tipulidae															
Dicranota	4	4	6	11				2		4		P			
Pedicia					2										
Prionocera													P		

Table 3.

Taxon	RR #1 5/23	RR #1 8/26	RR #2 5/23	RR #2 8/26	RR #3 5/23	RR #3 8/26	RR #3A 5/23	RR #3A 8/26	RR #4 5/23	RR #4 8/26	RRT #1 5/23	RRT #1 8/26	RRT #2 5/23	RRT #3 5/23	RRT #4 5/23
Odonata							NO SAMPLES COLLECTED								
Coenagrionidae															
Enallagma										11					
Nehallenia			4												
Gomphidae															
Stylogomphus				2		2									
Coleoptera (adults)															
Dytiscidae															
Uvarus									2					P	
Elmidae															
Ancronyx					P										
Stenelmis		22	2			17		34	2	9	P				P
Coleoptera (larvae)															
Dytiscidae															
Coptotomus		11		2		2									
Elmidae															
Stenelmis	2	24		4	4	30		17		19					
Gyrinidae															
Dineutus						2		24		15					
Hydrophilidae															
Berosus						2									
Psephenidae															
Psephenus	6	56	2	4	22	2		41	2	4	P				P
Lepidoptera															
Pyralidae															
Paragyractis		4								6					
Hemiptera															
Rhagoveliidae															
Rhagovelia		2				4		2				P			
Hirudinea															
Erpobdellidae															
Erpobdella					4			2							

Table 3.

Taxon	RR #1 5/23	RR #1 8/26	RR #2 5/23	RR #2 8/26	RR #3 5/23	RR #3 8/26	RR #3A 5/23	RR #3A 8/26	RR #4 5/23	RR #4 8/26	RRT #1 5/23	RRT #1 8/26	RRT #2 5/23	RRT #3 5/23	RRT #4 5/23
Gastropoda							NO SAMPLES COLLECTED								
Lymnaeidae															
Columella														P	
Lymnaea										4					
Physidae															
Physinae		2				2		4		4				P	
Planorbidae															
Helisoma					2	2		4				P		P	
Bivalvia															
Sphaeriidae															
Musculium	2														
Pisidium		2	2			2								P	
Sphaerium	2	2	2			4									
Amphipoda															
Gammaridae															
Gammarus	9	49	37	26	19	58		2	28	26		P			P
Haustoriidae															
Pontoporeia			4	2	2					26		P			
Isopoda															
Asellidae															
Caecidotea			4		15			2							
Lirceus	4														
Decopoda															
Orconectes						2									
Oligochaeta		4													
Platyhelminthes															
Planaria		2													
Total Taxa	21	26	26	17	26	28	-	23	12	27	12	12	3	7	6
Total Organisms/m^2	357	528	433	332	395	1068	-	1491	130	818					

P denotes presence only, no count made.

Table 4. Size Distribution of Macroinvertebrates

% per size class per station per date

Size Class (mm)	RR #1 5/23	RR #1 8/25	RR #2 5/23	RR #2 8/25	RR #3 5/23	RR #3 8/25	RR #3A 5/23	RR #3A 8/25	RR #4 5/23	RR #4 8/25
1	17	2	1	4	1	0	No Samples Collected	0	1	0
2	24	19	16	9	19	7		6	26	12
3	14	16	24	15	27	28		28	36	26
4	18	27	19	19	23	26		16	18	24
5	13	12	13	19	13	18		12	9	13
6	7	7	8	14	5	8		18	4	5
7	2	5	7	9	4	7		5	3	5
8	1	5	7	3	2	2		5	3	6
9	1	2	1	0	<1	2		3	0	3
10	<1	3	1	2	2	2		3	1	4
11	1	0	0	3	0	1		1	0	<1
12	<1	1	1	<1	0	<1		1	0	0
13	1	0	2	0	0	<1		<1	0	0
14	0	1	1	0	0	0		0	0	0
15	1	0	1	0	1	0		<1	1	<1
16	0	0	0	0	0	0		0	0	0
17	0	0	0	0	0	0		0	0	<1
18	0	0	0	0	0	0		0	0	<1
19	0	0	0	0	0	0		0	0	0
20	0	0	0	<1	<1	<1		<1	0	0
24	0	<1	0	0	0	0		0	0	0
25	0	0	0	<1	0	0		0	0	0
27	0	0	0	0	0	<1		0	0	0
31	0	<1	0	0	0	0		0	0	0
40	0	0	0	0	0	<1		<1	0	0
44	<1	0	0	0	0	0		0	0	0
54	0	0	0	<1	0	0		0	0	0
63	0	0	0	<1	0	0		0	0	0
Total # of Organisms/m^2	617	411	307	295	531	568	–	972	252	477

Table 5. Hellgrammite Survey

8/26/83 - 5 min. of sampling with D-net per station

	Station					
	RR #1	RR #2	RR #3	RR #3A	RR #4	RRT #1
Megalopterans	10	7	9	6	7	6

Table 6. Fish Captured by Seine (8/26/83)

Taxon		Station									
		RR #1		RR #2		RR #3		RR #3A		RR #4	
	Haul #	1	2	1	2	1	2	1	2	1	2
Cyprinidae											
Notropis cornutus (common shiner)								9	1		
N. hudsonius (spottail shiner)						1		1	75	17	6
N. rubellus (rosy-faced shiner)									40		
N. spilopterus (spotfin shiner)									1		
N. sp (shiner)		22		9	50	3	114				
Rhinichthys atratulus (blacknose dace)		4		1	3	8	3	1		3	1
R. cataractae (longnose dace)								1		1	
Semotilus corporalis (fallfish)				5		3		5	26	3	5
Catostomidae											
Catostomus commersoni (white sucker)			19								1
Cyprinodontidae											
Fundulus diaphanus (banded killifish)							1		3	1	
Centrarchidae											
Ambloplites rupestris (rock bass)							5				
Lepomis gibbosus (pumpkinseed sunfish)				5	7		5				
L. macrochirus (blugill sunfish)				8	4		2	2	4		
Micropterus dolomieui (smallmouth bass)		1	3	2	1		4	2			
M. salmoides (largemouth bass)									2		
Percidae											
Etheostoma olmstedi (tesselated darter)				1	3	2		4	3		
Salmonidae											
Salmo trutta (brown trout)			2					3			
Esocidae											
Esox niger (chain pickerel)									1		
Total per haul		27	24	31	68	17	134	28	156	24	13
Total per station		51		99		151		184		37	

Table 7. Analysis of Fish Gut Contents

Fish Species	Semotilus corporalis									
Length (mm)	140	180	55	60	50	55	30	30	40	40
Station	RR #2	RR #2	RR #2	RR #2	RR #2	RR #2	RR #3A	RR #3A	RR #4	RR #4
Gut Contents										
Amphipods										
Chironomids				1		4		1		
Mayflies									1	
Gastropods									1	
Unidentifiable matter					X	X		X	X	X
Empty	X						X			
Algae/Plant matter		X								
Larval fish/eggs			X							

Fish species	Notropis spp.					Catostomus commersoni	
Length (mm)	40	70	75	80	70	40	45
Station	RR #3	RR #3A	RR #3A	RR #3A	RR #4	RR #4	RR #4
Gut contents							
Amphipods							
Chironomids	3						
Mayflies							
Gastropods							
Unidentifiable matter		X	X	X	X	X	X
Empty							
Algae/Plant matter							
Larval Fish/Eggs							

Table 7.

Fish Species	Etheostoma olmstedi					Lepomis gibbosus	
Length (mm)	45	50	60	70	20	30	30
Station	RR #2	RR #3	RR #3	RR #3	RR #4	RR #3	RR #3
Gut Contents							
Amphipods	1					1	
Chironomids	5	7		6		3	4
Mayflies			1	1			
Gastropods							
Unidentifiable matter							
Empty					X		
Algae/Plant matter							
Larval Fish/eggs							

Fish Species	Rhinichthys cataractae				Rhinichthys atratulus
Length (mm)	55	85	35	40	35
Station	RR #2	RR #3A	RR #4	RR #4	RR #4
Gut Contents					
Amphipods					
Chironomids	16				
Mayflies					
Gastropods					
Unidentifiable matter			X		X
Empty		X		X	
Algae/Plant matter					
Larval fish/eggs					