New Jersey Department of Environmental Protection
Report on the Establishment of a
Total Maximum Daily Load for Fecal Coliform
and an Interim Total Phosphorus Reduction Plan
for the Whippany River Watershed

Executive Summary

Total Maximum Daily Loads (TMDLs) represent the assimilative or carrying capacity of the receiving water taking into consideration point and nonpoint sources of pollution, natural background, and surface water withdrawals. A TMDL is developed as a mechanism for identifying all the contributors to surface water quality impacts and setting goals for load reductions for specific pollutants as necessary to meet surface water quality standards. TMDLs are required, under Section 303(d) of the federal Clean Water Act, to be developed for waterbodies that cannot meet surface water quality standards after the implementation of technology-based effluent limitations. TMDLs may also be established to help maintain or improve water quality in waters that are not impaired. A TMDL establishes Waste Load Allocations and Load Allocations for point and nonpoint sources, respectively. Regulations concerning TMDLs are contained in EPA's Water Quality Planning and Management Regulations (40 CFR 130). "A TMDL is established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." (40 CRF 130.7(c))

Where TMDLs are required to address documented surface water quality impairment, allocations are made to the varying sources contributing to the water quality problem in order to reduce the total pollutant load received by the waterbody. Load reduction goals established through TMDLs are achieved through the issuance of wasteload allocations for points source discharges and load allocations for nonpoint source discharges. Since nonpoint source pollution, by definition, does not come from discrete, identifiable sources, load allocations would consist of the identification of categories of nonpoint sources that contribute to the parameters of concern. The load allocation would also include specific load reduction measures for those categories of sources, to be implemented through best management practices (BMPs) including local ordinances for stormwater management and nonpoint source pollution control, headwaters protection practices, or other mechanisms for addressing the priority issues of concern.

In May 1999, the New Jersey Department of Environmental Protection (Department) and USEPA Region II entered into a Memorandum of Agreement including an 8-year schedule to produce TMDLs for all water quality limited segments remaining on the 1998 Section 303(d) List of Water Quality Limited Waterbodies in New Jersey or provide information necessary to remove waterbodies from the list (see Appendix C). This

TMDL for the Whippany River Watershed is the first to be developed by the Department under this MOA and are scheduled to be established by December 31, 1999. This report explains the process under which the TMDL for fecal coliform bacteria in the Whippany River Watershed was developed and what the TMDL will require once it is established. Notice of the TMDL has been published in the New Jersey Register as an amendment to the Northeast Water Quality Management Plan pursuant to N.J.A.C. 7:15-3.4. The TMDL will also be included in the Whippany River Watershed Management Plan when it is published in early 2000. The purpose of the Whippany River Watershed Management Plan is to advance measurable goals, objectives and strategies to restore, enhance and protect the Whippany River Watershed so that it can be maintained as a viable and valuable resource for present and future generations.

Background Information

The TMDL for fecal coliform was developed as part of the Whippany River Watershed Project. The Whippany River Watershed Project was a pilot effort initiated in October 1993 to aid the Department in developing a comprehensive watershed management process that could be replicated throughout the state. An extensive technical effort has grown out of this project intended to identify, prioritize and analyze water quality in the Whippany River Watershed and to provide an understanding of the cause and effect relationships associated with all significant pollution sources, both point and nonpoint. The TMDL analysis represents a significant portion of this technical effort.

There has been significant public involvement in the Whippany River Watershed Project, formalized through the creation of the Whippany Watershed Partnership in 1994. The Whippany Watershed Partnership is comprised of approximately 120 representatives of local, county, regional, state and federal government agencies; local and regional businesses and industries; academia; environmental and civic groups; and area residents. The Whippany Watershed Partnership includes a Public Advisory Group (PAG) and several committees that have been working with the Department on different aspects of the Whippany River Watershed Project, including the development of the TMDL methodology. The mission of the Whippany Watershed Partnership is to regain the value of the Whippany River as a vital natural resource through the proper management of the Whippany River Watershed. Proper management means consideration of the entire watershed, including current and future water resources, and the interrelationships between: surface and ground waters, water quality and quantity (e.g. water supply, flooding, etc.), and water and land resources and their uses. Proper management also means consideration of the need to sustain communities and their beneficial growth and improvement while meeting mutually agreed upon environmental protection objectives. These objectives were collaboratively developed through the watershed management planning process and will be achieved through implementation of the Whippany River Watershed Management Plan.

The vision for the Whippany River Watershed is to continue the restoration of the Whippany River and manage its watershed so that we can once again have a viable natural resource that is valued for the many environmental, economic and aesthetic benefits it provides, including: diverse and abundant populations of fish, wildlife, aquatic habitat; clean and available water supplies; recreational opportunities and access; environmentally-responsible economic activity and environmentally compatible infrastructure. In order to realize this vision, the Whippany PAG formed several committees to focus on specific aspects of the watershed and the watershed planning process. A Technical Advisory Committee was formed to work with the Department to identify water quality issues of concern and develop a methodology for monitoring, modeling and assessment to evaluate the root cause of any verified water quality problems. The water quality assessment process began with a review and screening of the historical data for several parameters of concern, including but not limited to those identified as causes for impairment on the 303(d) List. Specific consideration was given to the limitations inherent in heavy metals data collected before "clean" sampling methods had been developed.

Surface Water Quality Standards

The Surface Water Quality Standards (N.J.A.C. 7:9B et seq.) apply to all waters of the State of New Jersey. Classifications and criteria for selected parameters that apply to the Whippany River are presented below.

Surface Water Classifications[1] within the Whippany River Watershed

Whippany River	
(Brookside) – Source to Whitehead Road Bridge	*FW2-TP(C1)*
(Morristown) – Whitehead Road Bridge to Rockaway River	*FW2-NT*
Whippany River Tributaries	
(Brookside) – Entire length	*FW2-TP(C1)*
(East of Brookside) – Entire length	*FW2-TM*
(East of Washington Valley) – Entire length	*FW2-TM*
(Gillespie Hill) – Entire length	*FW2-TP(C1)*
(Shongum Mountain) – Entire length	*FW2-NT*

Surface Water Quality Criteria

Surface Water Quality Criteria are found in the New Jersey Surface Water Quality Standards at N.J.A.C. 7:9B et seq. and are summarized below for the three major classes of pollutants.

Eutrophication Parameters

Eutrophication is the acceleration of the natural aging process that normally occurs in lakes over geologic time frames. Excessive primary production coupled with excessive sedimentation are the key processes involved in eutrophication. The undesirable effects of eutrophication include siltation and alteration of dissolved oxygen dynamics. Eutrophication is addressed in the surface water quality standards with the following criteria.

[1] "FW2" means those waters that are not "FW1" or Pinelands Waters
"TP" means trout production
"TM" means trout maintenance
"C1" means Category One waters
"NT" means non-trout

1. Total Phosphorus Criteria, N.J.A.C. 7:9B-1.14(c)5

   For FW2 lakes, ponds, reservoirs, or tributaries at the point where it enters such bodies of water, total phosphorus shall not exceed 0.05 mg/L.

   For FW2 streams: Total Phosphorus shall not exceed 0.10 mg/L unless it can be demonstrated that phosphorus is not a limiting nutrient and will not otherwise render the waters unsuitable for the designated uses.

2. The Surface Water Quality Standards Nutrient Policy #2, N.J.A.C. 7:9B-1.5(g)2

   Nutrient Policy #2 is a narrative criterion that reads:

   Except as due to natural conditions, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation, or otherwise render the waters unsuitable for the designated uses.

3. The Surface Water Quality Standards Nutrient Policy #3, N.J.A.C. 7:9B- 1.5(g)3

   Nutrient Policy #3 allows the Department to establish site-specific water quality criteria for nutrients that supercede the above generic criteria.

4. Dissolved Oxygen Criteria, N.J.A.C. 7:9B-1.14(c)2

   For FW2-TP: not less then 7.0 mg/L at any time.

   For FW2-TM: 24 hour average not less then 6.0 mg/L, but not less than 5.0 mg/L at any time.

   For FW2-NT: 24 hour average not less than 5.0 mg/L, but not less than 4.0 mg/L at any time.

   For FW2-TM and FW2-NT, supersaturated dissolved oxygen values shall be expressed as their corresponding 100 percent saturation values for purposes of calculating 24 hour averages.

Pathogen Indicators

Because pathogens (disease-causing organisms) present in surface waters are few in number and difficult to isolate, groups of more common bacterial species, commonly found in association with pathogens, are used as indicators of possible pathogenic contamination. Two groups of bacteria are currently included in the Surface Water Quality Standards as pathogen indicators: fecal coliforms and enterococci. Fecal coliform data have historically been used to determine impairment due to pathogenic contamination.

Fecal Coliform, N.J.A.C. 7:9B-1.14(c)1.ii

For FW2 Classifications: levels shall not exceed a geometric average of 200 counts per 100 ml, nor should more than 10 percent of the total samples taken during any 30-day period exceed 400 counts per 100 ml.

Toxics

Surface water quality criteria for toxics are listed individually in 7:9B-1.14(c). Criteria for toxic constituents of concern in the Whippany River Watershed are listed below.

Metals, N.J.A.C. 7:9B-1.14(c)13

- arsenic – 0.0170µg/L total recoverable for all FW2
- beryllium – no applicable criteria
- cadmium – 1.0 µg/L dissolved for all FW2 (EPA standard applies), depending on hardness
- chromium
  - trivalent - 180 µg/L dissolved for all FW2 (EPA standard applies), depending on hardness
  - hexavalent - 10 µg/L dissolved for all FW2 (EPA standard applies)
- copper –11 µg/L dissolved for all FW2 (EPA standard applies)
- lead – 2.5 µg/L dissolved for all FW2 (EPA standard applies), depending on hardness
- mercury – 0.012 µg/L dissolved for all FW2 (EPA standard applies)
- zinc - 100 µg/L dissolved for all FW2 (EPA standard applies), depending on hardness

Un-ionized Ammonia

- For FW2-TP and FW2-TM: 20µg/L 24 hr. average
- For FW2-NT: 50µg/L 24 hr. average

303(d) Listed Parameters

In accordance with the Federal Clean Water Act, the Department prepared New Jersey's 1998 list of water quality limited waterbodies. This list is required by section 303(d)(1)(A) of the Federal Clean Water Act and is a component of the Statewide Water Quality Management Plan, as required by the Water Quality Management Planning Rules at NJAC 7:15-2.1(a)8ii and 7:15-6. Section 303(d) of the Federal Clean Water Act requires New Jersey to identify waters that are not attaining or not expected to attain water quality standards after the implementation of technology based effluent limits. New Jersey must prioritize these water quality limited waterbodies for TMDL analyses that are planned within the next two years.

New Jersey's 303(d) List divides water quality characteristics for waters in the State of New Jersey into two categories. Part 1 lists waters where impairments of water quality are known or where exceedances are based on conventional pollutants (except for ammonia) and fecal coliform, fish and shell fish consumption advisories, and other exceedances of numerical criteria compiled through monitoring subjected to QA/QC procedures developed after 1994. Part 2 represents waters with evidence of water quality concerns but without sufficient information to characterize the waterbody as a "known water quality limited segment." Such waters either lack extensive data or the existing data indicates that further analysis is warranted. Heavy metals and ammonia fall into this "suspected" category. All chemicals suspected of causing water quality impairment undergo supplemental monitoring to confirm impairment and to develop appropriate management responses.

Below is a summary of the 1998 Section 303(d) <u>Known</u> Water Quality Impairment listings for the Whippany River (Part 1).

Waterbody Name	Reach #/Location	Pollutant/Impact: Water Quality Violation
Whippany River	02030103-024-020 Morristown	fecal coliform total phosphorus
Whippany River	02030103-024-020 near Pine Brook	dissolved oxygen fecal coliform total phosphorus

Below is a summary of the 1998 Section 303(d) <u>Suspected</u> Water Quality Impairment listings in the Whippany River (Part 2).

Waterbody Name	Reach #/Location	Pollutant/Impact: Water Quality Violation
Whippany River	02030103-024-020 near Pine Brook	ammonia, arsenic[4], beryllium[2,4], cadmium[2,4], chromium[2], copper[4], lead[4], zinc[3,4]

[2] Metal was proposed for delisting with respect to human health criteria for total recoverable metals in the 1998 Impaired Waterbodies List. The delisting will be reflected in the 2000 Impaired Waterbodies List.

[3] Metal was proposed for delisting with respect to aquatic life criteria for dissolved metals in the 1998 Impaired Waterbodies List. The delisting will be reflected in the 2000 Impaired Waterbodies List.

Whippany River	02030103-024	arsenic, beryllium[2], cadmium[2], chromium[2,3], copper, lead, mercury, zinc[3]

[4] Metal was inadvertently omitted from listing tables, but is listed as discussed in text (pages 15-17 and 25), in 1998 Impaired Waterbodies List. The table above includes these corrections.

Response to the 1998 303(d) List for the Whippany River

Suspected Water Quality Impairments

Analysis of Ambient Data

The original basis for listing the Whippany River on the 303(d) List was water quality violations observed in data collected in the early to mid 1980's from the Morristown and Pine Brook monitoring sites which was reviewed in the late 1980's for the State's 304(l) list. Many historical discharges are now no longer present and many discharges, while remaining, have undergone significant upgrades to their treatment systems. In order for the Department to assess current conditions, several recent reviews were undertaken of in-stream data collected at the Morristown and Pine Brook sites. An initial review of historical data was performed in 1994 for the Whippany Pilot Project in order to delineate pollutants of concern for the Project. A subsequent review to satisfy requirements specifically under 303(d) followed in 1997. The adopted de-listings in the 1998 303(d) list for beryllium, zinc, cadmium (for human health) and chromium in the current 303(d) List were based upon this second 303(d)-specific review.

In 1995, stream monitoring was performed in selected locations of the Whippany River according to a sediment screening methodology developed in 1994 to target metals monitoring. Metals were analyzed using Clean Methods[5] for copper, lead and cadmium. Results of this monitoring showed that these metals were below levels formerly indicated by previous traditional sampling. It is expected that the continued 303(d) listing of lead, copper, and chromium for violations of acute aquatic life criteria and for human health (lead) will only be temporary, pending the additional sampling necessary to satisfy the new protocols for delisting, currently being developed between USEPA Region II and the Department.

Department Response

Below is a summary of the responses the Department discussed in the 303(d) List for those toxics remaining on the list.

Ammonia: Municipal discharge data indicate a declining input of ammonia statewide and in the Whippany River. The Department is pursuing delisting ammonia for the Year 2000 303(d) List.

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[5] Clean Methods refers to the newer metals sampling protocols that greatly reduce the contamination and consequent false positives associated with historical metals data.

Arsenic: The current level of detection is 1.0 µg/L and the surface water quality criterion is 0.017 µg/L for human health as total recoverable. Due to low human health criterion in relation to the current minimum detection limit, laboratory procedures employing lower detection limits must be employed to reassess this metal statewide.

Beryllium: The Department is proposing to delist beryllium statewide, since there are no applicable surface water quality criteria associated with these elements. Results will be incorporated into the Year 2000 303(d) List.

Cadmium: The calculated aquatic life criterion of 1.1 µg/L is similar in value to the level of detection for cadmium of 1.0 µg/L. Therefore, this element will continue to be listed until such time as alternative analyses using lower detection limits can be applied.

Chromium: Review of the record (1990-1997) shows no violations as total recoverable using the human health criterion of 160 µg/L at the Morristown and Pine Brook stations. Total recoverable serves as a screening surrogate for the dissolved form using the aquatic life chronic criterion. In assessing the aquatic life support, the criteria for the hexavalent form is the most restrictive; the criteria are 15 µg/L and 10 µg/L for acute and chronic exposure respectively. No values as total recoverable chromium (sum of all valence states) exceed 2.0 µg/L at Morristown; however, one sample was 14 µg/L during the period of review at the site near Pine Brook. Therefore, the Department will conduct further analysis of the hexavalent state near Pine Brook.

Copper: Preliminary sampling in the Whippany River using clean methods and analyzing filtered samples indicate that copper levels are elevated. Therefore, additional monitoring is warranted to confirm concentration level for this element.

Lead: Preliminary sampling in the Whippany River using clean methods and analyzing filtered samples indicate that lead levels are elevated. Therefore, additional monitoring is warranted to confirm concentration level for this element.

Mercury: The current level of detection is 0.1 µg/L and the surface water quality criterion is 0.012 µg/L for chronic aquatic life. Due to low criterion in relation to the current minimum detection limit, laboratory procedures employing lower detection limits must be employed to reassess this metal statewide.

Zinc: Review of the record (1990-1997) at both Morristown and Pine Brook show no violation of the calculated aquatic life criteria of 49 and 42 µg/L, respectively, using total recoverable as a screening surrogate for dissolved. Therefore, the Department is pursuing delisting zinc at both locations for the Year 2000 303(d) List.

Resampling of the Whippany River and other sites within WMAs 3, 4, and 6 for metals as indicated above remains a very high Departmental priority. Low flow conditions are required to conduct this monitoring, and these have not occurred since before Hurricane

Floyd in September 1999. Since metal monitoring results to date have not confirmed any water quality impairments, TMDLs for metals are not warranted at this time.

Known Water Quality Impairments

The Department is required to establish TMDLs for any parameters identified as causing a water quality impairment to the Whippany River, pursuant to the TMDL MOA and the 1998 Section 303(d) list. These parameters were identified in the 1998 303(d) List as: dissolved oxygen, fecal coliform and total phosphorus. The Department is proposing a targeted response to address each of these parameters that includes: de-listing for dissolved oxygen, demonstrating that the Whippany River is in compliance with the Surface Water Quality Standards with respect to total phosphorus, and a TMDL for fecal coliform.

Dissolved Oxygen

The *1996 Statewide Water Quality Inventory Report for New Jersey* (the 305(b) Report) states that the Whippany River did not exceed surface water quality criteria for dissolved oxygen at Morristown and Pine Brook. These stations are monitored 5 times per year and the 305(b) report analysis was based on data collected between 1990 and 1994. Data collected from 1995 through October 1997 at Morristown and Pine Brook also showed no exceedences of dissolved oxygen criterion. Improving trends in dissolved oxygen concentration from 1973 to 1995 supports these findings. The 1996 305(b) report states:

> Comparisons of dissolved oxygen (DO) levels between 1973 and 1995 indicate that DO increased significantly between 1973 and 1980, and then again from 1980 to 1995. These are believed to be the results of substantial upgrades to the wastewater treatment systems that have occurred within the watershed and the corresponding substantial reduction in the discharge of oxygen demanding materials. These reductions are reflected in reduction in in-stream biological oxygen demand (BOD) of some 80% in twenty years in the Whippany River.[6]

Dissolved oxygen data, including diurnal samples taken in 1994 and 1995 from the Whippany River Mainstem, indicate that dissolved oxygen remains above the 24-hour average standard of 5.0 mg/L. These data support delisting at these locations, which will be pursued during the development of the Impaired Waterbodies List for 2000.

[6] page 69 of the 305(b) report

Total Phosphorus

According to the Surface Water Quality Standards Nutrient Policy #2 (N.J.A.C. 7:9B-1.5(g) 2): "…except as due to natural conditions, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation, or otherwise render the waters unsuitable for the designated uses." Under N.J.A.C. 7:9B-1.14(c) 5, " … Total Phosphorus [in an FW2 stream] shall not exceed 0.10 mg/L unless it can be demonstrated that *phosphorus is not a limiting nutrient* and will not otherwise render the waters unsuitable for the designated uses." (emphasis added)

The 1998 303(d) List identifies the Whippany River as impaired for Total Phosphorus because in-stream concentrations in some locations exceed 0.1 mg/l. Since the Department has determined that phosphorus is neither limiting primary production nor causing impairment of designated uses in the Whippany River,[7] the numerical Total Phosphorus criterion does not apply in the Whippany River. In addition, since there is no evidence of objectionable algal densities or nuisance aquatic vegetation in the Whippany River, there is no violation of the Nutrient Policy. Therefore, a TMDL for Total Phosphorus is not required at this time because the Whippany River is in compliance with the Surface Water Quality Standards with respect to phosphorus.

Despite the fact that the numerical phosphorus criterion does not apply in the Whippany River and the Whippany River is in compliance with the Surface Water Quality Standards with respect to phosphorus, the Department is not pursuing the removal of Total Phosphorus from the 303(d) List for the following reason. The Whippany River is a tributary to the larger Passaic River Basin, wherein phosphorus is known to contribute to the impairment of designated uses as evidenced by documented excesses in algal growth. The TMDL for Total Phosphorus in the Passaic River is scheduled for completion by June 30, 2002.[8] It is expected that phosphorus controls may be required in the Whippany River and other tributaries to the Passaic River, as well as within the mainstem, as part of the TMDL for Total Phosphorus in the Passaic River in 2002. However, the extent and nature of those controls is not known at this time and can only be determined through the TMDL process. At this time, the Department is implementing interim phosphorus restrictions (described below) on municipal dischargers within the Whippany River Watershed, limiting their discharge to existing effluent quality. This restriction will serve to minimize further phosphorus discharges to the Passaic River while the TMDL is being developed. In addition, the implementation of the TMDL for fecal coliform in the Whippany River Watershed will provide a residual reduction in

[7] Appendix E. *Determination that phosphorus is neither limiting primary production nor causing impairment of uses in the Whippany River*

[8] Appendix C. Memorandum of Agreement between U.S. EPA Region II and NJDEP. *Schedule to Establish Total Maximum Daily Loads for all Waterbodies Listed 1 in the State of New Jersey's 1998 303(d) List*. Signed May 1999.

phosphorus contributions from nonpoint sources of bacterial pollution that also contribute phosphorus.

The Passaic River TMDL process will address pollutants of concern including, at a minimum, dissolved oxygen, nutrients and pollutant parameters contributing to eutrophication. Significant point and nonpoint sources of phosphorus in the Whippany River may be affected by the outcome of the Passaic River TMDL development process. The Passaic River TMDL will be developed in collaboration with watershed partners in Watershed Management Area (WMA) 3 (Pompton, Pequannock, Wanaque and Ramapo River Watersheds), WMA 4 (Lower Passaic and Saddle River Watersheds) and WMA 6 (Whippany, Rockaway, Upper and Mid-Passaic River Watersheds). A Public Advisory Committee and a Technical Advisory Committee for WMA 6 has already been formed and is currently working with the Department to develop a Watershed Characterization and Assessment Report. Stakeholders from WMAs 3 and 4 will also be included in the development of the Passaic River TMDL.

Interim Total Phosphorus Reduction Plan

While the Whippany River is in compliance with the Surface Water Quality Standards with respect to phosphorus and no impairment of the River's designated uses are caused by excessive primary production, there is no doubt that excessive phosphorus levels further downstream are causing adverse impacts to the Passaic River. It is not known how much, if any, total phosphorus from the Whippany River is contributing to downstream total phosphorus levels. However, there is agreement among the Whippany Watershed Partnership that existing effluent quality should be maintained and any feasible short-term reductions in phosphorus levels should be pursued prior to the development of a phosphorus TMDL for the Passaic River in order to reduce or prevent further increases in phosphorus concentrations. This Interim Total Phosphorus Reduction Plan, developed from the recommendations of the Whippany River Watershed Technical Advisory Committee, is being implemented as an interim response to phosphorus reduction before the Passaic River TMDL is developed.

This Interim Total Phosphorus Reduction Plan requires that between the adoption of this Plan and the adoption of the Passaic River TMDL, municipal point source dischargers within the Whippany River will investigate and implement appropriate low cost methods to reduce phosphorus effluent loading. The goal of these interim measures is to achieve a net reduction of phosphorus loading from the permittees before the Passaic River TMDL has been developed. Furthermore, the Department will revise NJPDES permits based on a calculation of existing effluent quality and applicable low-cost improvement measures.

The permittees shall explore the low cost phosphorus reduction methods attached as Appendix D and provide a report to the Department within 6 months of the adoption date of this Interim Total Phosphorus Reduction Plan addressing the applicability of each method to permittees' treatment facilities. Appendix D is not an exclusive list, and permittees are encouraged to identify additional low cost phosphorus reduction methods. For each identified applicable method, the permittee shall immediately commence implementation and provide an implementation schedule as part of the report. If a permittee has previously identified and implemented low cost phosphorus reduction methods, the report shall identify the method(s), the date(s) of implementation, and the effectiveness of the method in reducing phosphorus loading. The Department shall determine and notify the permittees within 45 days of receipt whether the reporting requirement has been satisfied. In the event the Department determines the report to be deficient, the notice shall specify any deficiencies which must be addressed.

Pursuant to N.J.A.C. 7:14A – 16 et seq., the Department shall issue draft major modifications or draft permit renewals to the affected municipal NJPDES dischargers in the Whippany River (Appendix A) as expeditiously as possible but not later than one year after adoption of this plan. Such modifications or renewals will include total phosphorus effluent limitations based on existing effluent quality calculated in accordance with N.J.A.C. 7:14A – 13.8 (Appendix B) as well as implementation of low cost phosphorus reduction methods. The effluent limit shall be for a concentration expressed as a monthly average on a seasonal basis. The winter season shall be deemed to be November through April, and the summer season shall be deemed to be May through October. The permit modification or permit renewal shall include a phosphorus influent-monitoring requirement based on the phosphorus effluent monitoring frequency. These permit modifications affect only municipal dischargers since they comprise the vast majority of phosphorus point source load to the Whippany River.

Permittees may petition the Department to modify the existing effluent quality phosphorus effluent limitation established by the above to reflect an increase of influent phosphorus due to phosphorus-based corrosion control measures by a supplier of water. The Petition shall address: the water suppliers dosing practices, variation of phosphorus concentrations within the water supply distribution system, relationship of the water supply within the permittees service area (by percentage of permittees total flow), changes in industrial contributions, status and effectiveness of implemented low cost phosphorus reduction methods, and a demonstration of relationship between influent phosphorus and effluent phosphorus monitoring data.

In the event that a permittee either physically expands its facilities prior to the adoption of TMDL-based Wasteload Allocations for the Passaic River to accommodate additional influent or incurs capital costs greater than 25% of the present value of the facility to upgrade or replace portions of the existing treatment facility, the NJPDES permit shall be modified to include a phosphorus effluent limitation of 1.0 mg/L as a monthly average. In the event a permittee requests a flow re-rating which does not require expansion or upgrades of any kind to the existing treatment facility, the permit modification, if granted, shall include a monthly average loading limit for phosphorus based on the flow value prior to the re-rated flow value and the concentration value established pursuant to the above. The interim phosphorus limit shall remain in effect until establishment of the Passaic River Basin TMDL, at which time the NJPDES permits shall be modified to incorporate effluent limitations based on adopted Wasteload Allocations and, if appropriate, provide a schedule of compliance.

Recently, eight municipal NJPDES dischargers in the Passaic River Basin signed a stipulation of settlement, which is similar in nature and content to this described interim total phosphorus reduction plan. The Hanover STP mentioned in this report is party to that settlement.

Most of the short-term measures designed to mitigate fecal nonpoint source loading (see below) will also achieve an accompanying reduction in phosphorus. The Whippany River Watershed Nonpoint Source Pollution Control Guidance Manual prepared by the Whippany NPS Workgroup will serve as a general guide to local officials in selecting appropriate BMPs that best address nonpoint source pollutants of concern in their municipality or subwatershed. The guide will help the user through selecting specific source control measures that are pollutant specific as well as site specific.

Fecal Coliform

As stated previously, the Surface Water Criteria for fecal coliform is at N.J.A.C. 7:9B-1.14(c)1.ii

For FW2 Classifications: levels shall not exceed a geometric average of 200 counts per 100 ml, nor should more than 10 percent of the total samples taken during any 30-day period exceed 400 counts per 100 ml.

Sources

Fecal coliform is a group of bacteria used as an indication of the potential presence of pathogens (diseased causing organisms) of fecal origin. The sources of fecal coliform contamination have been narrowed down from a myriad of potential fecal nonpoint source pollutant sources. Source identification was determined from:

Evaluation of water quality data from the nonpoint source monitoring conducted in the Whippany River Watershed in 1996 and 1997[9] indicates high levels of fecal coliform at specific locations in the Watershed. These locations are indicative of certain land uses.

[9] Killam Associates. August 1997. *Whippany River Watershed Project, Storm Event Water Quality and Streamflow Data.* Storm #1: November 8-9, 1996; Storm #2: April 12, 1997; Storm #2a: July 9, 1997.

Killam Associates. October 1998. *Whippany River Watershed Project, Storm Event Water Quality and Streamflow Data.* Storm #3: June 12, 1998.

For example, the table below is a summary of the fecal coliform monitoring from November 9, 1996:

Station ID	Land Use	Range fecal coliform
LS-1 (AA)	Forest Land Cover	55 – 2,800
LS-2 (BB)	Mixed Land Use	7,600-21,000
LS-3 (CC)	Industrial	11,000 – 61,000
LS-4 (DD)	Low Density Residential	5,000 – 92,000
LS-5 (EE)	Wetlands Runoff	210 – 390

In addition, prior studies of a bathing beach in Mendham Township by local health officials indicated that septic systems might be the contributing factor to fecal coliform impairment during a storm event. Canada geese and associated fecal matter was observed visually by health officials at the Mendham Township bathing beach as well as at a Lake Parsippany bathing beach. The Department in collaboration with the Whippany NPS Workgroup and the Technical Advisory Committee narrowed down the scope of the primary sources of fecal contamination to:

Human Sources of Fecal Coliform:
- Malfunctioning or older improperly sized septic systems in the upper portion of the Whippany River Watershed

Non-Human Sources of Fecal Coliform:
- Canada geese, waterfowl and other wildlife
- Pet waste
- Stormwater basins which can act as accumulation points of fecal matter (from pets, waterfowl and wildlife)

Loading Capacity

The Whippany River Watershed Model was developed by the Department in collaboration with the Technical Advisory Committee and the Modeling Subcommittee. Water quality scientists on the TAC provided peer review throughout the development of the model and acceptance of the final product. The model integrates a landside runoff model with a spatially explicit receiving water model into a novel code, the theory for which is presented in Appendix F. Intensive steady-state monitoring events[10] were performed on three different occasions in 17 locations throughout the watershed to provide data for calibration and verification of the receiving water model. In addition, wet weather data were collected during three different storm events in 5 sub-watersheds and two in-stream locations to provide data for calibration and verification of the landside model. The landside model was calibrated successfully in four sub-watersheds for fecal coliform.

Fecal coliform concentrations were estimated by applying model coefficients determined from calibration and verification of individual sub-watersheds[11] to the Whippany River Watershed Model. Figure 1 shows the current condition in terms of daily fecal coliform concentrations and 30-day geometric mean concentrations simulated over one year. The applicable 30-day geometric mean criterion of 200 counts/100ml is also shown for comparison. The dry weather base concentration is about 225 most probable number (MPN) MPN/100ml, but storm events throughout the year drive the 30-day geometric mean considerably higher. Figure 2 estimates the annual loading profile of point and nonpoint sources, with nonpoint sources being broken down by land use. Point sources contribute a negligible portion of the annual load and in fact provide dilution of fecal coliform.

[10] NJDEP. *Steady state high and low flow water quality data*. Oct. 4-6, 1994, April 26-28, 1995, and Sept. 5-7, 1995. Whippany River Watershed Project.

[11] Omni Environmental Corporation. July 1999. *Whippany River Watershed Project, Stormwater Model Calibration and Verification Report.*

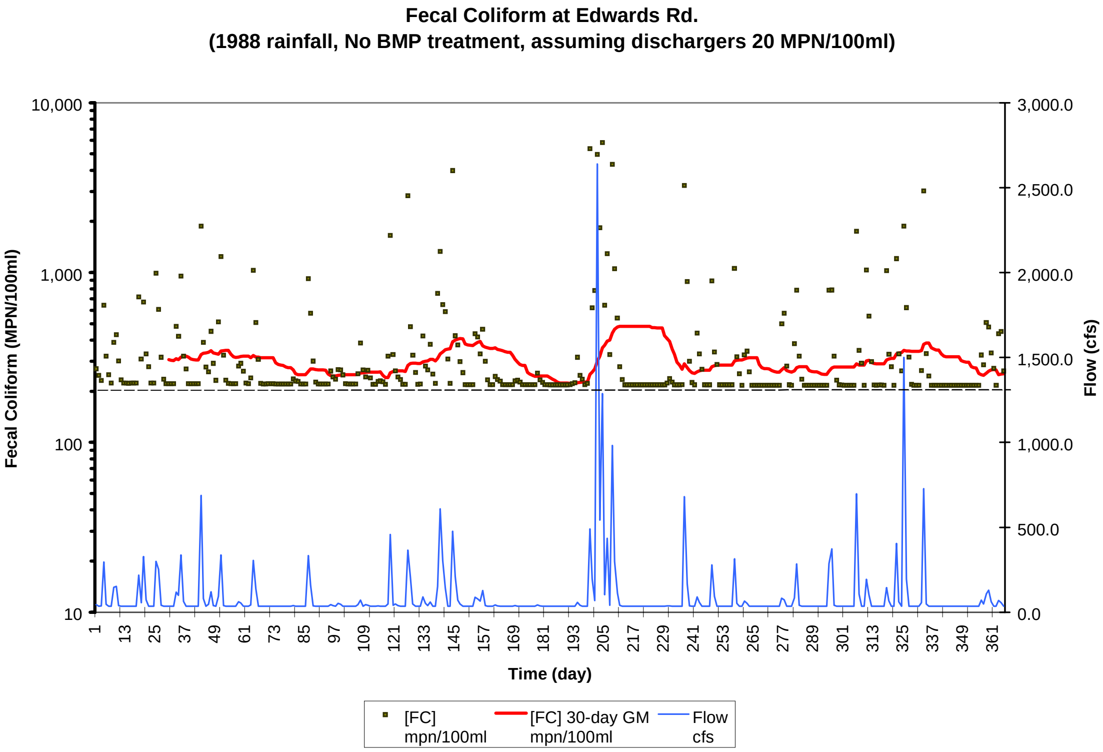

Figure 1 Model simulation of current condition

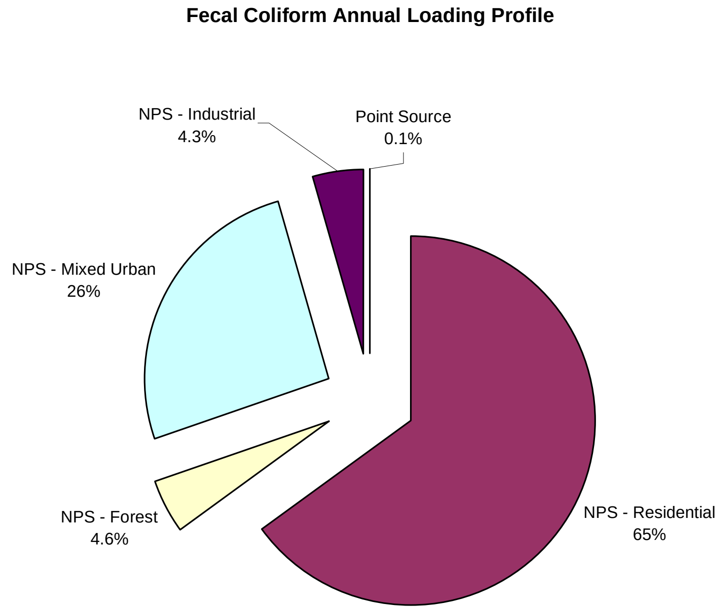

Figure 2 Model estimation of Point to Nonpoint Source Loading Profile

The target condition was determined by reducing nonpoint source loading rate such that the maximum 30-day geometric mean was set equal to the 200 MPN/100ml criterion (Figure 3). A 58.5% reduction on overall nonpoint source loads was necessary to achieve the simulated target condition. Notice that the base dry weather concentration in the target condition reduces to less than half the geometric mean criterion. Over the duration of the one-year simulation, only 6.3% of the daily concentrations were higher than 400 MPN/100ml.

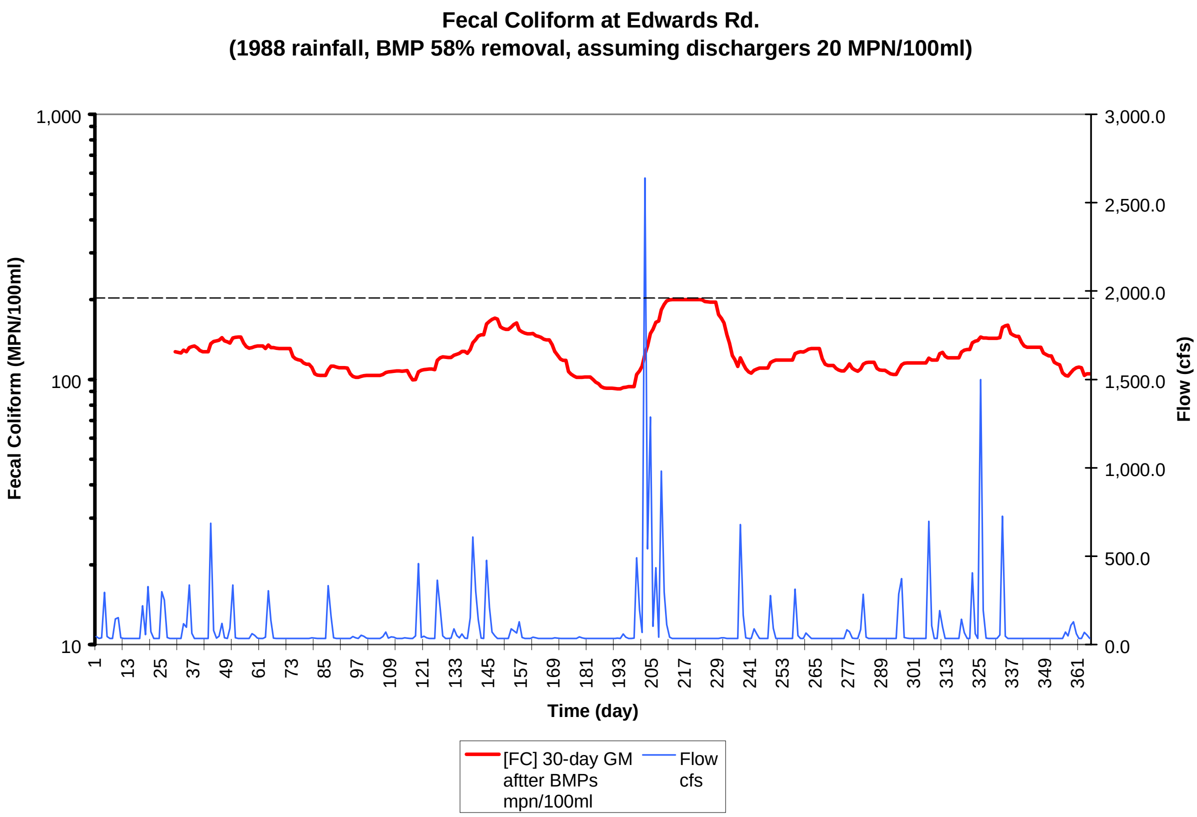

Figure 3 Model simulation of target condition

TMDL Calculation

Annual loads were estimated by summing up the daily loads over a one-year simulation. In order to comply with the 200 MPN/100ml 30-day geometric mean criterion for fecal coliform, the TMDL for the Whippany River Watershed is established as follows:

TMDL = 5.40e14 MPN/year
= 1.75e12 WLA + 5.38e14 LA

The TMDL is expressed as MPN/year because the loads are delivered in storm events and the criterion is expressed as a 30-day geometric mean. The federal TMDL regulations allow “appropriate measures” (40 CFR 130.2(I)) to be used to express TMDLs. MPN is the appropriate unit because it is the only unit of microbial indicators commonly measured. It is not possible to allocate storm-driven source loads using a daily time scale, since storm-driven nonpoint sources are episodic in nature.

Wasteload allocations for all point sources are combined into a single term based on current flows and concentrations (see Appendix A). Municipal dischargers are required to disinfect effluent prior to discharge and to meet surface water quality criterion for fecal coliform in their effluent. Since the dischargers routinely achieve essentially complete disinfection (less than 20 MPN/100ml), the requirement to disinfect is effectively more stringent than the fecal coliform effluent criterion. For the purposes of the TMDL calculation, municipal effluent was therefore assumed to contain 20 MPN/100ml. Current rather than permitted flows were used because the effluent acts to dilute the fecal coliform in the stream; permitted flows would result in a non-conservative calculation under current flows. The total point source contribution is a fraction of a percent of the total load, and in reality acts to improve the water quality with respect to fecal coliform. Consequently, this fecal coliform TMDL will not impose any change in current practice for point sources and will not result in changes to existing effluent limits.

Evaluating annual load using a dynamic model made it possible to calculate the impact of episodic loads on 30-day geometric mean (Figures 1 and 3). The critical condition occurs when the intense rainfall over about 10 days following a dry period drives the 30-day geometric mean to its highest point.

Seasonal Variations

Seasonal variations are accounted for by basing the TMDL on the highest 30-day geometric mean that occurs during the year. By reducing the nonpoint source load enough to make the highest 30-day geometric mean compliant with the fecal coliform criterion, the 30-day geometric means throughout the rest of the year will be proportionately less than the criterion.

Margin of Safety

A number of conservative assumptions implicit in the TMDL calculation provide the Margin of Safety necessary to account for "lack of knowledge concerning the relationship between effluent limitations and water quality." (40 CFR 130.7(c))

First, the choice of 1988 rainfall data provides a higher simulation of peak 30-day geometric mean compared to other rainfall years. 1988 total rainfall recurs every two years. Using drier rainfall years would reduce the fecal coliform, since it is rainfall that delivers virtually all the load. Using wetter rainfall years also reduces the simulated concentration of fecal coliform, since it is during the dry periods between storms that buildup occurs. Repeated rainfall events will provide dilution if there are not enough dry days for buildup to occur. 1988 rainfall included a very large 10 day storm event that was preceded by a long dry period. The subsequent peak 30-day mean drove the TMDL analysis and provided Margin of Safety.

Another conservative assumption was the use of current effluent flow from the municipal dischargers. Sewage treatment effluent is disinfected and contains extremely low bacterial counts. Permitted flows would provide more dilution and were not used to calculate the TMDL.

Finally, it is generally recognized that fecal contamination from stormwater poses much less risk of illness than fecal contamination from sewage or septic system effluent.[12] As Figure 2 shows, fecal coliform in the Whippany River is almost exclusively nonpoint source. Furthermore, most of the fecal coliform is flushed into the system during rainfall events and passes through the Whippany River in just a few hours. Bathing recreation is not a current use in the Whippany River, but bathing recreation in general occurs during dry periods.

Monitoring Plan

The Department will conduct follow-up monitoring through the Ambient Surface Water Monitoring Network program. In order to determine compliance with the pathogen indicator criteria, the Department samples each station in the network a minimum of 5 times in a 30-day period during the summer months of June to August. This sampling protocol is consistent with the Surface Water Quality Criteria for fecal coliform. At a minimum, the downstream station at Edward's Road that was used to calculate the fecal coliform TMDL will continue to be included in the Network and sampled annually accordingly. The Department fully expects that, after implementation of management measures to reduce nonpoint sources of fecal coliform, pathogen indicator levels will not exceed a geometric average of 200 MPN/100ml, nor will more than ten percent of the total samples taken during any 30-day period exceed 400 MPN/100ml.

Management Measures for Nonpoint Sources of Fecal Coliform

For each major nonpoint source category identified above, short-term management measures are identified below that will begin to reduce the source and/or the amount of fecal coliform discharged to the Whippany River. Unlike other pollutants that accumulate and persist in the environment after external sources have been removed, fecal coliform survives only a few days in the environment; therefore it is anticipated that the Whippany River will respond very quickly to reductions in fecal coliform sources. Additional measures will be required to verify and further reduce or eliminate each source of fecal coliform within the Whippany River Watershed in order to attain surface water quality standards.

Short-Term Management Measures

The following short-term measures either commenced in 1999 or will begin in early 2000 and will continue to be implemented throughout the next two years. These measures are aimed at reducing nonpoint source pollution in the Whippany River Watershed.

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[12] Cabelli, V. 1989. *Swimming-associated illness and recreational water quality criteria*. Wat. Sci. Tech. 21:17.

- Proposed inter-municipal agreement by the Whippany River Watershed Action Committee that calls for the 16 watershed municipalities to recommend specific actions and programs to preserve, protect and maintain the land and water resources of the Whippany River Watershed.

- In 1999, the Whippany River Watershed Action Committee was notified of a Section 319 (h) NPS pass through grant award in the amount of $17,5000 for restoration work in the watershed. Under this grant, the municipal Department of Public Works will implement BMPs for bacteria, phosphorus and sedimentation from nonpoint sources.

- In 1999, Hanover Township was notified of a Section 319 (h) NPS pass through grant award for $50,000 to work with the Whippany River Watershed Action Committee to develop model ordinances for the 16 watershed municipalities to adopt in order to reduce nonpoint source pollution from stormwater runoff.

- In 1999, Hanover Township was notified of a federal 604(b) pass through grant grant in the amount of $75,000 to conduct a diagnostic study of fecal impairment in the upper portions of the Whippany River Watershed.

- “A Cleaner Whippany River Watershed” nonpoint source pollution control guidance manual was accepted as a “living document” by the PAG at their December 7, 1999 meeting. It will be published in 2000 and formally presented at a workshop on May 11 and 12, 2000.

Whippany River Watershed Nonpoint Source Pollution Control Guidance Manual

Additional fecal coliform and phosphorus reductions will also be achieved through implementation of the Nonpoint Source Pollution Control Guidance Manual prepared by the Whippany NPS Workgroup entitled “A Cleaner Whippany River Watershed”. It was written to serve as a general guide to local officials in selecting appropriate BMPs that best address nonpoint source pollutants of concern in their municipality or subwatershed. The Guidance Manual will help the user through selecting specific source control measures that are pollutant specific as well as site specific. “A Cleaner Whippany River Watershed” is attached in Appendix G.

The Guidance Manual will be presented to local officials and township engineers in each of the 16 municipalities located within the Whippany River Watershed. The step-by-step approach promoted by the Guidance Manual, as well as the more common best management practices associated with land use, pre-development and/or redevelopment conditions throughout the watershed, will be presented in several workshops and field trips held throughout the 16 watershed municipalities. The Guidance Manual was distributed in January 2000 and subsequent workshops will be held in May 2000 to present the document to the public. The Urban Conservation Action Partnership, a public/private partnership for natural resources conservation, is the recipient of an FY 2000 Section 319 (h) pass through grant to promote the Guidance Manual in order to "increase environmental literacy of public officials and consulting engineers, heads of departments of public works, landscape architects and planners". The grant project includes an evaluation component which will ascertain whether BMPs were implemented with regularity after attending these workshops.

The Guidance Manual identifies thirteen stormwater source control measures and provides a methodology that will assist the user in choosing a suitable BMP(s). The user of the Guidance Manual will also be able to determine which nonpoint source pollutant is most suitably addressed by the BMP and what percentage pollution concentration reduction may be expected from implementing and maintaining the BMP. In many cases, a specific BMP may reduce several nonpoint source pollutants but, with different degrees of effectiveness. The Guidance Manual proposes seven decision-making tables that will be useful in the selection of an appropriate BMP:

Stormwater Treatment Suitability: Determine if the BMP meets both the hydrology storage and water quality treatment requirements.

Community and Environmental Factors: Targets the potential BMP to determine if it has any important community or environmental benefits or drawbacks that might influence the selection process.

Site Feasibility Factors: Determines if there site limitations such as soils, drainage area, slope, and geology that might hinder or assist the effectiveness of implementing the BMP.

Cost and Maintenance Factors: Identifies relative cost of Best management practices (high, medium or low) along with its maintenance factors.

Most Appropriate Land Uses for Best Management Practices: Identifies the appropriateness of the BMP based on the one of five development categories.

Estimated Pollutant Reduction Capability for Best Management Practices: Where information was available, table identifies pollutant concentration reduction percentages derived from research, modeling and best professional judgement.

Permitting Considerations: Provides local and permitting guidance based on site features such as wetlands.

The Whippany River Watershed NPS Workgroup has endorsed the short-term management measures, including the Guidance Manual, which will be implemented at the municipal level through a combination of municipal ordinances, local agreements, education and outreach, and pass through grants. These measures, once implemented, will begin to reduce fecal coliform levels within the Whippany River Watershed while longer term measures are being developed. The Whippany River Watershed Management Plan will also include these short-term measures and will promote these practices to ensure that they are implemented where practicable throughout the watershed.

Long-Term Management Strategies

While the short-term management measures will begin to reduce sources of fecal coliform in the Whippany River Watershed, additional measures will be needed to verify and further reduce or eliminate these sources. Some of these measures can be implemented now, where resources are available and sources have already been identified. Otherwise, specific watershed management strategies will be developed for each source identified below as part of the Watershed Management Area Plan for WMA 6. These strategies will be tailored to reduce each specific source's contribution of fecal coliform to the Whippany River Watershed. The strategies will all be designed to verify and assess these major source categories and to identify individual sources among them; develop specific measurable objectives; propose targeted management measures; identify measurable outcomes, deadlines, and responsible entities; and include monitoring and evaluation requirements to determine the success of the various management measures in achieving the strategies' objectives. These strategies will also address public involvement, operation and maintenance over time, and provide a cost-funding matrix.

The long-term management strategies will be developed collaboratively between the Department and the WMA 6 Public Advisory Committee, Technical Advisory Committee, Whippany Action Committee and Whippany Transition Team. The long-term strategies will be included in the WMA 6 Watershed Management Area Plan when it is developed.

<u>Source Categories for Long-Term Management Strategies</u>

Malfunctioning and Older Improperly Sized Septic Systems

Malfunctioning and older improperly designed septic systems contribute to fecal coliform loading in two ways: the system may fail hydraulically, where there is surface break out; or hydrogeologically, in which case the soils are inadequate to filter the pathogens. Specific management measures include:

- Conduct additional sanitary surveys and locate the systems using global positioning satellite system technology
- Implement results of the sanitary survey and diagnostic study resulting in a septic system management program

Canada Geese, Pest Waterfowl and other Wildlife

With the proliferation over the past 20 years of large corporate and recreational turf areas, the Canada goose resident population has exploded. Geese prefer to eat the low-fiber, high carbohydrate characteristics of mowed, fertilized turf. Consequently, parks, corporate lawns, and golf courses are subject to over browsing, shoreline erosion and excessive fecal matter near the water's edge. Specific management measures include:

- "No Feed Ordinances" for all waterfowl and wildlife
- Shoreline fencing and other barriers to eliminate access to grassed area along the waterways
- Habitat alteration; eliminate mowed turfgrass replace with buffer of tall grasses, shrubs and trees
- Overhead wire grids on ponds or lakes (outside of goose molting period) to restrict birds' access to the surface
- Hunting during established hunting seasons

Pet Waste

Pet waste contributes to fecal material and other nonpoint source pollutants such as nutrients. Bacterial levels in stormwater appear to be greater in residential areas than industrial or commercial zones. Thus the high concentration of pets associated with residential areas is a primary source of fecal contribution to stormwater. Specific management measures include:

- Adopt Pet Waste disposal ordinances for all 16 watershed municipalities
- Focus special attention to Patriot's Path along the Whippany River with signage and plastic bag dispensers
- Provide plastic bag dispensers in public recreation areas

Stormwater Basins

Stormwater detention/retention basins as well as wet storm ponds can act as accumulation points for fecal matter and other nonpoint source pollutants. A fast flush of runoff from a storm event detaches, mobilizes, and transports these substances directly to the nearest surface waters because of their design as flood control devices rather than as pollutant source control measures. Specific management measures include:

- Inventory stormwater basins and locate them using global positioning satellite system technology
- Conduct regularly scheduled stormwater basin cleanout programs
- Retrofit stormwater basins from flood control to nonpoint source control

Conclusion

With the implementation of short-term management strategies (to begin in 1999 and to be completed by 2002), long-term management strategies (to begin in 2004), and the Whippany River Watershed Nonpoint Source Pollution Control Guidance Manual, the Department has reasonable assurance that fecal coliform concentrations in the Whippany River will be brought into compliance with the Surface Water Quality Standards by 2005.

APPENDIX A

Whippany River Watershed[1] Municipal Dischargers

NJPDES #	FACILITY NAME	CURRENT FLOW MGD)	RECEIVING STREAM
NJ0024902	Hanover SA[2]	1.9	Whippany River
NJ0024911	Morris Twp – Butterworth	1.6	Whippany River
NJ0024970	Parsippany-Troy Hills SA[3]	12.3	Whippany River
NJ0025496	Morristown Town STP[4]	2.5	Whippany River
NJ0026689	NJDHS - Greystone Psych Hosp[5]	0.32	Whippany River
NJ0026751	Saint Mary's Abbey[6]	0.011	trib to Whippany River

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[1] List complied by the Department's Division of Water Quality in June 1999 and November 1999.

[2] Hanover S.A. is currently implementing the interim total phosphorus reduction plan via the January 20, 2000 Settlement Agreement with the Department.

[3] TMDL calculation did not include this facility because it discharges at the extreme downstream point in the watershed and was not included in the model domain.

[4] According to the Department's Division of Water Quality, Morristown, via a treatment plant upgrade, has brought their plant into compliance with their 1.0 mg/l phosphorus permitted effluent limitation and as such is not subject to any of the requirements of this plan.

[5] Greystone is scheduled to cease discharge; therefore an existing effluent equivalent calculation is not necessary for this sewage treatment plant.

[6] On December 31, 1994, an administrative consent order (ACO) was signed by the Department and by the owners/operators of the St. Mary's Abbey – Delbarton School Sewage Treatment Plant (STP). That ACO provides for either the construction of a sewer extension to convey all wastewater generated by the STP to the Township of Morris Butterworth STP or upgrade the existing STP to meet final effluent

limitation of the associated NJPDES Discharge Permit. The owners/operators of the STP have chosen to convey their wastewater to the Butterworth STP. The ACO includes an enforcement construction compliance schedule for construction of the conveyance system as well as a requirement by the owner/operator to evaluate and provide the Department with a written report summarizing the efforts taken to reduce the use of phosphate containing cleaning/washing materials within the Delbarton School.

APPENDIX B

Existing Effluent Quality Calculations

Existing NJPDES Regulations at NJAC 7:14A, Subchapter 13, describe how the Department will calculate seasonal effluent limitations for phosphorus in the Whippany River using existing effluent quality.

NJAC 7:14A-13.8 CALCULATION OF EFFLUENT LIMITATIONS USING EXISTING EFFLUENT QUALITY

(a) Effluent limitations based on existing effluent quality shall be calculated according to the following procedure:

1. The maximum projected effluent concentration shall be calculated in accordance with the statistical method contained in the USEPA TSD, as amended and or supplemented, unless the permittee demonstrates that the method in the TSD is not applicable and that an alternative statistical method more accurately estimates the maximum projected effluent concentration.

i. The following conditions apply:

(1) If at least 10 data points are available, a site-specific coefficient of variation shall be determined.

(2) If fewer than 10 data points are available the permit shall require monitoring and include a reopener clause to include existing effluent quality limitations based on 10 or more data points.

(3) The 95 percent confidence interval and the 95 percent probability basis shall be used.

ii. Effluent data generated during a documented facility upset, or other unusual event which has been identified and appropriately remedied by the permittee, may be eliminated when determining effluent limitations based on existing effluent quality;

2. The maximum daily limitation shall be set equal to the maximum projected effluent concentration; and

3. The average monthly limitation shall be calculated from the maximum daily limitation according to the procedure described in NJAC. 7:14A-13.6, using the sampling frequency required in the discharge permit. If the required sampling frequency is once per month or less, an average monthly limitation may be eliminated for that pollutant or pollutant parameter.

(b) Where an interim effluent limitation is required in accordance with NJAC. 7:14A-13.11 for the time period prior to the effective date of a final effluent limitation, limitations reflecting existing effluent quality shall be calculated in accordance with (a) above.

NJAC 7:14A-13.9 SEASONAL EFFLUENT LIMITATIONS

(a) Seasonal water quality based effluent limitations for continuous discharges may be developed in accordance with the following:

1. The permittee shall submit the necessary water quality studies that address any effects or potential effects on nutrient cycling and potential or actual adverse biological impacts in other waterbody segments related to nutrients.

2. The seasonal limitations shall be developed from a seasonal TMDL or a seasonal site-specific allocation for the specific pollutant(s) or pollutant parameter(s)

which addresses critical conditions applicable to each season for which an effluent limitation is requested.

3. Seasonal water quality based effluent limitations shall be developed only for the following parameters and groups of parameters and only insofar as the warm weather limitations cannot be achieved due to decreases in biological treatment efficiency during cold weather:

i. Parameters affecting dissolved oxygen dynamics in the receiving stream;

ii. Nutrients, including phosphorus and nitrogen; and

iii. Ammonia-N, to protect against toxic effects in the receiving water.

4. Except as specified at (a)5 below , seasonal water quality based effluent limitations shall be developed for two seasons in each year.

5. Seasonal WLAs or site specific allocations may be developed for shorter periods of time including more than two seasons, when the United States Geological Survey provides a reliable estimate of applicable stream design flows from a gauging station located in the vicinity of the discharge location.

APPENDIX C

Memorandum of Agreement between NJDEP and USEPA Region 2 to develop TMDLs

<u>Memorandum of Agreement</u>

<u>between</u>

<u>U.S. Environmental Protection Agency Region II</u>

<u>and</u>

<u>New Jersey Department of Environmental Protection</u>

<u>Schedule to Establish Total Maximum Daily Loads</u>

<u>for all Waterbodies Listed on the State of New Jersey's 1998 303(d) List</u>

I. <u>Background</u>:

1. The total maximum daily load (TMDL) program is statutorily authorized by Section 303(d) of the Clean Water Act, 33 U.S.C. § 1313 (d). CWA § 303(d) and its implementing regulations found at 40 C.F.R. § 130.7, provide for:

   A. Identification of waters for which applicable technology-based effluent limitations and other controls are not stringent enough to implement water quality standards;

   B. Establishment of a priority ranking for water quality-limited segments (WQLSs) still requiring TMDLs; and,

   C. Establishment of TMDLs, as necessary, for pollutants responsible for non-attainment of water quality standards in WQLSs.

2. This Memorandum of Agreement (MOA) includes a schedule to establish TMDLs for all WQLSs still requiring TMDLs, as identified in the NJDEP 1998 § 303 (d) list; and procedures by which TMDLs will be established, as necessary, for WQLSs identified on subsequent § 303 (d) lists.

II. Purpose:

3. The purpose of this MOA is to set forth the basic covenants and commitments between EPA Region II and the NJDEP, with respect to the development of a schedule to establish TMDLs for all WQLSs included on the New Jersey 1998 § 303(d) list, and procedures by which TMDLs will be established, as necessary, for WQLSs identified on subsequent § 303 (d) lists.

4. EPA Region II and the NJDEP hereby agree to maintain the high level of cooperation, coordination, and technical support necessary to assure the successful and effective establishment of TMDLs in accordance with the schedule below.

NJDEP and EPA Responsibilities:

5. Under this MOA, NJDEP agrees to establish TMDLs for all waterbodies included on the New Jersey 1998 § 303(d) list, or provide the information necessary to remove waterbodies from the list, as described in the schedule below. TMDLs established by NJDEP shall, at a minimum, include: an explanation of the procedures and assumptions used to develop the TMDL; the TMDL calculation; aggregate and individual waste load allocation (WLA); an aggregate load allocation (LA) or percent load reduction; and, a margin of safety (MOS).

6. The NJDEP shall provide a public comment period and respond to all comments received during the public comment period before submitting State established TMDLs to EPA for its review and decision. NJDEP and EPA shall work together to assure the TMDLs are consistent with federal and State requirements prior to being public noticed and prior to being issued as final TMDLs.

7. In fulfillment of New Jersey's responsibilities under its Continuing Planning Process, the NJDEP shall incorporate the final EPA approved/established TMDL/WLA/LA into its current Areawide

Water Quality Management Plan(s). The final EPA approved/ established TMDL shall be the governing TMDL, and as such shall be included in NJDEP's current Areawide Water Quality Management Plan(s), regardless of any TMDL previously incorporated by NJDEP into its current Areawide Water Quality Management Plan(s).

8. NJDEP shall, in accordance with the following schedule, establish TMDLs for all WQLSs listed on its 1998 § 303(d) list, or propose de-listing of specific WQLSs, in accordance with the applicable provisions of § 303(d) of the Clean Water Act, and its implementing regulations found at 40 C.F.R. § 130.7 and N.J.A.C. 7:15-5 and 6. NJDEP shall develop a proposed de-listing process for New Jersey and submit it to EPA for approval. EPA and NJDEP shall work together to develop mutually acceptable de-listing procedures which meet both federal and State requirements.

All future §303(d) lists shall include a proposed schedule for TMDLs for all WQLSs contained on those lists and shall also include any changes or updates to the schedule for TMDLs contained in this MOA. These lists will identify any "fast-track" TMDLs. ("Fast-track TMDLs" are any individual TMDLs that can be completed sooner than other TMDLs in a given watershed.) Once EPA has approved the subsequent §303(d) list and has determined that the updated TMDL schedule submitted with the list is consistent with the expectations of national guidance, the schedule contained in this MOA shall be considered modified. The schedule contained in this MOA or as modified by a subsequent §303(d) lists shall be incorporated into the appropriate Performance Partnership Agreement between NJDEP and USEPA Region II.

10. EPA shall, as necessary, provide program and legal guidance and technical support necessary to assist NJDEP in meeting the following schedule for the establishment of TMDLs for all WQLSs included on the New Jersey 1998 § 303(d) list.

11. EPA shall review and issue its decision on all final TMDLs submitted by the State within thirty (30) days of submittal.

IV. <u>Schedule for Establishment of TMDLs</u>:

12. As specified below, NJDEP agrees to: public notice; respond to comments received during the public comment period; establish; and submit to EPA, TMDLs for all WQLSs included on the New Jersey 1998 § 303(d) list no later than the dates listed below:

A.1. By June 30, 1999:

○ **New York/New Jersey Harbor Metals (Cu, Ni, & Pb) TMDLs**:

EPA shall, in cooperation with NJDEP, public notice, respond to comments received during the public comment period and establish Phase II Metal (Cu, Ni, & Pb) TMDLs, as necessary, for the New York/New Jersey Harbor.

A.2. By September 30, 1999:

○ **Delaware Estuary Volatile Organics TMDLs**:

NJDEP shall in cooperation with the Delaware River Basin Commission (DRBC), public notice; respond to comments received during the public comment period; establish; and submit to EPA, TMDLs, as necessary, for Volatile Organics in the Delaware Estuary.

A.3. By December 31, 1999:

NJDEP shall: public notice; respond to comments received during the public comment period; establish; and submit to EPA, TMDLs, as necessary, for the following watershed by December 31, 1999:

○**Whippany River Watershed**

B. By December 31, 2000:

NJDEP shall: public notice; respond to comments received during the public comment period; establish; and submit to EPA, Basic TMDLs*, as necessary, for the following two

(2) waterbodies identified as requiring Basic TMDLs in its 1998 § 303(d) list, by December 31, 2000:

○ **Strawbridge Lake (Burlington County)**

○ **Sylvan Lake (Burlington Township, Burlington County)**

* Basic TMDLs are TMDLs for water quality-limited segments for which basic TMDLs are appropriate (see NJAC 7:15-7). The term Basic TMDLs only applies to the above two waters listed on the NJDEP 1998 § 303(d) list.

C.1. By June 30, 2002:

NJDEP shall: public notice; respond to comments received during the public comment period; establish; and submit to EPA; TMDLs, as necessary, for the following watersheds by June 30, 2002:

○ **Rancocas, Cooper Rivers & Pennsauken Creek**

○ **Manasquan River**

○ **Pompton, Ramapo, Pequannock, & Wanaque Rivers**

○ **Lower Passaic River (non-tidal)**

○ **Upper Passaic & Rockaway Rivers**

C.2. By September 30, 2002:

○ **Delaware Estuary Dissolved Oxygen TMDLs:**

NJDEP shall, in cooperation with the DRBC, public notice; respond to comments received during the public comment period; establish; and submit to EPA, TMDLs for Dissolved Oxygen in the Delaware Estuary by September 30, 2002.

D.1. By June 30, 2003:

NJDEP shall: public notice; respond to comments received during the public comment period; establish, and submit to EPA, TMDLs, as necessary, for the following watersheds by June 30, 2003:

○ **Millstone River**

○ **North & South Branch of the Raritan River**

○ **Saddle River**

○ **Hackensack River & Pascack Creek**

○ **Raritan and South Rivers & Lawrence Brook**

○ **Walkill, Pochuck, and Papakating Creeks**

○ **Lower Delaware Tributaries**

D.2. By September 30, 2003:

○ **Delaware River/Estuary Metals, PCBs DDT & Derivatives TMDLs:**

NJDEP shall, in cooperation with DRBC, public notice; respond to comments received during the public comment period; establish; and submit to EPA, TMDLs for Metals, PCBs, DDT & Derivatives in the Delaware Estuary by September 30, 2003.

E. By June 30, 2004:

NJDEP shall: public notice; respond to comments received during the public comment period; establish; and submit to EPA, TMDLs, as necessary, for the following watersheds by June 30, 2004:

○ **Upper Delaware River Tributaries**

○ **Cohansey River**

○ **Monmouth Watershed**

○ **Maurice River***

* EPA and NJDEP are exploring the opportunity to complete the Maurice River TMDLs for pathogens and phosphorus sooner under EPA contract.

F.1. By June 30, 2005:

NJDEP shall: public notice; respond to comments received during the public comment period; period; establish; and submit to EPA, TMDLs, as necessary, for the following watersheds by June 30, 2005:

○ Elizabeth, Rahway & Woodbridge Rivers

○ **Crosswicks Creek**

F.2. By September 30, 2005:

○ **Delaware River/Estuary Fecal Coliform TMDLs:**

NJDEP shall, in cooperation with DRBC, public notice; respond to comments received during the public comment period; establish; and submit to EPA, TMDLs for Fecal Coliform in the Delaware Estuary by September 30, 2005.

G. 1. By June 30, 2006:

NJDEP shall: public notice; respond to comments received during the public comment period; establish; and submit to EPA, TMDLs, as necessary, for the following watersheds by June 30, 2006:

○ **Mullica & Wading Rivers**

○ **Great Egg Harbor, Tuckahoe River**

G.2. By June 30, 2006:

○ **Barnegat Bay Watershed TMDLs:**

NJDEP shall, in cooperation with the Barnegat Bay National Estuary Program, public notice; respond to comments received during the public comment period; establish; and submit to EPA, TMDLs for the Barnegat Bay Watershed, by June 30, 2006.

H.1. By June 30, 2007:

NJDEP shall: public notice; respond to comments received during the public comment period; establish; and submit to EPA, TMDLs, as necessary, for the following watersheds by June 30, 2007:

○ **Central Delaware Tributaries**

○ **Cape May Watersheds**

H.2. By June 30, 2007:

○ **NY/NJ Harbor PCBs; Dioxins; PAHs; Pesticides; Mercury; Dissolved Oxygen; and Fecal Coliform TMDLs:**

- NJDEP shall, in cooperation with the New York/New Jersey Harbor National Estuary Program, public notice; respond to comments received during the public comment period; establish; and submit to EPA, TMDLs for PCBs; Dioxins; PAHs; Pesticides; Mercury; Dissolved Oxygen; and Fecal Coliform in the NY/NJ Harbor by June 30, 2007.

- Within 9 months of the date that this MOA is signed by both parties, NJDEP with assistance from EPA, and the Harbor Estuary Program shall develop a schedule, including milestones, for the establishment of the above TMDLs. This schedule may shorten but will not extend the time frame for TMDL development in NY/NJ Harbor. Once agreed upon by both NJDEP and EPA, any accelerated schedule for establishment of TMDLs in NY/NJ Harbor will be incorporated into this MOA.

V. Legal Effect:

13. This MOA creates no cause of action against EPA or NJDEP. In addition, the execution and implementation of this MOA does not constitute an explicit or implicit agreement by either EPA or NJDEP to subject itself to the jurisdiction of any federal or state court. Nor shall this MOA be construed as an admission by EPA or NJDEP that either failed to implement the provisions of CWA section 303(d). Nor shall this MOA be construed as creating any right or benefit, substantive or procedural, enforceable in law or in equity, by any person or entity against EPA or NJDEP. This MOA shall not create any right to judicial review involving the compliance or noncompliance with this MOA.

14. Nothing in this MOA shall be construed to require actions by EPA or NJDEP that are inconsistent with State, or federal laws or regulations or any court order.

VI. Modification

15. EPA Region II and NJDEP understand that the covenants and commitments made pursuant to this MOA are based upon statutes and regulations currently in effect. Changes to such laws and/or regulations may require modification to this MOA. EPA and NJDEP also understand that this MOA may be modified in accordance with actions taken by courts of law. Finally, EPA and NJDEP may jointly modify this agreement to reschedule TMDL development to the extent that the overall schedule does not increase and that the delay of any one TMDL project is balanced by the advancement of another TMDL project. No modification to this schedule shall be necessary for completion of TMDLs in advance of this schedule.

VII. Termination

16. This MOA, and all responsibilities and obligations arising herein shall remain in effect until the parties have carried out such obligations and responsibilities. However, a change in the law or issuance of a court order may also give rise to termination of this MOA. Thus, either party may submit a written notice of termination to the other party within 30 days of any court order or change in the law requiring termination of this MOA. In addition, either party may submit a written

notice of termination when all responsibilities and obligations required by this MOA and the schedule herein, have been completed by both parties.

VIII. <u>Effective Date</u>

17. This MOA shall become effective on the date it is last signed by the parties below.*

For the New Jersey Department of Environmental Protection:

By: Robert C. Shinn, Jr., Commissioner
New Jersey Department of Environmental Protection
signed April 17, 1999*

For the U.S. Environmental Protection Agency, Region II:

By: Jeanne M. Fox, Regional Administrator
U.S. Environmental Protection Agency, Region II
signed May 10, 1999*

* signatures are shown on the original executed document

APPENDIX D

Potential Low Cost Phosphorus Control Alternatives

1. Reduction of MLSS (lowering of sludge age) in activated sludge system by increased sludge wasting.

2. Evaluation of recycle streams for minimization of phosphorus load. Streams to be evaluated:

a. Anaerobic digester supernatant

b. Sludge thickening overflow and/or filtrate

c. Sludge storage (aerobic digester) supernatant/decant liquor

d. Filter backwash

e. Ash pond supernatant for incineration facilities

Evaluation items:

f. Determination of concentration, load and composition(soluble versus particulate P)

g. Evaluation of relative importance of the recycle steam in the phosphorus mass balance

h. Means for reducing phosphorus release/recycle in the side streams by:

(1) Chemical addition (Pho-strip type process)

(2) aeration of sludge

(3) reduction of storage time

(4) other modifications in operation of sludge processing train

3. Evaluation of Passaic Basin contract facilities sludge processing and disposal locations to protect upstream reaches of the watershed from receiving phosphorus loads from downstream facilities through sludge disposal at upstream facilities.

a. Evaluate importance and impact of side streams from sludge processing

b. Evaluate impact of septage acceptance

c. Evaluate processing and disposal sites location potential impact on water quality

d. Evaluate significance of sludge, septage and liquid waste imported to the Passaic Basin

e. Evaluate handling of transported sludge

4. Reduction of particulate phosphorus discharged in effluent by increasing efficiency of capture of P-bearing solids by:

   a. Evaluate sludge blanket depth impact on effluent solids

   b. Improved performance of final clarifiers by addition of polymer or coagulant

   c. Attention to sludge bulking/foaming problems and associated losses of solids in final clarifier effluent

   d. Addition of small amounts of polymer or coagulant to tertiary filters

   Evaluate potential for improved clarifier performance by installation of:

   e. density current baffle

   f. flocculating center well

   g. spiral rakes

5. Evaluate potential for achieving enhanced biological phosphorus removal through low costs means such as conversion of existing tankage to create anaerobic/aerobic zones within the treatment train.

6. Evaluation of sources of phosphorus in wastewater.

   a. Verify if influent concentration indicates presence of phosphorus sources other than human wastes

   b. Perform evaluation of potential phosphorus contributors such as: major industries, commercial laundries, and facilities with large laundries such as hospital, schools and other institutions

   c. Use of phosphates by water supply company for corrosion control

d. Other potential sources

7. Nonpoint source control through cooperative efforts with county and municipalities.

8. Evaluate control of inflow/rainfall induced infiltration in the areas with potential high phosphorus concentration (farms, animal feedlots, stables, intensively fertilized agricultural and landscaped areas).

APPENDIX E

Determination that phosphorus is neither limiting primary production nor causing impairment of uses in the Whippany River

New Jersey Department of Environmental Protection

The current Surface Water Quality Standards (N.J.A.C. 7:9B-1.14(c)) state that "phosphorus as total P shall not exceed 0.1 [mg/l] in any stream, *unless it can be demonstrated that total P is not a limiting nutrient and will not otherwise render the waters unsuitable for the designated uses."* The SWQS further state as a nutrient policy (N.J.A.C. 7:9B-1.5(g)2): "Except as due to natural conditions, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation, or otherwise render the waters unsuitable for the designated uses." The following lines of evidence, taken together, sufficiently demonstrate to the Department that phosphorus in the Whippany River is not a limiting nutrient. Furthermore, since phosphorus is not otherwise rendering the Whippany River unsuitable and the Nutrient Policy is supported in the Whippany River, the numerical Total Phosphorus Criterion of 0.1 mg/l is not applicable in the Whippany River.

The net growth rate of phytoplankton populations is determined by their gross growth rate minus the rates of various losses, including dilution, sedimentation, physiological death, and grazing. Populations can be limited by their growth rates, one or more of their loss terms, or both; therefore, population increases can occur at both low and high growth rates. Low phytoplankton abundance does not necessarily mean that the growth rate is limited in any way. Phytoplankton growth rate is a function of light, temperature, and nutrient supply, and is often expressed as:

$$Growth = Growth_{\max} \times f(Light) \times f(Nutrients) \times f(Temp) \times [Phyto]$$

where: *Growth* = phytoplankton production rate (mg/l/day);

$Growth_{max}$ = maximum relative growth rate (per day)

f(Light) = limitation due to light intensity (dimensionless)

f(Nutrients) = limitation due to nutrients (dimensionless)

f(Temp) = limitation due to temperature (dimensionless)

[Phyto] = phytoplankton biomass concentration (mg/l)

The light, nutrient, and temperature limitation factors are dimensionless numbers from 0 to 1. The nutrient limitation factor is determined by the nutrient that is least available relative to the requirements of a particular phytoplankton population.

Algal cells require many elements in relatively fixed proportions in order to reproduce. While several "micronutrients," especially iron and cobalt,[7] may indeed be limiting primary production in some systems, discussions of nutrient limitation usually focus on the "macronutrients," namely nitrogen, phosphorus, and silica (for diatoms). Often the ratio between the available forms of nitrogen to phosphorus in the water column is used to help determine which nutrient might be limiting. If the ratio is higher than the

[7] Hecky, R.E. and P. Kilham. 1988. *Nutrient limitation of phytoplankton in freshwater and marine environments: A review of recent evidence on the effects of enrichment*. Limnol. Oceanogr. 33(4, part 2):796-822. Table 2.

optimum, one can conclude that nitrogen is not limiting; if the ratio is lower than optimum, one can conclude that phosphorus is not limiting.[8] However, phytoplankton communities may consist of several populations each with different optimal N:P ratios, which can range among phytoplankton species from 3 to 40 on a concentration basis.[9] Figure 1 shows the ratios of available forms of nitrogen to phosphorus (TIN/TOP[10]) at stations in the Whippany River along with total phosphorus concentrations at the same stations.

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[8] Rhee, G-Yull. 1978. *Effects of N:P atomic ratios and nitrate limitation on algal growth, cell composition, and nitrate uptake*. Limnol. Oceanogr. 23(1):10-25.

[9] Hecky, R.E. and P. Kilham. 1988. *Nutrient limitation of phytoplankton in freshwater and marine environments: A review of recent evidence on the effects of enrichment*. Limnol. Oceanogr. 33(4, part 2):796-822. Table 4.

[10] TIN = Total Inorganic Nitrogen, including nitrite-nitrate and ammonia
TOP = Total Ortho Phosphorus

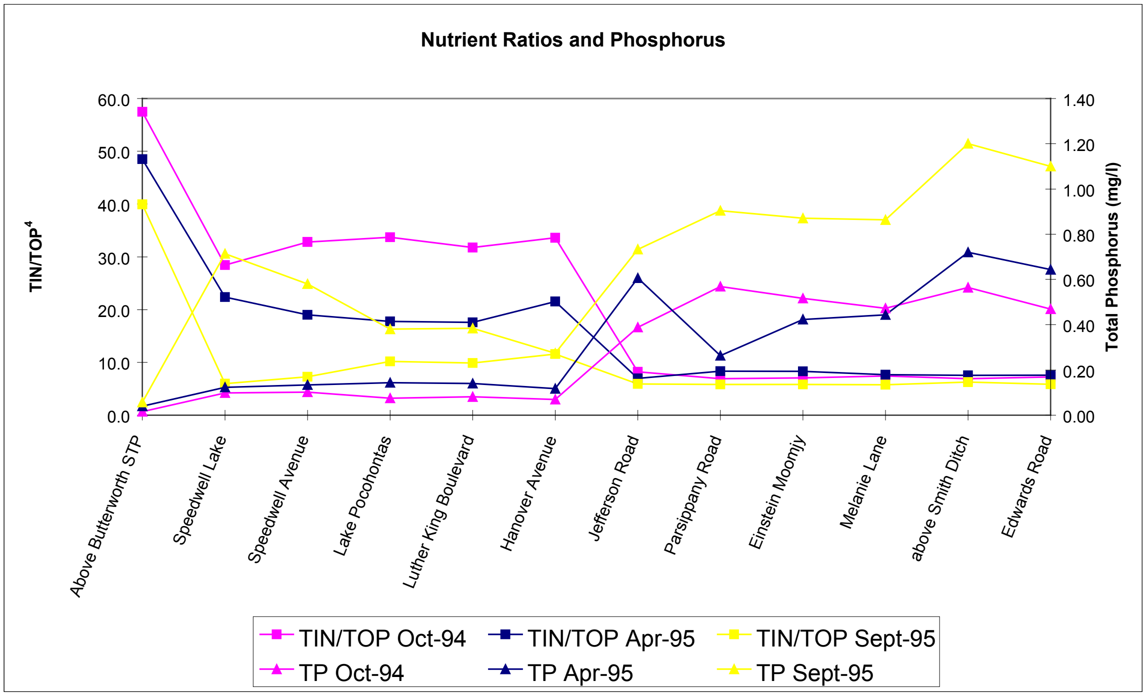

Figure 1 Data represent average of 3-day dry weather sampling events in each month

Upstream of the Butterworth municipal discharge, the data clearly demonstrate that nitrogen is not limiting. From Jefferson Road downstream it appears unlikely that phosphorus is limiting. Generally, stations with phosphorus concentrations near the Surface Water Quality Criterion of 0.1 mg/l have nutrient concentration ratios indicating that neither nitrogen nor phosphorus limitation is unlikely; stations with phosphorus concentrations well above the Surface Water Quality Criterion have nutrient concentration ratios that indicate phosphorus limitation is unlikely.

While TIN/TOP ratios can yield valuable insight, especially by demonstrating if a nutrient is clearly not limiting, they can never demonstrate that a nutrient is limiting. The concentration of the available nutrient must also be low enough to limit growth rate. For instance, a high TIN/TOP ratio could be used to rule out nitrogen limitation, since available phosphorus would be lower relative to phytoplankton requirements than available nitrogen. However, if the phosphorus is present in excess concentrations relative to the amount needed for growth, it is still not limiting growth; in other words, the concentration of available nutrients is sufficient to allow the phytoplankton to grow at a rate independent of the nutrient concentration. Such is the case in the Whippany River. While many phytoplankton communities and species have such high affinities for N and P that nutrient limitation does not occur at current analytically detectable levels[11], a general rule of thumb is that available nitrogen and phosphorus concentrations less than 0.015 mg/l and 0.002 mg/l, respectively, would be considered limiting[12]. Concentrations measured in the Whippany River have not come within an order of magnitude of what is typically considered limiting levels. Figure 2 shows TIN and TOP levels in the Whippany plotted against one another. Not only are the high levels of available nutrients clearly shown, but also the consistent and tight correlation between TIN and TOP demonstrates that one nutrient is not being disproportionately affected by biological processes. If one of the nutrients were limiting algal growth, one would expect it to be drawn down in concentration relative to the other during periods of heavy growth. Such is clearly not the case.

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[11] Hecky, R.E. and P. Kilham. 1988. *Nutrient limitation of phytoplankton in freshwater and marine environments: A review of recent evidence on the effects of enrichment*. Limnol. Oceanogr. 33(4, part 2):796-822. pp. 801-802.

[12] Lee, G.F. and A. Jones-Lee. 1998. *Determination of Nutrient Limiting Maximum Algal Biomass in Waterbodies.* Report G. Fred Lee & Associates, El Macero, CA. 8pp.

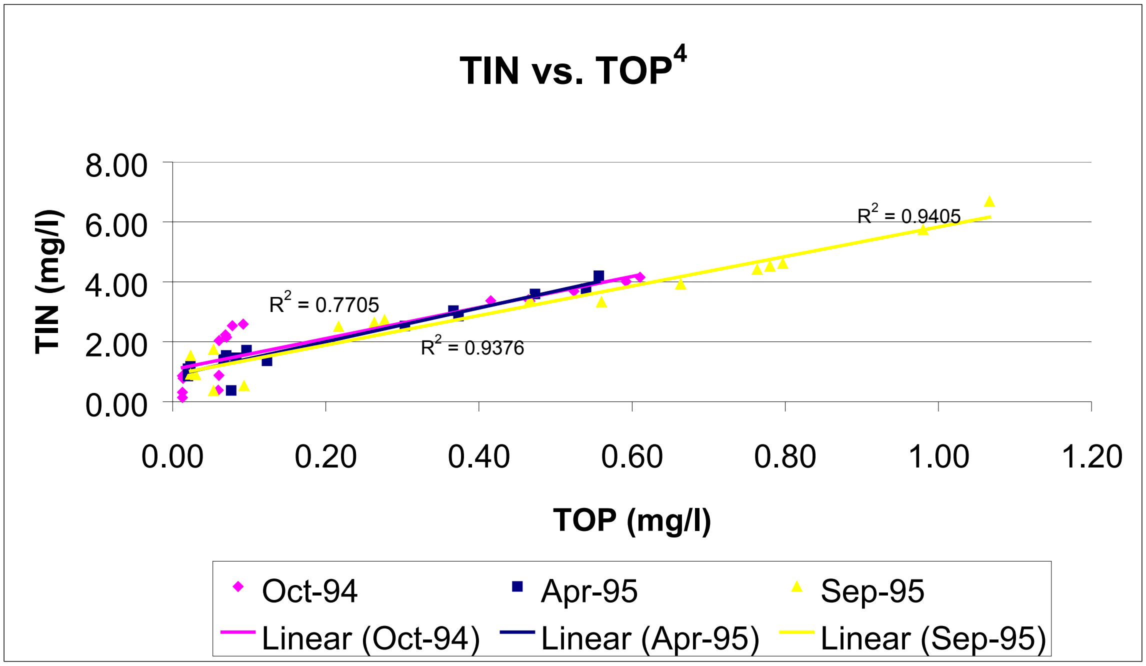

Figure 2 Data represent average of 3-day dry weather sampling events in each month

Further insight can be obtained by examining the water quality model of the Whippany River developed by the Department in conjunction with the Whippany River Watershed Technical Advisory Committee (TAC). As mentioned previously, the nutrient limitation terms, calculated each time step, are dimensionless numbers ranging from zero to one. They are a function of available nutrient concentrations[13] and a phytoplankton coefficient called the half-saturation constant, defined as the nutrient concentration required to achieve half of the maximum growth rate under certain conditions. The generalized Monod relationship is shown in Figure 3. The calibrated and verified

Whippany River Watershed model has been peer reviewed and approved by the TAC. Available nitrogen and phosphorus half-saturation values at various locations in the river were determined by calibration to vary from 0.01 to 0.025 mg/l and 0.001 to 0.005 mg/l, respectively, solidly within the range found in literature. Nutrient limitation factors near 1.0 indicate that phytoplankton growth rate is not being reduced due to limited nutrient supply; in other words, nutrient limitation is not occurring. Figure 3 shows the nutrient limitation factors calculated by the model at each sampling station during the three sampling events. According to the model, nutrient limitation is not important anywhere, and is nonexistent at locations where phosphorus is elevated in concentration.

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[13] While more sophisticated models use internal nutrient concentrations, they require an extensive amount of data. Like most water quality models that calculate algal growth, the Whippany River Watershed Model uses external (ambient) nutrient concentrations.

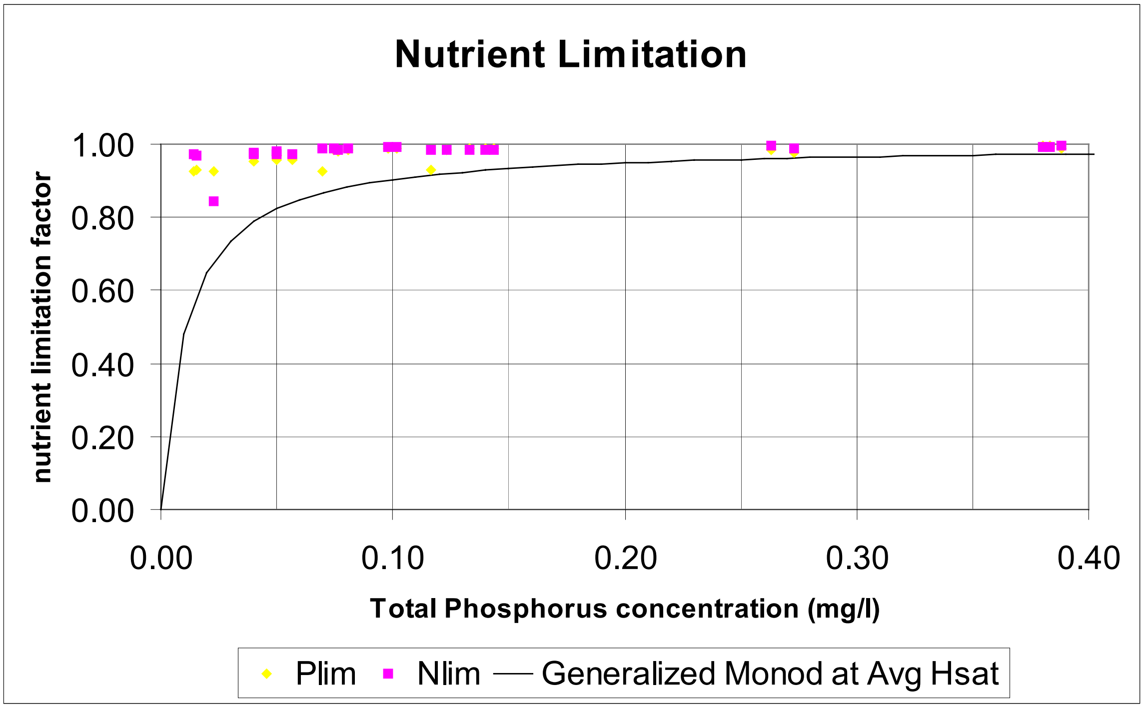

Figure 3 Data represent average of 3-day dry weather sampling events in each month

Taken together, these lines of evidence are more than sufficient to demonstrate that the Whippany River is not currently phosphorus limited.

It is important to recognize that just because phosphorus is not currently limiting does not automatically mean the numerical phosphorus criteria do not apply. If a waterbody is impaired due to excessive primary production, reducing phosphorus so that it becomes limiting is often the best strategy even when phosphorus is in excess[14]. The numerical phosphorus criteria apply unless it can be demonstrated that total P is not a

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[14] Lee, G.F. and R.A. Jones. 1988. *The North American Experience in Eutrophication Control through Phosphorus Management,* In: Proc. Int. Conf. Phosphate, Water and Quality of Life. Paris, France.

limiting nutrient **and** will not otherwise render the waters unsuitable for the designated uses. Furthermore, Nutrient Policy #2 must be satisfied.

Nutrient Policy #2 states: "Except as due to natural conditions, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation, or otherwise render the waters unsuitable for the designated uses." The Whippany River has been studied extensively and does not suffer from objectionable algal densities or nuisance aquatic vegetation[15]. Furthermore, oxygen levels are not depressed below the Surface Water Quality Criteria even in shallow impoundments such as Speedwell Lake[16]. Broad consensus was reached among the Public Advisory Committee members that despite the high nutrient levels in the Whippany River, uses do not appear to be impaired due to eutrophication.

In conclusion, it has been demonstrated to the Department's satisfaction that:

1. Total Phosphorus is not a limiting nutrient in the Whippany River;
2. Total Phosphorus has not rendered the Whippany River unsuitable for the designated uses;
3. there are not objectionable algal densities in the Whippany River; and

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[15] George Van Orden, Ph.D. *Effects of Nutrients within the Whippany River*. Letter to Sandra Cohen dated November 15, 1999.

[16] NJDEP. 1995. Diurnal D.O. Data from Whippany River. Bureau of Freshwater and Biological Monitoring.

4. there is not nuisance aquatic vegetation in the Whippany River.

Available data and analysis of nutrient concentrations in the Whippany River clearly lead to the conclusion that no impairment of the River's designated uses are caused by excessive primary production. This analysis further shows that algal growth is not phosphorus limited in the River. Accordingly, the numerical total phosphorus criterion of 0.1 mg/l does not apply to the Whippany River. Thus, the Whippany River is in compliance with the Surface Water Quality Standards with respect to phosphorus.

APPENDIX F

Whippany River Watershed Model Development

Introduction

Predictions of the fate and movement of dissolved constituents in rivers and estuaries are needed to understand the nature and scope of many water quality problems. The ability to make such predictions partially depends on the development of suitable numerical transport models. Fortunately, dissolved constituents are laterally well-mixed in many rivers and estuarine channels and, therefore, transport models that represent channels as one-dimensional entities are often adequate

The application of mathematical modeling techniques to water quality problems has proved to be a powerful tool in water resource management. As a diagnostic tool, it permits the abstraction of a highly complex real world. Realizing that no one can ever detail all the physical phenomena that comprise the natural world, the modeler attempts to identify and include only the phenomena, natural or man-made, that are relevant to the water quality problem under consideration. As a predictive tool, mathematical modeling permits the forecasting and evaluation of the effects of changes in the surrounding environment on water quality. Although engineering insight and political and socioeconomic concerns play important roles in water resource management, some water quality problems are of such a complex nature that the predictive capability of mathematical models provides the only real means for screening the myriad number of management alternatives.

It is important for a computer program to be very general in nature if it is to serve as the basis for the mathematical modeler. The program should be flexible enough to produce the modeler with the mechanisms to describe and provide input data for the geophysical morphology, the transport processes, and the transformation processes that go into the framework of the model. Transport processes, basically hydrodynamic in nature, include advection, turbulent diffusion, and, when spatial averaging is included, dispersion. Transformation (or reactive) process, which are the sources and sinks that act upon a particular water quality parameter, may be physical, chemical or biological.

Diffusion Analogy Flow Model (DAFLOW)

The model is designed to provide predictions of discharge and flow velocity using a minimum of field data and calibration. The model is designed to simulate flow in upland stream systems where the flow reversals do not occur and backwater conditions are not severe. If these two conditions are satisfied, the diffusion analogy form of the flow equations can be applied with acceptable accuracy even with minimal field data.

Branched Lagrangian Transport Model (BLTM)

A one-dimensional water-quality model based on the Lagrangian reference frame was previously developed for use in single-channel upland streams (Jobson 1980, Schoellhamer and Jobson 1986a, 1986b). Because of the accuracy and stability of this model, it has been generalized for use in a network of open channels with one-dimensional flow. BLTM may be useful in simulating transport of a conservative substance such as dye or reactions between water quality constituents in branched river systems, tidal canal systems, and deltaic channels.

The BLTM solves the convective-dispersion equation by using a Lagrangian reference frame in which the computational nodes move with the flow. The unsteady flow hydraulics must be supplied to the model and the constituent concentrations are assumed to have no effect on the hydraulics.

WASP5

The Chemostate modules regarding nutrients and DO related equations have been adapted for Whippany River Watershed Water Quality model.

The equations solved by WASP5 are based on the key principle of the conservation of mass. To perform the mass balance computations, the user must supply WASP5 with input data defining seven important characteristics:

- Simulation and output control
- Model segmentation
- Advective and dispersive transport
- Boundary conditions
- Point and diffuse source loads
- Kinetic parameter, constants, and time function

- Initial concentration

QUAL2E

The Temperature Module of Qual2e is adapted for Whippany River Model to account for the temperature response. The net energy flux passing the air-water interface (in Btu/ft^2-day) resulted from H_{sn}, the sum of net short-wave solar radiation flux, H_{an}, net long-wave atmospheric radiation flux, H_b, outgoing long-wave back radiation flux, H_c, convective energy flux and H_e, energy loss by evaporation.

Model Theory

DAFLOW

One dimensional transport models based on the Lagrangian reference frame have been found to be very accurate and stable (McBride and Rutherford, 1984; Thomson and others, 1984; O'Neill, 1981; Jobson, 1980, 1987). The flow model is designed to be used in conjunction with a transport model to form a transport modeling system.

Diffusion Analogy

The differential equations derived by Saint-Venant (1871) for one dimensional, unsteady flow are the theoretical basis for the diffusion analogy method. Assuming no lateral inflow, the saint-Venant equations for channel flow are

Continuity equation

$$\frac{\partial Q}{\partial X} + \frac{\partial A}{\partial t} = 0$$ **Equation 1**

Momentum equation

$$\frac{1}{g}\frac{\partial U}{\partial t} + \frac{U}{g}\frac{\partial U}{\partial X} + \frac{\partial Y}{\partial X} + S_f - S_o = 0$$ **Equation 2**

in which Q = volumetric rate of flow, A = area of flow, X = longitudinal distance along the channel, t = time, Y = depth of flow, U = average cross-sectional velocity, g = accerlation of gravity, S_f = friction slope, and S_o = bed slope.

If the acceleration terms ($\frac{1}{g}\frac{\partial U}{\partial t} + \frac{U}{g}\frac{\partial U}{\partial X}$) are neglected, the resulting equation is referred to as the diffusion wave equation. The diffusion analogy method used here solves the diffusion wave form of the equations with some additional simplifying assumptions.

Much geomorphic information suggests that, in and average sense, the cross-sectional area (A) of natural channels can be approximated by an equation of the form

$$A = A_1 Q_s^{A_2} + A_0$$ **Equation 3**

in which A_1 and A_2 are constants called the hydraulic geometry coefficient and hydraulic geometry exponent, respectively, for area, Q_s equal the normal discharge, and A_0 is the average cross-sectional area at zero flow.

The normal discharge is defined as the steady state discharge that corresponds to a cross-sectional area of A. The value of A_2 theoretically can range from 0 to 1 but its value is usually found to be about 0.66 ± 0.1 (Leopold and Maddock, 1953l Leopold and Miller, 1956; Boning, 1974; Boyle and Spar, 19985; and Graf, 1986). Likewise, the width, W, can be approximated by an equation of the form

$$W = W_1 \, Q_s^{W_2} \qquad \textbf{Equation 4}$$

in which W_1 and W_2 are the hydraulic geometry coefficient and exponent, respectively, for width. Table 1 contains a summary of some observed hydraulic geometry exponent.

For unsteady conditions the DAFLOW model assumes that discharge (Q) can be approximated by

$$Q = Q_s - D_f \frac{\partial A}{\partial X} \qquad \textbf{Equation 5}$$

in which D_f is the change in discharge caused by a unit change in the area gradient called a wave dispersion coefficient.

Considering the monoclonal rising wave illustrated in figure 1 moving down a rectangular channel of width W at a constant wave speed C. For a wave traveling downstream without changing shape, it is easily seen that

$$C = \frac{Q_{s2} - Q_{s1}}{A_2 - A_1} \approx \frac{\partial Q_s}{\partial A} \qquad \textbf{Equation 6}$$

Substituting equation 5 into equation 1 yields $\frac{\partial A}{\partial t}+\frac{\partial Q_s}{\partial A}\frac{\partial A}{\partial X}-D_f\frac{\partial^2 A}{\partial X^2}=0$, which by use of equation 6 reduces to the diffusion form of the flow equation

$$\frac{\partial A}{\partial t}+C\frac{\partial A}{\partial X}-D_f\frac{\partial^2 A}{\partial X^2}=0 \qquad \textbf{Equation 7}$$

Equation 7 indicates that the mass of water per unit length of channel obeys the one dimensional, convective-diffusion equation.

Because the flow hydrograph is approximated by a series of steady-state discharge (Q_S) called wave, it is convenient to transform equation 7 into an expression for normal discharge by use of equation 3 yields

$$\frac{\partial Q_s}{\partial t}+C\frac{\partial Q_s}{\partial X}-D_f\frac{\partial^2 Q_s}{\partial X^2}=0 \qquad \textbf{Equation 8}$$

Solution procedure

1. Equation 8 is first solved to determine the distribution of Q_S (area) along the channel at the end of the time interval
2. The volume of water stored in each subreach of the river is determined using equation 3 and the distribution of Q_S from step 1
3. The discharge out of each subreach is computed using the continuity equation

Table 1 Hydraulic geometry exponents as compiled from the indicated locations

			A_2			W_2		
Location	Reference	Conditions	Minimum	mean	maximum	minimum	mean	maximum
Midwest Rivers	Leopold and Maddock, 1953	All		0.66			0.26	
Ten streams in Illinois	Graf, 1986	All		0.65				
New Mexico	Leopold and Miller, 1956	All		0.66				
New Mexico	Leopold and Miller, 1956	Ephemeral		0.68		0.08	0.26	0.44
Theoretical	Daugherty and Ingersoll, 1954	Wide		0.60				
Throughout United States	Boning, 1974	Pool and riffle reaches		0.60				
Throughout United States	Boning, 1974	Channel controlled		0.74				

	reaches						
Throughout United States	Lock and dam reaches		0.50				
Colorado - Utah	281<Q<1841	0.24	0.66	0.70			
United States	Humid regions	0.47	0.61	0.82	0.11	0.21	0.35
United States	Semiarid		0.65			0.29	
United States	Mountain streams		0.59			0.11	

BLTM's One-Dimensional Transport Theory

In the Lagrangian reference frame, the continuity of mass equation is

$$\frac{\partial C}{\partial t} = \frac{\partial}{\partial \xi}\left(D \frac{\partial C}{\partial \xi} \right) + S + \Phi + K\left(C - CR \right) \qquad \textbf{Equation 9}$$

in which C is concentration, t is time, D is longitudinal dispersion coefficient, K is rate of production of the constituent, CR is the equilibrium concentration (that is, the concentration at which the internal production ceases), Φ is the rate of change in concentration due to tributary inflow, S is the rate of production of concentration, which is independent of the concentration (zero-order production rate) , and ξ is the Lagrangian distance coordinate given by

$$\xi = x - x_o - \int_{t_o}^{t} u\, dt' \qquad \textbf{Equation 10}$$

in which x is the Eulerian (stationary) distance coordinate along the river, u is the cross-sectional mean stream velocity, and x is the location of the parcel at time t .

Equation 1 is solved for each constituent modeled. It is convenient to number the constituents and then all equations can be represented by a single expression of the form

$$\frac{\partial C_i}{\partial t} = \frac{\partial}{\partial \xi}\left(D \frac{\partial C_i}{\partial \xi} \right) + S_i + \Phi_i + \sum_{n=1}^{m} K_{i,n}\left(C - CR_{i,n} \right) \qquad \textbf{Equation 11}$$

in which C_i , S_i , and Φ_i are as defined in equation 9, except that they apply to the specific constituent i. The summation term allows for the interaction between constituents where $K_{i,n}$ is the rate coefficient for the production of constituent i due to the presence of constituent n_i, and $CR_{i,n}$ is the concentration of constituent n at which the production of constituent i due to n ceases.

Equations 9 through 11 apply only to a single fluid parcel and, therefore, do not give the variation of concentration in space and time directly. Parcels are assumed to be completely mixed, and their volume is changed only by tributary flows. The variation of concentration in a river reach is approximated by solving equation 9 for a series of parcels spaced along the river at intervals of about $u\Delta t$. The concentration at any point is the concentration of the parcel at that point.

WASP5 Model

Assuming vertical and lateral homogeneity, the mass balance equation for a one-dimensional reach is:

$$\frac{\partial}{\partial t}(AC)=\frac{\partial}{\partial x}\left(-U_x\,AC+E_x\,A\frac{\partial C}{\partial x}\right)+A\left(S_L+S_B+S_K\right) \qquad \textbf{Equation 12}$$

In this model, only the Eutrophication Chemostate Equations were used for kinetic modules. There are four interacting systems in EUTRO4: phytoplankton kinetics, the phosphorus cycle, the nitrogen cycle, and the dissolved oxygen balance.

Phytoplankton Kinetics

Three phosphorus variables are modeled: phytoplankton phosphorus, organic phosphorus, and inorganic (orthophosphate) phosphorus.

$$S_{k4j} = \left(G_{p1j} - D_{p1j} - k_{s4j} \right) P_j \qquad \textbf{Equation 13}$$

where

S_{k4j} = reaction term, cells/L-day (or mg carbon/L-day)

P_j = phytoplankton population, cells/L (or mg carbon/L)

Gp1j = growth rate constant, day-1

Dp1j = depth plus respiration rate constant, day-1

ks4j = settling rate constant, day^{-1}

j = segment number, unitless

The Phosphorus Cycle

Phytoplankton Phosphorus

$$\frac{\partial \left(C_4\, a_{PC} \right)}{\partial t} = \left(G_{p1j} - D_{p1j} - \frac{v_{s4}}{D} \right) C_4\, a_{PC} \qquad \textbf{Equation 14}$$

Organic Phosphorus

$$\frac{\partial C_8}{\partial t} = D_{p1j}\, C_4\, a_{pc} - k_{83}\, \theta_{83}^{T-20}\, K_{mPc}\, C_8 - \frac{v_{s8}\left(1 - F_{D8} \right)}{D} C_8 \qquad \textbf{Equation 15}$$

Orthophosphate Phosphorus

$$\frac{\partial C_3}{\partial t} = -\, G_{p1j}\, C_4\, a_{pc} + k_{83}\, \theta_{83}^{T-20}\, K_{mPc}\, C_4 - \frac{v_{s3}\left(1 - F_{D3} \right)}{D} C_3 \qquad \textbf{Equation 16}$$

The Nitrogen Cycle

Four nitrogen variables are modeled: phytoplankton nitrogen, organic nitrogen, ammonia, and nitrate.

Phytoplankton Nitrogen

$$\frac{\partial\left(C_4\, a_{NC}\right)}{\partial t}=\left(G_{p1j}-D_{p1j}-\frac{v_{s4}}{D}\right)C_4\, a_{NC}$$ **Equation 17**

Organic Nitrogen

$$\frac{\partial C_7}{\partial t}=D_{p1j}\, C_4\, a_{NC}\, f_{ON}-k_{71}\,\theta_{71}^{T-20}\, K_{mPc}\, C_7-\frac{v_{s7}\left(1-F_{D7}\right)}{D}C_7$$ **Equation 18**

Ammonia Nitrogen

$$\frac{\partial C_1}{\partial t}=k_{71}\,\theta_{71}^{T-20}\,P_{NH_3}C_7-G_{p1j}\,P_{NH_3}C_4a_{NC}-k_{12}\theta_{12}^{T-20}\left(\frac{C_6}{K_{NIT}+C_6}\right)C_1+D_{p1j}C_4a_{NC}\left(1-f_{ON}\right)$$

Equation 19

Nitrate Nitrogen

$$\frac{\partial C_2}{\partial t}=k_{12}\,\theta_{12}^{T-20}\left(\frac{C_6}{K_{NIT}+C_6}\right)C_1+G_{p1j}(1-P_{NH_3})C_4a_{NC}-k_{2D}\theta_{2D}^{T-20}\left(\frac{K_{NO_3\,3}}{K_{NO_3}+C_6}\right)C_2$$

Equation 20

<u>Ammonia Preference Factor</u>

$$P_{NH_3} = C_1 \frac{C_2}{\left(K_{NIT} + C_1\right)\left(K_{NO_3} + C_2\right)} + C_1 \frac{K_{NO_3}}{\left(C_1 + C_2\right)\left(K_{NO_3} + C_2\right)}$$

Table 2 Phosphorus Reaction Terms

Description	Notation	Typical Value	Units
Phytoplankton biomass as carbon	P_c		mg C/L
Specific phytoplankton growth rate	G_{p1j}		day^{-1}
Phytoplankton loss rate	D_{p1j}		day^{-1}
Phosphorus to carbon ratio	a_{pc}	0.025	mg P /mg C
Dissolved organic phosphorus mineralization at 20^{o}C	K_{83}	0.22	day^{-1}
Temperature coefficient	ϑ_{83}	1.08	none
Half saturation constant for phytoplankton limitation of phosphorus recycle	K_{mPc}	1.0	mg C/L
Fraction of dead and respired phytoplankton recycled to the organic phosphorus pool	f_{op}	0.5	none
recycled to the phosphate phosphorus pool	$1-f_{op}$	0.5	none
Fraction dissolved inorganic phosphorus in the water column	f_{D3}	0.85, 0.70	none

Fraction dissolved organic phosphorus	f_{D8}	none
Organic matter settling velocity	v_{s8}	m/day
Inorganic sediment settling velocity	v_{s3}	m/day

Table 3 Nitrogen Reaction Terms

Description	Notation	Typical Value	Units
Nitrogen to carbon ratio	a_{NC}	0.25	mg N /mg C
Organic nitrogen mineralization rate @ 20°C	k_{71}	0.075	day^{-1}
Nitrification rate @ 20°C	k_{12}	0.09	day^{-1}
Temperature coefficient for nitrification	θ_{12}	1.08	none
Half saturation constant for oxygen limitation of nitrification	K_{NIT}	2.0	mg O_2 /L
Denitrification rate @ 20°C	k_{2D}	0.09	day^{-1}
Temperature coefficient for denitrification	θ_{2D}	1.045	none
Michaelis constant for denitrification	K_{NO_3}	0.1	mg O_2 /L
Fraction of dead and respired phytoplankton recycled			
to the organic nitrogen pool	f_{ON}	0.5	none
to the ammonia nitrogen pool	$(1 - f_{ON})$	0.5	none
Fraction dissolved organic nitrogen	f_{D7}	1.0	none
Organic matter settling velocity	v_{s3}		m/day

4.2.3.1.4 The Dissolved Oxygen Balance

Five state variables participate in the dissolved oxygen balance: phytoplankton carbon, ammonia, nitrate, carbonaceous biochemical oxygen demand, and dissolved oxygen

Equation 21 Carbonaceous BOD

$$\frac{\partial C_5}{\partial t} = k_d C_4 a_{OC} - k_d \theta_d^{T-20} C_5 \frac{C_4}{k_{BOD} + C_4} - \frac{v_{s3}\left(1 - f_{D5}\right)}{D} C_5$$

$$- \frac{5}{4}\frac{32}{14} k_{2D} \theta_{2D}^{T-20} \left(\frac{k_{NO_3}}{k_{NO_3} + C_6} \right) C_2$$

Equation 22

$$\frac{\partial C_6}{\partial t} = k_a \theta_a^{T-20} \left(C_s - C_6 \right) - k_D \theta_D^{T-20} C_5 \left(\frac{C_6}{k_{BOD} + C_6} \right)$$

$$- \frac{64}{14} k_{12} \theta_{12}^{T-20} \left(\frac{C_6}{k_{NIT} + C_6} \right) C_1 - \frac{32}{12} k_R \theta_R^{T-20} C_4 \frac{SOD}{D}$$

$$+ G_{p1j}\, C_4 \left(\frac{32}{12} + \frac{48\, a_{NC}}{14} \left(1 - P_{NH_3} \right) \right)$$

APPENDIX G

A CLEANER WHIPPANY RIVER WATERSHED: NONPOINT SOURCE POLLUTION CONTROL GUIDANCE MANUAL FOR MUNICIPAL OFFICIALS, ENGINEERS AND DPW PERSONNEL

Appendix G was published separately from this amendment and is available upon request:

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This document is also available on the following website:

http://www.state.nj.us/dep/watershedmgt/northeast_bureau.htm