Development and Water Quality Model Validation of a Phosphorus Trading Program for the Non-Tidal Passaic River Basin

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Executive Summary

A Total Maximum Daily Load (TMDL) for phosphorus has been developed for the Non-Tidal Passaic River Basin. The TMDL proposed watershed criteria in terms of a seasonal average concentration (June 15-September 1) of the response indicator, chlorophyll-*a* (chl-*a)*. These criteria require each regulated discharger within the model domain to achieve a long term average (LTA) effluent concentration of 0.4 mg/l of total phosphorus (TP). Some of the dischargers in the watershed can easily upgrade to achieve this long-term average effluent concentration while others are expected to require significant upgrades. Some of the dischargers can achieve even higher levels of phosphorus removal, beyond the required 0.4 mg/l. This wide range of discharger characteristics renders the Non-Tidal Passaic River Basin ideal for the implementation of a water quality trading program.

The TMDL model was used to develop trading ratios that would achieve compliance with TMDL water quality targets at two critical locations: the Wanaque Reservoir and Dundee Lake. These trading ratios provide the foundations for developing a point-to-point source trading program for the Non-Tidal Passaic River Basin. Extensive simulations of a variety of trading scenarios were conducted to validate the proposed trading program. In-stream water quality model simulations have verified that the recommended trading ratios will achieve compliance with TMDL water quality targets at the critical locations under high-stress trading conditions, heavy cross-tributary trading, critical diversion conditions, and scenarios where buyers are concentrated either upstream or downstream.

Key items within the report are a) the proposed formula for trading in Section V, b) allocations for trading listed in Table 5-4, c) recommended trading ratios listed in Table 5-7, and d) example trades illustrated in Appendix 3.

I. Introduction

The non-tidal portion of the Passaic River Basin encompasses 803 square miles, with 669 square miles of the watershed in New Jersey and the remainder in New York. Approximately ¼ of New Jersey's population (i.e., two million people) lives in this watershed. Three of New Jersey's twenty watershed management areas (WMAs), WMA 3, 4, and 6, can be found in the Non-Tidal Passaic River Basin. WMA 3 includes the Pompton, Pequannock, Wanaque, and Ramapo Rivers; WMA 4 includes the Lower Passaic and Saddle Rivers, and WMA 6 includes the Upper and Middle Passaic, Whippany, and Rockaway Rivers. In addition, 23 reservoirs, which provide potable water to the residents of New Jersey, are located within the non-tidal portion of the Passaic River Basin. The Wanaque Reservoir is the largest potable water source in the watershed, and it receives surface water from diversions of the Ramapo, Pompton, and the confluence of the Pompton and Passaic Rivers to supply water to the North Jersey District Water Supply Commission and the Passaic Valley Water Commission. Overall, about 50% of New Jersey's population receives drinking water from the Non-Tidal Passaic River Basin.

A Total Maximum Daily Load (TMDL) (NJDEP, 2008) for phosphorus has been adopted for the Non-Tidal Passaic River Basin (i.e., the river and its tributaries upstream of Dundee Dam, including the Wanaque Reservoir). Surface water samples have been collected at over 70 sampling stations within the watershed, including 24 wastewater treatment plants (WWTPs). For the TMDL study, a hydrodynamic model (USGS, 2007) and a water quality model (Omni Environmental, 2007a) were developed for the non-tidal portion of the Passaic River. These models, coupled with the LA-WATERS model (Najarian Associates, 2005) were used to identify the Wanaque Reservoir and Dundee Lake as the critical locations where phosphorus is causing excessive primary productivity. As part of the TMDL, the New Jersey Department of Environmental Protection (NJDEP) proposed watershed criteria in accordance with N.J.A.C. 7:9B-1.5(g)3 in these locations as the best means to ensure protection of the designated uses. The watershed criteria were proposed in terms of a seasonal average concentration (June 15-September 1) of the response indicator, chl-*a*. The proposed criteria were tailored to the unique characteristics of each critical location and were proposed as a seasonal average of 10 μg/L chl-*a* in the Wanaque Reservoir and a seasonal average of 20 μg/L chl-*a* in Dundee Lake (NJDEP, 2008).

The wasteload allocations for wastewater treatment facilities needed to meet the watershed criteria at Wanaque Reservoir and Dundee Lake were based on a LTA effluent concentration of 0.4 mg/l of TP for all wastewater dischargers within the model domain. Some of the dischargers in the watershed can easily upgrade to achieve the LTA effluent concentrations of 0.4 mg/l while others are expected to require significant upgrades. Some of the plants can achieve even higher levels of phosphorus removal, beyond the required 0.4 mg/l. This distribution in the ability of the present capacity of WWTPs to meet the designated TMDL standards, along with a wide range of flow capacities across WWTPs provides for substantive trading opportunities that would otherwise not exist in an industry characterized by relatively homogenous technology (Boisvert et al., 2008).

The goal of this project was to develop and evaluate an effective water quality trading program for the Non-Tidal Passaic River Basin that adheres to the United States Environmental Protection Agency (USEPA) Water Quality Trading Policy and meets the requirements of NJDEP which will result in complying with the Passaic Nutrient TMDL and thus attaining the State Water Quality Standards, facilitate the implementation of the TMDL, reduce the costs of compliance with the Clean Water Act regulations, establish incentives for voluntary reductions, and accelerate the implementation of the TMDL load reductions. Since the main sources of phosphorus in the watershed are point sources (i.e., WWTPs), the trading program was developed for point-to-point source trading. This report presents the development and water quality model validation of a water quality trading program for the Non-Tidal Passaic River Basin.

II. Literature Review

In terms of TMDL implementation, water quality trading offers a management alternative to regulations that specify effluent levels or particular abatement technologies for each source of emissions. Trading is a watershed-based and market-based approach that allows flexibility in individual emissions or abatement levels while meeting ambient water quality standards. The EPA supports water quality trading and issued policy guidance in 2003 on trading (USEPA, 2003). Trading is based on the premise that sources in a watershed can face very different costs to control the same pollutant. A trading program allocates a certain number of pollution allowances to sources in the watershed. The sources can either discharge under their allocation and sell their excess allowances or discharge over their allocation and purchase allowances. With appropriate restrictions on trade, the net effect will be to achieve targeted ambient levels of water quality throughout the watershed, ideally at a lower cost than requiring each individual source of emissions to implement pollution controls that individually and collectively comply with the required TMDL reductions. Trading can occur among point sources and nonpoint sources. Depending on the market structure of the program, sources can trade directly or indirectly with each other (USEPA, 2004).

The project team reviewed several water quality trading programs throughout the U.S. to learn how to best design trading for the Passaic. Results of those studies are detailed in Passaic Water Quality Trading Project (2006a, 2006b). Breetz et al. (2004) is also an excellent reference on U.S. water quality trading programs. Boisvert et al. (2007) provides an overview of economic issues germane to designing a trading program.

In terms of the scientific aspects of trading program design, there are two main issues: hot spot avoidance and trading ratios. In addition, overall simplicity of the trading program and clearly defined allocations are crucial. The approach toward all these issues for Passaic trading is discussed in Sections III, IV and V. Since Passaic trading will only involve point sources, our work benefited from several examples of point-point source trading programs (e.g., Long Island Sound, Lower Minnesota River, Neuse River), while recognizing that institutional and hydrologic features of the non-tidal Passaic differ from these previous programs. For example, in addressing trading in a watershed with complex surface water diversions and multiple TMDL critical locations like the Non-Tidal Passaic River Basin, no precedents in the literature were found. Hence this project offers new solutions that could be applied to similar watersheds. In a similar manner, the economic trading models (Sado et al., 2006; Boisvert et al., 2007, Boisvert et al., 2008) have broader relevance to water quality trading opportunities in watersheds of limited size with multiple management areas.

III. System Dynamics

Identification of potential hot spots

"Hot spots" describes localized areas with unacceptably degraded water quality due to high concentrations of a pollutant. The USEPA (2004) notes that one concern regarding water quality trading is the potential that trades will create hot spots immediately downstream of pollutant sources that purchase allowances. Trading programs must be designed to avoid such outcomes.

Correspondingly, water quality trading in the Non-Tidal Passaic River Basin must be structured so that no hot spots result from phosphorus trading. To achieve this objective, the first task is to define the concept of "phosphorus-induced hot spots," and identify where and under what conditions they can occur in the Non-Tidal Passaic River Basin.

Phosphorus-induced hot spots are locations in the watershed where excessive loading of phosphorus can increase the risk of algal blooms. A number of primary variables contribute to algal blooms including total phosphorus, total nitrogen, temperature and light. In addition, there are other secondary variables that affect algal blooms, namely stream flow, shade cover and turbidity. An extensive water quality study of the system (Omni, 2007a) indicated that excessive phosphorus concentrations in certain areas are more likely to stimulate algal blooms, as indicated by elevated levels of chl-*a* and increased diurnal fluctuations of dissolved oxygen. In contrast, equally high concentrations of phosphorus in other areas may not stimulate algal growth due to other limiting factors such as light availability or high stream velocity; these areas are not considered potential phosphorus-induced hot spots. Consequently, different locations in the watershed show varying sensitivity to water quality impacts from phosphorus loading (Figure 3-1). Therefore, certain locations are more vulnerable to hot spot effects than other locations in the watershed. Specifically, two locations were identified as potential phosphorus-induced hot spots based on interpretation of the Omni (2007a) study. These locations correspond directly to the TMDL critical locations of the Wanaque Reservoir and Dundee Lake (Figure 3-2).

Identification of Category 1 waters

Category 1 (C1) waters also must be addressed in the development of a water quality trading program. C1 waters are designated by the state of New Jersey for purposes of implementing the antidegradation policies set forth at N.J.A.C. 7:9B-1.5(d) to protect surface waters of exceptional value (NJDEP, 2004). In the Non-Tidal Passaic River Basin, 30% (~ 7.4 sq. miles) of the lake and reservoir area and 22% (~ 258 miles) of the stream miles are C1 waters. The C1 waters are outside the model domain and trades involving these areas would be problematic. An additional 2% of the stream miles (~ 26 miles) are Outstanding National Resource Waters, however there are no point sources which discharge into or upstream of these waters (Figure 3-3).

Surface water diversions

The presence of surface water diversions affects the conditions under which phosphorus-induced hot spots can occur. As noted above, the watershed is a source of drinking water for about one half of New Jersey's population. The Wanaque Reservoir system is the state's largest reservoir system and has an existing water allocation of 173 million gallons per day (MGD). It can receive up to 400 MGD from surface water diversions. Surface water is pumped to the Wanaque Reservoir from discrete points located downstream at a rate according to consumer demand, water availability and regulatory restriction (see Appendix 1 for details). This fundamentally alters the hydrology of the watershed, and diversions to the Wanaque Reservoir transform basic relationships of upstream and downstream between certain locations in the watershed. For example, when the Wanaque Reservoir does not require diverted inflow, the Passaic River is not a natural tributary or source of water to the reservoir. But when the Wanaque Reservoir does require high volumes of diverted inflow as occurred in a 2002 drought, the Upper Passaic River waters can be diverted to the reservoir, and the river effectively becomes "upstream" of the reservoir (Najarian Associates, 2005). The watershed hydrology thus fluctuates with the extent of surface water diversions, resulting in dynamic relationships of upstream and downstream that must be accounted for in designing a trading program that avoids the creation of hot spots.

As a result, the Wanaque Reservoir is only vulnerable to phosphorus-induced hot spots from water quality trading under the condition that surface water diversions are occurring; if surface water diversions are not occurring, the Wanaque Reservoir is not vulnerable to phosphorus-induced hot spots from water quality trading. In contrast, Dundee Lake, located at the watershed outlet, is vulnerable to being a phosphorus-induced hot spot from water quality trading under all stream flow conditions, regardless of the occurrence of surface water diversions. This distinction between the two locations is critical to the development of a water quality trading framework that avoids the creation of hot spots.

IV. Design of Trading Framework

This section describes the design of a framework to address the physical boundaries that govern trading among dischargers. The trading framework ensures the avoidance of phosphorus-induced hot spots and attainment of water quality standards.

Two categories of dischargers

To protect C1 waters, point sources that discharge either directly into C1 waters, or naturally upstream of C1 waters, should not be allowed to participate in the trading program; such dischargers are termed "Category 1 dischargers." In contrast, "Category 2 dischargers" are those point sources which do not discharge directly into C1 waters, or naturally upstream of C1 waters. Category 2 dischargers can participate in trading as buyers or sellers, provided they were included in the TMDL model domain (see Figure 4-1 and Table 4-1 for map and list of Category 1 and 2 dischargers). Note that there are 17 Category 1 dischargers and 35 Category 2 dischargers. Of the 35 Category 2 discharges, 23 of the 35 are contained within the TMDL model domain and are eligible to participate in the trading program. These eligible 23 Category 2 dischargers are the much larger group in terms of capacity and comprise 93% of the total permitted flow of all fifty-two dischargers in the basin. Trade eligibility is further restricted according to "management area" designation as described below.

Management area approach

In light of the system dynamics, the trading program development team (comprising experts in water quality modeling, wastewater treatment, environmental law and policy, and environmental economics) has proposed a trading framework that is expected to protect the Non-Tidal Passaic River Basin from phosphorus-induced hot spots associated with trading and result in compliance with the TMDL endpoints. The proposed framework establishes three "management areas" within the watershed. A management area is delineated so that its outlet represents the *only* hot spot concern in that management area. Since there are no hot spot concerns besides the management area outlets, bidirectional trades (i.e., seller can be upstream or downstream of the buyer) are allowed *within* the same management area. Trades are subject to a trading ratio to equalize the load traded and account for differences in attenuation of load from each WWTP relative to the management area outlet.

In contrast to a more rigid framework that stipulates the seller must always be upstream of the buyer, the Passaic trading framework increases opportunities for trading and potential market size. Compliance with TMDL water quality targets is defined as achieving the net effect of 0.4 mg/l LTA from each discharger at the TMDL critical locations. The trading framework is designed to comply with TMDL water quality targets on the basis that high phosphorus at some, not all, locations is a hot spot concern, namely the Wanaque Reservoir and Dundee Lake as determined from water quality studies conducted throughout the watershed (Omni, 2007a). Dundee Lake and the pump intake for surface water diversions to the Wanaque Reservoir (i.e., Wanaque South intake) are the two management area outlets; both outlet locations can receive phosphorus loads from upstream dischargers. Since the pump intake is located at the confluence of the Passaic and Pompton Rivers, and surface water diversions are designed to draw from either the Pompton River by itself *or* jointly from the Pompton and Passaic Rivers, the pump intake is the outlet for two separate management areas. In total, three management areas are delineated: the Pompton management area, the Upper Passaic management area and the Lower Passaic management area (Figure 4-2).

As described earlier, the trading framework allows bidirectional *intra*-management area trading so long as the appropriate trading ratios are applied (trading ratios are detailed in Section V). The project team then examined the question of *inter*-management area trading and the necessary restrictions to avoid phosphorus-induced hot spots.

Due to fluctuations in precipitation and demand for drinking water from the Wanaque Reservoir, three potential surface water diversion scenarios can occur with respect to the Wanaque South intake. These scenarios, termed "no diversion," "diversion" and "extreme diversion," are explained in detail below. Each scenario creates a different relationship between the three management areas and potential phosphorus-induced hot spots, and as a result restrictions on inter-management area trading could differ with each scenario.

In the "no diversion" scenario, the Wanaque South intake is not activated, thus the Wanaque Reservoir does not receive any phosphorus loads from dischargers (i.e., eligible buyers) in the watershed. (The "no diversion" scenario is estimated to have occurred on 63 percent of the days from October 1, 1999 through Nov 30, 2003 (Omni, 2007b)). This leaves Dundee Lake as the only potential phosphorus-induced hot spot. In this case, dischargers from the three management areas affect only Dundee Lake, and bidirectional trading can occur throughout the entire watershed; each management area can buy or sell with the other two management areas. The trading framework for the "no diversion" scenario is shown in Figure 4-3.

In the “diversion” scenario, the Wanaque South intake is partially activated. It diverts surface water to the Wanaque Reservoir from the Pompton River only and not from the Upper Passaic River. (The “diversion” scenario is estimated to have occurred on 19 percent of the days from October 1, 1999 through November 30, 2003 (Omni, 2007b)). Therefore, the phosphorus load from the Pompton management area is diverted upstream and impacts the Wanaque Reservoir, and all dischargers in the Upper and Lower Passaic management areas impact Dundee Lake. (A portion of the Pompton management area’s discharge reaches Dundee Lake, as well). In contrast with the “no diversion” scenario, the “diversion” scenario has two potential phosphorus-induced hot spots. To comply with TMDL water quality targets at the Wanaque South intake endpoint, the Pompton management area cannot buy phosphorus allowances from the other two management areas. Since dischargers from the Upper and Lower Passaic management areas affect only Dundee Lake, these two management areas can trade bidirectionally with each other. The trading framework for the “diversion” scenario is shown in Figure 4-4.

In the “extreme diversion” scenario, the Wanaque South intake is fully activated, and it diverts surface water to the Wanaque Reservoir from both the Pompton and Upper Passaic Rivers. (The “extreme diversion” scenario is estimated to have occurred on 19 percent of the days from October 1, 1999 through November 30, 2003 (Omni, 2007b)). Therefore, the phosphorus load from all dischargers in the Upper Passaic management area and from dischargers in the Pompton management area is diverted upstream and impacts the Wanaque Reservoir, and dischargers from the Lower Passaic management area impact Dundee Lake. (A portion of the Pompton and Upper Passaic management area discharge reaches Dundee Lake, as well). Similar to the “diversion” scenario, the “extreme diversion” scenario has two potential phosphorus-induced hot spots. However to comply with TMDL water quality targets at the Wanaque South intake endpoint, in this case the Pompton and Upper Passaic management areas cannot buy phosphorus allowances from the Lower Passaic management area. Since the Wanaque South intake is only affected by dischargers from the Pompton and Upper Passaic management areas, these two management areas can trade bidirectionally with each other. The trading framework for the “extreme diversion” scenario is shown in Figure 4-5.

In selecting a final trading framework, it is important to note the activation of the Wanaque South intake is highly variable both within a single year and between years. In terms of the three scenarios outlined above, a shift from one scenario to another can occur multiple times in a year. It would be impractical to expect the dischargers involved to constantly jump from one trading framework to another with each change in scenarios. That would likely increase transaction costs as dischargers would be forced to keep up to date with frequently changing trading restrictions. It would also present possibly insurmountable permitting/enforcement challenges. An alternative approach that would reduce transaction costs, achieve compliance with TMDL water quality targets under all diversion conditions, and reduce uncertainty and risk to water quality is to merge the three trading frameworks into a single framework on the basis of selecting the most stringent option in each possible inter-management area trade.

The resulting trading framework shown in Figure 4-6 restricts any trades that are not allowed from any of the three scenarios. The result shows that the most conservative option entails consideration of two possible diversion scenarios, and trading between management areas is restricted accordingly. Thus, of the six possible inter-management area trades, three are allowed and three are not allowed. The Lower Passaic management area can buy from but not sell to the other management areas. Conversely, the Pompton management area can sell to but not buy from the other management areas. Consequently, the Upper Passaic management area can buy allowances from the Pompton management area and sell allowances to the Lower Passaic management area.

For example, consider a pair of dischargers. Parsippany-Troy Hills Regional Sewerage Authority, located in the Upper Passaic Management Area, could buy from the Pompton Management Area's Two Bridges Sewerage Authority. However, Two Bridges could not buy from Parsippany-Troy Hills. This limitation allows for compliance with TMDL water quality targets at the Wanaque South intake at "diversion" scenario conditions and is applied for simplicity at all times.

As described further in the next section, all trades are subject to a trading ratio to equalize the load traded and to account for differences in attenuation of load from each discharger relative to the appropriate management area outlet.

V. Trading Formula

Discharger concentrations vs. loads

Achieving the goals of the proposed Passaic TMDL is driven primarily by discharger *concentration* of total phosphorus rather than *load* (NJDEP, 2008). The reason is that the growth of phytoplankton, the subject of proposed watershed criteria for the Wanaque Reservoir and Dundee Lake, is more affected by the concentration of orthophosphate in the water column than the mass of orthophosphate (Wool et al., 2003). The TMDL concluded that, within the model domain, a total phosphorus LTA effluent of

0.4 mg/l on an annual basis from each discharger is necessary to achieve water quality goals in the Wanaque Reservoir and Dundee Lake; a notable exception is dischargers downstream of the Pompton/Passaic River confluence (hereafter referred to as the Confluence) whose LTAs will be limited to 0.4 mg/l on a *seasonal* rather than *annual* basis (NJDEP, 2008).

Allocations

The trading program should be based on attaining the net effect of 0.4 mg/l LTA from each discharger on an annual basis (or seasonal basis for dischargers downstream of the Confluence), while realizing that transactions must occur in units of mass, rather than concentration for trading to be viable. The best way to achieve these objectives is to use a recent history of actual discharger flow, rather than permitted flow, as the basis for determining allocations in units of mass. If permitted flow were used instead to determine allocations, and assuming that permitted flows exceed actual discharger flows, sellers would receive allowances for more pounds than they had actually removed, thus posing a risk to the water body. Therefore unused capacity cannot be sold, nor should unused capacity be paid for, if trading is to achieve the discharger concentration-based goals that underlie the TMDL. Unused capacity is a factor in the watershed: total unused capacity among the 52 dischargers in the watershed stands at 34% (summarized by totaling columns 6 and 7 of Table 5.3). Figure 5-1 highlights unused capacity by percentage of permitted flow for each discharger. Also note that *prior* history of actual discharger flow, rather than actual discharger flow determined *at the end* of the trading period, is a more practical basis for allocations because it provides potential buyers and sellers with a clearly defined allocation *before* making any trades. It would increase uncertainty to design trading such that allocations were not known until after trades had been agreed to. Using a recent history of actual discharger flow, which we term *anticipated actual discharger flow*, as the basis for allocations helps to clearly define property rights, an essential precursor for a successful trading program. See Boisvert et al. (2007) for a discussion of the importance of clearly establishing property rights in establishing a well-functioning trading program.

Allocations should be based on the product of 0.4 mg/l LTA and Anticipated Actual Discharger Flow. The latter term refers to the average flow from a discharger over the past three calendar years prior to the start of watershed trading. The formula below proposes that actual discharger flow from 2005-2007 be the basis for Anticipated Actual Discharger Flow in the allocation.

Trading Formula

Recommend that for each discharger, allowance balance should be calculated as follows:

Balance = Allocation – Load Discharged - Actual load sold + Equalized load purchased

where

Allocation = (0.4 mg/l LTA[a] * Anticipated Actual Discharger Flow[b] * 3.785 l/gal * 365 days),

Load Discharged = (Load discharged during the trading period[c]),

Actual load sold = (Load below allocation that seller removed from wastewater and sold),

and

Equalized load purchased = (Actual load sold * Trading ratio $_{\text{seller to buyer}}$).

Notes:

a. Dischargers downstream of the Confluence have a summer allocation (May-October). All other dischargers have an annual allocation.

b. Anticipated Actual Discharger Flow(expressed in million gallons per day, or MGD) based on average of the most recent three years of actual discharger flow. If this number is greater than permitted flow, then use permitted flow instead.

c. The trading period is a full year for trades among Upper Passaic and Pompton Management Area dischargers, and a half-year (May-October) for trades with Lower Passaic Management Area dischargers.

When are trades made? When are they verified to have worked as expected? And how does the trading formula inform those processes? To answer the first question – when trades are made – the adopted TMDL (NJDEP, 2008) states that "the Department anticipates allowing 1 year from the date of permit issuance to… negotiate trades" (p.47). The NJDEP intends on issuing a NJPDES permit action for each of the affected dischargers that will implement the requirements of the adopted TMDL. This permit action will propose an appropriate compliance schedule for the final TMDL-based phosphorus effluent limitations. Consistent with the adopted TMDL, this permit action will allow for one (1) year from the effective date of this permit action for the dischargers to negotiate trades for the purposes of achieving compliance with the final TMDL-based effluent limitations and submit such trading proposals to the NJDEP for review and approval. The NJDEP fully intends on reviewing and approving acceptable trading proposals that are submitted subsequent to this deadline. However, under these scenarios, the Department does not anticipate extending the compliance schedule for the final phosphorus effluent limitations contained in the NJPDES permit for the affected facilities.

During the one year period of allowed trade negotiations, interested parties would apply the trading formula with an *exact* knowledge of their allocations, while needing to *estimate* their expected load to be discharged for the upcoming trading period. (A trading period is May-October when the Lower Passaic Management Area is involved, and a calendar year in all other cases). The buyer and seller would determine their load discharged over the trading period and apply the trading formula to verify that the seller removed enough phosphorus to offset the buyer for that trading period. To reiterate, the allocation is known before the trade goes into effect, while the load discharged is not known until the end of the trading period. Trades are negotiated on the basis of *estimating* the load to be discharged and subsequently verified using the actual data at the end of the trading period. To aid the verification process, an example trade verification form for the buyer and seller is shown in Appendix 2.

The form in Appendix 2 will not be used by NJDEP to verify trades. Final effluent limitations resulting from the approved trading agreements will be incorporated into NJPDES permits applicable to the appropriate dischargers. Therefore, verification of trades will occur consistent with final effluent limitation compliance and the enforcement provisions of N.J.A.C. 7:14 and 7:14A. As such, no NJDEP verification at the end of each trading period is necessary.

Additionally, to comply with TMDL water quality targets on an annual basis, a positive balance cannot be banked for use in a future trading period. Also, kilograms that are bought and sold need to be adjusted by a trading ratio to account for attenuation differences between the dischargers.

Appendix 3 contains examples of how to apply the trading formula.

This approach to calculating allowance balances will result in trades that achieve the goals of a concentration-driven TMDL. Provided that appropriate trading ratios are applied, trades conducted in this manner will achieve a net effect of 0.4 mg/l LTA from each discharger, and thus achieve TMDL water quality goals at the Wanaque Reservoir and Dundee Lake.

Trading ratios

Attenuation analysis and persistence coefficients

To successfully implement the proposed phosphorus TMDL for the Non-Tidal Passaic River Basin, water quality trading must achieve compliance with TMDL water quality targets at the Wanaque South intake and Dundee Lake critical locations under a wide range of flow conditions. Periods when surface water is diverted at the Wanaque South intake to supply the Wanaque Reservoir are of special concern in designing a trading program that ensures compliance with TMDL water quality targets. Differences in attenuation of effluent loads among trading participants must also be accounted for. The unique diversion conditions of the watershed have resulted in the design of the Passaic Trading Framework (Figure 4-6) which divides the watershed into three management areas and specifies which inter-management area trades are allowed. The next step, explained in this section, was to address the development of trading ratios to account for differences in load attenuation between each eligible pair of buyers and sellers.

A trading ratio accounts for differences in attenuation [A] of phosphorus load from each discharger and equalizes the load that is traded. Trading ratios are a common practice in water quality trading programs (e.g., Long Island Sound, Lower Minnesota

River) and are recommended by USEPA (2004) to ensure that trades protect water quality.

As described by Omni (2007c):

> Attenuation is a result of the uptake of orthophosphate by plants and the physical sorption and settling of orthophosphate and organic phosphorus that occurs in the stream. Plant uptake and settling vary spatially. This variability causes the loads from different source zones to be attenuated at different rates along the stream network. The phosphorus attenuation of a given point source zone depends on three factors: 1) the distance between the outlet of the point source zone and the target location; 2) the settling and uptake rates of orthophosphate and organic phosphorus occurring in the flow path from a given zone to a target location; and 3) the ratio of orthophosphate and organic phosphorus discharged from the point source zone.

Omni was contracted to apply the in-stream water quality model developed for the TMDL (Omni, 2007a), and derive total phosphorus persistence coefficients for the watershed. A persistence coefficient [P] represents the fraction of phosphorus discharged from a point source that reaches a particular downstream location; it is the fraction of phosphorus that is not attenuated (i.e., P=1-A). Omni's (2007c) methodology for deriving persistence coefficients can be summarized as follows:

1. Point sources were divided into ten zones (Table 5-1). Within each zone, no attenuation is assumed. (The project team subsequently merged the Whippany and Troy-Hill zones, yielding a total of nine zones).
2. A baseline simulation was executed in which each point source discharged 1.0 mg/l total phosphorus, consisting of 0.875 mg/l orthophosphate and 0.125 mg/l organic phosphorus at permitted flows.
3. One at a time, each point source zone was "turned off" and set to discharge zero load of total phosphorus. The result was then compared to the baseline simulation at a series of downstream locations. Thus the effect of completely

removing phosphorus from a particular point source zone could be quantified downstream.

4. The persistence coefficient was calculated.

> The zonal [persistence] coefficient [or ZPC] represents the equivalent total phosphorus load reduction at target location *j* due to a unit load reduction in the source zone *i*… For every pound of phosphorus reduced from a point source zone, how much is reduced at the various target locations [downstream]? If a 10-pound reduction at a point source zone results in a 9-pound reduction at a target location, the zonal [persistence] coefficient would be 0.90 (Omni, 2007c).

5. The above steps were performed for three separate diversion scenarios to obtain three sets of attenuation coefficients
    a. Water Year 2001, without any simulated diversions (i.e., No Diversion condition).
    b. Water Year 2001, with simulated diversions. This approximates the condition where water is diverted from only the Pompton River (i.e., Diversion condition).
    c. Water Year 2002, with simulated diversions. This approximates the condition where water is diverted from both the Upper Passaic and Pompton Rivers (i.e., Extreme Diversion condition).

Table 5-2 shows an example of zonal persistence coefficients for the Rockaway Zone under each diversion condition.

Derivation of trading ratios

The persistence coefficients were then used to develop trading ratios:

$$\text{Trading ratio}_{\text{seller to buyer}} =$$

$$(\text{Seller's persistence coefficient})_j \,/\, (\text{Buyer's persistence coefficient})_j$$

where *j* is a *shared* TMDL critical location

The trading ratio is based on the *relative* persistence of phosphorus discharged from two point sources toward a *shared* TMDL critical location. A trading ratio is necessary to equalize the load exchanged relative to the shared TMDL critical location. A trading ratio of 0.9 means that 1,000 kg abated by the seller has the same effect at the shared TMDL critical location as 900 kg abated by the buyer, therefore the seller's 1,000 kg is worth 900 kg to the buyer. Trading ratios vary depending on the buyer and seller in question. The same seller might find different trading ratios available depending on who the buyer is because relative persistence changes with each pair of point source zones. Given the same buyer/seller pair, a lower trading ratio is more conservative with respect to water quality protection. On the other hand, reducing the trading ratio will also make trades less economically desirable.

Identifying the shared TMDL critical location was a key task when deriving trading ratios for three distinct diversion conditions, as illustrated below.

In the case of the No Diversion condition, Dundee Lake is the only TMDL critical location affected by dischargers, and all trading ratios were calculated relative to Dundee Lake.

In the case of the Diversion condition, dischargers in the Upper and Lower Passaic Management Areas affect Dundee Lake, and trading ratios between point source zones of these two management areas were calculated relative to Dundee Lake. Dischargers in the Pompton Management Area affect both the Wanaque South intake and Dundee Lake, therefore trading ratios between point source zones of this management area were selected according to which TMDL critical location yielded the lower and more conservative trading ratio. Trading ratios between point source zones in the Pompton and Upper or Lower Passaic Management Areas were calculated relative to Dundee Lake.

In the case of the Extreme Diversion condition, dischargers in the Lower Passaic Management Areas affect Dundee Lake, and trading ratios between point source zones in this management area were calculated relative to Dundee Lake. Also, trading ratios between point source zones in the Lower Passaic Management Area and Pompton or Upper Passaic Management Areas were calculated relative to Dundee Lake. Dischargers in the Upper Passaic and Pompton Management Areas affect both the Wanaque South intake and Dundee Lake, therefore trading ratios between point source zones in these management areas were selected according to which TMDL critical location yielded the lower and more conservative trading ratio.

Trading ratios for prohibited inter-Management Area trades were set to zero.

Appendix 4 contains examples of the derivation of trading ratios.

Tables 5-3 and 5-4 list the point source zone and allocation for each discharger.

This process resulted in three possible sets of trading ratios for each buyer/seller pair. The three sets of trading ratios were then compiled into one matrix by selecting the minimum trading ratio, or worst case, for each buyer/seller pair. The resulting trading ratio matrix (Table 5-5) was thus expected to achieve compliance with TMDL water quality targets under all possible diversion conditions.

However, there are a number concerns about this matrix from an economic point of view. First, it could lead to overabatement in some areas relative to the least cost solution of meeting the TMDL. Second, the proposed trading ratio matrix is not symmetric, due to the selection of different diversion scenarios and TMDL critical locations as the basis for establishing trading ratios. The lack of symmetry results in multiple trading ratios related to a single trade depending on the path of the trade. In certain cases, for example, a buyer and seller could achieve one ratio through a direct trade or a different ratio if they trade indirectly through a third party. This is a concern from a project implementation perspective because the expansion of trading ratios beyond a simple symmetric pricing may discourage trading. The possibility of arbitrage, wherein A sells to B, B sells to C, and C subsequently sells back to A in a manner that A ends up with more allowances and/or more money than the original allocation, also arises with asymmetric trading ratios. However, here such an outcome is not possible as the proposed matrix is based on worst case ratios. Rather, it is more likely that price asymmetry could result in loss, or "leakage," of kilograms from the market. As a simple example, suppose that A sells one kilogram to B and subsequently asks for a kilogram back in a later trade. While such a sequence of trades might not appear rational, there is the potential that A "oversells" allowances early in the year and then realizes a shortage of allowances at the end of the trading period. If asymmetric worst case ratios are applied, then the amount that B has to sell back in the second trade will be larger than what B initially purchased from A. Although "leakage" of kilograms from the market might be desirable for water quality protection, this will reduce the transparency of the pricing mechanism and may inhibit trading, especially in cases for which the marginal gains of trade are likely to be small.

To address this issue, an alternative trading ratio matrix (Table 5-6) was developed that was based on the *average*, rather than the *minimum*, of the three trading ratio sets. Economically, the alternative table had the advantage of symmetry, and the higher trading ratios were more conducive to trading. However, in terms of water quality protection, the higher ratios in the alternative table were less conservative.

Trading scenario simulations described in the next section demonstrated that the alternative "average" table did not fully achieve compliance with TMDL water quality targets. In fact, for reasons described in Section V, a third trading ratio table (Table 5-7) was developed which reduced the ratios in Table 5-5 by 10%. (Intra-point source zone trading ratios remained at 1.00). Although the lack of symmetry in Table 5-7 is subject to the same economic concerns ascribed to the Table 5-5 matrix, its effects on the trading program are somewhat mitigated by the small number of expected trades (Sado, 2006) in that trading in the Passaic is much more likely to take the form of a limited number of bilateral trades rather than a high volume exchange market (Boisvert et al., 2007, 2008). Also, examination of the Table 5-7 numbers reveals that there are no situations where trading through a third party could offer a higher and more lucrative trading ratio. Thus the asymmetry of Table 5-7 does not allow for third party attempts to abuse the system.

Trading with the purveyor

The TMDL (NJDEP, 2008) allows for the possibility of trades between a discharger and the North Jersey District Water Supply Commission (NJDWSC). NJDWSC is responsible for the Wanaque Reservoir and Wanaque South intake. Since NJDWSC is not a New Jersey Pollutant Discharge Elimination System (NJPDES) permittee (NJDEP, 2008), a regulatory mechanism for trades between NJDWSC and dischargers would need to be developed before any such trades could occur. Scenario simulations may also need to be executed to verify compliance with TMDL water quality targets.

Putting aside the present lack of regulatory mechanism and scenario simulations, consider two trading scenarios where NJDWSC would purchase allowances. The first scenario would have NJDWSC buying allowances from dischargers upstream of the Passaic-Pompton confluence and simply retiring these allowances. The second scenario would have NJDWSC buying allowances from dischargers upstream of the Passaic-Pompton confluence and reselling these allowances. In the first scenario, NJDWSC could calculate the benefit of purchasing and retiring allowances by using the persistence coefficients in Table 5-8. This table lists the persistence coefficients relative to the Wanaque South intake of each point source zone in the Upper Passaic and Pompton Management Areas at extreme diversion conditions. The persistence coefficients reflect the proportion of discharger load that affects the intake. For example, if NJDWSC were to fund an upgrade for a discharger in the Whippany Zone, 100 kilograms abated by the discharger has the effect of abating 13 kilograms at the Wanaque South intake at extreme diversion conditions. In contrast, if a discharger in the Two Bridges Zone abates 100 kilograms, that translates directly into 100 kilograms abated at the Wanaque South intake. In this type of discharger-purveyor trade, the discharger that receives funding for the upgrade would still apply the trading formula and then calculate its new balance; in the formula the allocation remains the same. The load discharged is updated to the level the discharger achieves following its upgrade, and the "actual load sold" to NJDWSC is deducted from its balance. Further trades between dischargers would continue to follow the same trading formula and trading ratio matrix (Table 5-7).

In the second scenario where NJDWSC is buying and then reselling allowances, NJDWSC would pay dischargers upstream of the Passaic-Pompton confluence to upgrade to a higher treatment level, thereby obtaining the allowances generated from the upgrade. The NJDWSC could then sell these allowances to other dischargers that want to purchase allowances. In reselling the allowances, NJDWSC would adopt the trading ratio in Table 5-7 that applies to a direct sale from the discharger that upgraded to the discharger that purchases. For example, a direct sale from Rockaway Valley SA (in the Rockaway Zone) to Caldwell Boro STP (in the Upper Passaic Zone 2) has a trading ratio of 0.60. If Rockaway Valley SA abates 1,000 kg, it is worth 600 kg to Calwell Boro STP. Therefore, if NJDWSC pays Rockaway Valley SA to abate 1,000 kg at its outfall, NJDWSC could then sell those allowances to Caldwell Boro (in the Upper Passaic Zone 2) at a trading ratio of 0.60. Both dischargers would then apply the trading formula to update their balances. TMDL water quality targets at the critical locations are achieved because the Table 5-7 ratios are applied.

The opposite type of trade, where dischargers pay NJDWSC to directly treat the surface water diverted at the Wanaque South intake, is viable only if the trades address the need for dischargers in the Upper Passaic and Pompton Management Areas to treat in the November through April period. Provided that NJDWSC is adequately treating the diverted water, Dundee Lake becomes the sole TMDL critical location of concern, and the possibility of bidirectional trading between all management areas could be explored, as well as seasonal limits for dischargers in the Upper Passaic and Pompton Management Areas.

To properly compensate NJDWSC a discharger would first apply the trading formula to determine the magnitude of its negative balance and then multiply that by the appropriate persistence coefficient in Table 5-8 to determine its equalized load at the Wanaque South intake. For example, if a discharger in the Rockaway Zone had a balance of -1,000 kg, application of the 0.10 persistence coefficient equalizes that to 100 kg at the intake, and the discharger would need to compensate NJDWSC for removal of 100 kg at the intake. With respect to Dundee Lake, its balance of -1,000 kg remains unchanged and needs to be offset using trading ratios in Table 5-7.

Note that the dischargers in the Upper Passaic Management Area and Pompton Management Area only affect the Wanaque South intake at extreme diversion conditions and diversion or extreme diversion conditions, respectively. Since trades of this type would be done directly with NJDWSC, it might be feasible to only charge Upper Passaic Management Area dischargers in years when an extreme diversion occurs. Similarly, Pompton Management Area dischargers would only be charged in years when a diversion or extreme diversion occurs. The practicality of this approach would need to be determined by the parties involved.

VI. Trading scenarios

Scenario development objectives

A series of trade scenarios were simulated to investigate if the proposed management area framework and trading ratios would achieve compliance with TMDL water quality targets and ensure hot spot avoidance at the TMDL critical locations and other areas of concern. Scenarios that would most stress the system and simulate critical conditions were developed to test the proposed trading program.

There were four scenario development objectives:

1. Verify that trades between dischargers on different tributaries, or with the seller downstream, achieve compliance with TMDL water quality targets.
2. Investigate if trading ratios greater than one (1) achieve compliance with TMDL water quality targets. This applies to trades where the seller is downstream.
3. Compare trading ratios based on averages to trading ratios based on minima. Investigate if the former fully achieves compliance with TMDL water quality targets.
4. Investigate impact of using an allocation based on *anticipated* discharger flow rather than *actual* discharger flow. What happens in a dry year, when the actual discharger flow is less than anticipated and discharger flow and point sources can discharge more than 0.4 mg/l and still meet their allocation?

Various intra-management area and inter-management area trades were devised to test objectives 1 and 2. In particular, scenarios 2-13 tested objective 1, and scenarios 2, 3, 7-9 tested objective 2.

To test objectives 3 and 4, four cases were developed.

Case 1: Seller and buyer flows set to average discharger flow from 2004-2006; minimum trading ratio (Table 5-5) applied.

Case 2: Seller and buyer flows set to average discharger flow from 2004-2006; average trading ratio (Table 5-6) applied.

Case 3: Seller and buyer flows set to lowest annual discharger flow from 2004-2006; minimum trading ratio (Table 5-5) applied.

Case 4: Seller and buyer flows set to lowest annual discharger flow from 2004-2006; average trading ratio (Table 5-6) applied.

Note that average trading ratios (Table 5-6) are symmetric and thus more favorable to market transactions. However minimum trading ratios (Table 5-5) are more conservative for water quality protection. Also, the 2004-2006 period was used for calculating average discharger flows and allocations from each discharger because the 2007 data was incomplete at the time of scenario development. Finally, the 29 dischargers outside the model domain were not included in the trading scenario simulations because they are not eligible to trade.

Cases 3 and 4 are critical because at low effluent flow, the WWTPs can discharge at higher concentrations than in Cases 1 and 2 and still meet trading allocations.

Diversions

For each scenario, the most vulnerable diversion condition was assessed by referencing which diversion condition yielded the minimum trading ratio. The scenario was then simulated at that diversion condition. Scenarios 8-10 had two possible "most vulnerable diversion conditions;" separate simulations for the two diversion conditions were run.

Baseline simulations

Six baseline simulations (Table 6-1) were developed for comparison to the appropriate trading scenario and case. In each baseline, no trading occurs and all plants discharge 0.4 mg/l of total phosphorus. Each of the baseline simulations reflects one of the three diversion conditions, and one of the two sets of discharger flows.

Scenario development

Tables 6-2 and 6-3 list and describe each scenario.

In general terms:

- Scenario 1 was designed to test the safest form of trading, with the seller upstream on the same tributary.
- Scenario 2 was designed to test trading on the same tributary with the seller downstream.
- Scenarios 3 and 4 were designed to test cross-tributary trading with the trading ratio > 1 and then capped at 1.
- Scenarios 5-11 were designed to test a complex variety of cross-tributary and inter-MA (management area) trades.
- Scenario 12-13 were designed to test more straightforward inter-MA trades.

In table 6-2, note that depending on the WWTP flows and trading ratio applied, the buyer LTA can vary and still satisfy the trade. For example, in table 6-2 see Scenario 1, Case 1. In Case 1, plant flows are set to equal the anticipated actual discharger flows (i.e., average discharger flows from 2004-2006). The trading ratio is the minimum ratio from the three diversion conditions (in this case "extreme diversion"), so it is simulated at that condition. If the buyer discharges an LTA of 0.85 mg/l and the seller discharges at 0.1 mg/l, then the buyer's balance is offset. However, when scenario 1 is tested at Case 2 conditions, the higher trading ratio allows the buyer to discharge at 0.90 mg/l and still offset its balance. Thus comparing Case 1 to Case 2, and Case 3 to Case 4 provides a test of whether a higher trading ratio (and thus higher discharge LTAs) still results in compliance with TMDL water quality targets at average and less than average WWTP flow conditions.

Scenario results

TMDL critical location*:* Wanaque South intake

In all trading scenario simulations, the total phosphorus diverted at the Wanaque South intake was equal to or less than the baseline no-trade scenario (Table 6-4). In particular, scenarios 5 and 7-12 where the Two Bridges Sewerage Authority (TBSA) was a seller realized the greatest reductions in total phosphorus diverted. This is due to the TBSA outfall being located directly upstream of the intake. An upgrade at TBSA beyond the 0.4 mg/l requirement should have direct benefits to the amount of total phosphorus load diverted at the Wanaque South intake.

TMDL critical location: Dundee Lake

Initial results

Table 6-5 indicates that some trading scenario simulations yielded summer average chl-*a* concentrations that were up to 4% greater than the baseline no-trade scenario. Although the deviations were generally small (< 0.57 µg/l), the initial results were not acceptable in demonstrating compliance with TMDL water quality targets at Dundee Lake. Table 6-5 demonstrates that in Case 4, the average-based trading ratios from Table 5-6 did not result in compliance in 6 of 13 trade scenarios (e.g., scenarios 2, 5, 8-11). Of greater concern, in Case 3 the minimum-based trading ratios from Table 5-5 did not result in compliance in 2 of 13 trade scenarios (e.g., scenarios 2 and 8).

Analysis of the initial results found that the minimum-based ratios, and to a lesser extent the average-based ratios, were successful for most but not all cross-tributary and seller downstream trades. In particular, neither set of trading ratios was successful when buyers were concentrated upstream, as in scenarios 2 and 8.

Calibrated results

Because the minimum-based trading ratios (Table 5-5) did not achieve compliance with TMDL water quality targets at critical conditions (i.e., Case 3) under two scenarios, the Table 5-5 trading ratios were reduced by 10% resulting in the Table 5-7 set of trading ratios. (Intra-point source zone trading ratios were left at 1.00). Scenarios 2 and 8 at critical Case 3 conditions were re-simulated with Table 5-7 trading ratios (Table 6-6). With the reduced trading ratios, trading scenario simulations yielded summer average chl-*a* concentrations in Dundee Lake that were less than or equal to the baseline no-trade scenario (Table 6-7).

Other scenarios at Case 3 conditions, which had succeeded with Table 5-5 ratios, were not re-simulated with Table 5-7 ratios. Had they been re-simulated, the result would have been even more favorable than what is reflected in Cases 1 and 3 in Tables 6-4 and 6-5.

Other areas of concern

The Omni (2007a) report on TMDL model development referenced three locations as “areas of concern:” Passaic River near Chatham, Passaic River at Little Falls intake, and Peckman River mouth. Trading scenario output was analyzed at these locations in addition to the TMDL critical locations to verify that trades would not result in upstream hot spots. Figure 6-1 maps the TMDL critical locations and areas of concern.

The results described below are at critical Case 3 conditions, utilizing Table 5-5 trading ratios for all but scenarios 2 and 8. Had Table 5-7 trading ratios been applied to all Case 3 scenarios, equal or better results would have been obtained.

Passaic River near Chatham: All scenarios showed negligible differences in summer average dissolved oxygen concentrations (≤ 0.1 mg/l), maximum dissolved oxygen swing (≤ 0.1 mg/l), and percent dissolved oxygen compliance (≤ 0.1%), as compared to the baseline no-trade scenario.

Passaic River at Little Falls intake: All scenarios showed negligible differences (≤ 0.02 mg/l TP) in annual and summer average TP concentrations, as compared to the baseline no-trade scenario.

Peckman River mouth: All scenarios showed negligible differences in summer average dissolved oxygen concentrations (≤ 0.1 mg/l), maximum DO swing (≤ 1.0 mg/l), and percent dissolved oxygen compliance (≤ 0.4%), as compared to the baseline no-trade scenario.

Evaluation matrices

Table 6-9 defines the evaluation matrix criteria for each TMDL critical location and area of concern. Table 6-10 through 6-24 contain the evaluation matrices for each location with each trading ratio matrix. Only the scenarios that utilized the trading ratios of Table 5-7 (i.e., the most conservative set of ratios) were able to pass all the criteria at all locations.

Conclusion

Extensive simulations of a variety of trading scenarios were undertaken to validate the proposed trading program. In-stream water quality model simulations have verified that the reduced trading ratios in Table 5-7 should achieve compliance with TMDL water quality targets at the critical locations under high-stress trading conditions (dischargers emitting less than anticipated flow), heavy cross-tributary trading, critical diversion conditions, and scenarios where buyers are concentrated either upstream or downstream. Similar trends were predicted to occur at other areas of concern upstream of the TMDL critical locations. It is therefore recommended to apply the Table 5-7 trading ratios to safely execute water quality trading within a management area framework.

VII. Additional topics

Monitoring

Monitoring is important to verify that trades are having the desired effect on water quality. In addition to Discharge Monitoring Reports (DMRs), which document effluent levels at the discharger outfalls and are submitted by the discharger, in-stream monitoring should also be done. The draft Quality Assurance Project Plan (QAPP) in Appendix 6 details the methodology for in-stream monitoring of water quality for the Passaic trading program.

Finally, the likelihood of enforcement is as important as monitoring to the effectiveness of any trading program. There will be little incentive to verify the trade transactions unless there exists a relative certainty of NJDEP enforcement in the case of violation. The right of NJDEP to enforce against violating dischargers should be clearly stated in the compliance mechanism that governs trading.

Trading with Municipal Separate Storm Sewer Systems (MS4s) and Nonpoint Sources

The water quality trading program described in this report has been designed for trading between point sources. In the Non-Tidal Passaic River Basin, point sources are the dominant source of phosphorus loading (NJDEP, 2008), thus the focus on point-point source trading will be effective in implementing the TMDL.

A feasibility study of trading with MS4s was completed (Passaic Water Quality Trading Project, 2006c) and found that small dischargers of less than 1 MGD average flow could benefit if MS4s were required to reduce their load by 40% from current levels. The adopted TMDL assigns a MS4 load reduction of 60% in most of the drainage area. Further phosphorus load reduction to sell to other point sources would require accurate quantification. Moreover, the legal question of how an MS4 can generate allowances to sell if MS4s are required to remove loads to the "maximum extent feasible (MEF)" is unresolved at this time.

The Peckman River mouth was described in the Omni (2007a) report on TMDL model development as a potential area for nonpoint source trading. It was suggested that increased canopy cover might decrease the large diurnal swings of dissolved oxygen observed at this area of concern. To define the terms of a point-nonpoint source trade on the Peckman River, further studies should be done to quantify the benefit that increased canopy cover would have as compared to decreased phosphorus loading from point sources on the Peckman River.

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TABLES

Table 4-1: Category 1 and Category 2 dischargers

Discharger ID on Figure 3-4	Name	Category	Inside or outside model domain	NJPDES permit no.
1	Berkeley Heights	2	Inside	NJ0027961
2	Molitor Water Pollution	2	Inside	NJ0024937
3	Verona Twp STP #	2	Inside	NJ0024490
4	Warren Twp SA - Stage 1 & 2	2	Inside	NJ0022489
5	Warren Twp SA - Stage 4	2	Inside	NJ0022497
6	Warren Twp SA - Stage 5	2	Inside	NJ0050369
7	Chatham Township - Main	1	Outside	NJ0020290
8	Rockaway Valley SA	2	Inside	NJ0022349
9	Long Hill Twp STP - Stirling Hills	2	Inside	NJ0024465
10	Hanover SA STP	2	Inside	NJ0024902
11	Morris Twp - Butterworth	2	Inside	NJ0024911
12	Morris Twp - Woodland	1	Outside	NJ0024929
13	Parsippany-Troy Hills SA	2	Inside	NJ0024970
14	Morristown Town STP	2	Inside	NJ0025496
15	Florham Park SA	2	Inside	NJ0025518
16	Two Bridges SA	2	Inside	NJ0029386
17	Chatham Township - Chatham Glen	2	Inside	NJ0052256
18	Caldwell Boro STP	2	Inside	NJ0020427
19	Livingston Twp	2	Inside	NJ0024511
20	Wayne Twp - Mountain View #	2	Inside	NJ0028002
21	Cedar Grove Twp STP #	2	Inside	NJ0025330
22	Pompton Lakes MUA	2	Inside	NJ0023698
23	Wanaque Valley RSA	2	Inside	NJ0053759
24	Harrison Brook STP	2	Inside	NJ0022845
25	Exxon Research & Engineering Company	2	Outside	NJ0003476
26	Veterans Adm Medical Center	2	Outside	NJ0021083
27	Stonybrook School*	1	Outside	NJ0022276
28	Our Lady of Magnificent School*	1	Outside	NJ0024457
29	Oakland Care Center	1	Outside	NJ0029858
30	Jefferson Twp High - Middle School*	1	Outside	NJ0021091
31	Jefferson Twp - White Rock*	1	Outside	NJ0026867
32	West Milford Twp MUA – Highview*	1	Outside	NJ0027685
33	Ringwood Boro - Ringwood Acres	1	Outside	NJ0027006
34	Ringwood Plaza - Ringwood Assn	1	Outside	NJ0032395
35	Ringwood BOE - Erskine School	1	Outside	NJ0029432
36	W Milford Twp MUA - Crescent Park STP	1	Outside	NJ0026174
37	West Milford Twp MUA- Olde Milford	1	Outside	NJ0027677
38	Reflection Lake Garden Apts	1	Outside	NJ0027201
39	W Milford Shopping Center	1	Outside	NJ0024414

40	West Milford Twp MUA - Birchill	1	Outside	NJ0028541
41	West Milford Twp MUA - Awosting	1	Outside	NJ0027669
42	Chatham Hill STP	2	Inside	NJ0020281
43	New Providence Boro	2	Outside	NJ0021636
44	NJDHS - Greystone Psych Hosp	2	Outside	NJ0026689
45	Bayer Corporation #	2	Outside	NJ0104451
46	Nabisco Fair Lawn Bakery #	2	Outside	NJ0002577
47	Plains Plaza Shopping Center	2	Outside	NJ0026514
48	Ramapo River Club STP - Oakland Twp Riverbend	2	Outside	NJ0080811
49	Oakland Boro - Oakwood Knolls	2	Outside	NJ0027774
50	Ramapo BOE - Indian High	2	Outside	NJ0021253
51	Oakland Boro Skyview-Highbrook STP	2	Outside	NJ0021342
52	Oakland Boro - Chapel Hill Estates	2	Outside	NJ0053112

Dischargers in Lower Passaic Management Area subject to seasonal limits
* 0.4 mg/l does not apply, rather current permit limits apply
Note: Only the Category 2 dischargers that were inside the model domain are eligible to participate in the trading program.

Table 5-1: Point source zones developed for Omni attenuation analysis (Omni, 2007c)

Point Source Zone	Discharger
Dead River Zone	Harrison Brook STP
	Warren Twp SA - Stage 5
	Warren Twp SA - Stage 4
Upper Passaic Zone 1	Long Hill Twp STP - Stirling Hills
	Warren Twp SA - Stage 1 & 2
	Berkeley Heights
	Chatham Hill STP
	Chatham Township - Chatham Glen
Upper Passaic Zone 2	Florham Park SA
	Livingston Twp
	Caldwell Boro STP
	Molitor Water Pollution
Rockaway Zone	Rockaway Valley SA
Whippany Zone	Morris Twp - Butterworth
	Morristown Town STP
	Hanover SA STP
Troy Hill Zone	Parsippany-Troy Hills SA
Pompton Headwater Zone	Wanaque Valley RSA
	Pompton Lakes MUA
Two Bridges Zone	Two Bridges SA
Singac Zone	Wayne Twp - Mountain View
Peckman Zone	Verona Twp STP
	Cedar Grove Twp STP

Table 5-2: Rockaway Zone annual zonal persistence coefficients (ZPCs), adapted from Omni (2007c)

Station	Miles from point source zone outlet	ZPC, No Diversion	ZPC, Diversion	ZPC, Extreme Diversion
Rockaway just upstream of confluence with Whippany	6.2	0.85	0.85	0.78
Passaic just upstream of confluence with Pompton	20.5	0.67	0.67	0.54
Passaic at Little Falls	24.0	0.64	0.58	0.39
Passaic at Great Falls	28.4	0.64	0.56	0.30
Passaic at Dundee Dam	36.2	0.63	0.56	0.29
Wanaque South intake	20.7	____	____	0.10

Table 5-3: Point source zones and allocations for trading, listed in order of Discharger ID (2005-2007 avg. flow based on NJDEP OPRA DMR database, accessed August 5, 2008)

Discharger ID on Figure 3-4	Name	Category	Point Source Zone	Allocation (kg/yr)	2005-2007 avg. flow (MGD)	Permitted flow (MGD)	NJPDES permit no.
1	Berkeley Heights	2	Upper Passaic 1	872.3	1.5784	3.1	NJ0027961
2	Molitor Water Pollution	2	Upper Passaic 2	1,378.7	2.4946	3.5	NJ0024937
3	Verona Twp STP #	2	Lower Passaic 2	655.0	2.3703	3	NJ0024490
4	Warren Twp SA - Stage 1 & 2	2	Upper Passaic 1	207.7	0.3758	0.47	NJ0022489
5	Warren Twp SA - Stage 4	2	Dead	163.2	0.2953	0.8	NJ0022497
6	Warren Twp SA - Stage 5	2	Dead	93.1	0.1685	0.38	NJ0050369
8	Rockaway Valley SA	2	Rockaway	5,808.1	10.5092	12	NJ0022349
9	Long Hill Twp STP - Stirling Hills ^	2	Upper Passaic 1	497.4	1.0526	0.9	NJ0024465
10	Hanover SA STP	2	Whippany	1,144.2	2.0703	4.61	NJ0024902
11	Morris Twp – Butterworth	2	Whippany	1,109.4	2.0073	3.3	NJ0024911
13	Parsippany-Troy Hills SA	2	Whippany	6,946.3	12.5686	16	NJ0024970
14	Morristown Town STP	2	Whippany	1,426.5	2.5811	6.3	NJ0025496
15	Florham Park SA	2	Upper Passaic 2	500.2	0.9051	1.4	NJ0025518
16	Two Bridges SA	2	Two Bridges	3,207.5	5.8037	10	NJ0029386
17	Chatham Township - Chatham Glen	2	Upper Passaic 1	66.4	0.1202	0.155	NJ0052256
18	Caldwell Boro STP	2	Upper Passaic 2	2,166.2	3.9194	4.5	NJ0020427
19	Livingston Twp	2	Upper Passaic 2	1,219.1	2.2058	4.6	NJ0024511
20	Wayne Twp - Mountain View #	2	Lower Passaic 1	2,271.6	8.2203	13.5	NJ0028002
21	Cedar Grove Twp STP #	2	Lower Passaic 2	413.0	1.4947	2	NJ0025330

22	Pompton Lakes MUA	2	Pompton Headwater	499.2	0.9032	1.2	NJ0023698
23	Wanaque Valley RSA	2	Pompton Headwater	584.4	1.0574	1.25	NJ0053759
24	Harrison Brook STP	2	Dead	947.2	1.7138	2.5	NJ0022845
42	Chatham Hill STP ^	2	Upper Passaic 1	4.3	0.0077	0.03	NJ0020281
#	Lower Passaic Management Area subject to seasonal limits; summer allocation shown						
*	0.4 mg/l does not apply, rather current permit limits apply						
^	Permitted flow < actual flow; used permitted flow for allocation						

Note: Only the Category 2 dischargers that were inside the model domain are eligible to participate in the trading program.

Table 5-4: Point source zones and allocations for trading, listed in order of point source zone and allocation size (2005-2007 avg. flow based on NJDEP OPRA DMR database, accessed August 5, 2008)

Discharger ID on Figure 3-4	Name	**Point Source Zone**	Allocation (kg/yr)	2005-2007 avg. flow (MGD)	Permitted flow (MGD)	NJPDES permit no.
24	Harrison Brook STP	Dead River	947.2	1.7138	2.5	NJ0022845
5	Warren Twp SA - Stage 4		163.2	0.2953	0.8	NJ0022497
6	Warren Twp SA - Stage 5		93.1	0.1685	0.38	NJ0050369
20	Wayne Twp - Mountain View #	Lower Passaic 1	2,271.6	8.2203	13.5	NJ0028002
3	Verona Twp STP #	Lower Passaic 2	655.0	2.3703	3	NJ0024490
21	Cedar Grove Twp STP #		413.0	1.4947	2	NJ0025330
23	Wanaque Valley RSA	Pompton Headwater	584.4	1.0574	1.25	NJ0053759
22	Pompton Lakes MUA		499.2	0.9032	1.2	NJ0023698
8	Rockaway Valley SA	Rockaway	5,808.1	10.5092	12	NJ0022349
16	Two Bridges SA	Two Bridges	3,207.5	5.8037	10	NJ0029386
1	Berkeley Heights	Upper Passaic 1	872.3	1.5784	3.1	NJ0027961
9	Long Hill Twp STP - Stirling Hills ^		497.4	1.0526	0.9	NJ0024465
4	Warren Twp SA - Stage 1 & 2		207.7	0.3758	0.47	NJ0022489
17	Chatham Township - Chatham Glen		66.4	0.1202	0.155	NJ0052256
42	Chatham Hill STP		4.3	0.0077	0.03	NJ0020281
18	Caldwell Boro STP	Upper Passaic 2	2,166.2	3.9194	4.5	NJ0020427
2	Molitor Water Pollution		1,378.7	2.4946	3.5	NJ0024937
19	Livingston Twp		1,219.1	2.2058	4.6	NJ0024511
15	Florham Park SA		500.2	0.9051	1.4	NJ0025518
13	Parsippany-Troy Hills SA		6,946.3	12.5686	16	NJ0024970

14	Morristown Town STP	Whippany	1,426.5	2.5811	6.3	NJ0025496
10	Hanover SA STP		1,144.2	2.0703	4.61	NJ0024902
11	Morris Twp – Butterworth		1,109.4	2.0073	3.3	NJ0024911
#	Lower Passaic Management Area subject to seasonal limits; summer allocation shown					
*	0.4 mg/l does not apply, rather current permit limits apply					
^	Permitted flow < actual flow; used permitted flow for allocation					

Note: Only the Category 2 dischargers that were inside the model domain are eligible to participate in the trading program.

Table 5-5: Initial trading ratio matrix A, based on minima of three diversion scenarios (sellers in rows, buyers in columns)

		Upper Passaic Management Area					**Pompton Management Area**		**Lower Passaic Management Area**	
	Buyer / Seller	Dead River Zone	Upper Passaic Zone 1	Upper Passaic Zone 2	Whippany zone	Rockaway Zone	Pompton Headwater Zone	Two Bridges Zone	Lower Passaic Zone 1	Lower Passaic Zone 2
Upper Passaic Management Area	Dead River Zone	1.00	0.95	0.87	0.97	1.11	0.00	0.00	0.60	0.44
	Upper Passaic Zone 1	1.00	1.00	0.87	1.00	1.14	0.00	0.00	0.63	0.46
	Upper Passaic Zone 2	1.03	1.00	1.00	1.06	1.21	0.00	0.00	0.68	0.50
	Whippany zone	0.91	0.89	0.86	1.00	1.14	0.00	0.00	0.58	0.43
	Rockaway Zone	0.72	0.70	0.67	0.77	1.00	0.00	0.00	0.47	0.35
Pompton Management Area	Pompton Headwater Zone	0.54	0.51	0.48	0.56	0.69	1.00	0.80	0.32	0.24
	Two Bridges Zone	0.68	0.64	0.60	0.69	0.84	0.92	1.00	0.40	0.30
Lower Passaic Management Area	Lower Passaic Zone 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.74
	Lower Passaic Zone 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	1.00

Table 5-6: Initial trading ratio matrix B, based on averages of three diversion scenarios (sellers in rows, buyers in columns)

		Upper Passaic Management Area					**Pompton Management Area**		**Lower Passaic Management Area**	
	Buyer Seller	Dead River Zone	Upper Passaic Zone 1	Upper Passaic Zone 2	Whippany zone	Rockaway Zone	Pompton Headwater Zone	Two Bridges Zone	Lower Passaic Zone 1	Lower Passaic Zone 2
Upper Passaic Management Area	Dead River Zone	1.00	0.98	0.92	1.01	1.25	0.00	0.00	0.66	0.48
	Upper Passaic Zone 1	1.02	1.00	0.96	1.03	1.28	0.00	0.00	0.69	0.51
	Upper Passaic Zone 2	1.09	1.05	1.00	1.10	1.35	0.00	0.00	0.75	0.55
	Whippany zone	0.99	0.97	0.91	1.00	1.18	0.00	0.00	0.64	0.47
	Rockaway Zone	0.80	0.78	0.74	0.85	1.00	0.00	0.00	0.51	0.38
Pompton Management Area	Pompton Headwater Zone	0.59	0.56	0.52	0.61	0.76	1.00	0.98	0.35	0.26
	Two Bridges Zone	0.74	0.71	0.65	0.76	0.92	1.02	1.00	0.44	0.33
Lower Passaic Management Area	Lower Passaic Zone 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.88
	Lower Passaic Zone 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14	1.00

Table 5-7: FINAL trading ratio matrix, based on 90% of inter-point source zone ratios in Table 5-5 (sellers in rows, buyers in columns)

		Upper Passaic Management Area					Pompton Management Area		Lower Passaic Management Area	
	Buyer Seller	Dead River Zone	Upper Passaic Zone 1	Upper Passaic Zone 2	Whippany zone	Rockaway Zone	Pompton Headwater Zone	Two Bridges Zone	Lower Passaic Zone 1	Lower Passaic Zone 2
Upper Passaic Management Area	Dead River Zone	1.00	0.85	0.78	0.87	1.00	0.00	0.00	0.54	0.40
	Upper Passaic Zone 1	0.90	1.00	0.78	0.90	1.03	0.00	0.00	0.57	0.42
	Upper Passaic Zone 2	0.92	0.90	1.00	0.96	1.09	0.00	0.00	0.61	0.45
	Whippany zone	0.82	0.80	0.77	1.00	1.03	0.00	0.00	0.52	0.39
	Rockaway Zone	0.65	0.63	0.60	0.69	1.00	0.00	0.00	0.42	0.31
Pompton Management Area	Pompton Headwater Zone	0.49	0.46	0.43	0.50	0.62	1.00	0.72	0.29	0.21
	Two Bridges Zone	0.61	0.58	0.54	0.63	0.76	0.83	1.00	0.36	0.27
Lower Passaic Management Area	Lower Passaic Zone 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.66
	Lower Passaic Zone 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	1.00

Table 5-8: Persistence coefficients at Wanaque South intake, at extreme diversion conditions; adapted from Omni (2007c)

Point source zone	Persistence coefficient at Wanaque South intake
Dead River Zone	**0.13**
Upper Passaic Zone 1	**0.13**
Upper Passaic Zone 2	**0.15**
Whippany zone	**0.13**
Rockaway Zone	**0.10**
Pompton Headwater Zone	**0.95**
Two Bridges Zone	**1.00**

Table 6-1: Trade scenario baseline simulations

Baseline simulations	Description
1	No Diversions, all WWTPs at 2004-2006 average flow
2	Diversion, all WWTPs at 2004-2006 average flow
3	Extreme Diversion, all WWTPs at 2004-2006 average flow
4	No Diversions, all WWTPs at 2004-2006 minimum annual flow
5	Diversion, all WWTPs at 2004-2006 minimum annual flow
6	Extreme Diversion, all WWTPs at 2004-2006 minimum annual flow

“No Diversion” refers to no water diverted from the Upper Passaic or Pompton Rivers.

This was simulated at Water Year 2001 conditions;

“Diversion” refers to water diverted from the Pompton River only, as occurred in Water Year 2001;

“Extreme Diversion” refers to water diverted from the Upper Passaic River and Pompton River, as occurred in Water Year 2002.

Table 6-2: Trading scenarios and cases

Scenario	**Seller**	**Buyer**	Case 1, 2 seller flow (MGD)	Case 3, 4 seller flow (MGD)	Case 1, 2 buyer flow (MGD)	Case 3, 4 buyer flow (MGD)	Case 1, 3 trading ratio	Case 2, 4 trading ratio	All Cases: Seller LTA (mg/l)	Case 1: Buyer LTA (mg/l)	Case 2: Buyer LTA (mg/l)	Case 3: Buyer LTA (mg/l)	Case 4: Buyer LTA (mg/l)
1	Berkeley Hts	Florham Park	1.61	1.61	0.9	0.86	0.87	0.96	0.100	0.850	0.900	0.890	0.940
2	Caldwell	Bernards (Harrison Brook)	4.06	3.99	1.8	1.78	1.03	1.09	0.100	1.000	1.000	1.000	1.000
		Warren V			0.16	0.15				1.450	1.900	1.700	2.200
3	Parsippany-Troy Hills	Rockaway	12.61	12.48	10.31	10.06	1.13	1.17	0.100	0.955	0.987	0.980	1.015
	Caldwell		4.06	3.99			1.21	1.35					
4	Parsippany-Troy Hills	Rockaway	12.61	12.48	10.31	10.06	1.00		0.100	0.885		0.910	
	Caldwell		4.06	3.99									
5	Parsippany-Troy Hills	Verona	12.61	12.48	2.54	2.41	0.43	0.47	0.100	1.000	1.000	1.000	1.000
		Cedar Grove			1.4	1.23				1.050	1.250	1.350	1.600
	Rockaway		10.31	10.06			0.35	0.38	0.100				
		Bernards (Harrison Brook)			1.8	1.78	0.72	0.80		1.000	1.000	1.000	1.000
	Two Bridges		5.82	5.57			0.68	0.74	0.100				
		Warren V			0.16	0.15	0.68	0.74		1.000	1.000	1.000	1.000

		Warren IV			0.34	0.28	0.68	0.74		1.000	1.000	1.000	1.000
		Warren I-II			0.38	0.37	0.64	0.71		1.000	1.250	1.000	1.000
		Chatham Glen			0.12	0.12	0.64	0.71		1.130	1.130	1.300	1.650
6	Wayne (Mountain View)	Verona	8.3	8.18	2.54	2.41	0.74	0.88	0.100	0.870	0.950	0.950	1.000
		Cedar Grove			1.4	1.23	0.74	0.88		0.860	0.970	0.920	1.110
7	Parsippany-Troy Hills	Cedar Grove	12.61	12.48	1.4	1.23	0.43	0.47	0.100	2.250	2.440	2.580	2.800
	Rockaway		10.31	10.06			0.35	0.38					
		Warren V			0.16	0.15	0.72	0.80	0.100	1.700	1.700	1.700	1.700
	Two Bridges	Florham Park	5.82	5.57	0.9	0.86	0.60	0.65	0.100	1.555	1.670	1.645	1.770
	Berkeley Heights	Warren IV	1.61	1.61	0.34	0.28	1.00	1.02	0.100	2.280	2.360	2.780	2.870
	Pompton Lakes		0.96	0.89			0.54	0.59					
	Morristown	Morris-Butterworth	2.72	2.15	2.1	2.02	1.00	1.00	0.100	0.870	0.880	0.935	0.945
	Wanaque RSA		1.04	0.96			0.56	0.61					
8	Parsippany-Troy Hills	Bernards (Harrison Brook)	12.61	12.48	1.8	1.78	0.90	0.98	0.100	3.130	3.450	3.200	3.525
	Rockaway		10.31	10.06			0.72	0.80	0.100				
		Warren V			0.16	0.15	0.72	0.80		1.850	1.850	1.850	1.850
		Warren I-II			0.38	0.37	0.70	0.78		1.620	1.620	1.620	1.620

	Two Bridges	Morris-Butterworth	5.82	5.57	2.1	2.02	0.69	0.76	0.100	0.980	1.035	1.025	1.085
	Berkeley Heights	Warren IV	1.61	1.61	0.34	0.28	1.00	1.02	0.100	1.820	1.840	2.200	2.250
	Morristown	Florham Park	2.72	2.15	0.9	0.86	0.86	0.91	0.100	1.340	1.410	1.470	1.540
	Wanaque RSA		1.04	0.96			0.48	0.52	0.100				
	Pompton Lakes	Chatham Glen	0.96	0.89	0.12	0.12	0.51	0.56	0.100	1.630	1.760	1.660	1.780
9	Parsippany-Troy Hills	Cedar Grove	12.61	12.48	1.4	1.23	0.43	0.47	0.100	1.000	1.105	1.160	1.282
		Bernards (Harrison Brook)			1.8	1.78	0.90	0.98	0.100	1.000	1.000	1.000	1.000
		Florham Park			0.9	0.86	0.86	0.90	0.100	0.990	0.990	1.000	1.000
	Rockaway	Hanover	10.31	10.06	2.14	2.1	0.77	0.85	0.100	1.000	1.000	1.000	1.000
		Long Hill			1.07	1.03	0.70	0.78		1.015	1.015	1.015	1.015
		Molitor (Madison-Chatham)			2.5	2.48	0.67	0.74		1.000	1.135	1.052	1.190
	Two Bridges		5.82	5.57			0.60	0.65	0.100				
	Pompton Lakes		0.96	0.89			0.48	0.52	0.100				
	Morristown	Morris-Butterworth	2.72	2.15	2.1	2.02	1.00	1.00	0.100	0.870	0.880	0.937	0.945
	Wanaque RSA		1.04	0.96			0.56	0.61	0.100				
	Berkeley Heights	Warren IV	1.61	1.61	0.34	0.28	1.00	1.02	0.100	1.000	1.000	1.000	1.000

		Warren I-II			0.38	0.37	1.00	1.00		0.940	0.950	1.130	1.140
		Chatham Glen			0.12	0.12	1.00	1.00		1.000	1.000	1.000	1.000
10	Parsippany-Troy Hills	Cedar Grove	12.61	12.48	1.4	1.23	0.43	0.47	0.100	0.900	0.990	1.065	1.170
		Bernards (Harrison Brook)			1.8	1.78	0.90	0.98		1.000	1.000	1.000	1.000
		Morris-Butterworth			2.1	2.02	0.98	1.00		0.840	0.840	0.840	0.840
	Rockaway	Livingston	10.31	10.06	2.61	2.34	0.67	0.74	0.100	1.000	1.000	1.000	1.000
		Caldwell			4.06	3.99	0.67	0.74		1.000	1.110	1.117	1.230
	Morristown		2.72	2.15			0.86	0.91	0.100				
	Berkeley Hts		1.61	1.61			0.87	0.96	0.100				
	Two Bridges		5.82	5.57			0.60	0.65	0.100				
		Florham Park			0.9	0.86	0.60	0.65		0.960	0.960	0.960	0.960
	Wanaque RSA		1.04	0.96			0.48	0.52	0.100				
	Pompton Lakes		0.96	0.89			0.48	0.52	0.100				
11	Parsippany-Troy Hills	Wayne (Mountain View)	12.61	12.48	8.3	8.18	0.58	0.64	0.100	0.950	1.000	0.970	1.035
	Rockaway		10.31	10.06			0.47	0.51	0.100				
	Two Bridges		5.82	5.57			0.40	0.44	0.100				
	Morristown		2.72	2.15			0.58	0.64	0.100				
		Florham Park			0.9	0.86	0.86	0.91		1.400	1.575	1.495	1.495

	Berkeley Hts		1.61	1.61			0.87	0.96	0.100				
	Wanaque RSA		1.04	0.96			0.48	0.52	0.100				
		Chatham Glen			0.12	0.12	0.51	0.56		2.030	2.030	2.030	2.030
	Pompton Lakes		0.96	0.89			0.51	0.56	0.100				
12	Two Bridges	Florham Park	5.82	5.57	0.9	0.86	0.60	0.65	0.100	1.555	1.670	1.645	1.770
13	Parsippany-Troy Hills	Verona	12.61	12.48	2.54	2.41	0.43	0.47	0.100	1.038	1.100	1.097	1.165

Table 6-3: Description of trading scenarios for water quality simulation

Scenario	Description	Diversion condition
1	Basic case with seller upstream on the same tributary	Extreme diversion
2	Seller is downstream on the same tributary	No diversion
3	Cross tributary trade with trading ratio > 1, within Upper Passaic MA	Diversion
4	Same as scenario 3, but with ratio capped at 1.0	Diversion
5	Sellers are “Big Three” (Two Bridges, Rockaway, Par-Troy); inter-MA trades to Lower Passaic 2, Dead, and Upper Passaic 1 zones	Extreme diversion
6	Cross tributary trade within Lower Passaic MA	Extreme diversion
7	Complex scenario; Sellers are Big Three + 4 WWTPs currently below 0.7; several cross trib and inter-MA trades to Lower Passaic 2, Dead, Upper Passaic 2, and Whippany zones	Extreme diversion
8	Complex scenario; Sellers are Big Three + 4 WWTPs currently below 0.7; several cross trib and inter-MA trades to Dead, Upper Passic 1, Upper Passaic 2, and Whippany zones. Buyers concentrated upstream.	Extreme diversion, No Diversion
9	Complex scenario; Sellers are Big Three + 4 WWTPs currently below 0.7; several cross trib and inter-MA trades to Lower Passaic 2, Dead, Upper Passaic 1, Upper Passaic 2, and Whippany zones	Extreme diversion, No Diversion
10	Similar to scenario 9 but more buying on Upper Passaic 2 than Whippany zones	Extreme diversion, No Diversion
11	Complex scenario; Sellers are Big Three + 4 WWTPs currently below 0.7; several cross trib and inter-MA trades to Lower Passaic 1, Upper Passic 1, and Upper Passaic 2 zones.	Extreme diversion
12	Inter-MA trade from Two Bridges to Upper Passaic 2 zone	Extreme diversion
13	Inter-MA trade from Par-Troy to Lower Passaic 2 zone	Extreme diversion

Table 6-4: Ratio of trade scenario to baseline for TP load diverted at Wanaque South intake (adapted from Omni, 2007d); applied trading ratios based on Table 5-5 and Table 5-6

	2001[a]				2002[b]			
Scenario	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 1**	**Case 2**	**Case 3**	**Case 4**
1	-	-	-	-	1.00	1.00	1.00	1.00
2	-	-	-	-	-	-	-	-
3	1.00	1.00	1.00	1.00	-	-	-	-
4	1.00	-	1.00	-	-	-	-	-
5	-	-	-	-	0.76	0.76	0.77	0.77
6	-	-	-	-	1.00	1.00	1.00	1.00
7	-	-	-	-	0.72	0.72	0.73	0.73
8	-	-	-	-	0.78	0.79	0.79	0.80
9	-	-	-	-	0.76	0.76	0.77	0.78
10	-	-	-	-	0.76	0.77	0.78	0.78
11	-	-	-	-	0.71	0.71	0.71	0.71
12	-	-	-	-	0.82	0.82	0.83	0.83
13	-	-	-	-	0.96	0.96	0.96	0.96

Ratio ≤ 1.00 indicates that the trade simulation had equal or better water quality than the no-trade baseline simulation.

Cases 1 and 3 applied trading ratios from Table 5-5. Cases 2 and 4 applied trading ratios from Table 5-6.

a. Water Year 2001 results are at Diversion condition.

b. Water Year 2002 results are at Extreme Diversion Condition.

Table 6-5: Initial result of ratio of trade scenario to baseline for summer average chl-*a* at Dundee Lake (adapted from Omni, 2007d)

	2001[a]				**2002[b]**			
Scenario	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 1**	**Case 2**	**Case 3**	**Case 4**
1	-	-	-	-	0.99	0.99	0.99	0.99
2	1.01	1.01	1.01	1.01	-	-	-	-
3	0.98	0.99	0.98	0.99	-	-	-	-
4	0.97	-	0.97	-	-	-	-	-
5	-	-	-	-	0.97	0.99	0.99	1.01
6	-	-	-	-	0.97	0.99	0.97	0.99
7	-	-	-	-	0.92	0.94	0.94	0.97
8	0.96	0.98	0.97	0.99	0.99	1.01	1.01	1.04
9	0.95	0.96	0.96	0.97	0.97	1.00	1.00	1.02
10	0.95	0.96	0.96	0.97	0.96	0.99	0.99	1.02
11	-	-	-	-	0.96	0.99	0.98	1.01
12	-	-	-	-	0.99	0.99	0.99	1.00
13	-	-	-	-	0.98	0.99	0.99	1.00

Ratio ≤ 1.00 indicates that the trade simulation had equal or better water quality than the no-trade baseline simulation.

Cases 1 and 3 applied trading ratios from Table 5-5. Cases 2 and 4 applied trading ratios from Table 5-6.

a. Water Year 2001 results are at No Diversion condition, except in scenarios 3-4 where Diversion applies.

b. Water Year 2002 results are at Extreme Diversion Condition.

Table 6-6: Trading scenarios 2 and 8 re-simulated with Table 5-7 trading ratios

Scenario	Seller	Buyer	Case 3 seller flow (MGD)	Case 3 buyer flow (MGD)	Case 3 trading ratio	All Cases: Seller LTA (mg/l)	Case 3: Buyer LTA (mg/l)
2	Caldwell	Bernards (Harrison Brook)	3.99	1.78	**0.92**	0.100	**0.985**
		Warren V		0.15	**0.92**		**1.00**
8	Parsippany-Troy Hills	Bernards (Harrison Brook)	12.48	1.78	**0.82**	0.100	**2.910**
	Rockaway		10.06		**0.65**	0.100	
		Warren V		0.15	**0.65**		1.850
		Warren I-II		0.37	**0.63**		1.620
	Two Bridges	Morris-Butterworth	5.57	2.02	**0.63**	0.100	**0.968**
	Berkeley Heights	Warren IV	1.61	0.28	**1.00**	0.100	2.200
	Morristown	Florham Park	2.15	0.86	**0.77**	0.100	**1.360**
	Wanaque RSA		0.96		**0.43**	0.100	
	Pompton Lakes	Chatham Glen	0.89	0.12	**0.46**	0.100	**1.530**

Table 6-7: Calibrated result of ratio of case-scenario to baseline for summer average chl-*a* at Dundee Lake (adapted from Omni, 2007d)

	2001^a				2002^b			
Scenario	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 1**	**Case 2**	**Case 3**	**Case 4**
2	-	-	1.00	-	-	-	-	-
8	-	-	-	-	-	-	0.98	-

Ratio ≤ 1.00 indicates that the trade simulation had equal or better water quality than the no-trade baseline simulation.

Both simulations applied trading ratios from Table 5-7.

a. Water Year 2001 results are at No Diversion condition.

b. Water Year 2002 results are at Extreme Diversion Condition.

Table 6-8: Key for Figure 6-1

Name / Location	ID no. on map	Class
Dundee Lake / Passaic River at Dundee Dam	1	TMDL critical location
Wanaque South intake / on Pompton River just upstream of confluence with Passaic River	2	TMDL critical location
Passaic River near Chatham / USGS gage 01379500	3	Area of Concern
Passaic River at Little Falls intake	4	Area of Concern
Peckman River mouth	5	Area of Concern

Table 6-9: Definition of criteria for evaluation matrices

Location	Criteria 1	Criteria 2	Criteria 3	Criteria 4
Dundee Lake	Are cross-tributary trades simulated?	Did trading ratios > 1.00 result in ≤ summer avg. chl-*a* compared to baseline?	Did trading with WWTPs at average flows result in ≤ summer avg. chl-*a* compared to baseline?	Did trading with WWTPs at < average flows result in ≤ summer avg. chl-*a* compared to baseline?
Wanaque South intake	Are cross-tributary trades simulated?	Did trading ratios > 1.00 result in ≤ TP load diverted compared to baseline?	Did trading with WWTPs at average flows result in ≤ TP load diverted compared to baseline?	Did trading with WWTPs at < average flows result in ≤ TP load diverted compared to baseline?
Passaic R. near Chatham (USGS gage 01379500)	Are cross-tributary trades simulated?	Did trading ratios > 1.00 result in summer avg. DO concentration, max DO swing, and percent DO compliance within 0.2 mg/l, 1.0 mg/l and 0.5%, respectively, compared to baseline?	Did trading with WWTPs at average flows result in summer avg. DO concentration, max DO swing, and percent DO compliance within 0.2 mg/l, 1.0 mg/l and 0.5%, respectively, compared to baseline?	Did trading with WWTPs at < average flows result in summer avg. DO concentration, max DO swing, and percent DO compliance within 0.2 mg/l, 1.0 mg/l and 0.5%, respectively, compared to baseline?
Passaic R. at Little Falls intake	Are cross-tributary trades simulated?	Did trading ratios > 1.00 result in annual and summer avg. TP concentrations within 0.02 mg/l compared to baseline?	Did trading with WWTPs at average flows result in annual and summer avg. TP concentrations within 0.02 mg/l compared to baseline?	Did trading with WWTPs at < average flows result in annual and summer avg. TP concentrations within 0.02 mg/l compared to baseline?
Peckman R. mouth	Are cross-tributary trades simulated?	Did trading ratios > 1.00 result in summer avg. DO concentration, max DO swing, and percent DO compliance within 0.2 mg/l, 1.0 mg/l and 0.5%, respectively, compared to baseline?	Did trading with WWTPs at average flows result in summer avg. DO concentration, max DO swing, and percent DO compliance within 0.2 mg/l, 1.0 mg/l and 0.5%, respectively, compared to baseline?	Did trading with WWTPs at < average flows result in summer avg. DO concentration, max DO swing, and percent DO compliance within 0.2 mg/l, 1.0 mg/l and 0.5%, respectively, compared to baseline?

Table 6-10: Evaluation matrix of trade scenario results at Dundee Lake, using Table 5-5 trading ratios

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Fail	Fail	Fail
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Fail
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

Table 6-11: Evaluation matrix of trade scenario results at Dundee Lake, using Table 5-6 trading ratios

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Fail	Fail	Fail
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Fail
6	Yes	-	Pass	Pass
7	Yes	Pass	Pass	Pass
8	Yes	Fail	Fail	Fail
9	Yes	Fail	Pass	Fail
10	Yes	-	Pass	Fail
11	Yes	-	Pass	Fail
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

Table 6-12: Evaluation matrix of trade scenario results at Dundee Lake, using Table 5-7 trading ratios*

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

*Only scenarios 2 and 8, at Case 3 conditions, were actually simulated with Table 5-7 trading ratios. However based on the successful results of these critical simulations, and given that Table 5-7 ratios are more conservative than Table 5-5 ratios, it is reasonable to assume that all other scenarios would have successful results.

Table 6-13: Evaluation matrix of trade scenario results at Wanaque South intake, using Table 5-5 trading ratios

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

Table 6-14: Evaluation matrix of trade scenario results at Wanaque South intake, using Table 5-6 trading ratios

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	Pass	Pass	Pass
8	Yes	Pass	Pass	Pass
9	Yes	Pass	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

Table 6-15: Evaluation matrix of trade scenario results at Wanaque South intake, using Table 5-7 trading ratios*

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

*Only scenarios 2 and 8, at Case 3 conditions, were actually simulated with Table 5-7 trading ratios. However based on the successful results of these critical simulations, and given that Table 5-7 ratios are more conservative than Table 5-5 ratios, it is reasonable to assume that all other scenarios would have successful results.

Table 6-16: Evaluation matrix of trade scenario results at Passaic River near Chatham, using Table 5-5 trading ratios

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

Table 6-17: Evaluation matrix of trade scenario results at Passaic River near Chatham, using Table 5-6 trading ratios

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

Table 6-18: Evaluation matrix of trade scenario results at Passaic River near Chatham, using Table 5-7 trading ratios*

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

*Only scenarios 2 and 8, at Case 3 conditions, were actually simulated with Table 5-7 trading ratios. However based on the successful results of these critical simulations, and given that Table 5-7 ratios are more conservative than Table 5-5 ratios, it is reasonable to assume that all other scenarios would have successful results.

Table 6-19: Evaluation matrix of trade scenario results at Passaic River Little Falls intake, using Table 5-5 trading ratios

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

Table 6-20: Evaluation matrix of trade scenario results at Passaic River Little Falls intake, using Table 5-6 trading ratios

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

Table 6-21: Evaluation matrix of trade scenario results at Passaic River Little Falls intake, using Table 5-7 trading ratios*

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

*Only scenarios 2 and 8, at Case 3 conditions, were actually simulated with Table 5-7 trading ratios. However based on the successful results of these critical simulations, and given that Table 5-7 ratios are more conservative than Table 5-5 ratios, it is reasonable to assume that all other scenarios would have successful results.

Table 6-22: Evaluation matrix of trade scenario results at Peckman River mouth, using Table 5-5 trading ratios

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

Table 6-23: Evaluation matrix of trade scenario results at Peckman River mouth, using Table 5-6 trading ratios

Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

Table 6-24: Evaluation matrix of trade scenario results at Peckman River mouth, using Table 5-7 trading ratios*

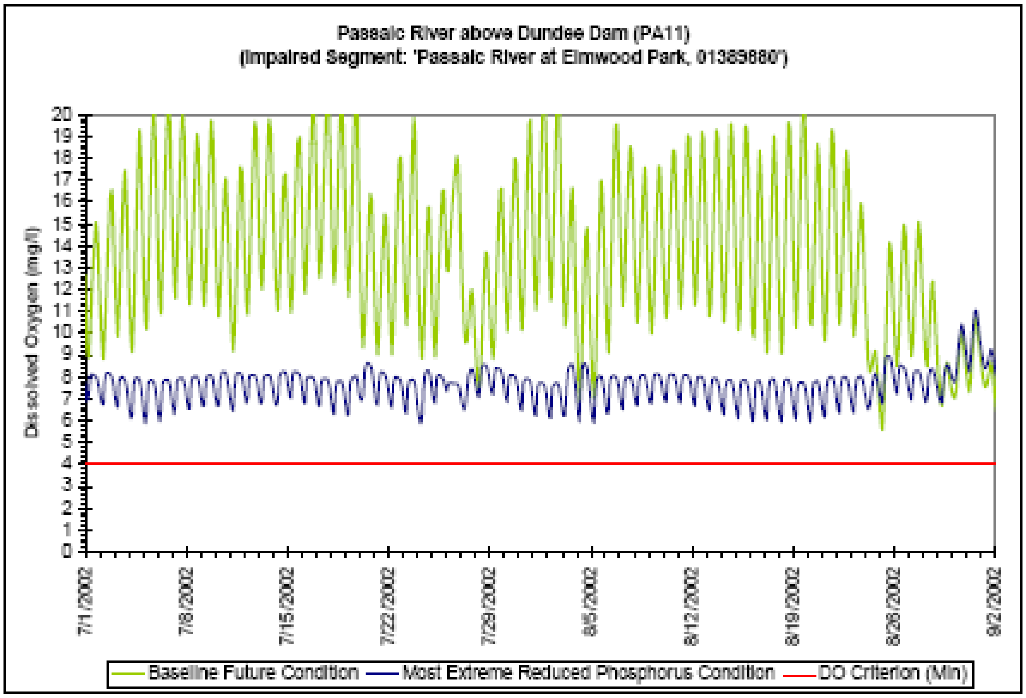
Scenario	Criteria 1	Criteria 2	Criteria 3	Criteria 4
1	No	-	Pass	Pass
2	No	Pass	Pass	Pass
3	Yes	Pass	Pass	Pass
4	Yes	-	Pass	Pass
5	Yes	-	Pass	Pass
6	Yes	-	Pass	Pass
7	Yes	-	Pass	Pass
8	Yes	-	Pass	Pass
9	Yes	-	Pass	Pass
10	Yes	-	Pass	Pass
11	Yes	-	Pass	Pass
12	Yes	-	Pass	Pass
13	Yes	-	Pass	Pass

*Only scenarios 2 and 8, at Case 3 conditions, were actually simulated with Table 5-7 trading ratios. However based on the successful results of these critical simulations, and given that Table 5-7 ratios are more conservative than Table 5-5 ratios, it is reasonable to assume that all other scenarios would have successful results.

FIGURES

Figure 3-1: Locations with varying sensitivity to phosphorus loading (adapted from Omni, 2007a)

a. Passaic River above Dundee Dam shows dramatic reduction in DO swing in response to reduced phosphorus loading (blue line) as compared to baseline (green line).



b. Dead River mouth shows almost no reduction in DO swing in response to reduced phosphorus loading (blue line) as compared to baseline (green line).

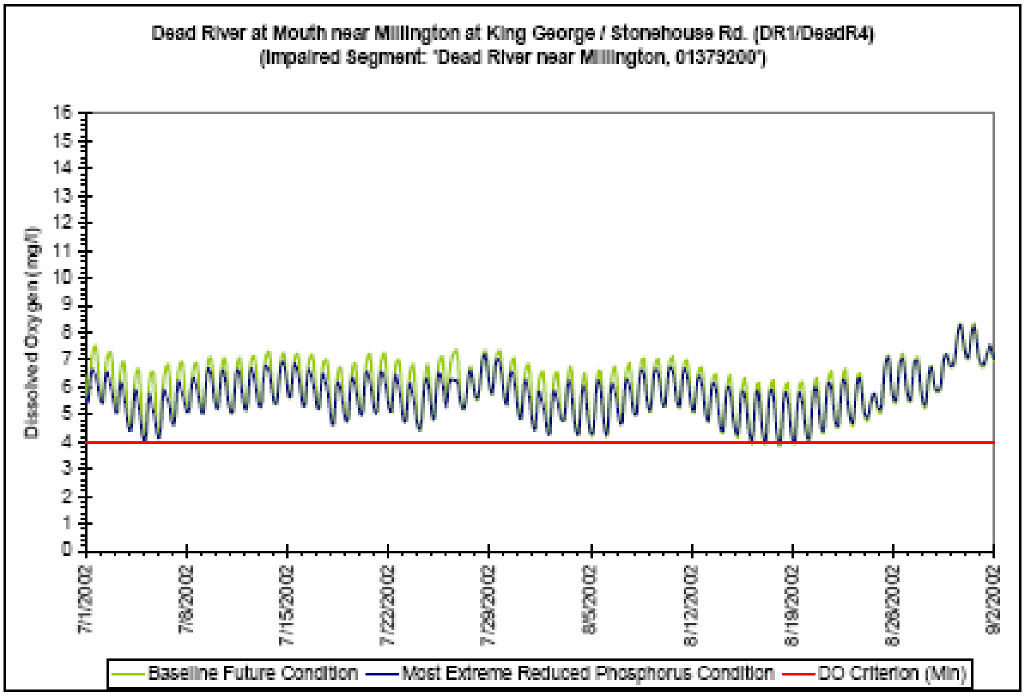
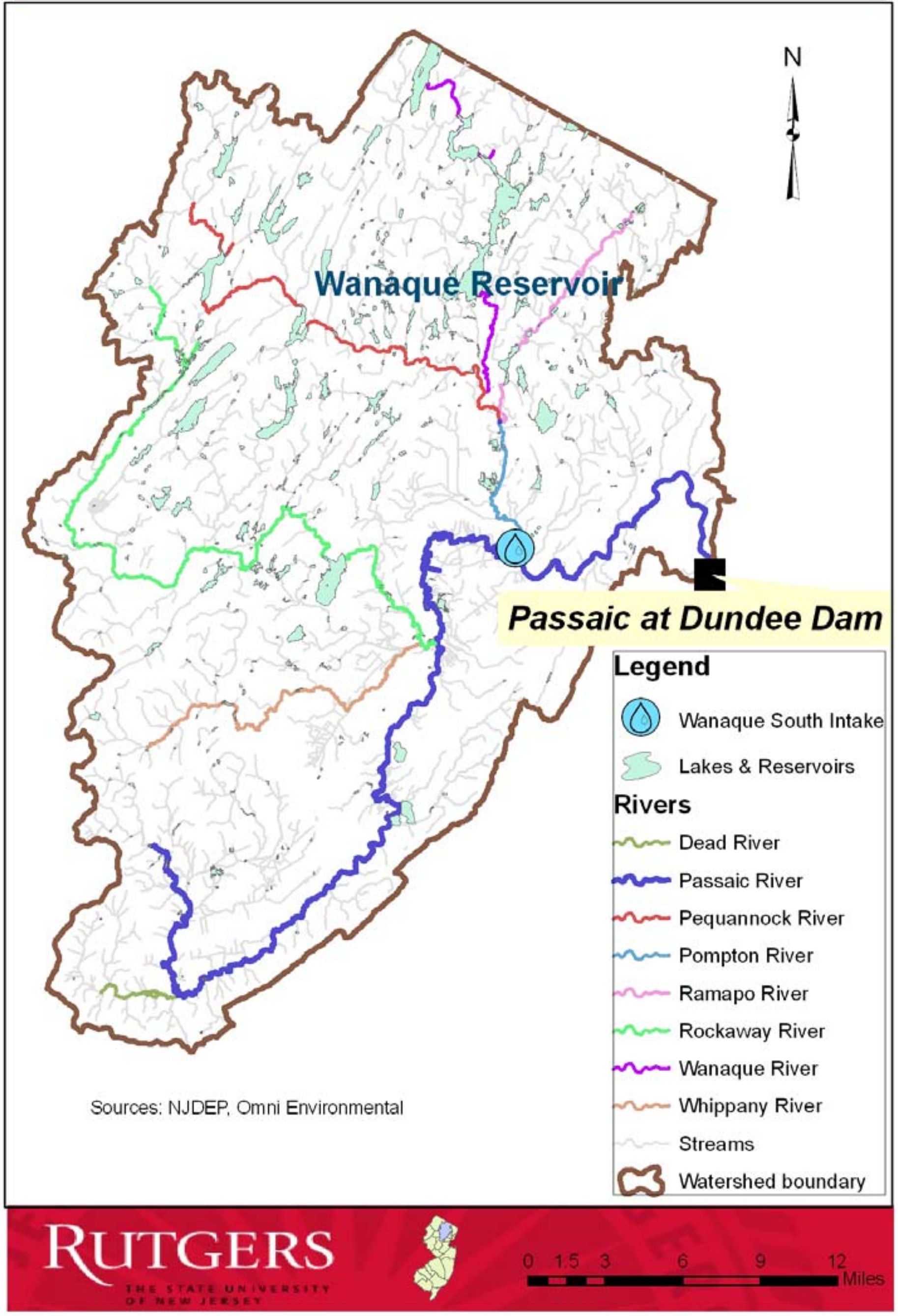
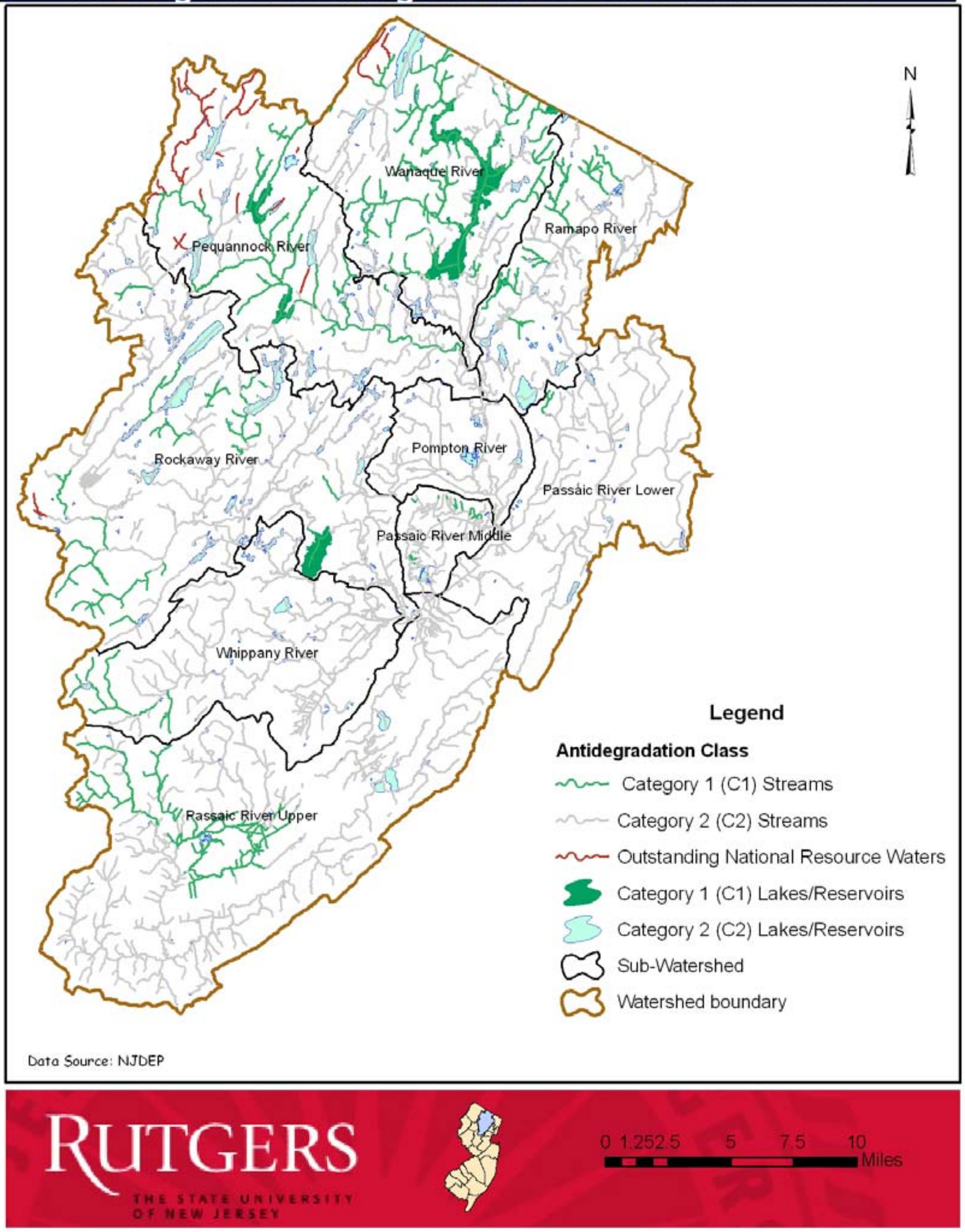


Figure 3-2 TMDL Critical Locations (identical to Potential Phosphorus Induced Hot Spots)



Sources: NJDEP, Omni Environmental

Figure 3-3
Antidegradation Categories for Surface Water Bodies



Data Source: NJDEP

Figure 4-1 Category 1 and Category 2 Dischargers

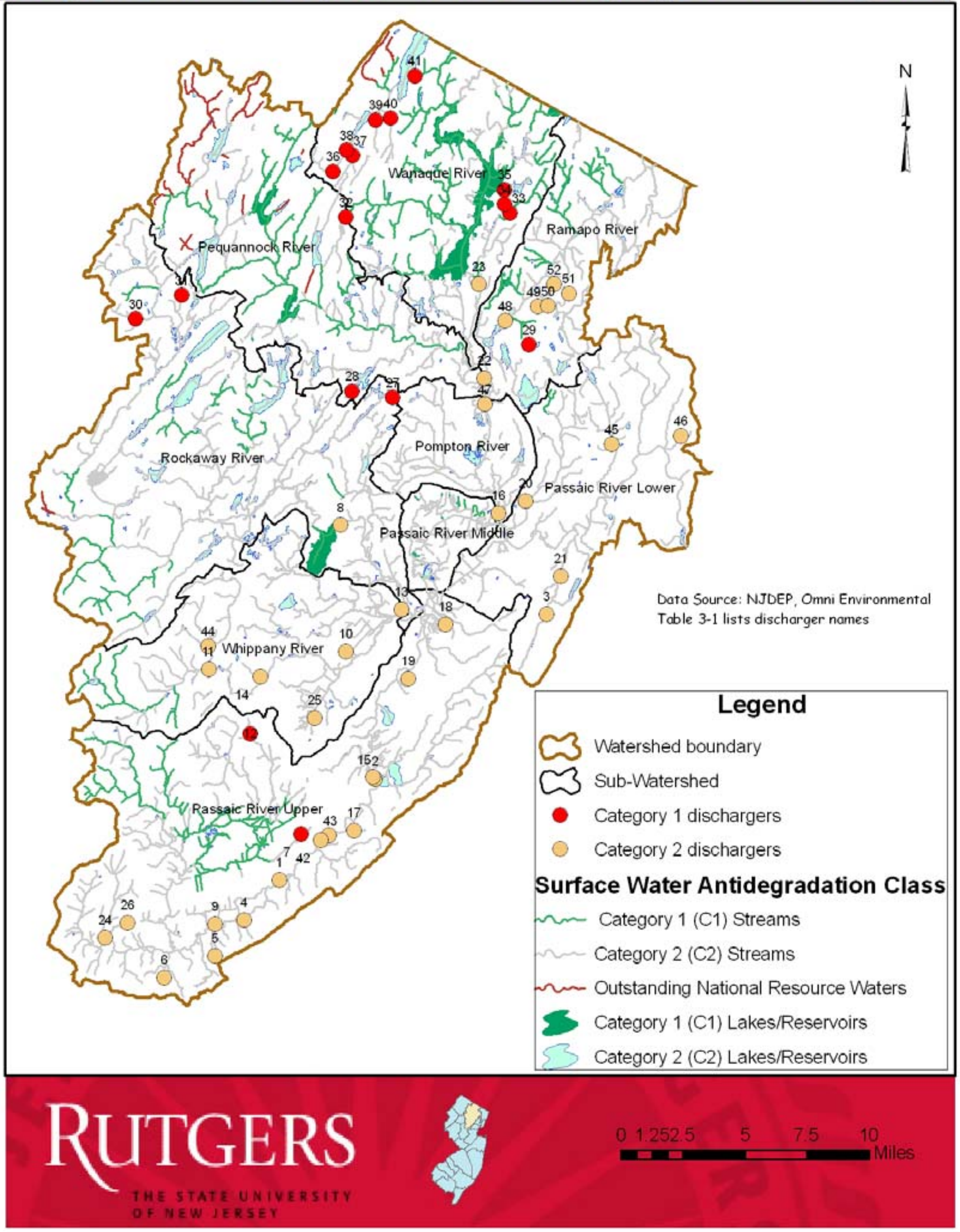
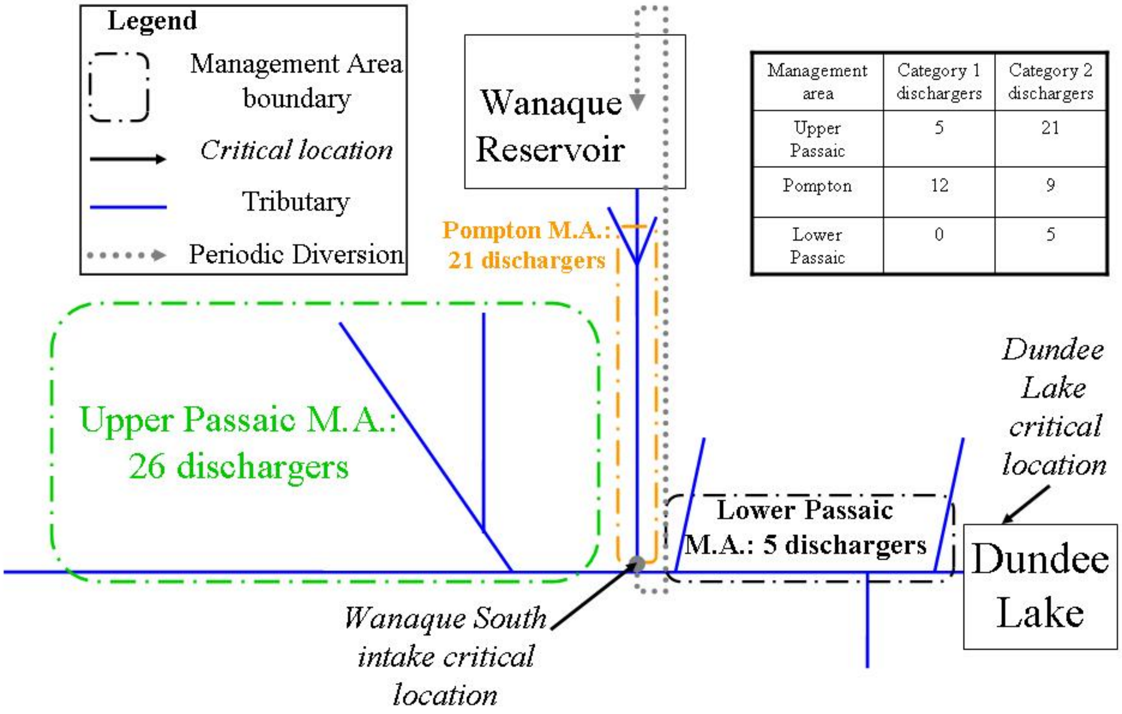
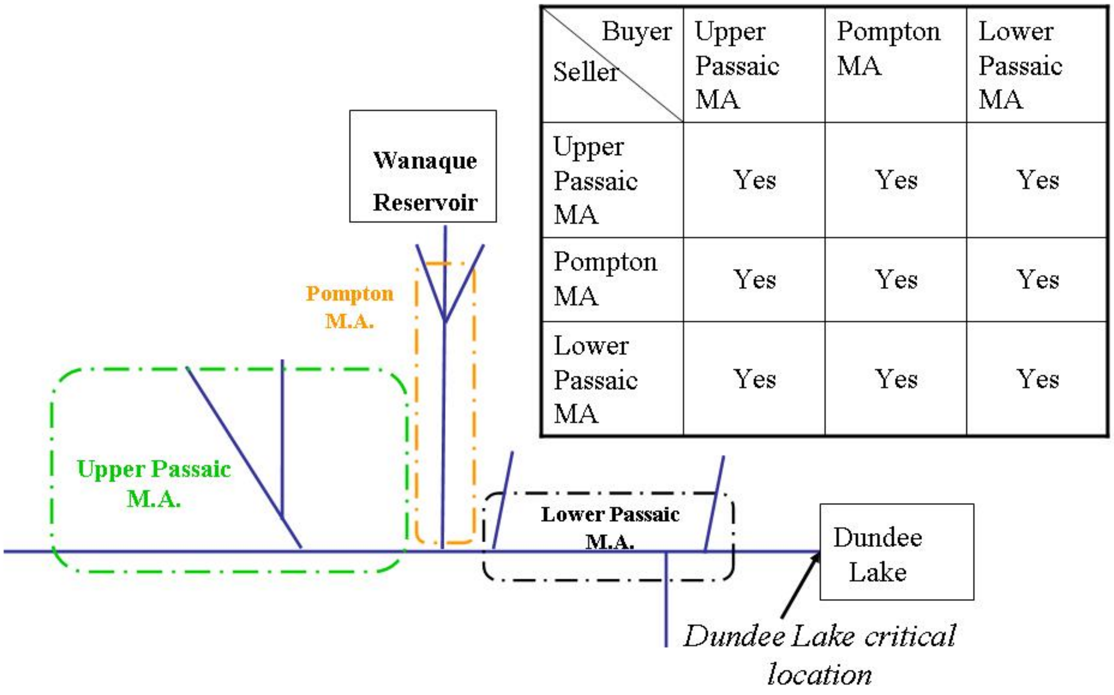


Figure 4-2
Passaic Trading Framework



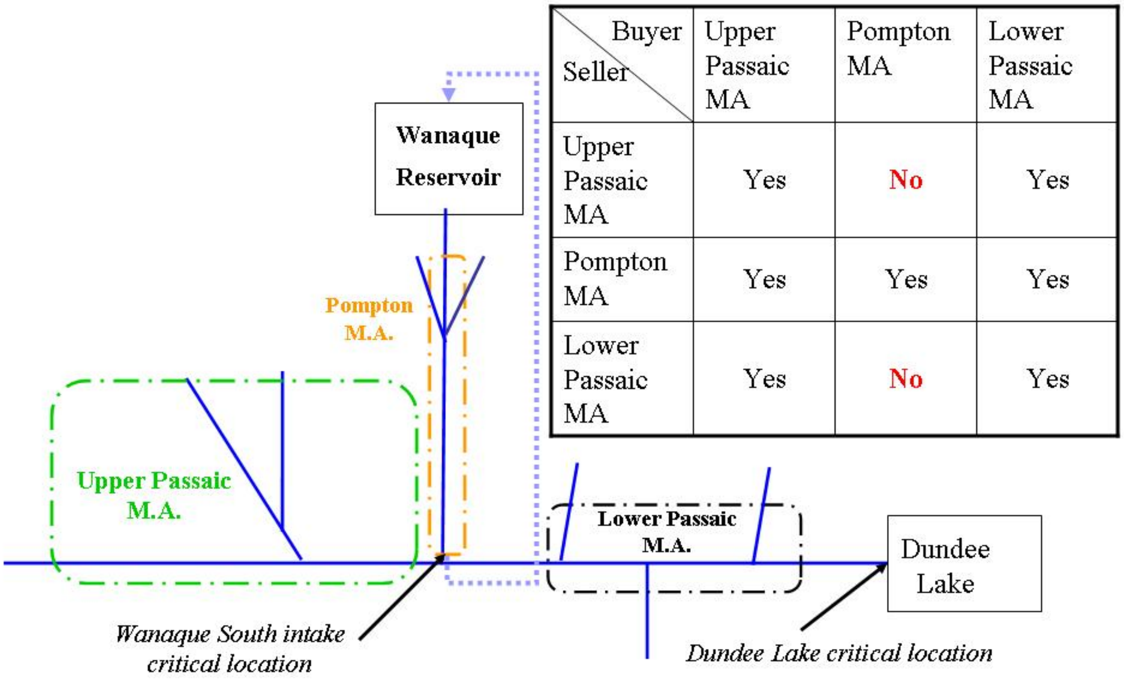
Management area	Category 1 dischargers	Category 2 dischargers
Upper Passaic	5	21
Pompton	12	9
Lower Passaic	0	5

Figure 4-3
Passaic Trading Table: No Diversion Scenario



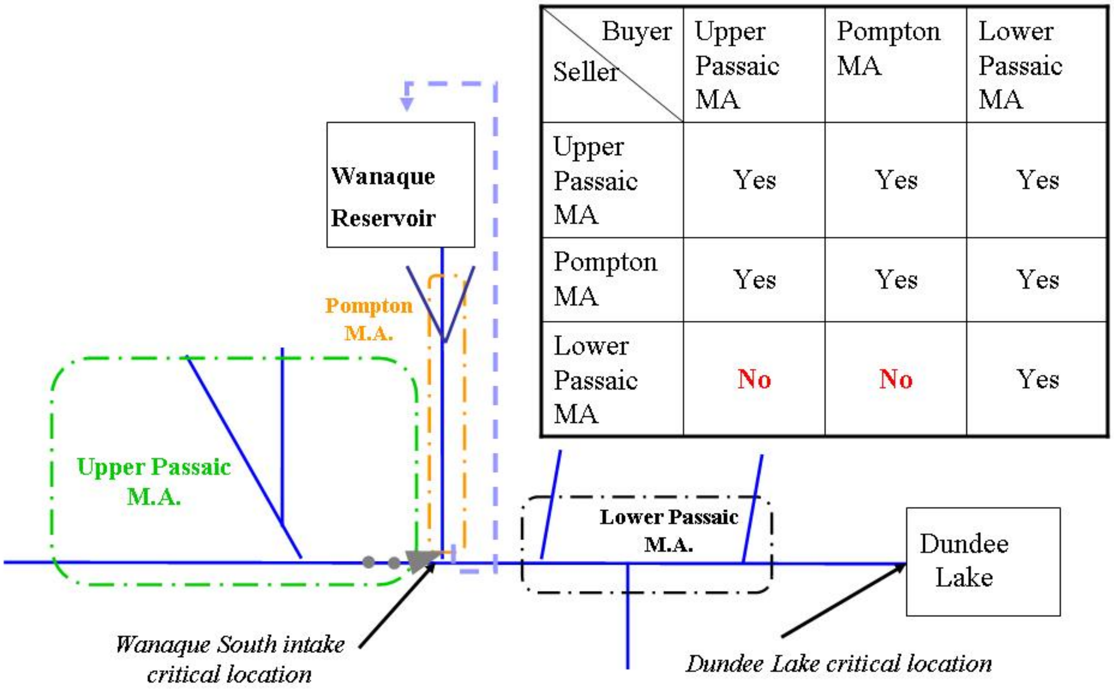
Buyer / Seller	Upper Passaic MA	Pompton MA	Lower Passaic MA
Upper Passaic MA	Yes	Yes	Yes
Pompton MA	Yes	Yes	Yes
Lower Passaic MA	Yes	Yes	Yes

Figure 4-4
Passaic Trading Table: Diversion Scenario



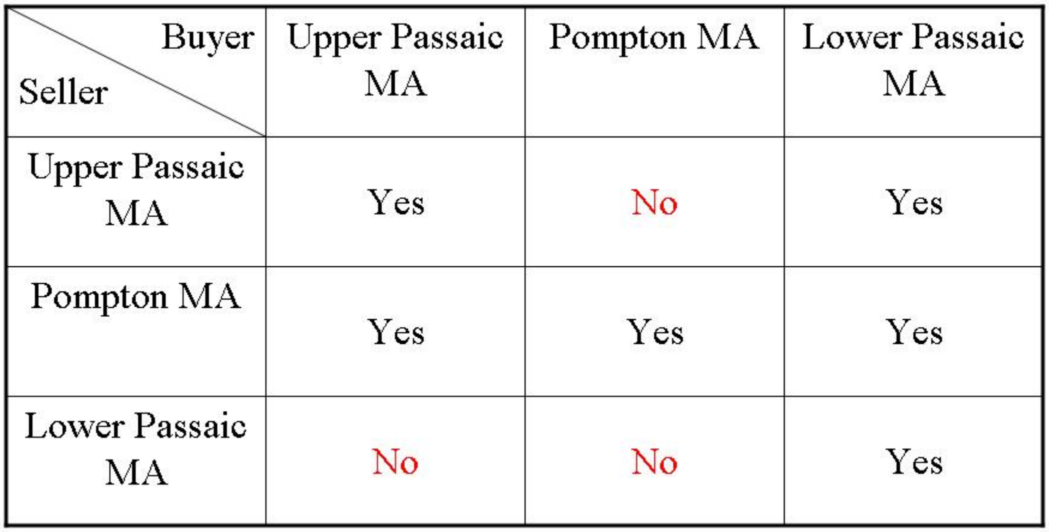
Buyer / Seller	Upper Passaic MA	Pompton MA	Lower Passaic MA
Upper Passaic MA	Yes	No	Yes
Pompton MA	Yes	Yes	Yes
Lower Passaic MA	Yes	No	Yes

Figure 4-5
Passaic Trading Table: Extreme Diversion Scenario



Buyer / Seller	Upper Passaic MA	Pompton MA	Lower Passaic MA
Upper Passaic MA	Yes	Yes	Yes
Pompton MA	Yes	Yes	Yes
Lower Passaic MA	No	No	Yes

Figure 4-6
Passaic Trading Framework: *Three* Management Areas Protecting *Two* Critical Locations



Buyer Seller	Upper Passaic MA	Pompton MA	Lower Passaic MA
Upper Passaic MA	Yes	No	Yes
Pompton MA	Yes	Yes	Yes
Lower Passaic MA	No	No	Yes

Figure 5-1: Percent capacity flow, 2005-2007 data
(source: NJDEP OPRA DMR database, accessed Jan 18 2008)

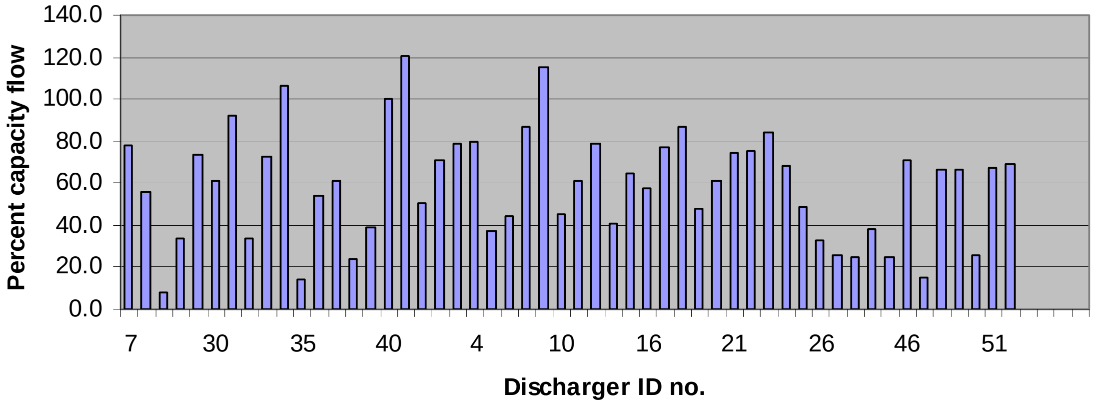
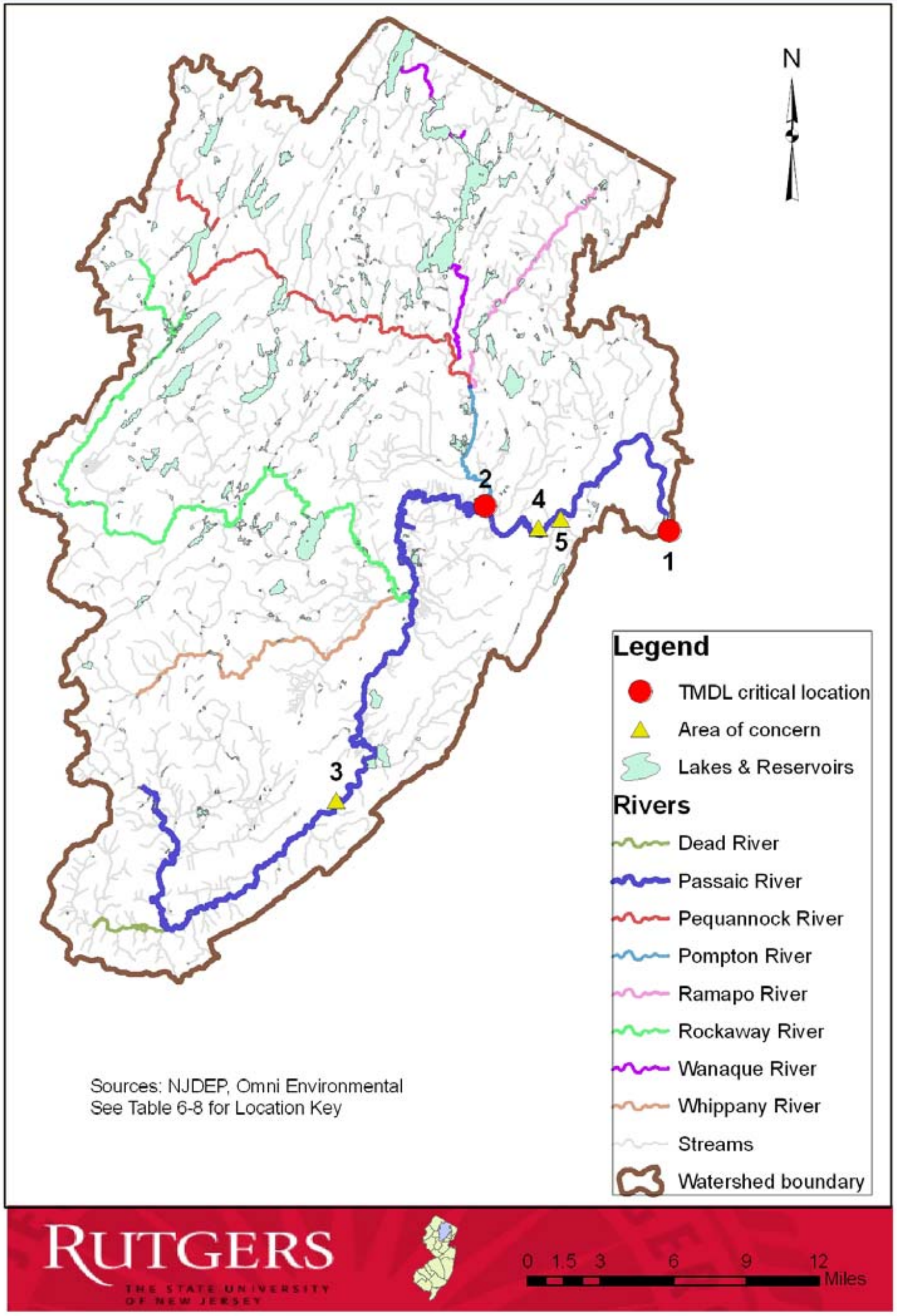


Figure 6-1: TMDL critical locations and areas of concern



Sources: NJDEP, Omni Environmental
See Table 6-8 for Location Key

Appendix 1:

Surface Water Diversions

APPENDIX 1: Surface Water Diversions

Definitions

- **Diversion –** is the removal of either groundwater or surface water from the natural hydrologic cycle. The NJDEP Bureau of Water Allocation is responsible for granting the privilege to a person to divert over 100,000 gallons per day (gpd) of water for any purpose other than agricultural or horticultural use. The NJDEP maintains extensive databases on water usage. The ability to use full diversions is typically related to satisfying other criteria (e.g., surface water diversion can be limited based upon requirements to maintain a certain stream flow past the diversion – **passing flow**).
- **Depletive Water Use –** "surface or ground water withdrawn from a selected watershed and discharged in another watershed. Also referred by others as **outof-basin transfers** (or inter-basin transfers) and wastewater and water exportations, depletive use has become a significant issue in New Jersey over the last several years as competition for water has increased."
- **Safe Yield From Surface Sources –** means the yield maintainable by a water system continuously throughout a repetition of the most severe drought of record, after compliance with requirements of maintaining minimum passing flows, assuming no significant changes in upstream or upbasin depletive withdrawals.
- **Minimum Passing Flow –** surface water diversions are limited by requirements to maintain a certain stream flow, or passing flow, downstream of the water intake. The New Jersey Department's Bureau of Water Allocation has set these passing flow requirements. Where not specified, statutory minimum passing flow is calculated as 125,000 gallons per square mile of contributing upstream unappropriated watershed for public water supplies.

Source: WMAs 3, 4, 6 Characterization and Assessment Studies (2002). Available at: http://www.njdwsc.com/prbwmp/intro.htm

The Wanaque and Monksville Reservoirs are owned and operated by the North Jersey District Water Supply Commission (NJDWSC). These two “run-of-theriver” reservoirs comprise one of the largest water supply/storage systems in New Jersey. This system is the primary source of drinking water for much of Passaic, Essex, Bergen and Hudson Counties. Following the completion of the Wanaque South Project in the late 1980s, the [existing water allocation] of this combined reservoir system was upgraded to 173 mgd. The system currently provides approximately 160 mgd of potable water supply to its customers (including other water companies).

To maintain this [allocation], the Wanaque Reservoir utilizes inflows from three separate sources: (1) its natural tributary system, which includes the Monksville Reservoir; (2) the Pompton Lakes intake, which is located on the Ramapo River; and (3) the Two Bridges intake, which is located on the Pompton River about 750 feet upstream from the confluence with the Passaic River. The NJDWSC has the capability of pumping up to 150 mgd from the Pompton Lakes intake, and up to 250 mgd from the Two Bridges intake. By design, when the diversion from the Two Bridges intake exceeds the available flow in the Pompton River, this intake has the ability to reverse flows in the lowermost reach of the Pompton River and tap the [the Pompton and Passaic Rivers at their confluence]. Thus, the entire upper Passaic watershed (with a drainage area of 361 square miles) becomes a contributing source to the Reservoir. To maintain water quality in the downstream portions of the Passaic, Pompton and Ramapo Rivers, NJDEP has implemented several restrictions on intake usage, including: (a) no diversions during July and August unless there is a declared drought emergency; (b) no diversions from the Pompton Lakes intake when flows in the Ramapo River are below 40 mgd; and (c) no diversions when flows in the Passaic River at Little Falls are below 17.6 mgd. (modified from Najarian (2005)).

Source: New Jersey Department of Environmental Protection (NJDEP). 2005. Amendment to the Northeast, Upper Raritan, Sussex County, and Upper Delaware Water Quality Management Plans: Phase I Passaic River Study Total Maximum Daily Load for Phosphorus in Wanaque Reservoir Northeast Water Region (*proposed*).

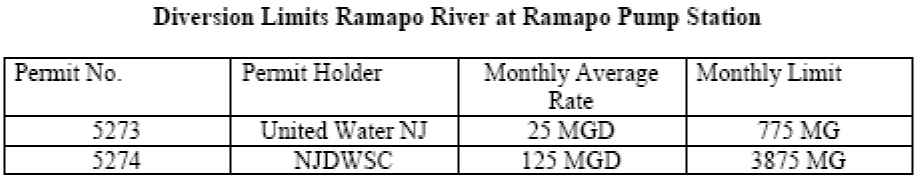
North Jersey District Water Supply Commission

The North Jersey District Water Supply Commission (NJDWSC) operates Wanaque Reservoir (29.6 billion gallons) above the town of Pompton Lakes on the Wanaque River and the Wanaque South Project, including Monksville Reservoir, Wanaque South Pump Station and the Ramapo Pump Station. NJDWSC was created in 1916 by enactment of the State Legislature to help develop and operate water supply systems in New Jersey's 11 northernmost counties. The NJDWSC serves as agent or trustee representing the joint interests of municipalities that contract with the Commission to share in various water projects implemented by the Commission.

Beginning in 1920, the Wanaque North Project includes the original construction of Wanaque Reservoir and various improvements to raise the reservoir level. The NJDWSC, per Allocation Permit No. 5329, can divert:

> "the entire runoff of the watersheds, provided, however, that at all times the flow of the Wanaque River below the Raymond Dam shall be maintained at an amount not less than seven million gallons per day (10.83 cfs) plus such quantity of water up to three million gallons per day (4.64 cfs) is discharged from storage in Greenwood Lake for use other than the use of the NJDWSC, an amount equal to such draft from Greenwood Lake shall be discharged from the Wanaque Reservoir, and, in addition thereto, such amount as shall be required to make the total discharge from the reservoir at least ten million gallons per day (15.47 cfs)."

The Wanaque North Project also includes the Ramapo Pump Station (constructed in 1953 @ 100 MGD) that transfers raw water from the Ramapo River at Pompton Lake to the Wanaque Reservoir. As part of the Wanaque South project the pumping capacity and diversion limits were increased. There are two permits with diversion limits as follows:

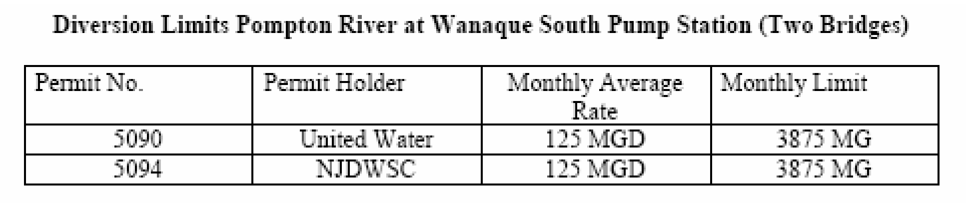


Diversion Limits Ramapo River at Ramapo Pump Station

Permit No.	Permit Holder	Monthly Average Rate	Monthly Limit
5273	United Water NJ	25 MGD	775 MG
5274	NJDWSC	125 MGD	3875 MG

There is a 40 MGD passing flow requirement and other water quality constraints. No pumping is allowed between July 1st and August 31st.

The Wanaque South Project includes the construction of the Monksville Dam and Reservoir (7 billion gallons) in 1987. Integral to the Wanaque South Project was the construction of the Wanaque South Pump Station , which transfers water from the confluence of the Pompton and Passaic Rivers (Two Bridges) to the Wanaque Reservoir and/or to the Oradell Reservoir in WMA 5. There are two permits with diversion limits as follows:



Diversion Limits Pompton River at Wanaque South Pump Station (Two Bridges)

Permit No.	Permit Holder	Monthly Average Rate	Monthly Limit
5090	United Water	125 MGD	3875 MG
5094	NJDWSC	125 MGD	3875 MG

There is a 92.6 MGD passing flow requirement at the Wanaque South Pump Station. (Two Bridges site) and detailed water quality constraints. However, NJDWSC is allowed to pump the differential of flows between actual diversion by PVWC (total of diversion at Two Bridges and Little Falls (WMA 4)) and 75 MGD after passing 17.6 MGD. No pumping by NJDWSC is allowed between July 1st and August 31st. In addition, PVWC, as part of its Permit No. 5099 can divert up to 75 MGD at the Two Bridges site. The PVWC permit allows year round pumping at the Two Bridges site as long as certain downstream water quality criteria are maintained.

It is noted that the NJSWSP indicates that the [water allocation] from the Wanaque South Project is 79.0 MGD, and the [water allocation] from the Wanaque North Project is 94.0 MGD. According to the NJSWSP the total [water allocation] of the system, as currently constructed, is therefore 173 MGD.

In addition, the 173 MGD is currently completely allocated to the contracting municipalities as indicated in Table 1.16.10. Of this total, 133.5 MGD of finished water can be provided on an average daily basis by NJDWSC to contracting members (per their allotments) and up to the remaining 39.5 MGD can be provided on an average daily basis by NJDWSC to United Water NJ as raw water transferred to Oradell Reservoir.

Passaic Valley Water Commission

PVWC owns and operates the Point View Reservoir, which is a 2.8 BG raw water reservoir that can be filled from the Pompton River, via a pump station, at a monthly average rate of 50 MGD (per Allocation Permit 5099). PVWC can fill this reservoir with the restriction of an 88 MGD passing flow in the river. PVWC can then release water from the reservoir back into the Pompton River during low flow conditions for use at the Little Falls Water Treatment Plant located in Totowa on the Passaic River. In addition, during July and August when the Wanaque South Aqueduct is not utilized by NJDWSC, PVWC can convey water from Point View Reservoir directly to the Two Bridges site, for transfer to Little Falls.

PVWC can pump water from the Wanaque South Pump Station (Two Bridges) at the confluence of the Pompton and Passaic River, via a pipeline, to the head of the Little Falls Treatment Plant. PVWC can divert a maximum daily rate of 75 MGD or a maximum of 2,325 million gallons during any month at this location. Per the water allocation permit, pumping at the Two Bridges location is restricted by a passing flow requirement of 17.6 MGD and additional water quality parameters.

PVWC is the primary public water user within WMA 4. PVWC has a very complex arrangement for obtaining and supplying water to its customer base. PVWC supplies water to its retail customers (cities of Paterson, Passaic, and Clifton) and wholesale customers with a combination of supply, either from the Little Falls Treatment Plant (raw water supply from Passaic or Pompton River) or redistributing treated water received from the North Jersey District Water Supply Commission (NJDWSC). Table 1.16.3 provides a summary of the different entities that PVWC supplies water to, and an estimate of inter-basin transfer.

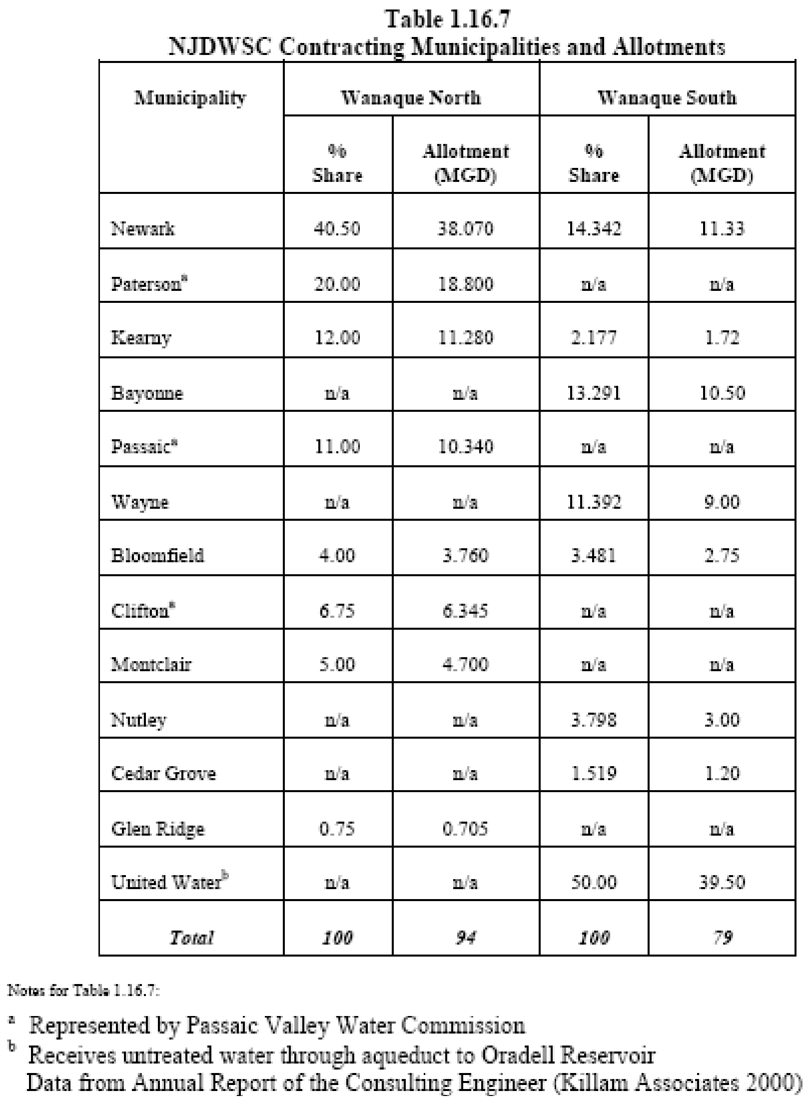


Table 1.16.7
NJDWSC Contracting Municipalities and Allotments

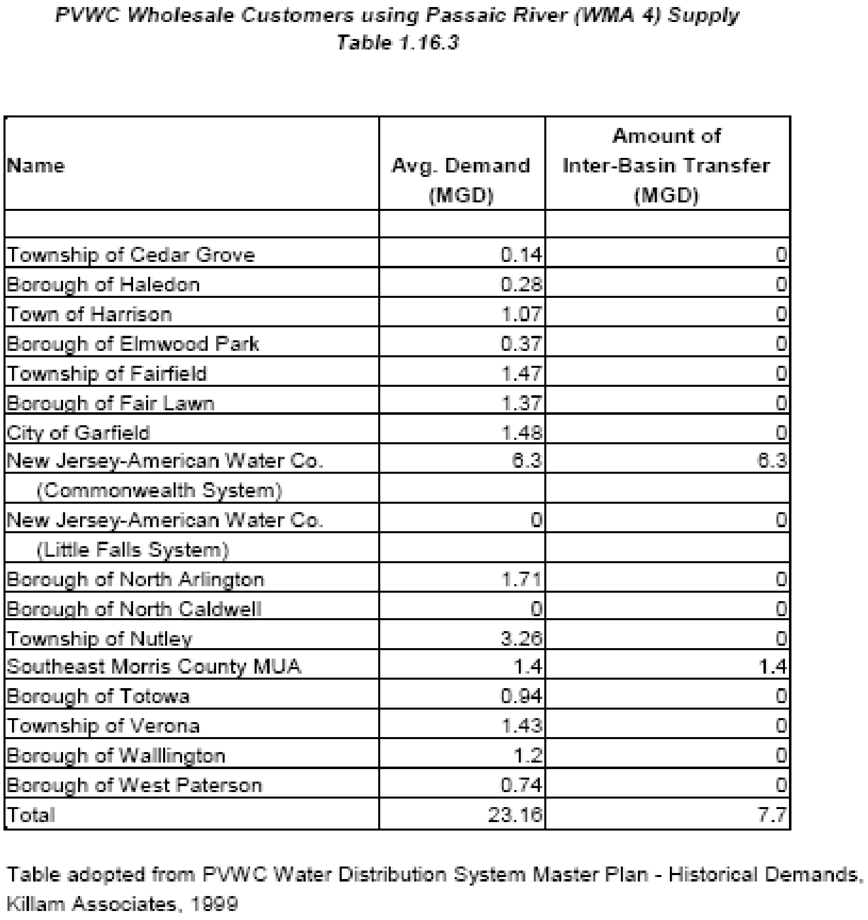
Municipality	Wanaque North		Wanaque South	
	% Share	Allotment (MGD)	% Share	Allotment (MGD)
Newark	40.50	38.070	14.342	11.33
Paterson[a]	20.00	18.800	n/a	n/a
Kearny	12.00	11.280	2.177	1.72
Bayonne	n/a	n/a	13.291	10.50
Passaic[a]	11.00	10.340	n/a	n/a
Wayne	n/a	n/a	11.392	9.00
Bloomfield	4.00	3.760	3.481	2.75
Clifton[a]	6.75	6.345	n/a	n/a
Montclair	5.00	4.700	n/a	n/a
Nutley	n/a	n/a	3.798	3.00
Cedar Grove	n/a	n/a	1.519	1.20
Glen Ridge	0.75	0.705	n/a	n/a
United Water[b]	n/a	n/a	50.00	39.50
Total	***100***	***94***	***100***	***79***

Notes for Table 1.16.7:

[a] Represented by Passaic Valley Water Commission

[b] Receives untreated water through aqueduct to Oradell Reservoir

Data from Annual Report of the Consulting Engineer (Killam Associates 2000)



PVWC Wholesale Customers using Passaic River (WMA 4) Supply
Table 1.16.3

Name	Avg. Demand (MGD)	Amount of Inter-Basin Transfer (MGD)
Township of Cedar Grove	0.14	0
Borough of Haledon	0.28	0
Town of Harrison	1.07	0
Borough of Elmwood Park	0.37	0
Township of Fairfield	1.47	0
Borough of Fair Lawn	1.37	0
City of Garfield	1.48	0
New Jersey-American Water Co.	6.3	6.3
(Commonwealth System)		
New Jersey-American Water Co.	0	0
(Little Falls System)		
Borough of North Arlington	1.71	0
Borough of North Caldwell	0	0
Township of Nutley	3.26	0
Southeast Morris County MUA	1.4	1.4
Borough of Totowa	0.94	0
Township of Verona	1.43	0
Borough of Walllington	1.2	0
Borough of West Paterson	0.74	0
Total	23.16	7.7

Table adopted from PVWC Water Distribution System Master Plan - Historical Demands, Killam Associates, 1999

In WMA 3:

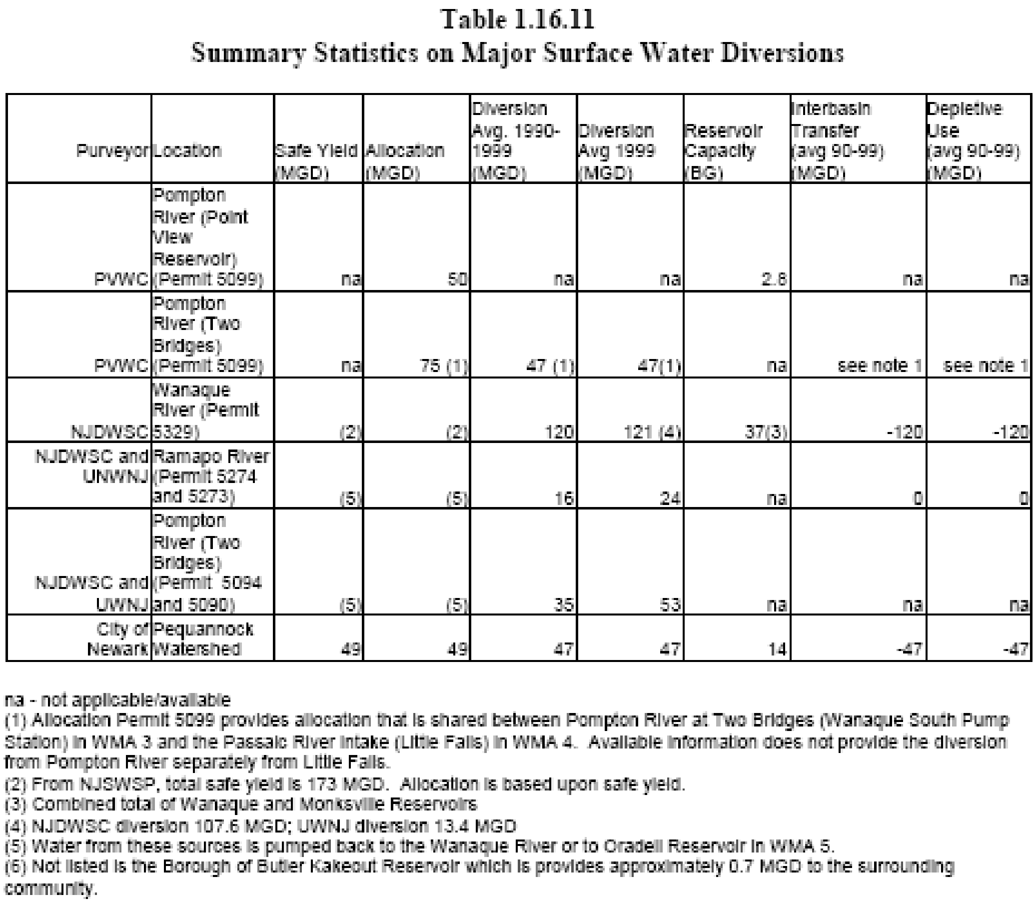


Table 1.16.11
Summary Statistics on Major Surface Water Diversions

Purveyor	Location	Safe Yield (MGD)	Allocation (MGD)	Diversion Avg. 1990-1999 (MGD)	Diversion Avg 1999 (MGD)	Reservoir Capacity (BG)	Interbasin Transfer (avg 90-99) (MGD)	Depletive Use (avg 90-99) (MGD)
PVWC	Pompton River (Point View Reservoir) (Permit 5099)	na	50	na	na	2.8	na	na
PVWC	Pompton River (Two Bridges) (Permit 5099)	na	75 (1)	47 (1)	47(1)	na	see note 1	see note 1
NJDWSC	Wanaque River (Permit 5329)	(2)	(2)	120	121 (4)	37(3)	-120	-120
NJDWSC and UNWNJ	Ramapo River (Permit 5274 and 5273)	(5)	(5)	16	24	na	0	0
NJDWSC and UWNJ	Pompton River (Two Bridges) (Permit 5094 and 5090)	(5)	(5)	35	53	na	na	na
City of Newark	Pequannock Watershed	49	49	47	47	14	-47	-47

na - not applicable/available
(1) Allocation Permit 5099 provides allocation that is shared between Pompton River at Two Bridges (Wanaque South Pump Station) in WMA 3 and the Passaic River intake (Little Falls) in WMA 4. Available information does not provide the diversion from Pompton River separately from Little Falls.
(2) From NJSWSP, total safe yield is 173 MGD. Allocation is based upon safe yield.
(3) Combined total of Wanaque and Monksville Reservoirs
(4) NJDWSC diversion 107.6 MGD; UWNJ diversion 13.4 MGD
(5) Water from these sources is pumped back to the Wanaque River or to Oradell Reservoir in WMA 5.
(6) Not listed is the Borough of Butler Kakeout Reservoir which is provides approximately 0.7 MGD to the surrounding community.

In WMAs 3 and 4:

Table 1.16.12
Passing Flows

Purveyor	Gaging Station	Passing Flow per NJAC 7:19 (Cu. Ft./Sec)	Passing Flow per Permit (Cu. Ft./Sec)
Passaic Valley Water Commission	Pompton River at Pompton Plains	92.8	136 (2)
Passaic Valley Water Commission	Passaic River at Little Falls	89.0	----
Passaic Valley Water Commission	Passaic River at Two Bridges	27.2	27.2
NJDWSC	Wanaque River	15.5	10.8 to 15.5
NJDWSC	Ramapo River	61.9	61.9
NJDWSC	Two Bridges	143.3 (1)	143.3 (1)
City of Newark	Macopin	12.3	12.3

(1) 27.2 cfs when PVWC is also diverting 75 MGD at Two Bridges.
(2) Permit 5099

The code indicates that where passing flow is not specified, it will be fixed by the Department based on an amount equal to the average daily flow for the driest month from records, or in lieu thereof, 125,000 gallons for each square mile of unappropriated watershed above the point of diversion (in addition to flows from any appropriated watershed above the point of diversion).

The code also indicates (NJAC 7:19-4.6 (d), 1) that fees will be paid by purveyors at a minimum charge of $1.00 per million gallons for each million gallons below the passing flow requirement, when the purveyor is diverting water. The maximum charge of $10.00 per million gallons shall apply on those days when the passing flow below the point of diversion is zero.

In WMA 6:

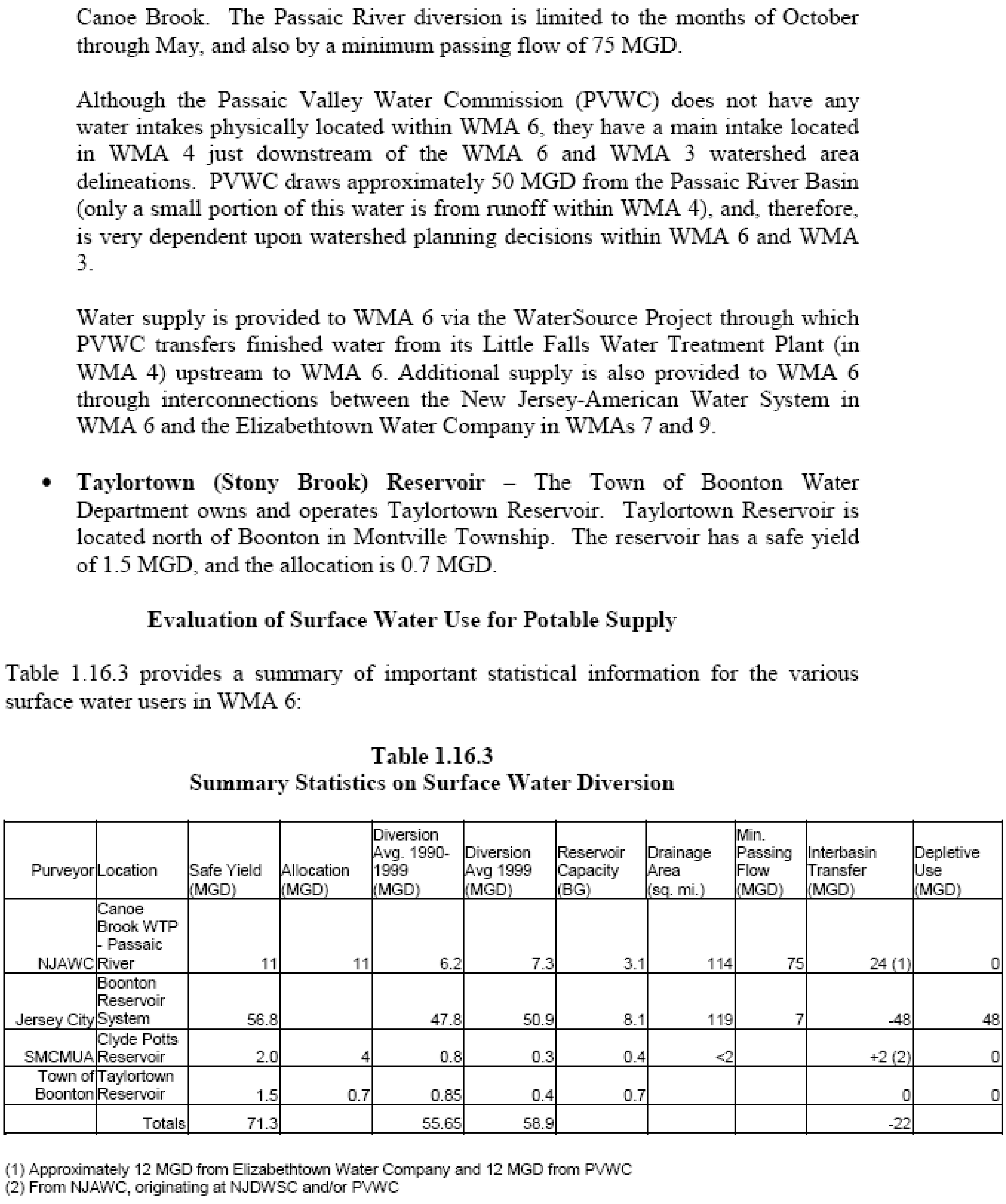
It is noted that the Passaic River and Rockaway River subwatersheds are currently used for major surface water supplies. The Clyde Potts Reservoir in the upper portion of the Whippany River subwatershed is an additional supply of surface water in WMA 6.

The following information is specific to those sources and users within the watershed:

- **Boonton Reservoir System** – The 8.1 BG **Boonton Reservoir** is owned by the City of Jersey City, and is filled by the **Rockaway River** and main tributaries (Beaver Brook, Green Pond Brook, and Stony Brook) within a drainage basin of over approximately 119 square miles. The **Splitrock Reservoir** which holds approximately 3.4 BG is part of the reservoir system. The reservoir system and watershed has a safe yield of 56.8 MGD.

- **Clyde Potts Reservoir** – This 400 million-gallon reservoir, maintained by SMCMUA, is located in Mendham Township, and is filled by a small adjacent watershed of Harmony Brook within the Whippany River watershed. This watershed and reservoir has a safe yield of 2 MGD.

- **Passaic River Basin** – The Passaic River supply is used by the New Jersey-American Water Company at their Canoe Brook Water Treatment Plant located in Millburn Township. The Water Company is permitted to divert 11 MGD from



Canoe Brook. The Passaic River diversion is limited to the months of October through May, and also by a minimum passing flow of 75 MGD.

Although the Passaic Valley Water Commission (PVWC) does not have any water intakes physically located within WMA 6, they have a main intake located in WMA 4 just downstream of the WMA 6 and WMA 3 watershed area delineations. PVWC draws approximately 50 MGD from the Passaic River Basin (only a small portion of this water is from runoff within WMA 4), and, therefore, is very dependent upon watershed planning decisions within WMA 6 and WMA 3.

Water supply is provided to WMA 6 via the WaterSource Project through which PVWC transfers finished water from its Little Falls Water Treatment Plant (in WMA 4) upstream to WMA 6. Additional supply is also provided to WMA 6 through interconnections between the New Jersey-American Water System in WMA 6 and the Elizabethtown Water Company in WMAs 7 and 9.

- **Taylortown (Stony Brook) Reservoir** – The Town of Boonton Water Department owns and operates Taylortown Reservoir. Taylortown Reservoir is located north of Boonton in Montville Township. The reservoir has a safe yield of 1.5 MGD, and the allocation is 0.7 MGD.

Evaluation of Surface Water Use for Potable Supply

Table 1.16.3 provides a summary of important statistical information for the various surface water users in WMA 6:

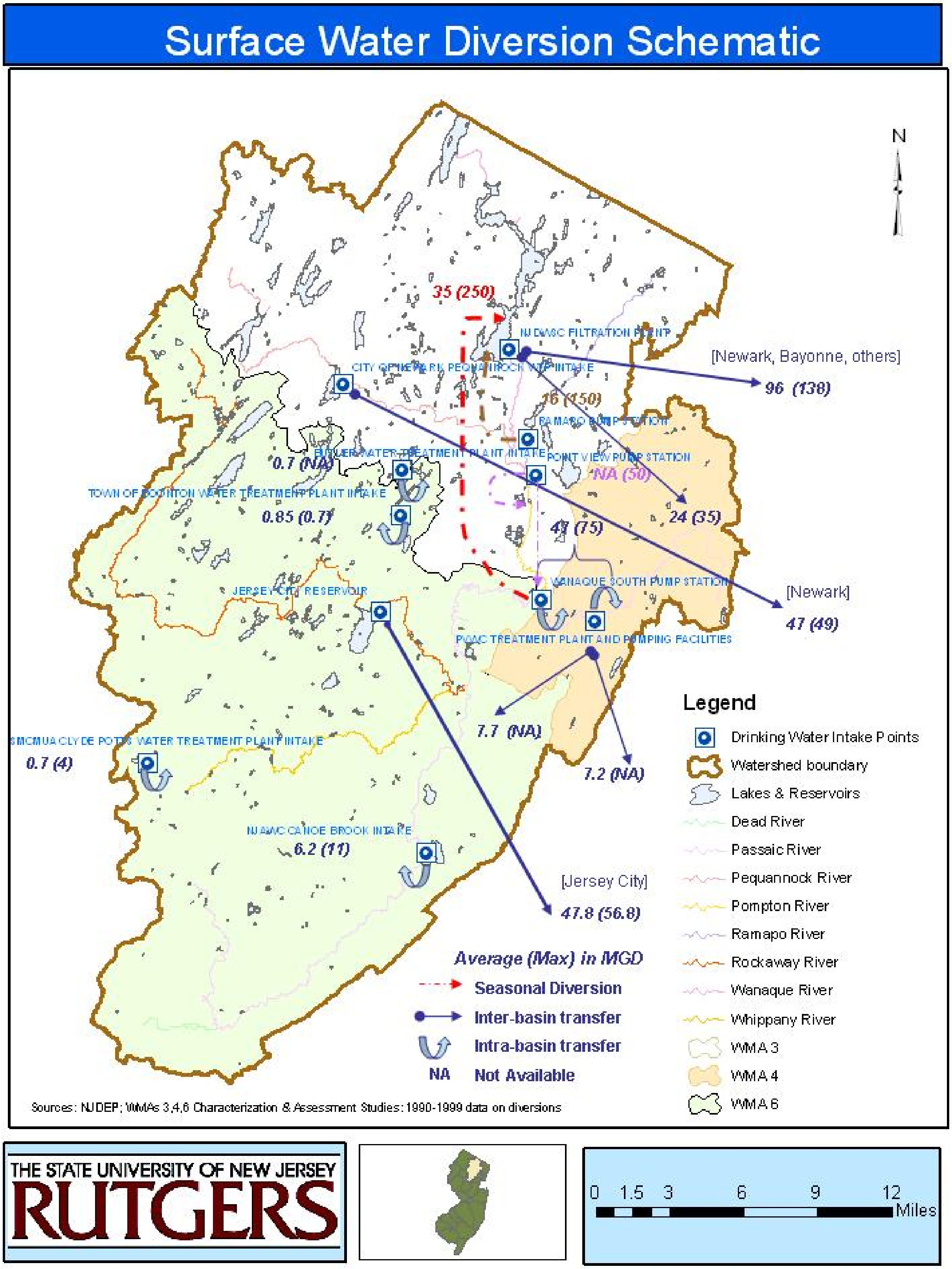
Table 1.16.3
Summary Statistics on Surface Water Diversion

Purveyor	Location	Safe Yield (MGD)	Allocation (MGD)	Diversion Avg. 1990-1999 (MGD)	Diversion Avg 1999 (MGD)	Reservoir Capacity (BG)	Drainage Area (sq. mi.)	Min. Passing Flow (MGD)	Interbasin Transfer (MGD)	Depletive Use (MGD)
NJAWC	Canoe Brook WTP - Passaic River	11	11	6.2	7.3	3.1	114	75	24 (1)	0
Jersey City	Boonton Reservoir System	56.8		47.8	50.9	8.1	119	7	-48	48
SMCMUA	Clyde Potts Reservoir	2.0	4	0.8	0.3	0.4	<2		+2 (2)	0
Town of Boonton	Taylortown Reservoir	1.5	0.7	0.85	0.4	0.7			0	0
	Totals	71.3		55.65	58.9				-22	

(1) Approximately 12 MGD from Elizabethtown Water Company and 12 MGD from PVWC
(2) From NJAWC, originating at NJDWSC and/or PVWC

Source: WMAs 3, 4, 6 Characterization and Assessment Studies (2002). Available at: http://www.njdwsc.com/prbwmp/intro.htm

The figure below visually summarizes the information in Appendix 1.



Surface Water Diversion Schematic

Sources: NJDEP; WMAs 3,4,6 Characterization & Assessment Studies: 1990-1999 data on diversions

Appendix 2:

Trade Verification Forms

Trade verification form
FOR SELLER

Facility	
1. Allocation (kg)	
2. Actual TP load discharged (kg)	
3. Actual qty. kilograms TP sold to____	________ actual kg sold to _____________
If facility has sold to more than one buyer, repeat Line 3 information for each additional buyer on lines below:	
3a.	
3b.	
3c.	
3d.	
4. Trading ratio (seller to buyer)	
If facility has sold to more than one buyer, repeat Line 4 information for each additional buyer on lines below:	
4a.	
4b.	
4c.	
4d.	
* 5. Equalized qty. kilograms TP sold to _____	(Multiply Line 3 by Line 4) ________ equalized kg sold to ___________
If facility has sold to more than one buyer, repeat Line 5 information for each additional buyer on lines below:	
5a.	
5b.	
5c.	
5d.	
6. Balance	(Subtract all information in items 2 and 3 from Line 1).

* Verify that ‘equalized kg sold to __’ in Line 5 matches ‘equalized kg purchased from __’ in Line 3 of BUYER form.

Trade verification form
FOR BUYER

Facility	
1. Allocation (kg)	
2. Actual TP load discharged (kg)	
* 3. Equalized qty. kilograms TP purchased from _____	________ equalized kg purchased from ___________
If facility has purchased from more than one seller, repeat Line 3 information for each additional seller on lines below:	
3a.	
3b.	
3c.	
3d.	
4. Balance	(Add all information in Items 1 and 3, then subtract Line 2).

* Verify that 'equalized kg purchased from __' in Line 3 matches 'equalized kg sold to ___' in Line 5 of SELLER form.

Appendix 3:

Example Trades

Example Trade #1
Intra-Upper Passaic MA trade

- Buyer: Harrison Brook STP (located in Dead River Zone)
  - Load discharged = 2418 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 1.71 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 947 kg/yr (Table 5-4)
  - **Balance** = Allocation – load discharged = **- 1471 kg**
- Seller: Caldwell Boro STP (located in Upper Passaic Zone 2)
  - Load discharged = 552 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 3.92 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 2,166 kg/yr (Table 5-4)
  - **Balance** = Allocation – load discharged = **1614 kg**
- **Trading ratio = 0.92 (Table 5-7)**
- **Harrison Brook needs to buy 1471 kg**
- **Caldwell Boro can sell 0.92 *1599 kg = 1471 *equalized* kg**
- **Calwell Boro new balance = 1614 kg – 1599 kg = 15 kg**
- **Harrison Brook new balance = -1471 kg + 1471 kg = 0 kg**
- *Note: Buyer must always be Category 2 discharger that is included in the model domain.*

Example Trade #2
Intra-Pompton MA trade

- Buyer: Two Bridges SA (located in Two Bridges Zone)
  - Load discharged = 7737 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 5.80 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 3208 kg/yr (Table 5-4)
  - **Balance** = Allocation – load discharged = **- 4529 kg**
- Seller: Wanaque Valley RSA (located in Pompton Headwater Zone)
  - Load discharged = 138 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 1.06 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 584 kg/yr (Table 5-4)
  - **Balance** = Allocation – load discharged = **446 kg**
- **Trading ratio = 0.72 (Table 5-7)**
- **Two Bridges SA needs to buy 4529 kg**
- **Wanaque Valley RSA can sell 0.72 *446 kg = 321 *equalized* kg**
- **Wanaque Valley RSA new balance = 446 kg – 446 kg = 0 kg**
- **Two Bridges SA new balance = - 4529 kg + 321 kg = - 4208 kg**
  - **Two Bridges must still buy 4208 kg from other sellers**
- *Note: Buyer must always be Category 2 discharger that is included in the model domain.*

Example Trade #3
Intra-Lower Passaic MA trade

- **Buyer: Cedar Grove Twp STP (located in Lower Passaic Zone 2)**
  - Summer discharge = 1662 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 1.49 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - *Summer* Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 413 kg/season (Table 5-4)
  - **Summer Balance** = Summer Allocation – load discharged = **- 1249 kg**
- **Seller: Wayne Twp – Mountain View (located in Lower Passaic Zone 1)**
  - Summer discharge = 560 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 8.22 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - *Summer* Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 2272 kg/season (Table 5-4)
  - **Summer Balance** = Summer Allocation – load discharged = **1712 kg**
- **Trading ratio = 0.66 (Table 5-7)**
- **Cedar Grove needs to buy 1249 kg for summer period.**
- **Wayne can sell 0.66 *1712 kg = 1130 *equalized* kg for summer period.**
- **Wayne Twp new summer balance = 1712 kg – 1712 kg = 0 kg**
- **Cedar Grove new summer balance = -1249 kg + 1130 kg = - 119 kg**
  - **Cedar Grove must still buy 119 kg from other sellers**
- *Note: Buyer must always be Category 2 discharger that is included in the model domain.*

Example Trade #4
Inter-MA trade, Pompton selling to Upper Passaic

- Buyer: Hanover SA STP (located in Whippany Zone)
  - Load discharged = 2902 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 2.07 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 1144 kg/yr (Table 5-4)
  - **Balance** = Allocation – Load discharged = **- 1758 kg**
- Seller: Two Bridges SA (located in Two Bridges Zone)
  - Load discharged = 815 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 5.80 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 3208 kg/yr (Table 5-4)
  - **Balance** = Allocation – Load discharged = **2393 kg**
- **Trading ratio = 0.63 (Table 5-7)**
- **Hanover needs to buy 1758 kg**
- **Two Bridges can sell 0.63 *2393 kg = 1508 *equalized* kg**
- **Two Bridges new balance = 2393 kg – 2393 kg = 0 kg**
- **Hanover new balance = -1758 kg + 1508 kg = - 250 kg**
  - **Hanover must still buy 250 kg from other sellers**
- *Note: Buyer must always be Category 2 discharger that is included in the model domain.*

Example Trade #5

Inter-MA trade, Upper Passaic selling to Lower Passaic

- **Buyer: Verona Twp STP (located in Lower Passaic Zone 2)**
  - Summer discharge = 1554 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 2.37 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - *Summer* Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 655 kg/season (Table 5-4)
  - **Summer Balance** = Summer Allocation – load discharged = **- 899 kg**
- **Seller: Parsippany-Troy Hills SA (located in Whippany Zone)**
  - Because buyer is in Lower Passaic MA, Parsippany-Troy Hills needs to make seasonal trade. It can only use allowances from summer to offset balance of buyer.
  - Summer discharge = 850 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 12.57 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - *Summer* Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 3473 kg/season (Table 5-4)
  - **Summer Balance** = Summer Allocation – load discharged = **2,623 kg**
- **Trading ratio = 0.39 (Table 5-7)**
- **Verona needs to buy 899 kg for summer period**
- **Parsippany-Troy Hills can sell 0.39 *2305 kg = 899 *equalized* kg for summer period**
- **Parsippany-Troy Hills new summer balance = 2623 kg – 2305 kg = 318 kg**
- **Verona new summer balance = -899 kg + 899 kg = 0 kg**
- *Note: Buyer must always be Category 2 discharger that is included in the model domain.*

Example Trade #6

Inter-MA trade, Pompton selling to Lower Passaic

- **Buyer: Nabisco Fair Lawn Bakery (located in Lower Passaic Zone 2)**
  - Summer discharge = 604 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 0.28 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - *Summer* Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 78 kg/season (Table 5-4)
  - **Summer Balance** = Summer Allocation – load discharged = **- 526 kg**
- **Seller: Pompton Lakes MUA (located in Pompton Headwater Zone)**
  - Because buyer is in Lower Passaic MA, Pompton Lakes needs to needs to make seasonal trade. It can only use allowances from summer to offset balance of buyer.
  - Summer discharge = 55 kg (hypothetical)
  - Anticipated Actual Discharger Flow = 0.90 MGD; (average of 2005-2007 Discharger flow, Table 5-4)
  - *Summer* Allocation = 0.4 mg/l * Anticipated Actual Discharger Flow = 249 kg/season (Table 5-4)
  - **Summer Balance** = Summer Allocation – load discharged = **194 kg**
- **Trading ratio = 0.21 (Table 5-7)**
- **Nabisco needs to buy 526 kg for summer period**
- **Pompton Lakes can sell 0.21 *194 kg = 41 *equalized* kg for summer period**
- **Pompton Lakes new summer balance = 194 kg – 194 kg = 0 kg**
- **Nabisco new summer balance = -526 kg + 41 kg = -485 kg; still needs to buy 485 kg from other sellers for summer**
- *Note: Buyer must always be Category 2 discharger that is included in the model domain.*

Appendix 4:

Example Derivations of Trading Ratios

Derivation of trading ratios: Example 1 intra-Upper Passaic MA trade

- Seller: Berkeley Heights (Upper Passaic Zone 1)
  - ZPC at Dundee Lake = 0.79, no diversion
  - ZPC at Dundee Lake = 0.64, diversion
  - ZPC at Dundee Lake = 0.39, extreme diversion
  - ZPC at Wanaque South = 0.13, extreme diversion
- Buyer: Rockaway Valley SA (Rockaway Zone)
  - ZPC at Dundee Lake = 0.63, no diversion
  - ZPC at Dundee Lake = 0.56, diversion
  - ZPC at Dundee Lake = 0.29, extreme diversion
  - ZPC at Wanaque South = 0.10, extreme diversion
- Trading ratio = (Seller ZPC/Buyer ZPC)
  - No diversion, trading ratio = 1.25 = 0.79/0.63
  - Diversion, trading ratio = 1.14 = 0.64/0.56
  - Extreme diversion, trading ratio = 1.30 = min (0.39/0.29 , 0.13/0.10)
  - **As in Table 5-7, select 0.90*1.14 as trading ratio = <u>1.03</u>**

Derivation of trading ratios: Example 2 intra-Pompton MA trade

- Seller: Two Bridges SA (Two Bridges Zone)
  - ZPC at Dundee Lake = 0.93, no diversion
  - ZPC at Dundee Lake = 0.47, diversion
  - ZPC at Wanaque South = 1.00, diversion
  - ZPC at Dundee Lake = 0.25, extreme diversion
  - ZPC at Wanaque South = 1.00, extreme diversion
- Buyer: Pompton Lakes MUA (Pompton Headwater Zone)
  - ZPC at Dundee Lake = 0.92, no diversion
  - ZPC at Dundee Lake = 0.51, diversion
  - ZPC at Wanaque South = 0.99, diversion
  - ZPC at Dundee Lake = 0.20, extreme diversion
  - ZPC at Wanaque South = 0.95, extreme diversion
- Trading ratio = (Seller ZPC/Buyer ZPC)
  - No diversion, trading ratio = 1.01 = 0.93/0.92
  - Diversion, trading ratio = 0.92 = min (0.47/0.51 , 1.0/0.99)
  - Extreme diversion, trading ratio = 1.05 = min (0.25/0.20 , 1.0/0.95)
  - **As in Table 5-7, select 0.90*0.92 as trading ratio = <u>0.83</u>**

Derivation of trading ratios: Example 3 intra-Lower Passaic MA trade

- Seller: Wayne Twp – Mountain View (Lower Passaic Zone 1)
  - ZPC at Dundee Lake = 0.93, no diversion
  - ZPC at Dundee Lake = 0.86, diversion
  - ZPC at Dundee Lake = 0.62, extreme diversion
- Buyer: Verona Twp (Lower Passaic Zone 2)
  - ZPC at Dundee Lake = 0.90, no diversion
  - ZPC at Dundee Lake = 0.89, diversion
  - ZPC at Dundee Lake = 0.84, extreme diversion
- Trading ratio = (Seller ZPC/Buyer ZPC)
  - No diversion, trading ratio = 1.03 = (0.93/0.90)
  - Diversion, trading ratio = 0.97 = (0.86/0.89)
  - Extreme diversion, trading ratio = 0.74 = (0.62/0.84)
  - **As in Table 5-7, select 0.90*0.74 as trading ratio = <u>0.66</u>**

Derivation of trading ratios: Example 4 inter-MA trade, Pompton selling to Upper Passaic

- Seller: Two Bridges SA (Two Bridges Zone)
  - ZPC at Dundee Lake = 0.93, no diversion
  - ZPC at Dundee Lake = 0.47, diversion
  - ZPC at Dundee Lake = 0.25, extreme diversion
  - ZPC at Wanaque South = 1.00, extreme diversion
- Buyer: Warren Twp SA – Stage 5 (Dead River Zone)
  - ZPC at Dundee Lake = 0.77, no diversion
  - ZPC at Dundee Lake = 0.62, diversion
  - ZPC at Dundee Lake = 0.37, extreme diversion
  - ZPC at Wanaque South = 0.13, extreme diversion
- Trading ratio = (Seller ZPC/Buyer ZPC)
  - No diversion, trading ratio = 1.21 = (0.93/0.77)
  - Diversion, trading ratio = 0.76 = (0.47/0.62)
  - Extreme diversion, trading ratio = 0.68 = min (0.25/0.37 , 1.0/0.13)
  - **As in Table 5-7, select 0.90*0.68 as trading ratio = <u>0.61</u>**

Derivation of trading ratios: Example 5
inter-MA trade, Pompton selling to Lower Passaic

- Seller: Two Bridges SA (Two Bridges Zone)
  - ZPC at Dundee Lake = 0.93, no diversion
  - ZPC at Dundee Lake = 0.47, diversion
  - ZPC at Dundee Lake = 0.25, extreme diversion
- Buyer: Wayne Twp – Mountain View (Lower Passaic Zone 1)
  - ZPC at Dundee Lake = 0.93, no diversion
  - ZPC at Dundee Lake = 0.86, diversion
  - ZPC at Dundee Lake = 0.62, extreme diversion
- Trading ratio = (Seller ZPC/Buyer ZPC)
  - No diversion, trading ratio = 1.00 = (0.93/0.93)
  - Diversion, trading ratio = 0.55 = (0.47/0.86)
  - Extreme diversion, trading ratio = 0.40 = (0.25/0.62)
  - **As in Table 5-7, select 0.90*0.40 as trading ratio = 0.36**

Derivation of trading ratios: Example 6
inter-MA trade, Upper Passaic selling to Lower Passaic

- Seller: Parsippany-Troy Hills SA (Whippany Zone)
  - ZPC at Dundee Lake = 0.73, no diversion
  - ZPC at Dundee Lake = 0.64, diversion
  - ZPC at Dundee Lake = 0.36, extreme diversion
- Buyer: Cedar Grove Twp STP (Lower Passaic Zone 2)
  - ZPC at Dundee Lake = 0.90, no diversion
  - ZPC at Dundee Lake = 0.89, diversion
  - ZPC at Dundee Lake = 0.84, extreme diversion
- Trading ratio = (Seller ZPC/Buyer ZPC)
  - No diversion, trading ratio = 0.81 = (0.73/0.90)
  - Diversion, trading ratio = 0.72 = (0.64/0.89)
  - Extreme diversion, trading ratio = 0.43 = (0.36/0.84)
  - **As in Table 5-7, select 0.90*0.43 as trading ratio = <u>0.39</u>**

Appendix 5:

Ten Steps to Passaic Trading

Ten Steps to Passaic Trading

1. Are you eligible to participate in the trading program? (Check Table 5-4)
    - ❖ Only Category 2 dischargers that are contained within the model domain are eligible to buy phosphorus allowances.
2. Which management area are you in? Check the Passaic Trading Framework to find out which management areas you can trade with.
3. Which point source zone are you in?
    - ❖ If you're in the Lower Passaic Zone 1 or 2, or trading with either of those zones, then trades are made on a seasonal basis (May-Oct)
    - ❖ Otherwise, trades are made on an annual basis (Jan – Dec)
4. What is your allocation? (Check Table 5-4)
5. How many kg/yr of TP do you expect to discharge? Is that number greater or less than your allocation?
6. Who do you want to trade with?
7. What is the trading ratio between you and the facility you want to trade with? (Check Table 5-7)
8. Apply the trading ratio (choose the ratio of seller to buyer in Table 5-7) to convert the *actual* TP sold into *equalized* kg bought
9. What balance will you have after trading? (Apply the trading formula on next slide)
10. *See Examples in Appendix 2*

Passaic Trading Formula

Balance =

Allocation – Load discharged

\- Actual load sold + Equalized load purchased

- Equalized load = (Actual load * Trading ratio of seller to buyer)
- Allocations are listed in Table 5-4
- Trading ratios are listed in Table 5-7
- Load discharged determined on an annual basis for dischargers upstream of the Confluence. For dischargers downstream of the Confluence and any other dischargers they trade with, load discharged determined on a seasonal basis (May-Oct).

Appendix 6:

Draft Quality Assurance Project Plan (QAPP)

QUALITY ASSURANCE PROJECT PLAN

Water Quality Trading in the Non-Tidal Passaic River Watershed
Surface Water Quality Monitoring Program

Rutgers Cooperative Extension Water Resources Program (RCE WRP)

Contract Agreement No. WS972841-04-0
Targeted Watershed Grant
for
"Development, Implementation and Evaluation of a Water Quality Trading Program"

January 30, 2008
Revised May 15, 2008
Revised September 15, 2008
Revised July 16, 2009

1. Title and Approval Sheet

QUALITY ASSURANCE PROJECT PLAN

Water Quality Trading in the Non-Tidal Passaic River Watershed Surface Water Quality Monitoring Program

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Signature Date

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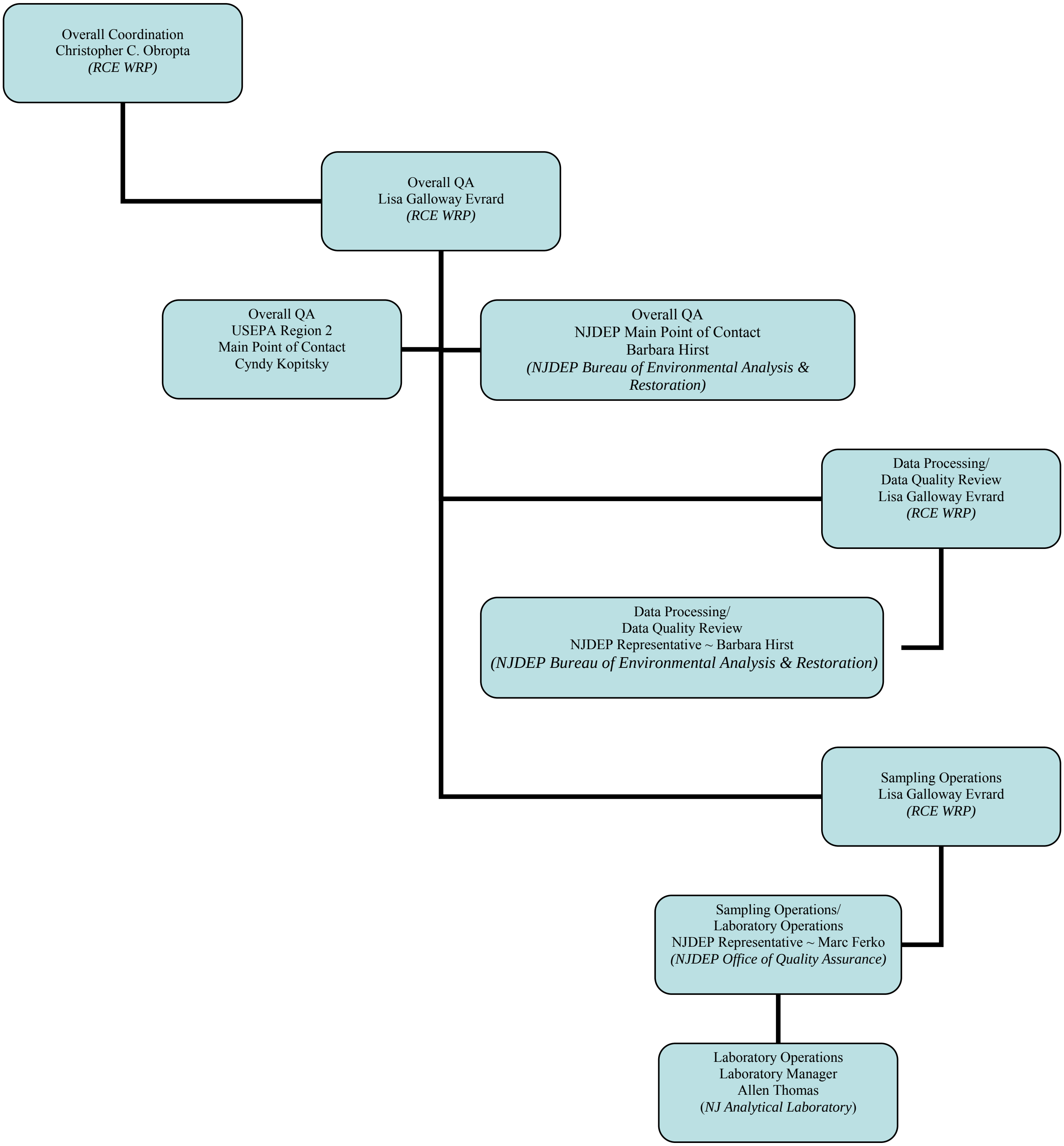
4. Project/Task Organization

Project Organization and Responsibility:

Laboratory Operations:	(Laboratory Representative)	Allen Thomas (*NJ Analytical Laboratory*)
	(NJDEP Representative)	Marc Ferko (*NJDEP Office of Quality Assurance*)
Sampling Operations:	(RCE WRP Representative)	Lisa Galloway Evrard (*RCE WRP*)
	(NJDEP Representative)	Marc Ferko (*NJDEP Office of Quality Assurance*)
Data Processing/ Data Quality Review:	(RCE WRP Representative)	Lisa Galloway Evrard (*RCE WRP*)
	(NJDEP Representative)	Barbara Hirst (*NJDEP Bureau of Environmental Analysis & Restoration*)
Overall QA:	(RCE WRP Representative)	Lisa Galloway Evrard (*RCE WRP*)
	(USEPA Region 2 Main Point of Contact)	Cyndy Kopitsky *(USEPA Region 2)*
	(NJDEP Representative)	Barbara Hirst (*NJDEP Bureau of Environmental Analysis & Restoration*)
Overall Coordination:	(RCE WRP Main Point of Contact)	Christopher C. Obropta (*RCE WRP)*

Organizational Chart:



5. Special Training Needs/Certification

Special certification requirements are not needed by any project personnel for field activities pertaining to this monitoring program. Field personnel will be trained annually in the collection of surface water quality samples in accordance with the NJDEP Field Procedures Manual (Go to http://www.state.nj.us/dep/srp/guidance/fspm/) by the Sampling Operations RCE WRP Representative. Sample analysis will be done by the NJDEP certified laboratory, New Jersey Analytical Laboratories. Laboratory certification is documented and assured by the NJDEP Office of Quality Assurance under NJAC 7:18 Regulations Governing the Certification of Laboratories and Environmental Measurements.

6. Problem Definition/Background

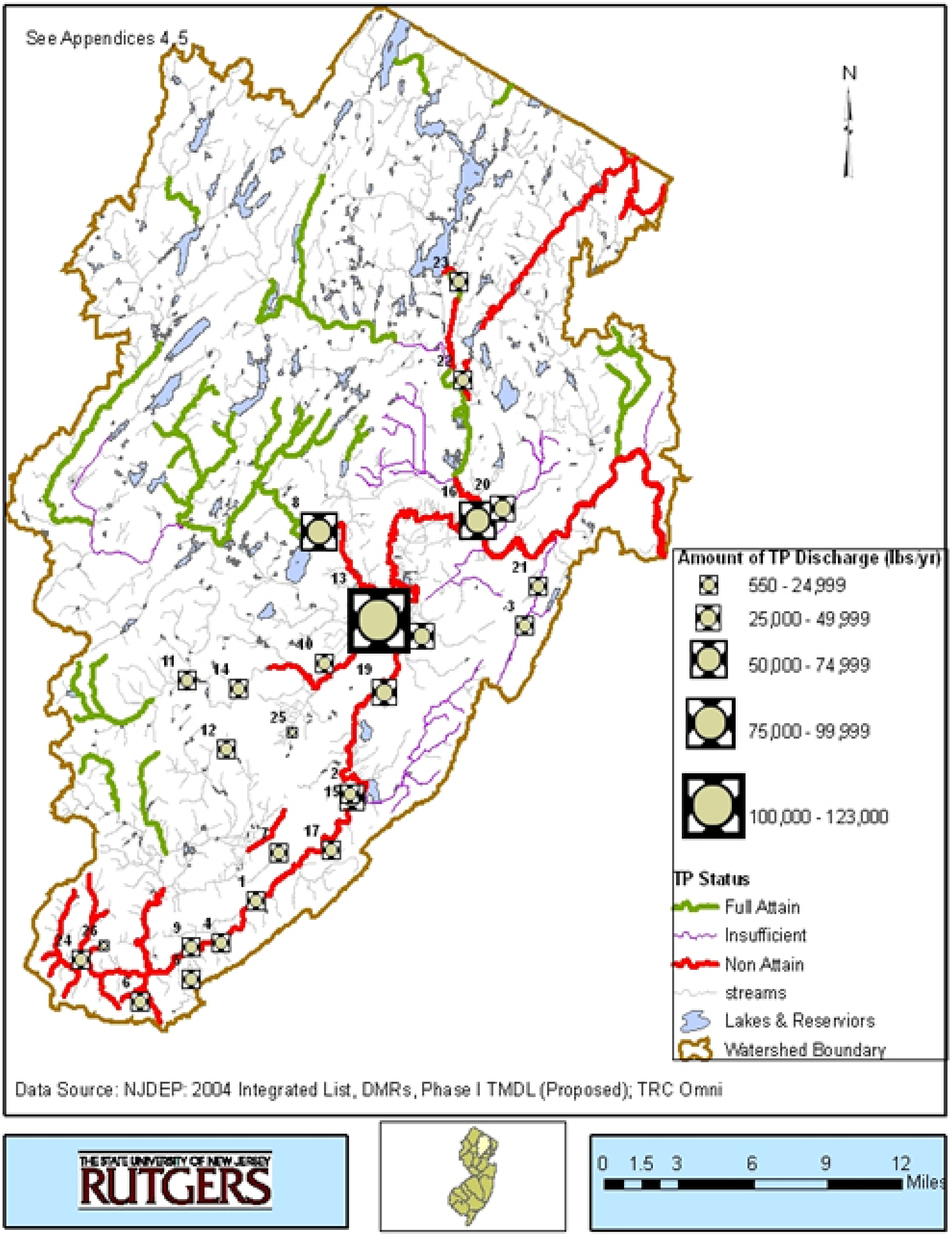
Background: The non-tidal portion of the Passaic River Watershed encompasses 803 square miles, with 669 square miles of the watershed in New Jersey. About 25% of New Jersey's population (i.e., 2 million people) lives in this watershed. Three of New Jersey's twenty watershed management areas (WMAs 3, 4, and 6) overlap with the Non-Tidal Passaic River Watershed.

The New Jersey Department of Environmental Protection (NJDEP) proposed on May 7, 2007 and adopted on April 24, 2008 a total maximum daily load (TMDL) report to address phosphorus impairments in the Non-Tidal Passaic River Watershed. Excess phosphorus can cause algal blooms, reduced dissolved oxygen, and eutrophication of water bodies, which can result in fish kills and drinking water supply taste and odor problems. The surface water quality criteria for total phosphorus, as reported in NJAC 7:9B 1.14(d) – General Surface Water Quality Criteria, are as follows:

5. Phosphorus, Total (mg/L)	*i.*	*Lakes: Phosphorus as total P shall not exceed 0.05 in any lake, pond or reservoir, or in a tributary at the point where it enters such bodies of water, except where watershed or site-specific criteria are developed pursuant to N.J.A.C. 7:9B-1.5(g)3.*	*FW2*
	ii.	*Streams: Except as necessary to satisfy the more stringent criteria in paragraph i above or where watershed or site-specific criteria are developed pursuant to N.J.A.C 7:9B-1.5(g)3, phosphorus as total P shall not exceed 0.1 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.*	*FW2*

The following figure outlines phosphorus impaired streams and total phosphorus loading from wastewater treatment plants (WWTP) within the Non-Tidal Passaic River Watershed. The TMDL aims to achieve seasonal chlorophyll-a criteria in the Wanaque Reservoir (i.e., 10 µg/l for June 15-September 1) and Dundee Lake (i.e., 20 µg/l for June 15-September 1) through reduced phosphorus loading from point and nonpoint sources within the watershed.

Phosphorus Impaired Streams & WWTP Loads



Data Source: NJDEP: 2004 Integrated List, DMRs, Phase I TMDL (Proposed); TRC Omni

Most of the 22 sewage treatment plants in the Non-Tidal Passaic River Watershed will need to invest heavily on upgraded equipment to comply with the proposed phosphorus wasteload allocations. A trading program has been proposed as a cost effective alternative to meeting the phosphorus effluent standard. In 2005, the EPA awarded a Targeted Watershed Grant to fund the development of the trading program. An active coalition of point sources, the NJDEP, and a team of experts from Rutgers and Cornell Universities have been assembled to complete this endeavor. The project design, implementation and evaluation will extend from 2005-2010. The trading program will focus on both point-point and point-nonpoint trading opportunities. Potential participants include sewage treatment plants and municipal stormwater sources. This trading program will provide a cost-effective way to implement the TMDL.

> The following is taken from the April 24, 2008 adopted TMDL report, which is available at http://www.nj.gov/dep/watershedmgt/DOCS/TMDL/passaic_tmdl.pdf :
>
> > *Dischargers will be allowed to engage in water quality trading negotiations to effect a change in effluent limits, with Department approval. It should be note that, in June 2005 EPA awarded a Targeted Watershed grant in the amount of $900,000 to Rutgers University for the purpose of developing a water quality trading pilot with respect to the phosphorus impairment in the Passaic River basin. This project has been investigating the options for and overall viability of a trading approach in the Passaic River basin. This project will produce a set of tools and rules that will govern allowable trades within the study area. These will include trading ratios and management zones within which trades can occur and still achieve the TMDL outcomes at the critical locations. Once the proposed tools and rules are developed, they will be subject to public comment. Following this process, as well as Department and EPA approval of the protocols, interested permittees can proceed to negotiate trades that achieve the desired result in a more cost effective way. For example, it may be more cost effective for a few larger facilities to upgrade to a higher level than for all treatment facilities to upgrade to the same level. Because diversion of Pompton and Passaic River water into the Wanaque Reservoir is a loading source, another option in the portion of the watershed above the confluence of the Pompton and Passaic Rivers is to trade wastewater treatment plant upgrades for treatment of river water by NJDWSC prior to diversion to the reservoir. The Department anticipates allowing 1 year from the date of permit issuance, provided the terms of acceptable trades have been subject to public comment and approved by EPA and the Department, to negotiate trades so that treatment plant upgrades consistent with permit limits are implemented within the compliance schedules that will be set forth in the permits.*

Purpose: This surface water quality monitoring program has been initiated by the Rutgers Cooperative Extension Water Resources Program (RCE WRP) to provide baseline monitoring of conditions before trading takes place, as well as monitoring of conditions after trading occurs. The data will simply be used to compare the pre-trade levels of the chemical parameter of concern (i.e., phosphorus) with the post-trade levels. This is not a research project; this is a monitoring program. Baseline monitoring would add to the TMDL study dataset collected in 2003 and would provide an updated description of conditions in the watershed prior to trading. (The TMDL study dataset collected in 2003 can be found at http://www.nj.gov/dep/watershedmgt/tmdl.htm under “Additional Resources” for “Total

Maximum Daily Load Report for the Non-Tidal Passaic River Basin Addressing Phosphorus Impairments.") By collecting more data now *before* trading starts, a better evaluation can be made in the future *after* trading starts regarding the impacts of trading on water quality.

In addition, as stated previously, in 2005 the EPA awarded a Targeted Watershed Grant to fund the development of the trading program. Preparation/development of a monitoring program is a condition of the Targeted Watershed Grant funding.

Usage: These data will be used by the NJDEP Bureau of Analysis and Restoration to compare instream phosphorus levels pre-trade and post-trade as part of the ongoing development and implementation of a water quality trading program for the Non-Tidal Passaic River Watershed.

7. Project/Task Description

Monitoring Network Design and Rationale

Sampling Locations:

The sampling locations are shown on Map 1 and Map 2 of Attachment A. Table 1 of Attachment A describes the TMDL endpoints and areas of concern, six sampling locations in total, which should be monitored before and after trading takes place. Table 2 of Attachment A describes all the dischargers that would be eligible buyers. Monitoring will be done directly downstream of any of these dischargers that choose to buy credits, both before and after trading takes place.

A WAAS-enabled Garmin Rino 120 GPS (global positioning system) unit will be used to locate and identify the sampling locations. Sampling locations will be marked with surveying flags. Field personnel will take GPS readings in the field to aid in verifying the correct sampling locations during the first sampling event.

Basis for Sampling Locations:

Surface water quality sampling will be conducted to assess the concentration of phosphorus in the Non-Tidal Passaic River Watershed at key locations (i.e., at TMDL endpoints, areas of concern, and at trading locations), as well as the movement of phosphorus, to document improvements in water quality due to trading.

Temporal and Spatial Aspects of Sampling:

Surface water quality samples will be collected from all sampling locations in a downstream to upstream order to avoid disturbances to downstream water column samples twice per month, independent of weather, for six months prior to trading (i.e., pre-trade sampling preferably during the months of May - October) and six months after trading (i.e., post-trade sampling preferably during the months of May - October).

All scheduling is subject to the natural occurrence of appropriate stream flow conditions (i.e., non-flooding conditions). In accordance with the NJDEP Field Sampling Procedures Manual (Go to http://www.state.nj.us/dep/srp/guidance/fspm/ , see Section 6.8.1.1, Chapter 6D – page 59 of 188), field personnel will not wade into flowing water when the product of depth (in feet) and velocity (in feet per second) equals ten or greater to ensure the health and safety of all field personnel. If the stream flow conditions preclude entry into the stream, samples will be collected from the closest bridge crossing to that location or from the stream bank.

For the most part, the waterways within the Non-Tidal Passaic River Watershed are uniformly mixed which warrants grab sampling (Go to http://www.state.nj.us/dep/srp/guidance/fspm/, see Section 6.8.2.2.3, Chapter 6D-Page 66 of 188 of the Field Sampling Procedures Manual). A single grab sample will be collected at all locations where the stream width is six feet or less. At stream locations with a width greater than six feet, a minimum of three subsurface grab samples (i.e., quarter points) will be collected at equidistant points across the stream. The number of individual samples in a composite varies with the width of the stream being sampled. Horizontal intervals will be at least one foot wide (Go to http://www.state.nj.us/dep/srp/guidance/fspm/, see Section 6.8.2.2.2, Chapter 6D – Page 64 of 188 of the Field Sampling Procedures Manual). These grab samples then will be composited in a larger volume container from which the desired volume will be transferred to the sample bottles. A dedicated large volume container will be assigned to each sample location.

Field equipment used for surface water quality sample collection (i.e., bottles and buckets) will be decontaminated/cleaned in the laboratory prior to each sampling event. A dedicated large volume container will be assigned to each sample location. Prior to each sampling event, the large volume containers will be decontaminated in the laboratory using the following procedures in accordance with the Field Sampling Procedures Manual (Go to http://www.state.nj.us/dep/srp/guidance/fspm/, see Chapter 2A – Page 10 of 61): 1) laboratory grade glassware detergent plus tap water wash, 2) generous tap water rinse, 3) distilled/deionized water rinse, 4) 10% nitric acid rinse, 5) distilled/deionized water rinse. Note that the samples collected will not be analyzed for metals or organics. Also, field equipment decontamination water will be disposed of in accordance with the laboratory's Standard Operating Procedures and Quality Assurance Manual.

Monitoring Parameters

Surface water quality sample collection will be conducted by the RCE WRP. Collected samples will be analyzed for total phosphorus and dissolved orthophosphate phosphorus by New Jersey Analytical Laboratories (NJDEP Certified Laboratory #11005).

Schedule[*]

Task	Date
Submit QAPP	January 2008
Conduct monthly surface water sampling	• Six months before trading takes place (12 events, preferably during the months of May - October) • Six months after trading takes place (12 events, preferably during the months of May - October)
Submit data and summary report to NJDEP and USEPA Region 2	• Within three months of conclusion of pre-trade surface water sampling (interim report – includes pre-trade data) • Within three months of conclusion of post-trade surface water sampling (final report – includes an analysis of pre-trade vs. post-trade data)

[*] All scheduling is subject to the natural occurrence of appropriate stream flow conditions (i.e., non-flooding conditions).

8. Quality Objectives and Criteria for Measurement Data ~ precision, bias, representativeness, comparability, completeness and sensitivity

The data collected in accordance with this QAPP will help describe surface water quality conditions within the Non-Tidal Passaic River Watershed before and after trading. The data will help to verify if the trading is actually working to reduce in-stream phosphorus levels.

A table of parameter detection limits, quantitation limits, accuracy, and precision applicable to this monitoring program, and which helps to ensure that the measured data is acceptable for use in comparing water quality conditions within the watershed before and after trading, is provided in Attachment E.

Data validation (i.e., the determination of any bias in the data) will be performed by New Jersey Analytical Laboratories. Any irregularities noted will be reported via quality control summaries to the RCE WRP and shall include the following:

Method Blank: The method blank cannot show the presence of the parameter of interest above the reported detection limit. Analysis of the batch should not continue until the source of the problem has been corrected.

Laboratory Fortified Blank (LFB): Where appropriate, the LFB must fall within the QC control limits. If the LFB is outside the limits, the following corrective actions should be taken:

- Check data and recovery calculations
- Check reference QC standard
- Reanalyze sample batch

QC Matrix Spike: The matrix spike should fall within the QC limits established for each methodology. The corrective actions should be as follows:

- Check data and recovery calculations
- Check whether LFB and reference standard are acceptable
- If only the matrix spike is not within control limits, check other analytes present for possible sample matrix interference as detailed in the specific method. If the sample matrix is identified as the problem, this may be footnoted. If the matrix spike is consistently outside for a particular parameter, another methodology may have to be considered for sample analysis.
- Check reference QC standard, if one was performed in that batch.
- If the matrix spike is not within control limits, check for presence of that analyte at a high value, which may be greater than the spike amount, causing invalid spike recovery.

Precision: Precision of method is evaluated by control charts, continuously maintained and updated at quarterly intervals. Matrix Spike Duplicates (MSD) must have a relative percent difference (RPD) equal to or lower than the calculated maximum RPD. If reproducibility cannot be achieved and sample matrix interferences are not apparent, batch reanalysis should occur. Calculations, dilutions, etc. should be checked prior to reanalysis.

Accuracy:

- Initial and continuing calibrations must be within acceptance criteria.
- LFB acceptance by control limits shall be continuously maintained and updated. LFB result must fall within control limits.
- Recovery control charts must be continuously maintained and updated. All parameters will have upper and lower warning limits (UWL/LWL) set at two standard deviation (SD) units, and upper and lower control limits (UCL/LCL) set at three SD units. Matrix spikes must fall within control limits unless sample value (raw) is four or more times concentrations of spike level.

Representativeness: See Section 7. **Project/Task Description**, <u>Monitoring Network Design and Rationale</u>. Surface water quality sampling will be conducted to assess the concentration of phosphorus in the Non-Tidal Passaic River Watershed at key locations (i.e., at TMDL endpoints, areas of concern, and at trading locations), as well as to assess the movement of phosphorus, to document improvements in water quality due to trading.

Comparability: Sample collection and handling methods, as well as sample preparation and analytical procedures will remain consistent from pre-trade monitoring to post-trade monitoring. Any deviations will be noted in the interim and final reports.

Completeness: This monitoring program proposes 12 pre-trade sampling events and 12 post-trade sampling events. It is very difficult to prepare a definite schedule at this point due to the uncertain initiation of trades. Additional sampling events may be required to address seasonal variation in surface water quality under the pre and post trade scenarios. Additional sampling events will provide a more statistically robust and complete data set for comparing the pre and post trade condition.

Sensitivity: As previously noted, a table of parameter detection limits, quantitation limits, accuracy, and precision applicable to this monitoring program, and which help to ensure that the measured data is acceptable for use in comparing water quality conditions within the watershed before and after trading, are provided in Attachment E. These tables also contain project detection limits which are sensitive enough to reflect exceedances of the surface water quality criteria for total phosphorus.

9. Non-direct Measurements (Secondary Data)

Flow at the closest USGS gaging station (i.e., Station #01379500) will be recorded for each sampling event. The RCE WRP acknowledges that recent stream discharge data provided by the USGS is provisional data subject to revision. Stream discharge data will not be used until it is approved for publication. Information concerning the accuracy and appropriate uses of these data will be obtained from the station manager, whose name is shown on the single station data summary pages, or from the USGS surface-water specialist in USA care of the webmaster email alias NWISWeb Support Team.

10. Field Monitoring Requirements

10.1 Monitoring Process Design

See Section 7.0 above, especially Monitoring Network Design and Rationale.

10.2 Monitoring Methods

All sampling procedures will be in conformance with the NJDEP 2005 Field Sampling Procedures Manual (Go to http://www.state.nj.us/dep/srp/guidance/fspm/).

Field equipment used for surface water quality sample collection (i.e., bottles and buckets) will be decontaminated/cleaned in the laboratory prior to each sampling event. A dedicated large volume container will be assigned to each sample location. Prior to each sampling event, the large volume containers will be decontaminated in the laboratory using the following procedures in accordance with the Field Sampling Procedures Manual (Go to http://www.state.nj.us/dep/srp/guidance/fspm/, see Chapter 2A – Page 10 of 61): 1) laboratory grade glassware detergent plus tap water wash, 2) generous tap water rinse, 3) distilled/deionized water rinse, 4) 10% nitric acid rinse, 5) distilled/deionized water rinse. Note that the samples collected will not be analyzed for metals or organics. Also, field equipment decontamination water will be disposed of in accordance with the laboratory's Standard Operating Procedures and Quality Assurance Manual.

Manual composite sampling for wider portions of the streams will be conducted in accordance with the methods outlined in section 6.8.2.2.2 of the Field Sampling Procedures Manual (Go to http://www.state.nj.us/dep/srp/guidance/fspm/, see Chapter 6D – page 64 of 188).

Grab sampling where the natural stream conditions make compositing unnecessary will be conducted in accordance with the methods outlined in section 6.8.2.2.3 of the Field Sampling Procedures Manual (Go to http://www.state.nj.us/dep/srp/guidance/fspm/, see Chapter 6D – page 66 of 188).

10.3 Field QC Activities

To address quality control in field sampling operations, a field blank and duplicate sample will be collected. The field blank will be analyzed to assess contamination that could occur during the sampling event. The quality indicator for the duplicate sample is 10%; if the concentration difference of any of the targeted analytes in the duplicate sample is greater than ±10% of the reported value of the original sample, then the data will be discarded, and the sampling procedure will be reevaluated to provide more representative samples.

11. Analytical Requirements

11.1 Analytical Method Requirements

Measurements of the sampled parameters will be performed in accordance with the methodologies identified in Table 1B – List of Approved Inorganic Test Procedures (40 CFR Part 136.3) of Attachment B. Sample containers, preservation techniques, and holding times will be in accordance with procedures/methods identified in Table II (40 CFR Part 136.3) of Attachment C. New Jersey Analytical Laboratories will provide appropriate containers for all analyses. Any deviations from the test procedures and/or preservation methods and holding times will be reported to the NJDEP Office of Quality Assurance and will be noted in the final report from the laboratory.

11.2 Laboratory QC Checks

NJAC 7:18 Regulations Governing the Certification of Laboratories and Environmental Measurements (i.e., 7:18-5.5 ~ Subchapter 5 Chemical Testing Requirements for quality assurance/quality control program) will be followed for all quality assurance and quality control (QA/QC) practices, including detection limits, quantitation limits, precision, and accuracy. A table of parameter detection limits, quantitation limits, accuracy, and precision applicable to this monitoring program is provided in Attachment E. New Jersey Analytical Laboratories, in cooperation with the NJDEP Office of Quality Assurance, will perform all required laboratory QC checks.

12. Sample Handling and Custody Requirements

Sample containers, preservation techniques, and holding times will be in accordance with the procedures/methods identified in Table II (40 CFR Part 136.3) of Attachment C. New Jersey

Analytical Laboratories will provide appropriate containers for all analyses. Samples will be stored on ice in coolers provided by New Jersey Analytical Laboratories. Any deviations from the preservation methods and holding times will be reported to the QA Officer and will be noted in the final report from the laboratory.

Chain of Custody procedures will be followed for all samples collected for this monitoring program. A sample chain of custody form is provided in Attachment D. A sample is in someone's "custody" if 1) it is in one's actual physical possession, 2) it is in one's view, after being in one's physical possession, 3) it is in one's physical possession and then locked up so that no one can tamper with it, and 4) it is kept in a secured area, restricted to authorized personnel only.

The samples collected will be recorded and documented on a chain of custody by the sampler and transported to the analytical laboratory. Upon arrival at the analytical laboratory, the samples will be signed for by laboratory personnel and logged in to the laboratory's sample storage facilities for analysis in accordance with the laboratory's standard operating procedures and QA/QC manual which are approved by the NJDEP Office of Quality Assurance under NJAC 7:18 Regulations Governing the Certification of Laboratories and Environmental Measurements (i.e., 7:18-5.5 ~ Subchapter 5 Chemical Testing Requirements for quality assurance/quality control program and 7:18 ~ Subchapter 9 Sample Requirements).

13. Testing, Inspection, Maintenance and Calibration

Calibration and preventative maintenance of laboratory equipment will be in accordance with the laboratory's standard operating procedures and QA/QC manual which are approved by the NJDEP Office of Quality Assurance under NJAC 7:18 Regulations Governing the Certification of Laboratories and Environmental Measurements (i.e., 7:18-5.5 ~ Subchapter 5 Chemical Testing Requirements for quality assurance/quality control program).

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14. Data Management

The RCE WRP, for a minimum of five years, will keep all laboratory reports, quality control summaries, and chain of custody forms on file in both hard and digital format, and all applicable data will be included in the interim and summary reports to NJDEP and USEPA Region 2. An electronic version of all interim and summary reports will be provided electronically on a CD.

15. Assessments/Oversites

Performance and Systems Audits:
All NJDEP certified laboratories participate annually in a NJDEP mandated Performance Testing program. The NJDEP Office of Quality Assurance conducts a performance audit of each laboratory that is certified. The NJDEP Office of Quality Assurance also periodically conducts on-site technical systems audits of each certified laboratory. The findings of these audits, together with the NJDEP mandated Performance Testing program, are used to update each laboratory's certification status. The NJDEP Office of Quality Assurance periodically conducts

field audits of project sampling operations. The Office of Quality Assurance will be contacted during the project to schedule a field audit at their convenience.

Corrective Action:
All NJDEP certified laboratories must have a written corrective action procedure which they adhere to in the event that calibration standards, performance evaluation results, blanks, duplicates, spikes, etc. are out of the acceptable range or control limits. If the acceptable results cannot be obtained for the above-mentioned QA/QC samples during any given day, sample analysis must be repeated for that day with the acceptable QA/QC results. The QA Officer. will be notified if there are any deviations from the approved work plan. All signatories of this QAPP will be notified when deviations to the QAPP are made prior to their implementation.

16. Data Review, Verification, Validation, and Usability

16.1 Data Review, Validation and Verification

Tables of parameter detection limits, quantitation limits, accuracy, and precision applicable to this study are provided in Attachment E. Quality objectives and criteria for measurement data are described in Section 8 of this QAPP.

16.2 Reconciliation with User Requirements

Validation of the data produced by this monitoring program will be conducted by New Jersey Analytical Laboratories in cooperation with the NJDEP Office of Quality Assurance and the RCE WRP QA Officer. The QA Officer will receive notification of any deficiencies noted during sample collection or at the laboratory in regard to detection limits, quantitation limits, precision, and accuracy. The QA Officer will inspect the raw data. This inspection will include an assessment of the field blank and duplicate samples to determine the error associated with the sampling procedure. Any errors found in the sampling or laboratory procedures will be noted and reported to the monitoring program personnel, and corrected as soon as possible.

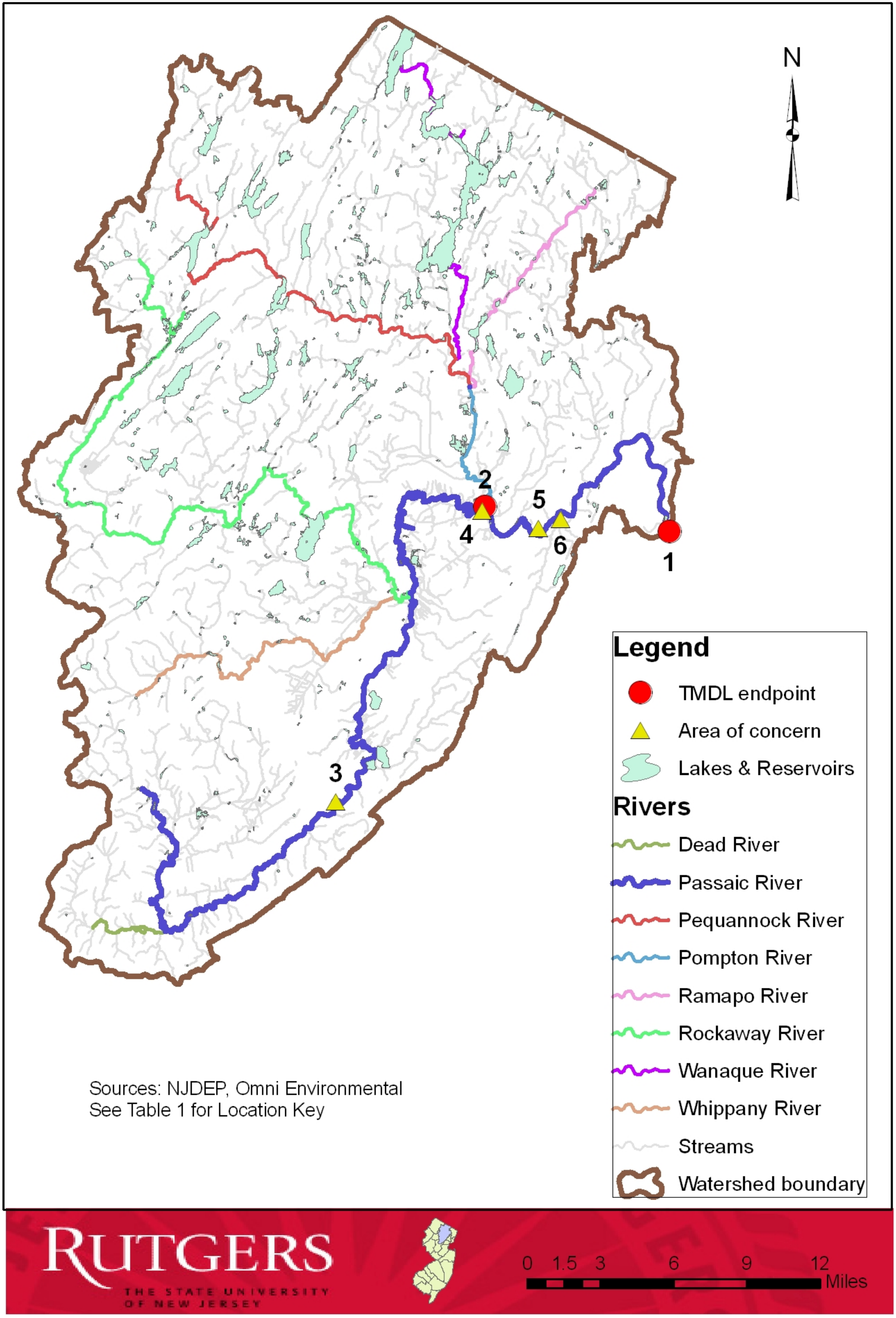
17. Reports to Management, Documentation, Records

An interim and summary report will be submitted to the NJDEP Bureau of Analysis and Restoration by the Project Officer, Christopher C. Obropta, and will include at a minimum an Introduction, Purpose and Scope, Results and Discussion, Conclusions and Recommendations, and an appendix with data tables. These reports will also be submitted to Cyndy Kopitsky, the USEPA Region 2 Main Point of Contact for this monitoring program. An electronic version of all reports and data will be provided on a CD. The interim and summary report, along with all supporting data and records, will be maintained by the QA Officer, Lisa Galloway Evrard, at the offices of the RCE WRP.

ATTACHMENT A

Proposed Monitoring Locations
Non-Tidal Passaic River Watershed

Map 1: Future Monitoring Locations for Water Quality Trading (TMDL endpoints, areas of concern)



Sources: NJDEP, Omni Environmental
See Table 1 for Location Key

Map 1 shows the TMDL endpoints (NJDEP, 2007) and areas of concern (Omni Environmental, 2007). Monitoring should be done at these locations before and after trading takes place.

Table 1: Key for Map 1

Name / Location	ID no. on map	Class
Dundee Lake / Passaic River at Dundee Dam	1	TMDL endpoint
Wanaque South intake / on Pompton River just upstream of confluence with Passaic River	2	TMDL endpoint
Passaic River near Chatham / USGS gage 01379500	3	Area of Concern
Passaic River at Two Bridges / just upstream of confluence with Pompton River	4	Area of Concern*
Passaic River at Little Falls intake	5	Area of Concern
Peckman River mouth	6	Area of Concern

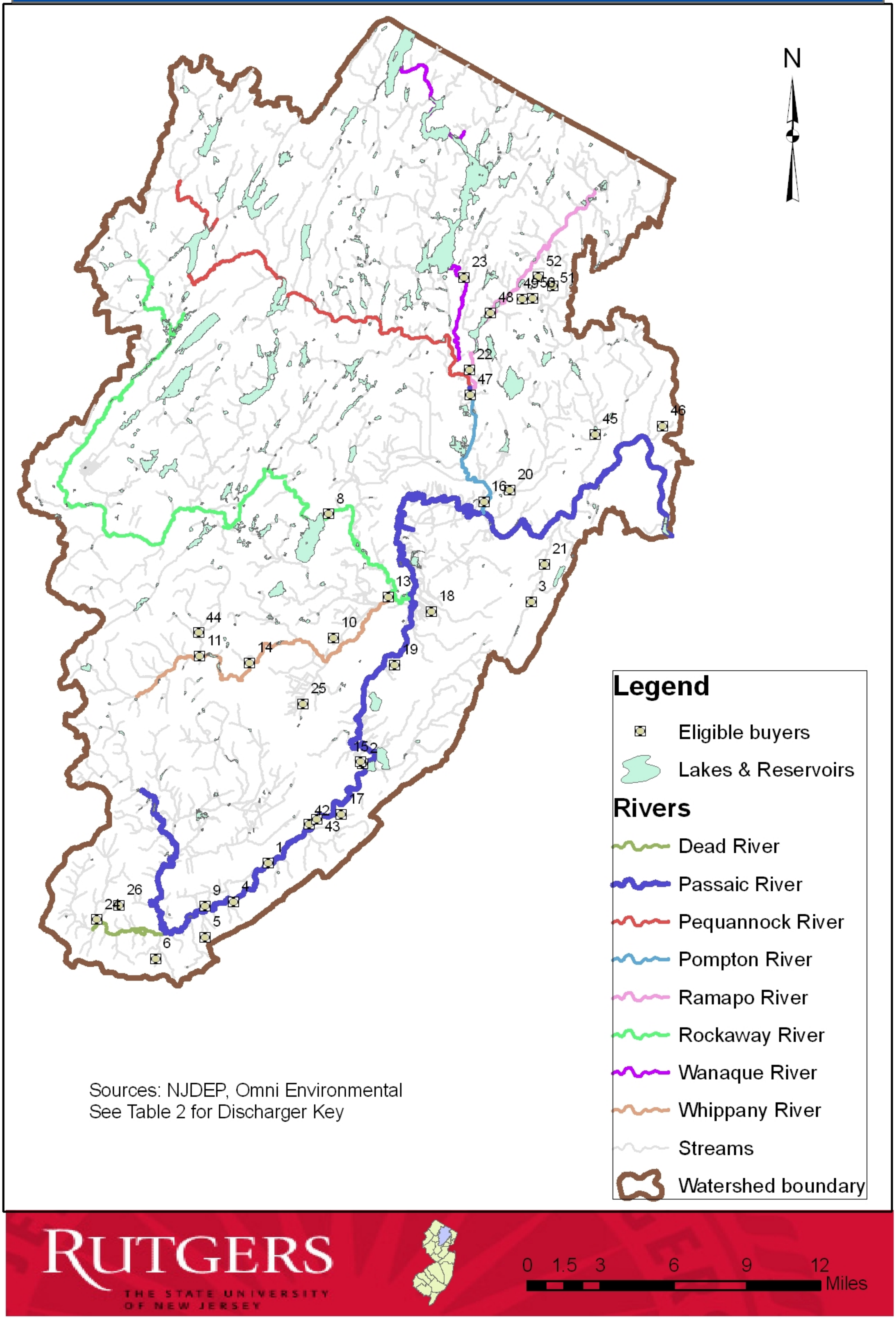
* This location is not listed as an "area of concern" in the Omni Environmental (2007) report, however its proximity to the Wanaque South intake merit its inclusion in monitoring.

References:

New Jersey Department of Environmental Protection (NJDEP) 2007. Total Maximum Daily Load Report for the Non-Tidal Passaic River Basin Addressing Phosphorus Impairments – PROPOSED. Division of Watershed Management, Trenton, New Jersey.

Omni Environmental Corporation, 2007. The Non-Tidal Passaic River Basin Nutrient TMDL Study Phase II Watershed Model and TMDL Calculations: Final Report. Princeton, New Jersey

Map 2: Future Monitoring Locations for Water Quality Trading (downstream of any buyers)



Sources: NJDEP, Omni Environmental
See Table 2 for Discharger Key

Map 2 shows the eligible buyers in the trading program. Monitoring should be done directly downstream of any of these dischargers that choose to buy credits, before and after trading takes place.

Table 2: Key for Map 2. All dischargers shown are Category 2 (i.e., eligible buyers).

Discharger ID no.	Name
1	Berkeley Heights
2	Molitor Water Pollution
3	Verona Twp STP #
4	Warren Twp SA - Stage 1 & 2
5	Warren Twp SA - Stage 4
6	Warren Twp SA - Stage 5
8	Rockaway Valley SA
9	Long Hill Twp STP - Stirling Hills
10	Hanover SA STP
11	Morris Twp - Butterworth
13	Parsippany-Troy Hills SA
14	Morristown Town STP
15	Florham Park SA
16	Two Bridges SA
17	Chatham Township - Chatham Glen
18	Caldwell Boro STP
19	Livingston Twp
20	Wayne Twp - Mountain View #
21	Cedar Grove Twp STP #
22	Pompton Lakes MUA
23	Wanaque Valley RSA
24	Harrison Brook STP
25	Exxon Research & Engineering Company
26	Veterans Adm Medical Center
42	Chatham Hill STP
43	New Providence Boro
44	NJDHS - Greystone Psych Hosp
45	Bayer Corporation #
46	Nabisco Fair Lawn Bakery #
47	Plains Plaza Shopping Center
48	Ramapo River Club STP - Oakland Twp Riverbend
49	Oakland Boro - Oakwood Knolls
50	Ramapo BOE - Indian High
51	Oakland Boro Skyview-Highbrook STP
52	Oakland Boro - Chapel Hill Estates

ATTACHMENT B

Table 1B – List of Approved Inorganic Test Procedures
40 CFR Part 136.3
July 1, 2008

Available at: http://edocket.access.gpo.gov/cfr_2008/julqtr/pdf/40cfr136.3.pdf

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter	Methodology[58]	Reference (method number or page)					
		EPA[35][52]	Standard methods (18th, 19th)	Standard methods (20th)	Standard methods online	ASTM	USGS/AOAC/ other
42. Organic carbon—Total (TOC), mg/L.	Combustion or oxidation.	....	5310 B, C, or D	5310 B, C, or D	5310 B, C, or D–00.	D2579–93 (A or B).	973.47,[3] p. 14[24]
43. Organic nitrogen (as N), mg/L.	Total Kjeldahl N (Parameter 31) minus ammonia N (Parameter 4).						
44. Orthophosphate (as P), mg/L.	Ascorbic acid method:						
	Automated, or	365.1, Rev. 2.0 (1993).	4500–P F	4500–P F	....	....	973.56[3], I–4601–85[2]
	Manual single reagent	....	4500–P E	4500–P E	....	D515–88(A)	973.55[3]
	Manual two reagent	365.3 (Issued 1978)[1].					
	Ion Chromatography	300.0, Rev 2.1 (1993) and 300.1, Rev 1.0 (1997).	4110 B	4110 B	4110 B–00	D4327–97, 03	993.30[3]
	CIE/UV	....	....	....	....	....	D6508, Rev. 2[54]
45. Osmium—Total[4], mg/L.	Digestion[4] followed by:						
	AA direct aspiration, or.	....	3111 D	....	3111 D–99.		
	AA furnace	252.2 (Issued 1978)[1].					
46. Oxygen, dissolved, mg/L.	Winkler (Azide modification), or.	....	4500–O C	4500–O C	4500–O C–01	D888–92, 03 (A).	973.45B[3], I–1575–78[8]
	Electrode	....	4500–O G	4500–O G	4500–O G–01	D888–92, 03 (B).	I–1576–78[8]
47. Palladium—Total,[4] mg/L.	Digestion[4] followed by:						
	AA direct aspiration, or.	....	3111 B	....	3111 B–99	....	p. S27[10]
	AA furnace	253.2[1] (Issued 1978).	....	....	....	....	p. S28[10]

	DCP						See footnote[34]
48. Phenols, mg/L	Manual distillation[26] Followed by:	420.1[1] (Rev. 1978).					See footnote[27]
	Colorimetric (4AAP) manual, or.	420.1[1] (Rev. 1978).					See footnote[27]
	Automated	420.4 Rev. 1.0 (1993).					
49. Phosphorus (elemental), mg/L.	Gas–liquid chromatography.						See footnote[28]
50. Phosphorus—Total, mg/L.	Persulfate digestion followed by:[20]		4500–P B.5	4500–P B.5			973.55[3]
	Manual or	365.3[1] (Issued 1978).	4500–P E	4500–P E		D515–88(A).	
	Automated ascorbic acid reduction.	365.1 Rev. 2.0 (1993).	4500–P F	4500–P F			973.56[3], I–4600–85[2]
	Semi–automated block digestor.	365.4[1] (Issued 1974).				D515–88(B)	I–4610–91[48]
51. Platinum—Total,[4] mg/L.	Digestion[4] followed by:						
	AA direct aspiration		3111 B		3111 B–99.		
	AA furnace	255.2[1].					
	DCP						See footnote[34]
52. Potassium—Total,[4] mg/L.	Digestion[4] followed by:						
	AA direct aspiration		3111 B		3111 B–99		973.53[3], I–3630–85[2]
	ICP/AES	200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B–99.		
	Flame photometric, or.		3500–K D	3500–K B	3500–K B–97.		
	Colorimetric						317 B[17]
	Ion Chromatography					D6919–03.	
53. Residue—Total, mg/L	Gravimetric, 103–105°.		2540 B	2540 B	2540 B–97		I–3750–85[2]
54. Residue—filterable, mg/L.	Gravimetric, 180°		2540 C	2540 C	2540 C–97		I–1750–85[2]
55. Residue—non–filterable (TSS), mg/L.	Gravimetric, 103–105 °C post washing of residue.		2540 D	2540 D	2540 D–97		I–3765–85[2]
56. Residue—settleable, mg/L.	Volumetric, (Imhoff cone), or gravimetric.		2540 F	2540 F	2540 F–97.		
57. Residue—Volatile, mg/L.	Gravimetric, 550 °C	160.4[1]					I–3753–85[2]

75. Zinc –Total[4], mg/L	Digestion[4] followed by:						
	AA direct aspiration[36].		3111 B or C		3111 B or C–99	D1691–95, 02 (A or B).	974.27[3], p. 37[9], I–3900–85[2]
	AA furnace	289.2[1] (Issued 1978).					
	ICP/AES[36]	200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B–99[59]		I–4471–97[50]
	ICP/MS	200.8, Rev. 5.4 (1994).				D5673–03	993.14[3]
	DCP,[36] or					D4190–94, 99	See footnote[34]
	Colorimetric (Dithizone) or.		3500–Zn E.				
	(Zincon)		3500–Zn F	3500–Zn B	3500–Zn B–97		See footnote[33]

Table 1B Notes:

[1] "Methods for Chemical Analysis of Water and Wastes," Environmental Protection Agency, Environmental Monitoring Systems Laboratory–Cincinnati (EMSL–CI), EPA–600/4–79–020 (NTIS PB 84–128677), Revised March 1983 and 1979 where applicable.

[2] Fishman, M. J., *et al.* "Methods for Analysis of Inorganic Substances in Water and Fluvial Sediments," U.S. Department of the Interior, Techniques of Water-Resource Investigations of the U.S. Geological Survey, Denver, CO, Revised 1989, unless otherwise stated.

[3] "Official Methods of Analysis of the Association of Official Analytical Chemists," Methods Manual, Sixteenth Edition, 4th Revision, 1998.

[4] For the determination of total metals (which are equivalent to total recoverable metals) the sample is not filtered before processing. A digestion procedure is required to solubilize analytes in suspended material and to break down organic-metal complexes (to convert the analyte to a detectable form for colorimetric analysis). For non–platform graphite furnace atomic absorption determinations a digestion using nitric acid (as specified in Section 4.1.3 of Methods for the Chemical Analysis of Water and Wastes) is required prior to analysis. The procedure used should subject the sample to gentle, acid refluxing and at no time should the sample be taken to dryness. For direct aspiration flame atomic absorption determinations (FLAA) a combination acid (nitric and hydrochloric acids) digestion is preferred prior to analysis. The approved total recoverable digestion is described as Method 200.2 in Supplement I of "Methods for the Determination of Metals in Environmental Samples" EPA/600R–94/111, May, 1994, and is reproduced in EPA Methods 200.7, 200.8, and 200.9 from the same Supplement. However, when using the gaseous hydride technique or for the determination of certain elements such as antimony, arsenic, selenium, silver, and tin by non–EPA graphite furnace atomic absorption methods, mercury by cold vapor atomic absorption, the noble metals and titanium by FLAA, a specific or modified sample digestion procedure may be required and in all cases the referenced method write–up should be consulted for specific instruction and/or cautions. For analyses using inductively coupled plasma-atomic emission spectrometry (ICP–AES), the direct current plasma (DCP) technique or the EPA spectrochemical techniques (platform furnace AA, ICP–AES, and ICP–MS) use EPA Method 200.2 or an approved alternate procedure (e.g., CEM microwave digestion, which may be used with certain analytes as indicated in Table IB); the total recoverable digestion procedures in EPA Methods 200.7, 200.8, and 200.9 may be used for those respective methods. Regardless of the digestion procedure, the results of the analysis after digestion procedure are reported as "total" metals.

[5] Copper sulfate may be used in place of mercuric sulfate.

[6] Manual distillation is not required if comparability data on representative effluent samples are on file to show that this preliminary distillation step is not necessary: however, manual distillation will be required to resolve any controversies.

[7] Ammonia, Automated Electrode Method, Industrial Method Number 379–75 WE, dated February 19, 1976, Bran & Luebbe (Technicon) Auto Analyzer II, Bran & Luebbe Analyzing Technologies, Inc., Elmsford, NY 10523.

[8] The approved method is that cited in "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments", USGS TWRI, Book 5, Chapter A1 (1979).

[9] American National Standard on Photographic Processing Effluents, April 2, 1975. Available from ANSI, 25 West 43rd st., New York, NY 10036.

[10] "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," Supplement to the Fifteenth Edition of *Standard Methods for the Examination of Water and Wastewater* (1981).

[11] The use of normal and differential pulse voltage ramps to increase sensitivity and resolution is acceptable.

[12] Carbonaceous biochemical oxygen demand (CBOD$_5$) must not be confused with the traditional BOD$_5$ test method which measures "total BOD." The addition of the nitrification inhibitor is not a procedural option, but must be included to report the CBOD$_5$ parameter. A discharger whose permit requires reporting the traditional BOD$_5$ may not use a nitrification inhibitor in the procedure for reporting the results. Only when a discharger's permit specifically states CBOD$_5$ is required can the permittee report data using a nitrification inhibitor.

[13] OIC Chemical Oxygen Demand Method, Oceanography International Corporation, 1978, 512 West Loop, P.O. Box 2980, College Station, TX 77840.

[14] Chemical Oxygen Demand, Method 8000, Hach Handbook of Water Analysis, 1979, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.

[15] The back titration method will be used to resolve controversy.

[16] Orion Research Instruction Manual, Residual Chlorine Electrode Model 97–70, 1977, Orion Research Incorporated, 840 Memorial Drive, Cambridge, MA 02138. The calibration graph for the Orion residual chlorine method must be derived using a reagent blank and three standard solutions, containing 0.2, 1.0, and 5.0 mL 0.00281 N potassium iodate/100 mL solution, respectively.

[17] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater,* 14th Edition, 1976.

[18] National Council of the Paper Industry for Air and Stream Improvement, Inc., Technical Bulletin 253, December 1971.

[19] Copper, Biocinchoinate Method, Method 8506, Hach Handbook of Water Analysis, 1979, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.

[20] When using a method with block digestion, this treatment is not required.

[21] Hydrogen ion (pH) Automated Electrode Method, Industrial Method Number 378–75WA, October 1976, Bran & Luebbe (Technicon) Autoanalyzer II. Bran & Luebbe Analyzing Technologies, Inc., Elmsford, NY 10523.

[22] Iron, 1,10-Phenanthroline Method, Method 8008, 1980, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.

[23] Manganese, Periodate Oxidation Method, Method 8034, Hach Handbook of Wastewater Analysis, 1979, pages 2–113 and 2–117, Hach Chemical Company, Loveland, CO 80537.

[24] Wershaw, R. L., *et al.*, "Methods for Analysis of Organic Substances in Water," Techniques of Water-Resources Investigation of the U.S. Geological Survey, Book 5, Chapter A3, (1972 Revised 1987) p. 14.

[25] Nitrogen, Nitrite, Method 8507, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.

[26] Just prior to distillation, adjust the sulfuric-acid-preserved sample to pH 4 with 1 + 9 NaOH.

[27] The approved method is cited in *Standard Methods for the Examination of Water and Wastewater,* 14th Edition. The colorimetric reaction is conducted at a pH of 10.0±0.2. The approved methods are given on pp 576–81 of the 14th Edition: Method 510A for distillation, Method 510B for the manual colorimetric procedure, or Method 510C for the manual spectrometric procedure.

[28] R.F. Addison and R. G. Ackman, "Direct Determination of Elemental Phosphorus by Gas–Liquid Chromatography," *Journal of Chromatography,* Vol. 47, No.3, pp. 421–426, 1970.

[29] Approved methods for the analysis of silver in industrial wastewaters at concentrations of 1 mg/L and above are inadequate where silver exists as an inorganic halide. Silver halides such as the bromide and chloride are relatively insoluble in reagents such as nitric acid but are readily soluble in an aqueous buffer of sodium thiosulfate and sodium hydroxide to pH of 12. Therefore, for levels of silver above 1 mg/L, 20 mL of sample should be diluted to 100 mL by adding 40 mL each of 2 M $Na_2S_2O_3$ and NaOH. Standards should be prepared in the same manner. For levels of silver below 1 mg/L the approved method is satisfactory.

[30] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater,* 15th Edition.

[31] For samples known or suspected to contain high levels of silver (e.g., in excess of 4 mg/L), cyanogen iodide should be used to keep the silver in solution for analysis. Prepare a cyanogen iodide solution by adding 4.0 mL of concentrated NH_4OH, 6.5 g of KCN, and 5.0 mL of a 1.0 N solution of I_2 to 50 mL of reagent water in a volumetric flask and dilute to 100.0 mL. After digestion of the sample, adjust the pH of the digestate to >7 to prevent the formation of HCN under acidic conditions. Add 1 mL of the cyanogen iodide solution to the sample digestate and adjust the volume to 100 mL with reagent water (NOT acid). If cyanogen iodide is added to sample digestates, then silver standards must be prepared that contain cyanogen iodide as well. Prepare working standards by diluting a small volume of a silver stock solution with water and adjusting the pH>7 with NH_4OH. Add 1 mL of the cyanogen iodide solution and let stand 1 hour. Transfer to a 100-mL volumetric flask and dilute to volume with water.

[32] Stevens, H.H., Ficke, J. F., and Smoot, G. F., "Water Temperature—Influential Factors, Field Measurement and Data Presentation," Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 1, Chapter D1, 1975.

[33] Zinc, Zincon Method, Method 8009, Hach Handbook of Water Analysis, 1979, pages 2–231 and 2–333, Hach Chemical Company, Loveland, CO 80537.

[34] "Direct Current Plasma (DCP) Optical Emission Spectrometric Method for Trace Elemental Analysis of Water and Wastes, Method AES0029," 1986—Revised 1991, Thermo Jarrell Ash Corporation, 27 Forge Parkway, Franklin, MA 02038

[35] Precision and recovery statements for the atomic absorption direct aspiration and graphite furnace methods, and for the spectrophotometric SDDC method for arsenic are provided in Appendix D of this part titled, "Precision and Recovery Statements for Methods for Measuring Metals."

[36] Microwave-assisted digestion may be employed for this metal, when analyzed by this methodology. "Closed Vessel Microwave Digestion of Wastewater Samples for Determination of Metals", CEM Corporation, P.O. Box 200, Matthews, NC 28106–0200, April 16, 1992. Available from the CEM Corporation.

[37] When determining boron and silica, only plastic, PTFE, or quartz laboratory ware may be used from start until completion of analysis.

[38] Only use n-hexane extraction solvent when determining Oil and Grease parameters—Hexane Extractable Material (HEM), or Silica Gel Treated HEM (analogous to EPA Method 1664A). Use of other extraction solvents (e.g., those in the 18th and 19th editions) is prohibited.

[39] Nitrogen, Total Kjeldahl, Method PAI-DK01 (Block Digestion, Steam Distillation, Titrimetric Detection), revised 12/22/94, OI Analytical/ALPKEM, P.O. Box 9010, College Station, TX 77842.

[40] Nitrogen, Total Kjeldahl, Method PAI–DK02 (Block Digestion, Steam Distillation, Colorimetric Detection), revised 12/22/94, OI Analytical/ALPKEM, P.O. Box 9010, College Station, TX 77842.

[41] Nitrogen, Total Kjeldahl, Method PAI–DK03 (Block Digestion, Automated FIA Gas Diffusion), revised 12/22/94, OI Analytical/ALPKEM, P.O. Box 9010, College Station, TX 77842.

[42] Method 1664, Revision A "*n*-Hexane Extractable Material (HEM; Oil and Grease) and Silica Gel Treated *n*-Hexane Extractable Material (SGT-HEM; Non-polar Material) by Extraction and Gravimetry" EPA–821–R–98–002, February 1999. Available at NTIS, PB–121949, U.S. Department of Commerce, 5285 Port Royal, Springfield, VA 22161.

[43] USEPA. 2001. Method 1631, Revision E, "Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry" September 2002, Office of Water, U.S. Environmental Protection Agency (EPA–821–R–02–024). The application of clean techniques described in EPA's draft Method 1669: *Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels* (EPA–821–R–96–011) are recommended to preclude contamination at low-level, trace metal determinations.

[44] Available Cyanide, Method OIA–1677, "Available Cyanide by Flow Injection, Ligand Exchange, and Amperometry," ALPKEM, A Division of OI Analytical, P.O. Box 9010, College Station, TX 77842–9010.

[45] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Ammonia Plus Organic Nitrogen by a Kjeldahl Digestion Method," Open File Report (OFR) 00–170.

[46] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Chromium in Water by Graphite Furnace Atomic Absorption Spectrophotometry," Open File Report (OFR) 93–449.

[47] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Molybdenum by Graphite Furnace Atomic Absorption Spectrophotometry," Open File Report (OFR) 97–198.

[48] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Total Phosphorus by Kjeldahl Digestion Method and an Automated Colorimetric Finish That Includes Dialysis" Open File Report (OFR) 92–146.

[49] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Arsenic and Selenium in Water and Sediment by Graphite Furnace-Atomic Absorption Spectrometry" Open File Report (OFR) 98–639.

[50] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Elements in Whole-water Digests Using Inductively Coupled Plasma-Optical Emission Spectrometry and Inductively Coupled Plasma-Mass Spectrometry," Open File Report (OFR) 98-165.

[51] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Inorganic and Organic Constituents in Water and Fluvial Sediment," Open File Report (OFR) 93–125.

[52] All EPA methods, excluding EPA Method 300.1, are published in "Methods for the Determination of Metals in Environmental Samples," Supplement I, National Exposure Risk Laboratory-Cincinnati (NERL–CI), EPA/600/R–94/111, May 1994; and "Methods for the Determination of Inorganic Substances in Environmental Samples," NERL–CI, EPA/600/R–93/100, August, 1993. EPA Method 300.1 is available from *http://www.epa.gov/safewater/methods/pdfs/met300.pdf*.

[53] Styrene divinyl benzene beads (e.g., AMCO–AEPA–1 or equivalent) and stabilized formazin (e.g., Hach StablCal™ or equivalent) are acceptable substitutes for formazin.

[54] Method D6508, Rev. 2, "Test Method for Determination of Dissolved Inorganic Anions in Aqueous Matrices Using Capillary Ion Electrophoresis and Chromate Electrolyte," available from Waters Corp, 34 Maple St., Milford, MA, 01757, Telephone: 508/482–2131, Fax: 508/482–3625.

[55] Kelada-01, "Kelada Automated Test Methods for Total Cyanide, Acid Dissociable Cyanide, and Thiocyanate," EPA 821–B–01–009, Revision 1.2, August 2001, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161 [Order Number PB 2001–108275]. The toll free telephone number is: 800–553–6847. Note: A 450–W UV lamp may be used in this method instead of the 550–W lamp specified if it provides performance within the quality control (QC) acceptance criteria of the method in a given instrument. Similarly, modified flow cell configurations and flow conditions may be used in the method, provided that the QC acceptance criteria are met.

[56] QuikChem Method 10–204–00–1–X, "Digestion and Distillation of Total Cyanide in Drinking and Wastewaters using MICRO DIST and Determination of Cyanide by Flow Injection Analysis" is available from Lachat Instruments 6645 W. Mill Road, Milwaukee, WI 53218, Telephone: 414–358–4200.

[57] When using sulfide removal test procedures described in Method 335.4, reconstitute particulate that is filtered with the sample prior to distillation.

[58] Unless otherwise stated, if the language of this table specifies a sample digestion and/or distillation "followed by" analysis with a method, approved digestion and/or distillation are required prior to analysis.

[59] Method 245.7, Rev. 2.0, "Mercury in Water by Cold Vapor Atomic Fluorescence Spectrometry," February 2005, EPA–821–R–05–001, available from the U.S. EPA Sample Control Center (operated by CSC), 6101 Stevenson Avenue, Alexandria, VA 22304, Telephone: 703–461–2100, Fax: 703–461–8056.

[60] The use of EDTA may decrease method sensitivity in some samples. Analysis may omit EDTA provided that all method specified quality control acceptance criteria are met.

[61] Samples analyzed for available cyanide using Methods OIA–1677 or D6888–04 that contain particulate matter may be filtered only after the ligand exchange reagents have been added to the samples, because the ligand exchange process converts complexes containing available cyanide to free cyanide, which is not removed by filtration. Analysts are further cautioned to limit the time between the addition of the ligand exchange reagents and sample analysis to no more than 30 minutes to preclude settling of materials in samples.

TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS

Parameter[1]	EPA method number[2, 7]			Other approved methods			
	GC	GC/MS	HPLC	Standard Methods [Edition(s)]	Standard Methods Online	ASTM	Other
1. Acenaphthene	610	625, 1625B	610	6440 B [18th, 19th, 20th].		D4657–92 (99)	See footnote[9], p. 27
2. Acenaphthylene	610	625, 1625B	610	6410 B, 6440 B, [18th, 19th, 20th].	6410 B–00	D4657–92 (99)	See footnote[9], p. 27
3. Acrolein	603	624[4], 1624B.					
4. Acrylonitrile	603	624[4], 1624B.					
5. Anthracene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B–00	D4657–92 (99)	See footnote[9], p. 27
6. Benzene	602	624, 1624B		6200 B [20th] and 6210 B [18th,19th], 6200 C [20th] and 6220 B [18th,19th].	6200 B and C–97.		
7. Benzidine		625[5], 1625B	605				See footnote[3], p.1
8. Benzo(a)anthracene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B–00	D4657–92 (99)	See footnote[9], p. 27
9. Benzo(a)pyrene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B–00	D4657–92 (99)	See footnote[9], p. 27
10. Benzo(b)fluoranthene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B–00	D4657–92 (99)	See footnote[9], p. 27
11. Benzo(g,h,i) perylene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B–00	D4657–92 (99)	See footnote[9], p. 27
12. Benzo(k) fluoranthene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B–00	D4657–92 (99)	See footnote[9], p. 27
13. Benzyl chloride							See footnote[3], p. 130: See footnote[6], p. S102
14. Benzyl butyl phthalate	606	625, 1625B		6410 B [18th, 19th, 20th].	6410 B–00		See footnote[9], p. 27

ATTACHMENT C

Table II - Required Containers, Preservation Techniques, and Holding Times
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the Regional Administrator, to the Alternate Test Procedure Program Coordinator, Washington, DC, for technical review and recommendations for action on the variance application. Upon receipt of the recommendations from the Alternate Test Procedure Program Coordinator, the Regional Administrator may grant a variance applicable to the specific discharge to the applicant. A decision to approve or deny a variance will be made within 90 days of receipt of the application by the Regional Administrator.

TABLE II—REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter No./name	Container [1]	Preservation [2,3]	Maximum holding time [4]
Table IA—Bacterial Tests:			
1–5. Coliform, total, fecal, and *E. coli*.	PA, G	Cool, <10 °C, 0.0008% $Na_2S_2O_3$ [5].	6 hours.[22,23]
6. Fecal streptococci	PA, G	Cool, <10 °C, 0.0008% $Na_2S_2O_3$ [5].	6 hours.[22]
7. Enterococci	PA, G	Cool, <10 °C, 0.0008% $Na_2S_2O_3$ [5].	6 hours.[22]
8. Salmonella	PA, G	Cool, <10 °C, 0.0008% $Na_2S_2O_3$ [5].	6 hours.[22]
Table IA—Aquatic Toxicity Tests:			
9–11. Toxicity, acute and chronic	P, FP, G	Cool, ≤6 °C [16]	36 hours.
Table IB—Inorganic Tests:			
1. Acidity	P, FP, G	Cool, ≤6 °C [18]	14 days.
2. Alkalinity	P, FP, G	Cool, ≤6 °C [18]	14 days.
4. Ammonia	P, FP, G	Cool, ≤6 °C [18], H_2SO_4 to pH<2	28 days.
9. Biochemical oxygen demand	P, FP, G	Cool, ≤6 °C [18]	48 hours.
10. Boron	P, FP, or Quartz	HNO_3 to pH<2	6 months.
11. Bromide	P, FP, G	None required	28 days.
14. Biochemical oxygen demand, carbonaceous.	P, FP G	Cool, ≤6 °C [18]	48 hours.
15. Chemical oxygen demand	P, FP, G	Cool, ≤6 °C [18], H_2SO_4 to pH<2	28 days.
16. Chloride	P, FP, G	None required	28 days.
17. Chlorine, total residual	P, G	None required	Analyze within 15 minutes.
21. Color	P, FP, G	Cool, ≤6 °C [18]	48 hours.
23–24. Cyanide, total or available (or CATC).	P, FP, G	Cool, ≤6 °C [18], NaOH to pH>12 [6], reducing agent [5].	14 days.
25. Fluoride	P	None required	28 days.
27. Hardness	P, FP, G	HNO_3 or H_2SO_4 to pH<2	6 months.
28. Hydrogen ion (pH)	P, FP, G	None required	Analyze within 15 minutes.
31, 43. Kjeldahl and organic N	P, FP, G	Cool, ≤6 °C [18], H_2SO_4 to pH<2	28 days.
Table IB—Metals: [7]			
18. Chromium VI	P, FP, G	Cool, ≤6 °C [18], pH = 9.3–9.7 [20]	28 days.
35. Mercury (CVAA)	P, FP, G	HNO_3 to pH<2	28 days.
35. Mercury (CVAFS)	FP, G; and FP-lined cap [17].	5 mL/L 12N HCl or 5 mL/L BrCl [17].	90 days.[17]
3, 5–8, 12, 13, 19, 20, 22, 26, 29, 30, 32–34, 36, 37, 45, 47, 51, 52, 58–60, 62, 63, 70–72, 74, 75. Metals, except boron, chromium VI, and mercury.	P, FP, G	HNO_3 to pH<2, or at least 24 hours prior to analysis [19].	6 months.
38. Nitrate	P, FP, G	Cool, ≤6 °C [18]	48 hours.
39. Nitrate-nitrite	P, FP, G	Cool, ≤6 °C [18], H_2SO_4 to pH<2	28 days.
40. Nitrite	P, FP, G	Cool, ≤6 °C [18]	48 hours.
41. Oil and grease	G	Cool to ≤6 °C [18], HCl or H_2SO_4 to pH<2.	28 days.
42. Organic Carbon	P, FP, G	Cool to ≤6 °C [18], HCl, H_2SO_4, or H_3PO_4 to pH<2.	28 days.
44. Orthophosphate	P, FP, G	Cool, ≤6 °C [18]	Filter within 15 minutes; Analyze within 48 hours.
46. Oxygen, Dissolved Probe	G, Bottle and top	None required	Analyze within 15 minutes.
47. Winkler	G, Bottle and top	Fix on site and store in dark	8 hours.
48. Phenols	G	Cool, ≤6 °C [18], H_2SO_4 to pH<2	28 days.
49. Phosphorous (elemental)	G	Cool, ≤6 °C [18]	48 hours.
50. Phosphorous, total	P, FP, G	Cool, ≤6 °C [18], H_2SO_4 to pH<2	28 days.
53. Residue, total	P, FP, G	Cool, ≤6 °C [18]	7 days.
54. Residue, Filterable	P, FP, G	Cool, ≤6 °C [18]	7 days.
55. Residue, Nonfilterable (TSS)	P, FP, G	Cool, ≤6 °C [18]	7 days.
56. Residue, Settleable	P, FP, G	Cool, ≤6 °C [18]	48 hours.

TABLE II—REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES—Continued

Parameter No./name	Container[1]	Preservation[2,3]	Maximum holding time[4]
57. Residue, Volatile	P, FP, G	Cool, ≤6 °C[18]	7 days.
61. Silica	P or Quartz	Cool, ≤6 °C[18]	28 days.
64. Specific conductance	P, FP, G	Cool, ≤6 °C[18]	28 days.
65. Sulfate	P, FP, G	Cool, ≤6 °C[18]	28 days.
66. Sulfide	P, FP, G	Cool, ≤6 °C[18], add zinc acetate plus sodium hydroxide to pH>9.	7 days.
67. Sulfite	P, FP, G	None required	Analyze within 15 minutes.
68. Surfactants	P, FP, G	Cool, ≤6 °C[18]	48 hours.
69. Temperature	P, FP, G	None required	Analyze.
73. Turbidity	P, FP, G	Cool, ≤6 °C[18]	48 hours.
Table IC—Organic Tests[8]			
13, 18–20, 22, 24–28, 34–37, 39–43, 45–47, 56, 76, 104, 105, 108–111, 113. Purgeable Halocarbons.	G, FP-lined septum	Cool, ≤6 °C[18], 0.008% $Na_2S_2O_3$[5].	14 days.
6, 57, 106. Purgeable aromatic hydrocarbons.	G, FP-lined septum	Cool, ≤6 °C[18], 0.008% $Na_2S_2O_3$[5], HCl to pH 2[9].	14 days.[9]
3, 4. Acrolein and acrylonitrile	G, FP-lined septum	Cool, ≤6 °C[18], 0.008% $Na_2S_2O_3$[5], pH to 4–5[10].	14 days.[10]
23, 30, 44, 49, 53, 77, 80, 81, 98, 100, 112. Phenols[11].	G, FP-lined cap	Cool, ≤6 °C[18], 0.008% $Na_2S_2O_3$[5].	7 days until extraction, 40 days after extraction.
7, 38. Benzidines[11, 12]	G, FP-lined cap	Cool, ≤6 °C[18], 0.008% $Na_2S_2O_3$[5].	7 days until extraction.[13]
14, 17, 48, 50–52. Phthalate esters[11].	G, FP-lined cap	Cool, ≤6 °C[18]	7 days until extraction, 40 days after extraction.
82–84. Nitrosamines[11, 14]	G, FP-lined cap	Cool, ≤6 °C[18], store in dark, 0.008% $Na_2S_2O_3$[5].	7 days until extraction, 40 days after extraction.
88–94. PCBs[11]	G, FP-lined cap	Cool, ≤6 °C[18]	1 year until extraction, 1 year after extraction.
54, 55, 75, 79. Nitroaromatics and isophorone[11].	G, FP-lined cap	Cool, ≤6 °C[18], store in dark, 0.008% $Na_2S_2O_3$[5].	7 days until extraction, 40 days after extraction.
1, 2, 5, 8–12, 32, 33, 58, 59, 74, 78, 99, 101. Polynuclear aromatic hydrocarbons[11].	G, FP-lined cap	Cool, ≤6 °C[18], store in dark, 0.008% $Na_2S_2O_3$[5].	7 days until extraction, 40 days after extraction.
15, 16, 21, 31, 87. Haloethers[11]	G, FP-lined cap	Cool, ≤6 °C[18], 0.008% $Na_2S_2O_3$[5].	7 days until extraction, 40 days after extraction.
29, 35–37, 63–65, 107. Chlorinated hydrocarbons[11].	G, FP-lined cap	Cool, ≤6 °C[18]	7 days until extraction, 40 days after extraction.
60–62, 66–72, 85, 86, 95–97, 102, 103. CDDs/CDFs[11].			
Aqueous Samples: Field and Lab Preservation.	G	Cool, ≤6 °C[18], 0.008% $Na_2S_2O_3$[5], pH<9.	1 year.
Solids and Mixed-Phase Samples: Field Preservation.	G	Cool, ≤6 °C[18]	7 days.
Tissue Samples: Field Preservation	G	Cool, ≤6 °C[18]	24 hours.
Solids, Mixed-Phase, and Tissue Samples: Lab Preservation.	G	Freeze, ≤ 10 °C	1 year.
Table ID—Pesticides Tests:			
1–70. Pesticides[11]	G, FP-lined cap	Cool, ≤6 °C[18], pH 5–9[15]	7 days until extraction, 40 days after extraction.
Table IE—Radiological Tests:			
1–5. Alpha, beta, and radium	P, FP, G	HNO_3 to pH<2	6 months.
Table IH—Bacterial Tests:			
1. *E. coli*	PA, G	Cool, <10 °C, 0.0008% $Na_2S_2O_3$[5].	6 hours.[22]
2. Enterococci	PA, G	Cool, <10 °C, 0.0008% $Na_2S_2O_3$[5].	6 hours.[22]
Table IH—Protozoan Tests:			
8. Cryptosporidium	LDPE; field filtration	0–8 °C	96 hours.[21]

TABLE II—REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES—Continued

Parameter No./name	Container [1]	Preservation [2,3]	Maximum holding time [4]
9. Giardia	LDPE; field filtration	0–8 °C	96 hours.[21]

[1] "P" is polyethylene; "FP" is fluoropolymer (polytetrafluoroethylene (PTFE; Teflon®), or other fluoropolymer, unless stated otherwise in this Table II; "G" is glass; "PA" is any plastic that is made of a sterlizable material (polypropylene or other autoclavable plastic); "LDPE" is low density polyethylene.

[2] Except where noted in this Table II and the method for the parameter, preserve each grab sample within 15 minutes of collection. For a composite sample collected with an automated sampler (e.g., using a 24-hour composite sampler; see 40 CFR 122.21(g)(7)(i) or 40 CFR Part 403, Appendix E), refrigerate the sample at ≤6 °C during collection unless specified otherwise in this Table II or in the method(s). For a composite sample to be split into separate aliquots for preservation and/or analysis, maintain the sample at ≤6 °C, unless specified otherwise in this Table II or in the method(s), until collection, splitting, and preservation is completed. Add the preservative to the sample container prior to sample collection when the preservative will not compromise the integrity of a grab sample, a composite sample, or an aliquot split from a composite sample; otherwise, preserve the grab sample, composite sample, or aliquot split from a composite sample within 15 minutes of collection. If a composite measurement is required but a composite sample would compromise sample integrity, individual grab samples must be collected at prescribed time intervals (e.g., 4 samples over the course of a day, at 6-hour intervals). Grab samples must be analyzed separately and the concentrations averaged. Alternatively, grab samples may be collected in the field and composited in the laboratory if the compositing procedure produces results equivalent to results produced by arithmetic averaging of the results of analysis of individual grab samples. For examples of laboratory compositing procedures, see EPA Method 1664A (oil and grease) and the procedures at 40 CFR 141.34(f)(14)(iv) and (v) (volatile organics).

[3] When any sample is to be shipped by common carrier or sent via the U.S. Postal Service, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of Table II, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

[4] Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before the start of analysis and still be considered valid (e.g., samples analyzed for fecal coliforms may be held up to 6 hours prior to commencing analysis). Samples may be held for longer periods only if the permittee or monitoring laboratory has data on file to show that, for the specific types of samples under study, the analytes are stable for the longer time, and has received a variance from the Regional Administrator under § 136.3(e). For a grab sample, the holding time begins at the time of collection. For a composite sample collected with an automated sampler (e.g., using a 24-hour composite sampler; see 40 CFR 122.21(g)(7)(i) or 40 CFR Part 403, Appendix E), the holding time begins at the time of the end of collection of the composite sample. For a set of grab samples composited in the field or laboratory, the holding time begins at the time of collection of the last grab sample in the set. Some samples may not be stable for the maximum time period given in the table. A permittee or monitoring laboratory is obligated to hold the sample for a shorter time if it knows that a shorter time is necessary to maintain sample stability. *See* § 136.3(e) for details. The date and time of collection of an individual grab sample is the date and time at which the sample is collected. For a set of grab samples to be composited, and that are all collected on the same calendar date, the date of collection is the date on which the samples are collected. For a set of grab samples to be composited, and that are collected across two calendar dates, the date of collection is the dates of the two days; e.g., November 14–15. For a composite sample collected automatically on a given date, the date of collection is the date on which the sample is collected. For a composite sample collected automatically, and that is collected across two calendar dates, the date of collection is the dates of the two days; e.g., November 14–15.

[5] Add a reducing agent only if an oxidant (e.g., chlorine) is present. Reducing agents shown to be effective are sodium thiosulfate ($Na_2S_2O_3$), ascorbic acid, sodium arsenite ($NaAsO_2$), or sodium borohydride ($NaBH_4$). However, some of these agents have been shown to produce a positive or negative cyanide bias, depending on other substances in the sample and the analytical method used. Therefore, do not add an excess of reducing agent. Methods recommending ascorbic acid (e.g., EPA Method 335.4) specify adding ascorbic acid crystals, 0.1–0.6 g, until a drop of sample produces no color on potassium iodide (KI) starch paper, then adding 0.06 g (60 mg) for each liter of sample volume. If $NaBH_4$ or $NaAsO_2$ is used, 25 mg/L $NaBH_4$ or 100 mg/L $NaAsO_2$ will reduce more than 50 mg/L of chlorine (see method "Kelada-01" and/or Standard Method 4500–CN for more information). After adding reducing agent, test the sample using KI paper, a test strip (e.g. for chlorine, SenSafe™ Total Chlorine Water Check 480010) moistened with acetate buffer solution (see Standard Method 4500–Cl.C.3e), or a chlorine/oxidant test method (e.g., EPA Method 330.4 or 330.5), to make sure all oxidant is removed. If oxidant remains, add more reducing agent. Whatever agent is used, it should be tested to assure that cyanide results are not affected adversely.

[6] Sample collection and preservation: Collect a volume of sample appropriate to the analytical method in a bottle of the material specified. If the sample can be analyzed within 48 hours and sulfide is not present, adjust the pH to > 12 with sodium hydroxide solution (e.g., 5% w/v), refrigerate as specified, and analyze within 48 hours. Otherwise, to extend the holding time to 14 days and mitigate interferences, treat the sample immediately using any or all of the following techniques, as necessary, followed by adjustment of the sample pH to > 12 and refrigeration as specified. There may be interferences that are not mitigated by approved procedures. Any procedure for removal or suppression of an interference may be employed, provided the laboratory demonstrates that it more accurately measures cyanide. Particulate cyanide (e.g., ferric ferrocyanide) or a strong cyanide complex (e.g., cobalt cyanide) are more accurately measured if the laboratory holds the sample at room temperature and pH > 12 for a minimum of 4 hours prior to analysis, and performs UV digestion or dissolution under alkaline (pH=12) conditions, if necessary.

(1) Sulfur: To remove elemental sulfur (S_8), filter the sample immediately. If the filtration time will exceed 15 minutes, use a larger filter or a method that requires a smaller sample volume (e.g., EPA Method 335.4 or Lachat Method 01). Adjust the pH of the filtrate to > 12 with NaOH, refrigerate the filter and filtrate, and ship or transport to the laboratory. In the laboratory, extract the filter with 100 mL of 5% NaOH solution for a minimum of 2 hours. Filter the extract and discard the solids. Combine the 5% NaOH-extracted filtrate with the initial filtrate, lower the pH to approximately 12 with concentrated hydrochloric or sulfuric acid, and analyze the combined filtrate. Because the detection limit for cyanide will be increased by dilution by the filtrate from the solids, test the sample with and without the solids procedure if a low detection limit for cyanide is necessary. Do not use the solids procedure if a higher cyanide concentration is obtained without it. Alternatively, analyze the filtrates from the sample and the solids separately, add the amounts determined (in µg or mg), and divide by the original sample volume to obtain the cyanide concentration.

(2) Sulfide: If the sample contains sulfide as determined by lead acetate paper, or if sulfide is known or suspected to be present, immediately conduct one of the volatilization treatments or the precipitation treatment as follows: Volatilization—Headspace expelling. In a fume hood or well-ventilated area, transfer 0.75 liter of sample to a 4.4 L collapsible container (e.g., Cubitainer™). Acidify with concentrated hydrochloric acid to pH < 2. Cap the container and shake vigorously for 30 seconds. Remove the cap and expel the headspace into the fume hood or open area by collapsing the container without expelling the sample. Refill the headspace by expanding the container. Repeat expelling a total of five headspace volumes. Adjust the pH to > 12, refrigerate, and ship or transport to the laboratory. Scaling to a smaller or larger sample volume must maintain the air to sample volume ratio. A larger volume of air will result in too great a loss of cyanide (> 10%). Dynamic stripping: In a fume hood or well-ventilated area, transfer 0.75 liter of sample to a container of the material specified and acidify with concentrated hydrochloric acid to pH < 2. Using a calibrated air sampling pump or flowmeter, purge the acidified sample into the fume hood or open area through a fritted glass aerator at a flow rate of 2.25 L/min for 4 minutes. Adjust the pH to > 12, refrigerate, and ship or transport to the laboratory. Scaling to a smaller or larger sample volume must maintain the air to sample volume ratio. A larger volume of air will result in too great a loss of cyanide (> 10%). Precipitation: If the sample contains particulate matter that would be removed by filtration, filter the sample prior to treatment to assure that cyanide associated with the particulate matter is included in the measurement. Ship or transport the filter to the laboratory. In the laboratory, extract the filter with 100 mL of 5% NaOH solution for a minimum of 2 hours. Filter the extract and discard the solids. Combine the 5% NaOH-extracted filtrate with the initial filtrate, lower the pH to approximately 12 with concentrated hydrochloric or sulfuric acid, and analyze the combined filtrate. Because the detection limit for cyanide will be increased by dilution by the filtrate from the solids, test the sample with and without the solids procedure if a low detection limit for cyanide is necessary. Do not use the solids procedure if a higher cyanide concentration is obtained without it. Alternatively, analyze the filtrates from the sample and the solids separately, add the amounts determined (in µg or mg), and divide by the original sample volume to obtain the cyanide concentration. For removal of sulfide by precipitation, raise the pH of the sample to > 12 with NaOH solution, then add approximately 1 mg of powdered cadmium chloride for each mL of sample. For example, add approximately 500 mg to a 500-mL sample. Cap and shake the container to mix. Allow the precipitate to settle and test the sample with lead acetate paper. If necessary, add cadmium chloride but avoid adding an excess. Finally, filter through 0.45 micron filter. Cool the sample as specified and ship or transport the filtrate and filter to the laboratory. In the laboratory, extract the filter with 100 mL of 5% NaOH solution for a minimum of 2 hours. Filter the extract and discard the solids. Combine the 5% NaOH-extracted filtrate with the initial filtrate, lower the pH to approximately 12 with concentrated hydrochloric or sulfuric acid, and analyze the combined filtrate. Because the detection limit for cyanide will be increased by dilution by the filtrate from the solids, test the sample with and without the solids procedure if a low detection limit for cyanide is necessary. Do not use the solids procedure if a higher cyanide concentration is obtained without it. Alternatively, analyze the filtrates from the sample and the solids separately, add the amounts determined (in µg or mg), and divide by the original sample volume to obtain the cyanide concentration. If a ligand-exchange method is used (e.g., ASTM D6888), it may be necessary to increase the ligand-exchange reagent to offset any excess of cadmium chloride.

(3) Sulfite, thiosulfate, or thiocyanate: If sulfite, thiosulfate, or thiocyanate is known or suspected to be present, use UV digestion with a glass coil (Method Kelada-01) or ligand exchange (Method OIA–1677) to preclude cyanide loss or positive interference.

(4) Aldehyde: If formaldehyde, acetaldehyde, or another water-soluble aldehyde is known or suspected to be present, treat the sample with 20 mL of 3.5% ethylenediamine solution per liter of sample.

(5) Carbonate: Carbonate interference is evidenced by noticeable effervescence upon acidification in the distillation flask, a reduction in the pH of the absorber solution, and incomplete cyanide spike recovery. When significant carbonate is present, adjust the pH to ≥12 using calcium hydroxide instead of sodium hydroxide. Allow the precipitate to settle and decant or filter the sample prior to analysis (also see Standard Method 4500–CN.B.3.d).

(6) Chlorine, hypochlorite, or other oxidant: Treat a sample known or suspected to contain chlorine, hypochlorite, or other oxidant as directed in footnote 5.

[7] For dissolved metals, filter grab samples within 15 minutes of collection and before adding preservatives. For a composite sample collected with an automated sampler (e.g., using a 24-hour composite sampler; see 40 CFR 122.21(g)(7)(i) or 40 CFR Part 403, Appendix E), filter the sample within 15 minutes after completion of collection and before adding preservatives. If it is known or suspected that dissolved sample integrity will be compromised during collection of a composite sample collected automatically over time (e.g., by interchange of a metal between dissolved and suspended forms), collect and filter grab samples to be composited (footnote 2) in place of a composite sample collected automatically.

[8] Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

[9] If the sample is not adjusted to pH 2, then the sample must be analyzed within seven days of sampling.

[10] The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

[11] When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity (*i.e.*, use all necessary preservatives and hold for the shortest time listed). When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to ≤6 °C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6–9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (regarding the requirement for thiosulfate reduction), and footnotes 12, 13 (regarding the analysis of benzidine).

[12] If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0 ± 0.2 to prevent rearrangement to benzidine.

[13] Extracts may be stored up to 30 days at < 0 °C.

[14] For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7–10 with NaOH within 24 hours of sampling.

[15] The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

[16] Sufficient ice should be placed with the samples in the shipping container to ensure that ice is still present when the samples arrive at the laboratory. However, even if ice is present when the samples arrive, it is necessary to immediately measure the temperature of the samples and confirm that the preservation temperature maximum has not been exceeded. In the isolated cases where it can be documented that this holding temperature cannot be met, the permittee can be given the option of on-site testing or can request a variance. The request for a variance should include supportive data which show that the toxicity of the effluent samples is not reduced because of the increased holding temperature.

[17] Samples collected for the determination of trace level mercury (<100 ng/L) using EPA Method 1631 must be collected in tightly-capped fluoropolymer or glass bottles and preserved with BrCl or HCl solution within 48 hours of sample collection. The time to preservation may be extended to 28 days if a sample is oxidized in the sample bottle. A sample collected for dissolved trace level mercury should be filtered in the laboratory within 24 hours of the time of collection. However, if circumstances preclude overnight shipment, the sample should be filtered in a designated clean area in the field in accordance with procedures given in Method 1669. If sample integrity will not be maintained by shipment to and filtration in the laboratory, the sample must be filtered in a designated clean area in the field within the time period necessary to maintain sample integrity. A sample that has been collected for determination of total or dissolved trace level mercury must be analyzed within 90 days of sample collection.

[18] Aqueous samples must be preserved at ≤6 °C, and should not be frozen unless data demonstrating that sample freezing does not adversely impact sample integrity is maintained on file and accepted as valid by the regulatory authority. Also, for purposes of NPDES monitoring, the specification of "≤ °C" is used in place of the "4 °C" and "< 4 °C" sample temperature requirements listed in some methods. It is not necessary to measure the sample temperature to three significant figures ($\frac{1}{100}$th of 1 degree); rather, three significant figures are specified so that rounding down to 6 °C may not be used to meet the ≤6 °C requirement. The preservation temperature does not apply to samples that are analyzed immediately (less than 15 minutes).

[19] An aqueous sample may be collected and shipped without acid preservation. However, acid must be added at least 24 hours before analysis to dissolve any metals that adsorb to the container walls. If the sample must be analyzed within 24 hours of collection, add the acid immediately (see footnote 2). Soil and sediment samples do not need to be preserved with acid. The allowances in this footnote supersede the preservation and holding time requirements in the approved metals methods.

[20] To achieve the 28-day holding time, use the ammonium sulfate buffer solution specified in EPA Method 218.6. The allowance in this footnote supersedes preservation and holding time requirements in the approved hexavalent chromium methods, unless this supersession would compromise the measurement, in which case requirements in the method must be followed.

[21] Holding time is calculated from time of sample collection to elution for samples shipped to the laboratory in bulk and calculated from the time of sample filtration to elution for samples filtered in the field.

[22] Samples analysis should begin immediately, preferably within 2 hours of collection. The maximum transport time to the laboratory is 6 hours, and samples should be processed within 2 hours of receipt at the laboratory.

[23] For fecal coliform samples for sewage sludge (biosolids) only, the holding time is extended to 24 hours for the following sample types using either EPA Method 1680 (LTB–EC) or 1681 (A–1): Class A composted, Class B aerobically digested, and Class B anaerobically digested.

[38 FR 28758, Oct. 16, 1973]

EDITORIAL NOTE: For FEDERAL REGISTER citations affecting §136.3, see the List of CFR Sections Affected, which appears in the Finding Aids section of the printed volume and on GPO Access.

§ 136.4 Application for alternate test procedures.

(a) Any person may apply to the Regional Administrator in the Region where the discharge occurs for approval of an alternative test procedure.

(b) When the discharge for which an alternative test procedure is proposed occurs within a State having a permit program approved pursuant to section 402 of the Act, the applicant shall submit his application to the Regional Administrator through the Director of the State agency having responsibility for issuance of NPDES permits within such State.

(c) Unless and until printed application forms are made available, an application for an alternate test procedure may be made by letter in triplicate. Any application for an alternate test procedure under this paragraph (c) shall:

(1) Provide the name and address of the responsible person or firm making the discharge (if not the applicant) and the applicable ID number of the existing or pending permit, issuing agency, and type of permit for which the alternate test procedure is requested, and the discharge serial number.

(2) Identify the pollutant or parameter for which approval of an alternate testing procedure is being requested.

(3) Provide justification for using testing procedures other than those specified in Table I.

(4) Provide a detailed description of the proposed alternate test procedure, together with references to published studies of the applicability of the alternate test procedure to the effluents in question.

(d) An application for approval of an alternate test procedure for nationwide use may be made by letter in triplicate to the Alternate Test Procedure Program Coordinator, Office of Science and Technology (4303), Office of Water, U.S. Environmental Protection Agency, 1200 Pennsylvania Ave., NW., Washington, DC 20460. Any application for an alternate test procedure under this paragraph (d) shall:

(1) Provide the name and address of the responsible person or firm making the application.

(2) Identify the pollutant(s) or parameter(s) for which nationwide approval of an alternate testing procedure is being requested.

(3) Provide a detailed description of the proposed alternate procedure, together with references to published or other studies confirming the general applicability of the alternate test procedure to the pollutant(s) or parameter(s) in waste water discharges from representative and specified industrial or other categories.

(4) Provide comparability data for the performance of the proposed alternate test procedure compared to the performance of the approved test procedures.

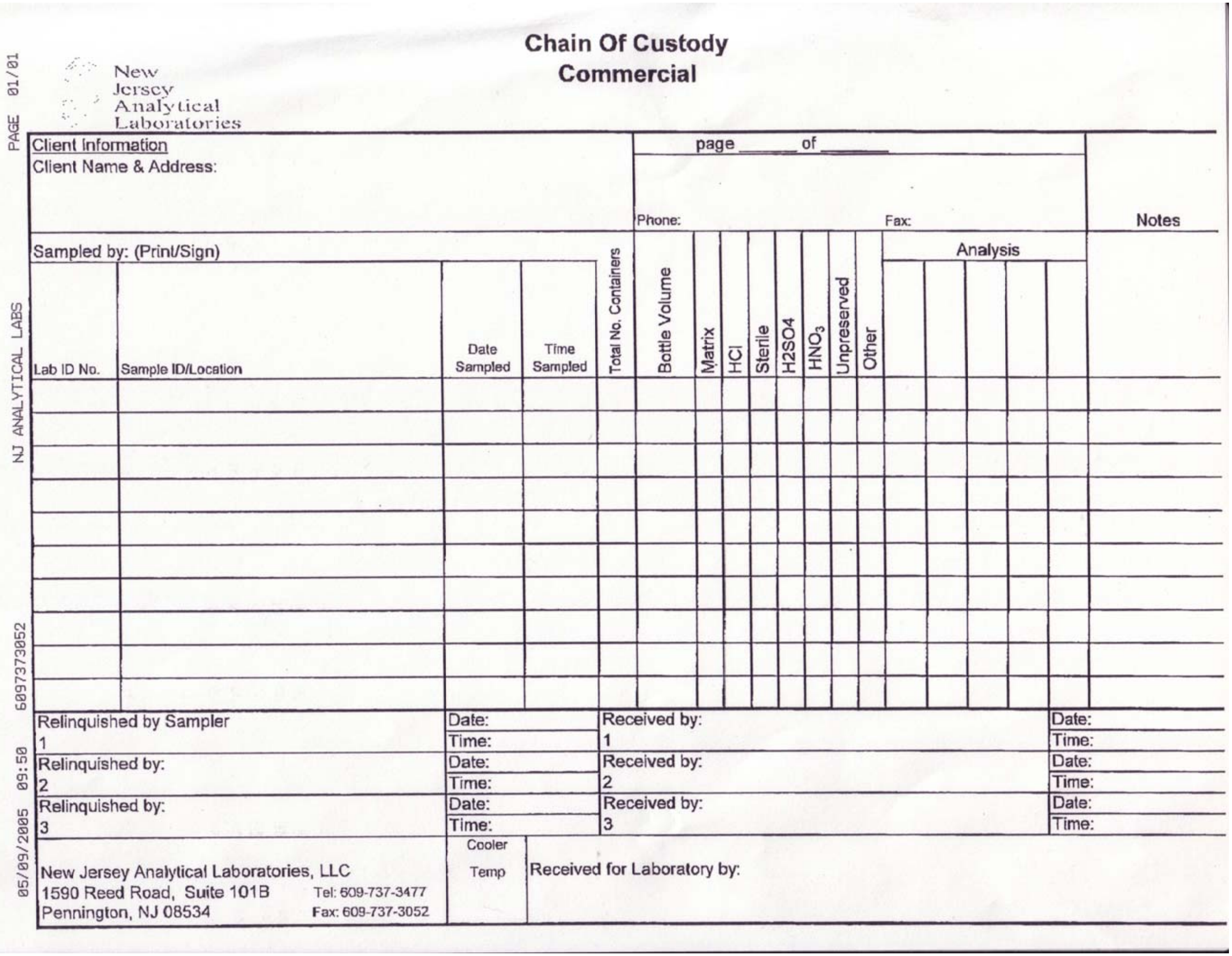
[38 FR 28760, Oct. 16, 1973, as amended at 41 FR 52785, Dec. 1, 1976; 62 FR 30763, June 5, 1997; 72 FR 11239, Mar. 12, 2007]

§ 136.5 Approval of alternate test procedures.

(a) The Regional Administrator of the region in which the discharge will

ATTACHMENT D

Sample Chain of Custody Form



05/09/2005 09:50 6097373052 NJ ANALYTICAL LABS PAGE 01/01

New
Jersey
Analytical
Laboratories

Chain Of Custody
Commercial

Client Information

Client Name & Address:

page _____ of _____

Phone: Fax:

Sampled by: (Print/Sign)

Lab ID No.	Sample ID/Location	Date Sampled	Time Sampled	Total No. Containers	Bottle Volume	Matrix	HCl	Sterile	H2SO4	HNO_3	Unpreserved	Other	Analysis					Notes

Relinquished by Sampler 1	Date: Time:	Received by: 1	Date: Time:
Relinquished by: 2	Date: Time:	Received by: 2	Date: Time:
Relinquished by: 3	Date: Time:	Received by: 3	Date: Time:

New Jersey Analytical Laboratories, LLC
1590 Reed Road, Suite 101B Tel: 609-737-3477
Pennington, NJ 08534 Fax: 609-737-3052

Cooler Temp

Received for Laboratory by:

ATTACHMENT E

Table of Parameter Detection Limits, Accuracy, and Precision

Parameter Detection Limits, Accuracy, and Precision

Parameter:	**Dissolved Ortho-Phosphate (as P) (mg/L)**	**Total Phosphorus (as P) (mg/L)**
Referenced Methodology – (NJDEP Certified Methodology)	EPA 365.3	SM 4500-P B5 + E
Technique Description	Ascorbic Acid, Manual Two Reagents	Persulfate Digestion + Manual
Method Detection Limit (ppm)-Calculated	0.0029	0.0060
Instrument Detection Limit (ppm)	NA	NA
Project Detection Limit (ppm)	0.01	0.02
Quantitation Limit (ppm)	0.01	0.02
Accuracy (mean % recovery)	106.9	108.6
Precision-% (mean – RPD)	2.18	2.80
Accuracy Protocol (% recovery for LCL/UCL)	83.8/ 130.0	91.3/ 126.0
Precision Protocol-% (maximum RPD)	8.10	10.13

RPD – Relative % Difference; NA – Not Applicable;
LCL/UCL – Lower Control Limit/Upper Control Limit

Laboratory: New Jersey Analytical Laboratories (NJDEP #11005)