Attachment A4

Analysis of the Rhode Island Department of Environmental Management's
Evaluation of Nitrogen Targets and WWTF Load Reductions for the Providence and Seekonk Rivers

In December of 2004 RIDEM issued a study entitled *Evaluation of Nitrogen Targets and WWTF Load Reductions for the Providence and Seekonk Rivers* ("The 2004 Evaluation"). The study attempts to provide the substantiation of the permit limits for Total Nitrogen proposed by RIDEM for the treatment plants discharging into the Providence and Seekonk River systems. It uses research conducted by the Marine Ecosystems Research Laboratory (MERL) at the University of Rhode Island in the early 1980's on nutrient enrichment of Narragansett Bay, and data collected in 1995 and 1996 to support its conclusions. The study was developed by RIDEM when it initial efforts to construct a more formal total maximum daily load (TMDL) analysis using a numerical model to simulate the Providence/Seekonk River systems were unsuccessful.

Based on our review as described further below, the central problems with this analysis are that:

It does not present a cohesive analysis of the dissolved oxygen dynamics of the Providence and Seekonk Rivers. The analysis ignores fundamental and critically important factors, including local sources of oxygen demanding substances and the impacts of physical processes such as elevated temperature and stratification on the oxygen dynamics of the Providence and Seekonk Rivers.

It is inconsistent with previous studies, including studies of their own, about the sources of nitrogen discharged to the Providence/Seekonk River systems and Narragansett Bay.

In extrapolating the results of the MERL experiments it generally ignores the significant differences between the conditions in Narragansett Bay that the MERL simulates, and the Providence and Seekonk River system.

In crafting its nitrogen reduction strategy, DEM appears to have ignored the significant nitrogen reduction programs now underway or already undertaken by numerous Rhode Island communities. By ignoring the progress made since the 1995/1996 timeframe they fail to put the impact of its recommendations into perspective, and leaves one with the impression that nothing has been done since 1995/1996.

This is particularly vexing for Woonsocket, because there has been a substantial decline in the volume of wastewater discharged since the 1995/1996 time frame, owing to the loss of several large manufacturing companies with high sewer use. But more importantly, because the City has invested over $20 million in its wastewater plant, RIDEM seems to ignore that the City has reduced its total nitrogen load by almost 70 % from their baseline conditions.

Our concerns are more fully discussed below.

The analysis fails to properly analyze the oxygen deficits in the Providence River system.

The oxygen dynamics of an urban river/estuary system that receives discharges of oxygen demanding pollutants from multiple sources is very complicated. Any analysis of the conditions should take into account all potential sources of oxygen demanding substances, the impacts of physical conditions such as stratification, temperature, tidal stage, wind induced mixing and re-aeration, as well as the potential impacts of algae on the oxygen conditions. The complexity of

these interactions is presumably the reason that RIDEM originally undertook to establish a model of the Seekonk and Providence River systems to develop a TMDL.

Having failed in its initial attempt to develop a numerical model of the system, RIDEM has then turned to an overly simplistic adaptation of local research. RIDEM'S analysis is based entirely on an extrapolation of the concept that excess nitrogen leads to algal growth, which can lead to diminished DO. The work is based solely on the nitrogen flux into the Providence river system, and draws from the system loading response in the Marine Ecosystems Research Laboratory (MERL) studies conducted at URI in the 1980's. The analysis completely ignores any other pollutant sources that impact the local oxygen conditions, and fails to consider major differences between the physical characteristics of the Providence and Seekonk River systems, and that of Narragansett Bay which the MERL experiments were built to simulate.

While the literature is quite clear that nutrient over-enrichment can lead to low dissolved oxygen, it is imperative that one fully understands the reasons for low dissolved oxygen before one launches a nitrogen reduction program based on the DO in the Providence River. Careful attention must be given to these other DO sinks that may be as important, or more important than the nitrogen flux in order to avoid the inappropriate expenditure of limited public funds .

Inaccuracies with respect to Watershed Sources of Nitrogen.

RIDEM's analysis incorrectly assigns all the nitrogen discharged from the Blackstone River to two wastewater treatment plants (WWTP) and makes conceptual and computational errors in estimating the delivery of these loads to the Seekonk River. These errors and inaccuracies magnify the potential impacts of the City's discharge on the Seekonk and Providence River System.

RIDEM attributes essentially all the N discharged at the mouth of the Blackstone river to the UBWPAD and Woonsocket WWTPs. See page 20 of The 2004 Evaluation, where RIDEM asserts that compared to these discharges "other watershed sources [of nitrogen] are assumed to be negligible". This assertion apparently serves to justify the analysis presented on page 18 of The 2004 Evaluation that expresses the level of discharge of Nitrogen from the Blackstone into the Seekonk river as a function of the level of discharge of from the treatment plants.

This analysis is correct only to the extent that there are no other sources of nitrogen in the Blackstone system. However, virtually all studies done on the Blackstone River suggest that the two treatment plants contribute on the order of 60 % of the nitrogen discharged into the Blackstone River system, as follows.

> The Blackstone River Initiative studies in which RIDEM participated indicated that in dry weather, these large plants represent between 40 and 60 % of the N load. (See data and analysis on pages 4-11 and 4-15 of the BRI May 2001 Report). During wet weather, the two large plants represent about 60 % of the ammonia and 33 % of the nitrate (see page 7-50 of the BRI May 2001 Report). As a practical matter, then the BRI suggests that the large plants are approximately 60 % of the watershed loads of Nitrogen.
>
> The Governor's Panel on Nutrient and Bacteria Pollution recognized the importance of other sources when it says ..."Other analyses show general agreement regarding total loading but decompose the "river/stream" component to provide more insight into sources by recognizing that it is, in large part, due to wastewater treatment facilities

(WWTFs) and atmospheric deposition. Alexander et al. (2001) estimated that 62% of the total came from point sources, 19% from non-agricultural nonpoint sources, 6% from fertilizer and 3% from livestock in addition to the 10% from atmospheric deposition. Castro et al. (2001) estimated 73% of their total loading figure came from human sewage (through WWTFs and Individual Sewage Disposal Systems (ISDSs)), 13% from atmospheric deposition, 10.5% from agricultural runoff, and 3% from urban nonpoint sources. The analysis reported by Roman et al. (2000) estimated that wastewater treatment facilities contributed 73% of the nitrogen load, atmospheric deposition 23%, and agriculture 4%. RIDEM (2000)5 estimated that WWTFs contributed 66% of the total nitrogen to Upper Narragansett Bay; rivers and runoff (not including WWTFs) 30%, and direct atmospheric deposition 4%. Moore et al. (in press), using a similar but higher resolution technique than Alexander et al. (2001), estimated that total nitrogen load from the Providence /Seekonk River was 68% municipal wastewater, 15% atmospheric deposition, 14% runoff from developed lands, and 3% runoff from agricultural lands. All these analyses agree that wastewater treatment plants are the major source of nitrogen to the Bay. (See http://www.ci.uri.edu/GovComm/Documents/Phase1Rpt/Docs/Nutrient-Bacteria.pdf, page 2)

Finally, studies conducted by the USGS indicate that for the Providence River system, approximately 68 % of the total nitrogen load is from municipal wastewater treatment plants, with the remainder attributed to nonpoint sources. (see http://water.usgs.gov/pubs/sir/2004/5012/SIR2004-5012_report.pdf, page 23).

The erroneous assumptions adopted by RIDEM significantly impact their analysis, and overstate the impacts of the Blackstone River treatment plants on the receiving waters. It can be shown by simple algebra that if the WWTP discharge is 60 % of the total nitrogen load, and that the amount discharged from the Blackstone River to the Seekonk River is 87 % of the amount discharged by the WWTP's, then the River Delivery Factor is more on the order of 52 %, rather than 87 %. This issue is important because it indicates that a discharge of 10 mg/l into the Blackstone might be more like a discharge of 5 mg/l directly into the Providence and Seekonk rivers simply because of natural attenuation of the nitrogen load.

RIDEM is imprecise with respect to its citation of supporting source documents.

RIDEM makes reference to studies conducted on Long Island Sound to support its analysis of River Delivery Factors. The River Delivery Factor is used to estimate the amount of nitrogen that makes it to the Providence and Seekonk Rivers as a function of the amount discharged at ts source. The River Delivery Factor accounts for the biological and physical process that serve to reduce the delivery of nitrogen downstream, either through instream dentirification, or through permanent burial of nitrogen in bottom sediments. RIDEM cites studies conducted on the Long Island Sound system, and suggests that river delivery factors in that study ranged from 52 to 90 %. This is apparently intended to justify RIDEM's use of an 87 % river delivery factors, presumably on the theory that it is within the range of estimated values from the Long Island Sound studies.

A more complete discussion of the Long Island Sound Studies, would however, show that the report actually says that "..losses during river transport are generally modest except for the highly impounded Housatonic River where long travel times allow for almost a 50 percent loss from the upper reaches to Long Island Sound". (see http://dep.state.ct.us/wtr/lis/nitrocntr/tmdl.pdf,

page 28) Since the Blackstone is a highly impounded river system, it is logical to expect that some greater attenuation of the nitrogen load would be achieved on this system, as compared to other systems discharging into the Seekonk and Providence rivers. In fact, the delivery assigned by RIDEM to the Blackstone was the highest of all three systems contributing nitrogen to the Providence River.

Contradictory Data are Presented in the Analysis

In support of its arguments RIDEM presents a variety of plots and data from the MERL experiments as well as from a cruise in the summers of 1995 and 1996. The MERL data are synthesized in figures 1 through 11 of The 2004 Evaluation, and information for the 1995 and 1996 cruises are presented in figures 13 through 18 of The 2004 Evaluation. The MERL data show that high levels of chlorophyll result in increasing average dissolved oxygen, but lower instantaneous oxygen concentrations, owing to diurnal swings in oxygen production and consumption by phytoplankton. The plots presented by DEM appear to indicate that low values for dissolved oxygen (associated with the 8x, 16 and 32x loading conditions) occur simultaneously with the high chlorophyll values (See figures 3 and 9 of The 2004 Evaluation).

In contrast, the data from 1995 and 1996 show that the occurrence of low DO and high chlorophyll in the Providence and Seekonk river systems are not occurring simultaneously. On pages 13 through 16 of The 2004 Evaluation, RIDEM presents plots of oxygen and chlorophyll-a concentrations at depth along a transect from the upper reaches of the Seekonk River, down to the Upper portions of Narragansett Bay. The plots show that the year with the worst DO problem (1996) has far less chlorophyll-a than 1995. The extent of hypoxia, both vertically in the water column and longitudinally along the length of the Rivers, is far greater in 1996 than in 1995, whereas the 1995 chlorophyll data show far greater algal abundance. As discussed by RIDEM, there is a 10 fold difference in chlorophyll a from 1995 to 1996. This contradiction is further highlighted by the charts on page 17 of The 2004 Evaluation that show the higher the chlorophyll-a, the higher the DO. These points are highly inconsistent with the underlying hypothesis of RIDEM and points out the importance of thoroughly understanding all the DO demands before establishing a DO restoration plan.

We should note that our preliminary investigations of the climatic conditions of the summers of 1995 and 1996 indicate that they were so radically different that they may not be simply averaged in the way that RIDEM has done without great caution. The summer of 1995 was among the driest recorded for 132 years of record at a location in the Blackstone watershed (34th driest), while the summer of 1996 was amongst the wettest (9th wettest). The difference could markedly impact the fate of pollutants in such a way as to make simple averaging of data across the two years inappropriate.

This extreme differences in climactic conditions is contrary to the claim made by RIDEM that its samples were taken during "typical summer season flows" (page 10 of The 2004 Evaluation), which would lead one to believe that the summers sampled reflected average or normal conditions. But it is consistent with the arguments made by RIDEM to explain the difference between 1996 and 1995 chlorophyll levels (page 11), where the difference in flushing times owing to higher river flows – which was a result of greater rainfall – is used to explain the year on year differences in chlorophyll a concentrations.

Unsubstantiated extrapolation of the MERL experiments to the Providence/Seekonk River System.

The use of the MERL data to analyze the Seekonk and Providence River system is questionable in that there are several critical and important differences between the conditions in the Bay and in the Providence and Seekonk River systems. .

As RIDEM points out, on page 12 of The 2004 Evaluation, the MERL experiments were conducted under simulated flushing conditions that are almost 7.8 times lower than the conditions in the Providence River (27 day flushing time in the Bay versus 3.5 day flushing time in the River). The higher flushing rates of the Providence River would lead to lower nutrient loadings (expressed as mass per unit volume) and therefore much less algal activity. Indeed, RIDEM uses exactly this logic to explain why the observed chlorophyll a values in 1996 are an order of magnitude lower than observed in 1995. While RIDEM suggests that for some pollutants the hydraulic residence time might overstate the transport of the pollutant out of the river segment, no explanation, data or other information is presented as to how this would operate in the Providence and Seekonk River systems.

As a first approximation, the relationship between the standing concentration and flushing rates out varies inversely with respect to each other. Thus, an increase in flushing rate by a factor of 7.8 would result in a decrease in concentration of by a factor of 7.8. Stated another way, a loading rate of 32 x in the Seekonk River will have the effect of a loading rate of 4X in the bay at large system.

Unsubstantiated Time Period for Nitrogen Control

RIDEM's analysis of the conditions of the Providence and Seekonk River systems is based on data from May 31, 1995 through September 21 of 1995 and from May 2, 1996 through November 14, 1996. The data presented suggests that DO problems commence in the Providence and Seekonk systems in June, and have dissipated by approximately September. We believe this actually the result of the onset of elevated temperature and stratification of the system in the June time frame, and the occurrence of major late summer, early fall storms that serve to break up the stratification of the system and provide robust and deep mixing which reoxygenates the water column.

Although the period of DO problem is typically the summer, RIDEM has established total nitrogen limitations for the period of April 1 thorough October 31, without any specific justification as to these specific dates. This is an issue for wastewater treatment facilities (especially the early April time frame) because this is often a period of high flow and low water temperatures, which requires facilities to be constructed larger than otherwise needed to accommodate the biological kinetics of nitrification and denitrification processes.

RIDEM Fails to Incorporate All available Information into its Analysis

RIDEM uses data from the 1995/1996 time frame to analyze the condition of the Providence and Seekonk River systems. They appeared to have ignored other readily available sources of information concerning the dynamics of dissolved oxygen in the Providence and Seekonk rivers that could serve to validate their analyses. In particular, RIDEM participated in an EMPACT program that deployed continuous recording sensors (salinity, temperature, dissolved oxygen,

amongst other parameters) at various locations in the Providence and Seekonk River systems for upwards of two years. That information is available on the worldwide web at http://www.narrabay.com/empact/ . Combined with concurrent discharge monitoring reports from the various wastewater treatment plants and flow data gathered from USGS gages, this would result in an extensive data set that could serve to validate RIDEM's conclusions. The lack of analysis of this information in the December 2004 report is surprising.

RIDEM ignores the fact that Woonsocket already meets the essential elements of the new permit

The new permit imposes limits of 667 pounds per day of total nitrogen, and a concentration limit of 5 mg/l. These reflect reductions from 1,175 pounds per day and an average of at least 19.1 mg/l used as the 1995/1996 baseline loading conditions in RIDEM's analysis. With respect to the impacts on the Providence/Seekonk system and Narragansett Bay, it is the mass emission rate that is most important; the volume of flow discharged by Woonsocket is insignificant, and does not perceptibly impact the concentration of pollutants in the Providence/Seekonk system or the Bay. Whether Woonsocket discharges 667 pounds of nitrogen in 1 or 5 or 15 million gallons per day of effluent is not material to the receiving waters.

For the period April through October of 2004, monthly data submitted to RIDEM by the City shows that the City discharged an average of only 364 pounds per day of Nitrogen, which is a 69 % reduction from the baseline condition, and only 55 % of the mass allowed by the proposed permit. The average concentration was approximately 6.5 mg/l. Although slightly above the 5.0 mg/l limit of the permit, the City is well within the far more important mass emission rates.

RIDEM appears not to have considered these facts at all in developing its approach for nitrogen control, nor has it considered other efforts being undertaken by local dischargers to effect similar Nitrogen load reductions. Recognizing all the uncertainties admitted to by RIDEM concerning the studies, and the issues presented herein, it would seem prudent to consider these factors in the development of a nitrogen control strategy.

RIDEM presents no rationale for its two tier permit structure

RIDEM's permitting strategy establishes permit limits of 5 mg/l for the Woonsocket facility, as well as for those of the Narragansett Bay Commission. For four other plants, East Providence, Cranston, West Warwick and Warwick, The 2004 Evaluation sets limits at 8 mg/l. No rationale is presented for this difference, and none is readily apparent from the technical information presented.

Attachment A5

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

MITT ROMNEY
Governor

KERRY HEALEY
Lieutenant Governor

ELLEN ROY HERZFELDER
Secretary

ROBERT W. GOLLEDGE, Jr.
Commissioner

February 11, 2004

Mr. Joseph B. Haberek, P.E.
RIDEM
235 Promenade Street,
Providence, Rhode Island, 02908-5767

Re: *RIDEM Permits and Modifications to Permits (PN04-15), and Documents in Support of Permit Limits including, "Evaluation of Nitrogen Targets and WWTF Load Reductions for the Providence and Seekonk Rivers".*

Dear Mr. Haberek:

The MA Department of Environmental Protection (MADEP) wishes to thank you for the opportunity to comment on the proposed RIPDES permits and documents upon which the proposed permit limits were based. MADEP understands the importance of the overall goals of preserving, protecting and restoring the water quality of the Providence and Seekonk Rivers and Narragansett Bay. Based upon past and present information, MADEP is in agreement that significant effects have been well established in these receiving waters. Observations by RIDEM have documented high levels of increased algal productivity, low dissolved oxygen, and additional violations of water quality standards that translate into detrimental effects on fishing and shellfishing and the overall health of the Rivers and Bay.

MA DEP also supports RIDEM's statements that an adaptive management approach is needed to set forth a nutrient reduction and cleanup plan that is technically sound, environmentally responsive, and economically achievable. Overall, our goal is to limit and reduce the nutrient impacts in the Blackstone River system and achieve water quality compliance. Although MADEP is in agreement on the approach and overall goals outlined in the various documents provided, we believe that the information and data upon which the permit limits are based are insufficient to justify specific reductions from Massachusetts' facilities. To address these areas the MA DEP is providing the following recommendations and actions for your consideration:

- Monitor and establish MA Wastewater Treatment Facility (WWTF) loadings, and loading at the state line to define MA contribution. (MADEP)

- Optimize existing operations at the Upper Blackstone Water Pollution Abatement District, Attleborough and North Attleborough wastewater treatment facilities to reduce nitrogen in their effluent to the extent practicable (MADEP).

- Determine loadings for all potential sources. (RI with MA input)

- Expand upon the evaluation in this report to include the additional sources including CSOs, local nonpoint sources, atmospheric inputs, etc. along with wet weather inflows and their respective and relative contributions to the Bay. (RI)

- Define a target concentration in the Bay and/or river needed to meet load reductions predicted by the analysis. (RI with MA input)

- Determine nitrogen attenuation in the MA portion (and to the Bay) of the rivers. (MA joint effort with RI)

- Based on the loading analyses, evaluate the necessity of load reductions at MA facilities after the completion of RI's WWTF upgrades, as sources closest to the problem need to be dealt with first. (RI joint effort with MA)

- Re-evaluate the loadings from UBWPAD facility now under design once the WWTF is constructed and on-line (MADEP).

As previously noted, our review of the data and other supporting documents have raised a number of concerns and issues that we believe need to be resolved to justify pushing limit of technology permitting decisions in MA. These concerns fall into several categories, which can be summarized as follows:

1. The analysis completed by RIDEM did not account for non-POTW loadings and their potential impacts including, but not limited to, combined sewer overflows (CSO's) and storm water contributions.

2. The analysis treated all POTW contributions equally rather than consider greater reductions for those facilities located closer to the receiving water where impacts have been observed.

3. The model used by RIDEM didn't account for all sources and sinks of nitrogen to the impacted water bodies nor did it consider the importance of detention time and hydrodynamics of both the river and embayment systems.

A more detailed explanation of each of these, as well as other issues, is attached to this letter. However a brief explanation follows.

MA DEP believes, the identification of all sources and their relative importance have not been well established in the RI DEM documents, which is the basis for the proposed permit limits. Major omissions not identified in the documents include, but are not limited to, nitrogen loads from local contributing non-point sources such as groundwater (i.e. septic system) and combined CSOs, atmospheric deposition, effect of sediments on nitrogen flux, and effects of tidal ranges and currents within the Bay and River systems on dispersion, dilution, and effective retention time. Without a complete, consistent, and logically progressed evaluation of the sources and their contributions, financially expensive solutions are being proposed in these documents for implementation without confidence that the projected benefits will be obtained once construction is completed and the solutions are implemented.

The present analyses are also based on extrapolation from a series of laboratory tank studies (MERL) to a dynamically active river and bay system. These laboratory experiments replaced the computer model, which had been discarded due to an inability to calibrate the model in the shallow areas where impacts are documented and in the deep channel where stratification occurs. If the results of a computer model cannot be used to replicate this complex system, MA DEP questions if a static laboratory study and desktop analysis could justify the proposed specific permit limits. In addition, while the unique aspects of the Seekonk and Providence Rivers currently preclude representing them in a mathematical model, it seems likely that the open water portion of Narragansett Bay could be modeled and such a model would be a useful tool to addressing water quality issues and alternative control strategies.

Among loading models, those based on area alone, although useful, are the most uncertain. For example, in the case of the Providence and Seekonk Rivers, area-loading rates were used to estimate impacts using the URI MERL experiments however the MERL experiment used a dramatically different residence time (27 days) than is likely experienced in the two river systems (on the order of hours or a couple of days). Such a discrepancy is at best inconsistent and not representative of the actual condition in the rivers. This strongly suggests the need to approach controls through adaptive management, a major component of which has to be a technically sound monitoring program. Such a program must recognize that natural systems are highly variable and more than one data set is needed to characterize such systems. Rhode Island does indicate it has plans to track the changes resulting from the reductions in N loads required in the proposed NPDES permits to its major wastewater treatment plants. MA DEP supports this effort, and recommends that the monitoring be expanded to also document the impacts of those changes in both the riverine and marine waters. We also note that funding seems to be for only one year (2005) right now.

These issues aside, the one remaining and potentially most detrimental to the Providence and Seekonk Rivers and possibly the Bay, which is not discussed in the report, are the significant quantity of CSOs in this highly urbanized area. CSOs typically discharge large quantities of nitrogen over short periods of time into these confined river channels. No mention or related analyses is included in the documentation provided. MA DEP is under the impression that there is a plan to increase the Bucklin Point Facility to discharge up to 116 mgd in part to help address the CSO problem. This number far dwarfs any contribution from upstream MA WWTFs, which are moderated by distance through instream and sediment attenuation. Since CSO discharges are a significant contributor to nitrogen loads in the River and Bay, DEP believes that any analysis of cause and effect on these waterways without the inclusion of wet weather and CSO effects is a major omission. In the permits, these large nutrient pulses are being regulated using monthly average loads with no regard to daily maximum concentrations or total daily loads, the time period over which the CSOs discharge, into these confined and shallow waterways.

MA DEP would also like to note that our review of the supporting documents indicates that final decisions as to the level of nitrogen reduction required at each facility appear to be based on both the size of the facility and the cost to achieve the desired limits rather than the proximity and combined impact these facilities have on the receiving waters. For example, RIDEM has proposed that the larger facilities of Bucklin Point, Fields Point and Upper Blackstone WPAD achieve a permit limit of 5.0 mg/l total nitrogen while the remaining RI facilities, as well as the MA facilities in Attleboro and North Attleboro, would have a proposed limit of 8.0 mg/l. MA DEP questions the validity of this approach for several reasons. First, a footnote to RIDEM's cost analysis clearly states that cost evaluation incorporated should not be used for facilities over 30.0 mgd yet it appears it was for the three larger facilities. Second, MA DEP believes RIDEM needs to justify why the UBWPAD needs to achieve a discharge of 5.0 mg/l TN when it is 50 miles away and receives significant dilution and possibly significant attenuation before getting to RI while the remainder of the facilities in RI, that total well in excess of the UBWPAD (more than 50 mgd) and discharge directly to the impacted waters only have to achieve 8.0 mg/l.