Rhode Island Environmental Monitoring Collaborative

Annual Report to the Rhode Island Bays, Rivers and Watersheds Coordination Team

Priority Monitoring Initiatives

June 2010

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Submitted by

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Preface

Environmental monitoring is essential to effective management of our natural resources. The information generated via monitoring is necessary not only to understanding the condition of our environment, but also measuring progress toward a healthy, sustainable bay and watershed. This report is not intended to describe the full range of monitoring activities undertaken collectively by state or federal agencies, their partners, their contractors; or academic institutions and non-governmental organizations (NGOs). Rather, this annual report captures the actions undertaken during 2009 to enhance, strengthen or expand critical water-related monitoring programs previously identified by the RIEMC as of highest importance. As evidenced in the report, environmental monitoring in Rhode Island continues to be a highly collaborative effort among state agencies, academic researchers, other governmental and NGOs as well as citizen volunteers. The RIEMC will continue to provide leadership and a forum that facilitates coordination and collaboration among those involved in monitoring Rhode Island's environment.

Unfortunately, recent economic conditions and associated state fiscal constraints have begun to erode the prior progress made toward building monitoring capacity in RI. During 2009, reductions in staff and funding have resulted in the curtailment or suspension of several priority monitoring activities. These include:

- the collection of fish tissue samples for contaminant analysis,
- aquatic invasive species training workshops for volunteer monitors, and
- DEM's continued development of an improved system for water quality data storage and dissemination.

Looking ahead to FY2011, the RIEMC has identified other programs that are threatened with disruption due to the imminent loss of federal funding, in particular NOAA funding associated with the Bay Window Program. Vulnerable activities include:

- the dissolved oxygen surveys in the upper Bay region,
- monthly multi-parameter surveys of the bay conducted by the National Marine Fisheries Service (NMFS),
- commercial fisheries monitoring,
- nutrient and benthic sampling in the Bay, and
- potentially much of the fixed-site monitoring network in Narragansett Bay.

The sponsoring agencies of affected programs continue to explore and pursue funding options, with a goal of securing sustainable funding for core programs. In early 2010, Rhode Island received approval of federal funding for invasive species work which is expected to allow the resumption of training volunteer monitors. Over the next year the RIEMC will need to track and assess the further loss of critical existing monitoring activities, while at the same time updating the list of prioritized gaps in environmental monitoring in Rhode Island. In response to the these challenging times, it will be important for the RIEMC, through communication and collaboration, to work toward solutions that avert further loss of critical monitoring activities, and that continue to generate information needed by decision-makers.

RI Environmental Monitoring Collaborative

Synopses of Work Accomplished in 2009
Priority RIEMC Monitoring Activities

Streamflow Gage Network
provided by Sue Kiernan, RI DEM

The Rhode Island network of continuous streamflow gages continued operation and was expanded during 2009. A total of 36 gages are maintained by the United States Geological Survey (USGS) via contracts with the Rhode Island Department of Environmental Management (DEM), the Rhode Island Water Resources Board (WRB), Providence Water Supply Board, and Ocean State Power. The expansion resulted from the Providence Water Supply Board (PWSB) contracting to upgrade gages to allow for continuous measurements of flow in five additional tributary streams in the Scituate Reservoir watershed. The new information enables the PWSB to make estimates of pollutant loadings within watersheds in addition to its practice of tracking concentrations of potential pollutants in tributary streams. At the state level, one gage was eliminated (Catamint Brook – Cumberland) resulting in a net increase of four gages over 2008.

Streamflow data are critically important and used for a variety of purposes including, but not limited to:

- Continuing development of DEM standards to ensure adequate flows in rivers and streams;
- Pollutant loading calculations and development of water quality restoration plans (TMDLs);
- Water quality modeling;
- Drought management;
- Emergency management including floodplain management;
- Basin planning related to water supply management;
- Water supply development planning and design in the Big River Watershed (WRB).

Measurement at the gages throughout the network is expected to continue for the next several years. Once a sufficient time series of data is available, data analysis is expected to establish the means to estimate with confidence the expected flow regime in the stream or river. As such analyses are completed the design of the network may change, possibly reducing the number of gages needed to be maintained long-term.

Streamflow data are made available on a real-time basis by USGS at:

http://tinyurl.com/RIEMC-FLOW

See Appendix A for a list of current network gages.

Funding for sustaining the streamflow gage network emerged as a concern in 2009. Due to budget reductions at DEM, the Coordination Team was asked and agreed to cover a larger portion of contractual costs for the streamflow gage network operations during state FY2010. The same need for funding has been projected for state FY2011 and subsequent years if not otherwise addressed. This shift in source of funding reduces the capacity of the Coordination Team to address other priority needs and highlights the need to develop a strategy to return a sufficient amount of funding to state agency budgets to support the recurring expenses associated with core water monitoring programs such as the stream gage network.

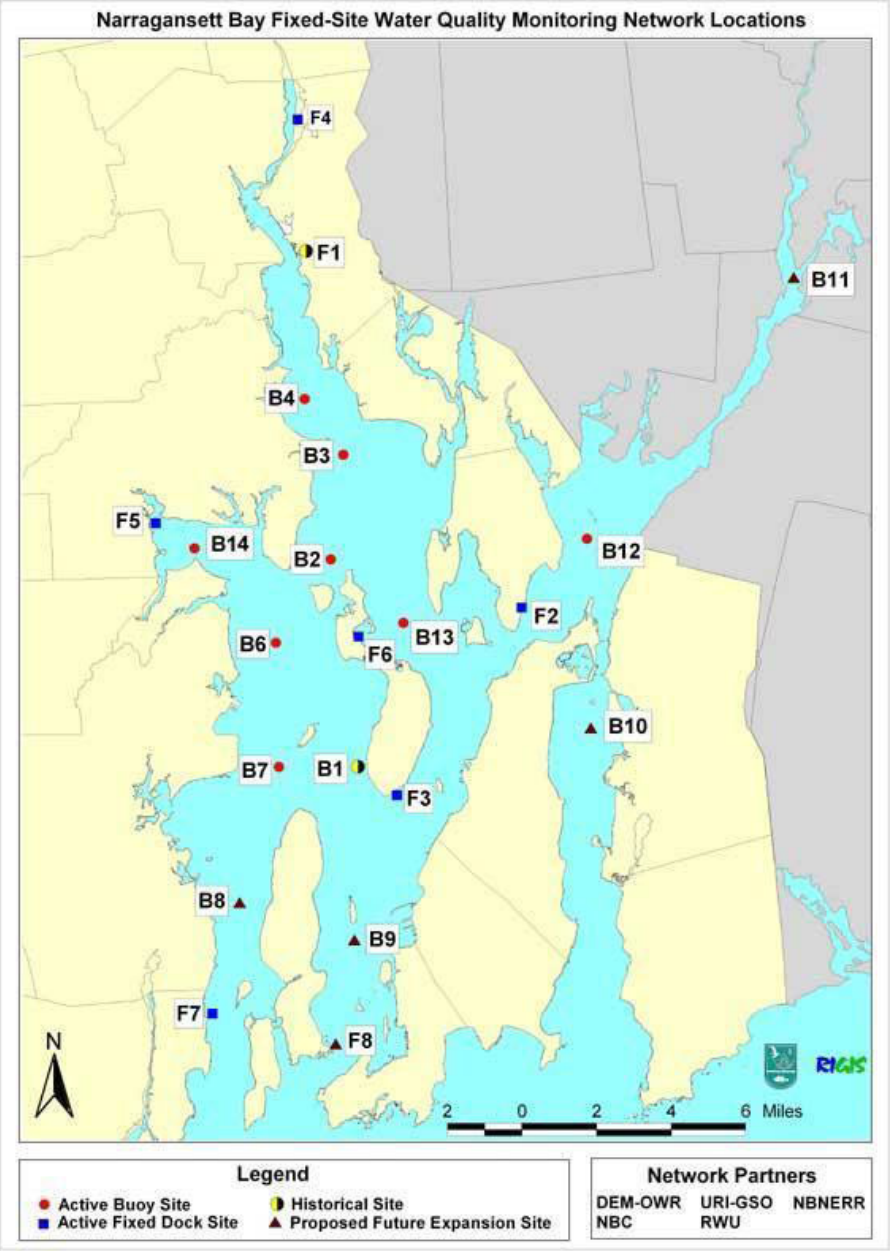
Record Spring River Flows Measured by Stream Gages

As this report was being prepared, Rhode Island experienced historic flooding in late March 2010. Along with other meteorological data, the RI stream gage network provided essential data to federal, state and local officials before, during and after flooding occurred. As river levels rose to record heights in the central and southern regions of the state, the United States Geological Survey (USGS), which maintains the gage network under agreements with RI and others, deployed personnel to take on-site measurements to capture information on peak flows. USGS reported the high flows caused damage at certain locations: inundating one station on the Big River near Nooseneck and destroying the station on the Congdon River. Both were repaired quickly with the latter station being re-located about 300 feet upstream. Assessment of the streamflow data at 27 gages, revealed that 21 stream gages recorded the highest discharge measurements for their periods of record – the time period for which data has been collected. For 12 of the gages, the periods of record are long-term ranging from 30 – 70 years. Further analysis of the streamflow data is being used to understand the flooding event and its implications for future floodplain management.

Narragansett Bay Fixed-Site Monitoring Network (NBFSMN)
provided by Sue Kiernan, RI DEM

The Narragansett Bay Fixed-Site Monitoring Network, a multi-agency collaborative monitoring program, continued operations during 2009 in order to provide critical information to state managers and researchers on the extent of hypoxia and other water quality conditions in Narragansett Bay. Over time the network will allow the state to track expected changes in water quality as additional wastewater treatment facility improvements are constructed to further reduce the total loadings of nitrogen to the upper Bay. During 2009, the network operated with a total of 13 locations: 8 buoys and 5 land-based sites. The network is standardized on YSI equipment that uses sensors to measure water quality every 15 minutes, 24 hours per day. Most stations are operated seasonally from May to October. In the fall of 2009, year-round monitoring was initiated at the Conimicut station in the upper bay to provide additional data for researchers studying potential ecological changes in the Bay. Four other land-based stations operated year-round as well (Fig. 1).

Figure 1.



During the summer season, data were reviewed weekly as part of DEM's tracking of Bay conditions. DEM uses the information to prepare as needed for responding to potential adverse events such as fish kills. Hypoxic events were documented between June and September of 2009. Processed network datasets (2003-2008) are posted on the DEM website at http://www.dem.ri.gov/bart/netdata.htm with summaries and raw data also posted to www.narrbay.org web site. Data were previously used by DEM to designate an additional 7.62 square miles of mid Narragansett Bay as impaired due to low dissolved oxygen (DO) in 2008. Data from 2009 indicated a continuing presence of intermittent hypoxia in the upper Bay region.

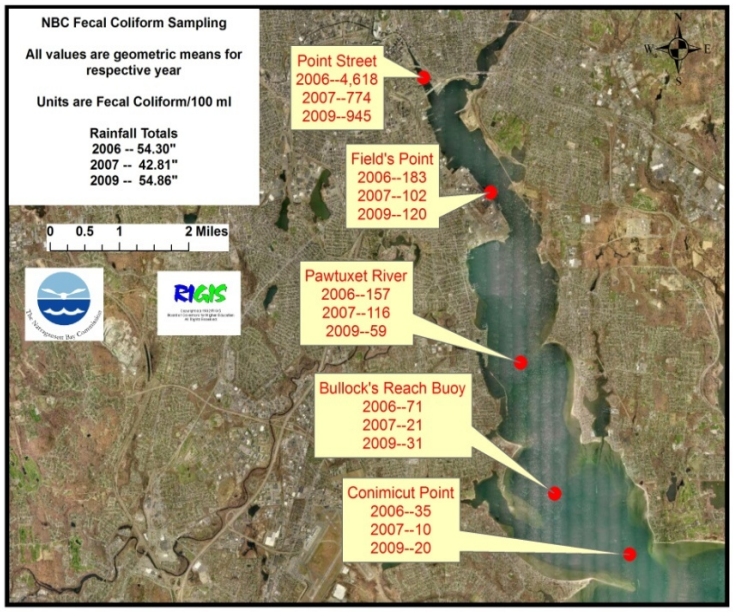
Continued funding for the network is a priority concern in state FY 2011. Nine of the 13 stations are maintained under an agreement between the DEM Office of Water Resources and the University of Rhode Island Graduate School Of Oceanography (URI GSO). Funding for this agreement was secured from the National Oceanographic and Atmospheric Administration (NOAA) Bay Window Program and the BRW Coordination Team. While NOAA funding is available through the summer of 2010, it will be essential to find an alternate source of funding by October 2010. NBC maintains two stations: one site (F4) is located at the Phillipsdale Landing dock on the Seekonk River, downstream of the Bucklin Point Wastewater Treatment facility. The second monitoring site (B4) is a buoy located at Bullock's Reach in the Providence River, several miles downstream from the Field's Point facility. The remaining sites are maintained and funded by the Narragansett Bay National Estuarine Research Reserve (a NOAA/DEM partnership). Additional funds are needed to add stations to portions of the Bay not yet covered in the monitoring network, including the lower Bay and Sakonnet River. A detailed report on network activities during 2005-2008 is available: http://www.dem.ri.gov/bart/pdf/nbfsmin.pdf

Researchers and managers are collaborating to use the fixed-site datasets in combination with other data in a continuing effort to improve the understanding of the extent and nature of hypoxia in Narragansett Bay. Recent analyses have quantified the frequency of low DO events and documented their occurrence between June and October in the mid to upper Bay, Providence and Seekonk Rivers and Greenwich Bay (RIDEM, 2009). The years with the higher frequencies of events tend to have high late-spring river inflows and/or warmer temperatures (Codiga et al., 2009).

Special Topic: Continued Assessment of Combined Sewer Overflow Abatement

Work continued in 2009 to evaluate the performance of the Combined Sewer Overflow (CSO) Tunnel implemented by NBC. In addition to monitoring by the DEM Shellfish Water Quality Monitoring Program, NBC regularly monitors fecal coliform levels at 20 stations in the Seekonk and Providence Rivers. A review of data from the 13 stations located in the Providence River, which is downstream of Phase I of the CSO Tunnel, was done to compare bacteria levels before and after the tunnel went on-line. In comparing the fecal data for one year prior to the opening of the tunnel (October 2007 – October 2008) versus one year post tunnel operation (November 2008 – November 2009), an overall 28% reduction in the fecal geomean was seen for the 13 stations. Ten out of the 13 stations sampled had a decrease in fecal geomeans between these two time periods even though there was an increase of 13.8 inches of rain in the year after the tunnel opened. Figure 2 shows three years of data at five NBC fecal monitoring stations. In 2006 and 2009, the metropolitan Providence area was impacted by similar annual rainfall amounts of just over 54 inches, while 2007 was considered a dry year with only 42.8 inches of rain. Fecal geomeans at these stations were much lower in 2009 than in 2006, even though rainfall amounts were similar (Fig. 2). Additional analysis of the data relative to the timing of rainfall events would further characterize the nature of reductions seen to date.

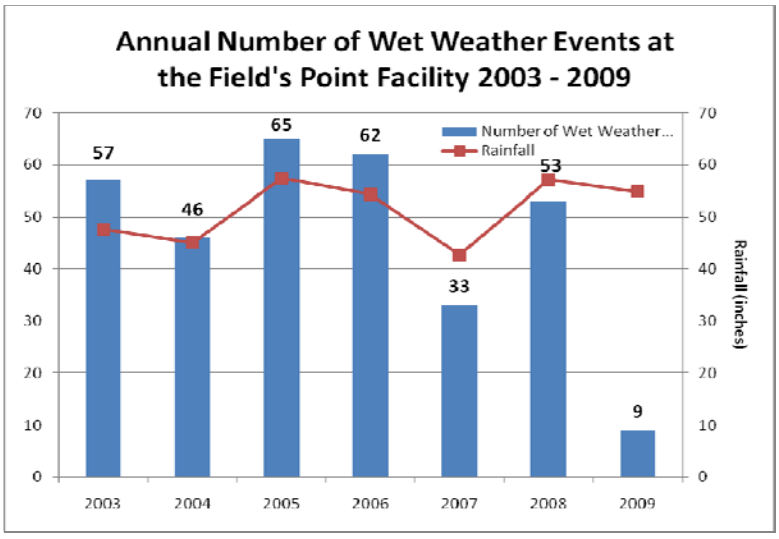
Figure 2.



Due to the operation of the CSO tunnel, the number of wet weather discharges from the Field's Point facility decreased significantly in 2009 when compared to prior years. In 2009 there were only 9 wet weather events from Field's Point, a significant reduction considering the amount of rainfall for that year. During the first year of operation, 1.2 billion gallons of CSO wastewater was captured by the tunnel and received full secondary treatment at Field's Point (Fig. 3).

In 2009, as a result of reduced fecal contamination of shellfishing beds attributable to the successful operation of the NBC CSO tunnel, there were three instances in which the DEM was able to open the upper Narragansett Bay shellfishing beds earlier than expected. This was accomplished through a DEM plan to cooperatively monitor the upper bay for bacteria following rain events. On February 27, 2009, DEM was able to open Conditional Area A four days early, while on September 4, Conditional Areas A & B were opened two days early and on September 18 DEM was able to open Conditional Area A three days early. Cooperative fecal monitoring activities between NBC and DEM made these early openings possible, benefitting Rhode Island shellfishermen.

Figure 3.



Large River Water Quality Monitoring
provided by Sue Kiernan, RI DEM and
Thomas Uva, Narragansett Bay Commission

In 2009, Rhode Island continued to more fully implement its monitoring strategy for large rivers. Pursuant to a cooperative agreement with DEM, six stations are monitored monthly by the United States Geological Survey (USGS). The stations are located on the Branch, Blackstone, Pawtuxet, and Pawcatuck Rivers and provide data that are representative of river conditions influenced by large drainage areas. Monthly data are obtained for a range of water quality parameters including nutrients and pathogens. Samples are analyzed at quarterly intervals for metals. Data undergo federal quality assurance procedures and then are made available via the USGS information system – NWIS at http://tinyurl.com/RIEMC-WATER

These data are critically important for evaluating long-term trends and tracking pollutant loadings into the Upper Bay from the rivers. They are also used in various state water programs. One station is monitored near the MA/RI state line on the Blackstone in order to help define pollutant contributions from the Massachusetts portion of that watershed. Three others are located near the mouths of the Blackstone, Pawtuxet and Pawcatuck Rivers in order to be representative of the pollutant loadings from these tributaries into coastal waters. To fully implement this program, as recommended in the RI Water Monitoring Strategy, a second station on the Pawtuxet River would need to be added along with ensuring regular monitoring of the Taunton River in Massachusetts. The Taunton River empties into the Mt. Hope Bay region of greater Narragansett Bay.

The Narragansett Bay Commission (NBC) has well established bacteria and nutrients monitoring initiatives designed to evaluate water quality conditions and nutrient loadings of all the large river tributaries to the Upper Bay. In 2005 the NBC established a large river nutrients monitoring program to evaluate nutrient loadings from the local area rivers flowing into the Upper Bay from Rhode Island. This initiative was greatly expanded in 2006 to include stations near the RI/MA border at rivers entering the Upper Bay from Massachusetts. Monitoring is conducted bimonthly at the RI/MA border stations and samples are analyzed for the full suite of nitrogen parameters, orthophosphate, silicate and total suspended solids. Total organic carbon was added in late 2009 to the list of parameters that can be analyzed by the NBC Laboratory and this parameter will be analyzed at all river and bay nutrients monitoring locations beginning in early 2010.

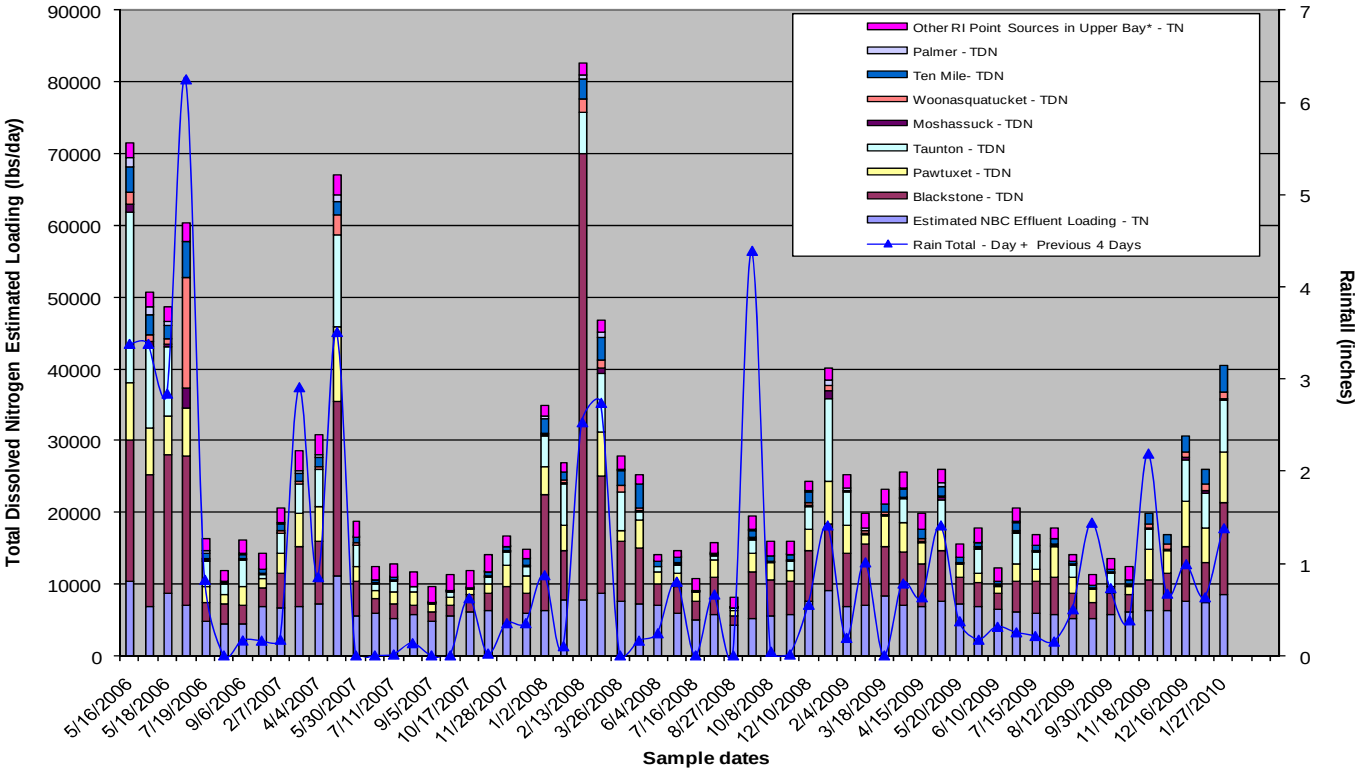
Rivers sampled at the state borders by the NBC include the Blackstone, Taunton, Ten Mile, Warren Reservoir, Kickemuit, Palmer, Runnins, Cole and Lee Rivers. In addition to the border nutrients monitoring initiative, the NBC also samples the

Woonasquatucket, Moshassuck, and Pawtuxet Rivers as well as the Blackstone River at Slater Mill Dam every other week for these same parameters.

Using conservative estimates of nitrogen (N) loading to the upper Bay, NBC has used its data from 2005 to 2009, along with data from surrounding wastewater treatment facilities that discharge directly into the Bay to estimate that the Blackstone, Taunton, and Pawtuxet Rivers contribute 51% of the total measured N loading to the Bay compared to 23% for the NBC WWTFs. Given that the dominant sources of N loading to the rivers are also wastewater treatment facilities located upstream in both RI and MA, this finding is generally consistent with other overall estimates of total N loadings to the Bay which assign 62-73% to WWTFs. (Pryor et al., 2007)

Also consistent with prior findings, NBC's data show that the Blackstone River, including inputs from WWTFs, contributes the most N to the Providence and Seekonk Rivers and Upper Bay, with the Field's Point WWTF having the second highest measured loading. The NBC is upgrading the Field's Point facility to achieve compliance with new RIPDES permit limits of 5 ppm total N (seasonally May – October). This project, currently under construction, is expected to be completed in 2014. Once the Field's Point and Bucklin Point WWTFs meet the 5 ppm limit, N loadings from the NBC facilities are expected to be reduced by 70% from 2003 levels, the year of the Greenwich Bay Fish Kill.

Figure 4. *Estimated total dissolved nitrogen loading from stations sampled by NBC on each sample date, along with the rain total for the day of sampling plus the previous four days.*



*RI Point Sources include: Blount Seafood, East Providence WWTF, Woonsocket WWTF, Bristol WWTF and E. Greenwich WWTF

The NBC continued its urban rivers bacteria monitoring program established as an element of the agency's Nine Minimum CSO Control Program. Samples are collected every week from twenty (20) sites located upstream and downstream of combined sewer overflow pipes to identify dry weather overflows and to establish baseline bacteria levels that will be used to gauge the success of the NBC CSO abatement projects. The twenty samples are collected from specific sites along the Moshassuck, Woonasquatucket, West, Blackstone, Seekonk, and Providence Rivers. A location on the mouth of the Pawtuxet River was added in 2005.

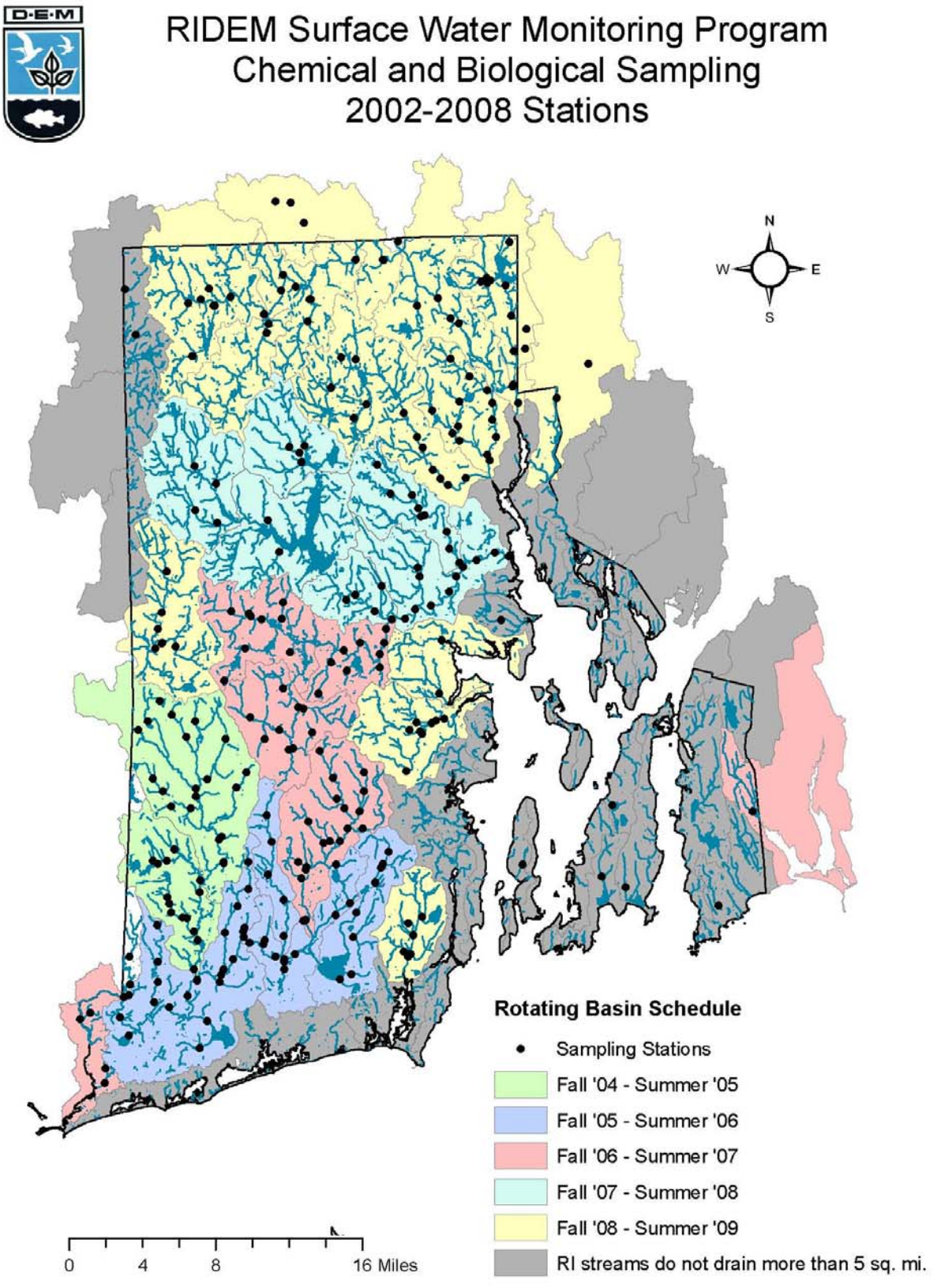
Rotating Assessments of Rivers & Streams
provided by Sue Kiernan, RI DEM

Aimed at reducing a large gap in available data, RIDEM adopted a rotating basin monitoring strategy to characterize water quality in wadeable rivers and streams in 2004. Under this program, a portion of the state's rivers and streams are sampled each year for physical, chemical and biological (macroinvertebrate) parameters. Statewide between 2004 and 2009 over 200 stations were established and sampled during five rotational cycles in all stream drainage areas of 5 mi^2 or larger (Fig. 5).

The fifth cycle was completed in the fall of 2009, with data being collected for the first time on many rivers and streams. Data from the program have been applied by DEM in the statewide assessment of water quality conditions that will generate a report later in 2010. Due to lack of staffing, DEM is currently unable to separately summarize these results. DEM estimates the rotating basin approach will have successfully reduced the data gap concerning the percentage of rivers with no available data from 51% in 2008 to about 31% in 2010. Many of the rivers and streams remaining unassessed are those located within small drainage areas; e.g. small coastal streams. A separate monitoring protocol will need to be developed to address these small streams. DEM plans to utilize the assessment results from 2010 to refine the sampling design for this program and initiate the next cycle of rotating basin monitoring in 2011. Among other uses, DEM is using the data for development of biocriteria and to study the relationship between land use (impervious cover) and water quality conditions as part of refinements to the water quality management program.

The program has been implemented by DEM with support services from the Department of Health (DOH) Laboratory for sample analyses and the ESS Group, Inc. for collection and taxonomic identification of macroinvertebrate samples. The program is supported by DEM with federal funds from the Environmental Protection Agency (EPA). Reductions in staffing at DEM currently present a challenge to the continuing implementation of the program.

Figure 5.



*Although watershed basin lines extend beyond state borders, targeted sites were located within state boundaries.

Rotating Assessments of Coastal Waters
provided by Sue Kiernan, RIDEM

The Rhode Island Water Monitoring Strategy identified a need to sample portions of the state's coastal waters on a rotating basis similar to the approach applied to rivers. The intent of these efforts would be to supplement the ongoing monitoring activities which provide valuable data but are either geographically restricted or focused on limited parameters. DEM's Shellfish Water Quality Monitoring Program collects bacteriological data in most of the state's estuarine waters, and NBC collects bacteriological and nutrient data from the state's urban rivers, Providence River and Upper Bay. Other established Bay-wide monitoring strategies provide information on temperature, nutrients, DO, chlorophyll levels and certain other parameters in Narragansett Bay but are not considered representative of the conditions in the Bay's coves and embayments. With no funding, routine monitoring of the Bay's coves and embayments has not yet been implemented on a systematic basis and as a result there are continuing data gaps. In the state's coastal ponds, again DEM's Shellfish Water Quality Monitoring Program routinely collects bacteriological data and in 2009 the DEM TMDL program completed monitoring in the estuarine lower Pawcatuck River and its tributary, Mastuxet Brook. During 2009, volunteers working with URI's Watershed Watch Program collected data from 12 coastal ponds and embayments across the state. Lacking a comprehensive monitoring program, the data gaps in the southwestern coastal ponds are considered a priority by state managers due to local concerns of worsening water quality conditions and the active efforts underway to restore water quality through improved wastewater and stormwater management in this region.

Freshwater Fish Contamination
provided by Sue Kiernan, RI DEM

One of the state's largest data gaps continues to be information on fish tissue contamination. RI has never established its own program to screen fish tissue, and has instead utilized limited data generated primarily by EPA researchers to identify waters that require fish consumption advisories for protection of public health. The data that is available suggests mercury levels in fish tissue are often elevated. This finding is consistent with information being generated in neighboring New England states that have conducted more extensive testing. As a result, in addition to certain marine fish, the Rhode Island Department of Health has advised women who are pregnant, nursing, or planning to have a baby in the next year not to eat freshwater fish from Rhode Island waters except for stocked trout. Other specific fish consumption advisories are posted at: http://www.health.ri.gov/healthyhousing/mercury/fish.php

Progress toward addressing this gap was slowed in 2009 due to staffing reductions at DEM. During 2007-2008, collaboration among the DEM Division of Fish and Wildlife,

Office of Water Resources and EPA led to the generation of fish tissue data from fish collected during regularly scheduled surveys of fish communities. The surveys utilized electroshocking to identify the number and species of freshwater fish living in a water body. During these surveys, a sub-sample of fish was retained for fish tissue sampling and analysis. This program allowed fish tissue samples to be collected from multiple species of fish in ten lakes and portions of the Pawcatuck and Blackstone Rivers during 2007-2008. Unfortunately staffing limitations curtailed the program in 2009 and only two locations (Stafford Pond and Carbuncle Pond) were sampled this past year (data still pending). New data are shared with and reviewed by the HEALTH Office of Environmental Risk Assessment to determine if any further fish advisories are needed. Looking to next year, DEM is unlikely to resume monitoring unless staffing levels improve.

To address mercury pollution, DEM participated in the development of a Northeast Regional TMDL for Mercury approved in 2007 (NEIWPCC, 2007). This work identified atmospheric deposition as the largest source of mercury and noted a significant contribution from sources (coal-burning power plants) from outside the region. For more information see: http://www.neiwpcc.org/mercury/MercuryTMDL.asp The NEIWPCC is currently pursuing funding to develop a regional mercury monitoring program that may provide another means for tracking mercury levels in fish over time provided RI can identify funding to support participation.

Invasive Species

provided by Sue Kiernan, RI DEM; David Gregg, RINHS; Ken Raposa, NBNERR; and Kevin Cute, CRMC

Collaborative work by DEM, CRMC, RI Natural History Survey (RINHS), and URI Watershed Watch during 2009 continued as part of a collaborative effort to characterize and raise public awareness of the problems associated with invasive species. With respect to aquatic invasive species (AIS), monitoring efforts were aimed at gathering additional data to characterize the nature and extent of AIS infestations in both marine and freshwaters. In addition, surveillance was undertaken at select freshwater sites which were targeted the prior year for management actions to remove AIS.

In 2009, CRMC implemented an AIS volunteer monitoring project under the Rhode Island Aquatic Invasive Species Management Plan (RIAIS Plan). Funding for this project and all others implemented through the RIAIS Plan are supported by an annual federal grant. Data were collected at marinas and other sites where floating docks occur, as the targeted species typically settle and grow on their submerged portions. Volunteers were recruited and trained to identify established AIS and potential invaders. The five sampling stations that were monitored from May to October 2009 represented good geographic coverage and a range of temperatures and salinities. As

the majority of marine AIS are introduced via commercial shipping (ballast water exchange and hull fouling) major ports were also targeted as sampling sites. The sampling stations included Save The Bay/Pt. Edgewood Marina (Providence/Cranston), Allen Harbor Marina (North Kingstown), Pt. Judith Marina (South Kingstown), Ft. Adams Boat Basin (Newport), and Colt State Park (Bristol). It is intended that the Project shall be a permanent initiative to provide the state with its first database focused on marine AIS.

A total of 20 AIS were targeted and the volunteers were provided with species ID cards to assist them in correctly identifying field specimens. ID cards were divided into two groups: thirteen cards displayed AIS already known to be established in Narragansett Bay, and seven cards showed "potential" AIS that may reach the state's coastal waters in the near future. Twelve of the thirteen known AIS were found during the Project's duration. None of the seven potential AIS were found. It is expected that the Project will expand in the future, both as it adds more floating docks as sampling stations, and as it examines different habitats such as cobble beaches, tidepools, and benthic areas.

Also in marine waters, during 2009, the Narragansett Bay National Estuary Research Reserve (NBNERR), located on Prudence Island, continued monitoring for the Asian shore crab, H*emigrapsus sanguineus*, recording site characteristics and crab metrics (density, size, sex-ratios) monthly at four permanent stations around NBNERR.

In freshwaters, additional data generated by the DEM Office of Water Resources and others reinforced prior findings of the widespread occurrence of AIS in Rhode Island. RIDEM continued to integrate AIS screening into the field reconnaissance for the Rotating Basin Water Quality Monitoring Program and conducted its third consecutive year of summer surveys at public access points on lakes and ponds to screen for the presence of invasive plants. Between 2007 and 2009, DEM observed one or more aquatic invasive plant species in 66% of 87 lakes and ponds surveyed. Sixty percent (60%) of the lakes were infested with more than one AIS. Variable milfoil (M. *Heterophyllum*) is the most prevalent aquatic invasive species, present in 47% of the lakes inspected; followed by fanwort (C. *Caroliniana*) in 37%. During 2009, DEM also documented AIS in 13 rivers, with variable milfoil and fanwort the most common invasive plants. The data are compiled and reflected in a map made available via the agency website at: http://www.dem.ri.gov/programs/benviron/water/wetlands/pdfs/invasive.pdf

Monitoring efforts in 2009 resulted in the documentation of additional aquatic invasive species in RI. DEM documented two populations of Brazilain elodea (E. *densa*) marking the first confirmations of this species in Rhode Island. A small infestation was detected by consultants in Hundred Acre Pond (South Kingstown). A second larger population was discovered by DEM in Arnold Pond in Coventry. DEM confirmed the only known infestation of parrot feather (M. *aquaticum*) in Pocassett Pond following a report from a consultant.

Two new populations of water chestnut (T. *natans*) were also discovered. The largest known population of water chestnut in the state was discovered by the RINHS in Chapman Pond (Westerly), which is also plagued by Eurasian milfoil. The second new population was uncovered by the DEM TMDL Program during its work on the Turner Reservoir in East Providence, an impoundment on the Ten Mile River. Further inspections confirmed its presence upstream in contiguous Central Pond. These discoveries bring the total number of waterbodies in RI known to be infested with water chestnut to four.

Figure 6.
9/12/2009 water chestnut pull at Chapman Pond, Westerly. This event was organized by RINHS with the Westerly Land Trust, with assistance from the Town of Westerly and RIDEM. Over 1,600 pounds of water chestnut were pulled - less than half of what was there that day. RINHS and the Westerly Land Trust plan a second pull at Chapman Pond for July 2010.

The detection of new AIS through monitoring has led to management responses. In October, the RINHS, working with the Westerly Land Trust and with assistance from the Town of Westerly and RIDEM, organized a community water chestnut pull. Over 1,600 pounds were pulled and additional actions are planned for 2010. Additionally, repeat visits to pull water chestnut were made at Belleville Pon , the target of a volunteer pull in 2008

Freshwater invasive species, in particular plants, continue to be a topic of growing concern for lakefront landowners and the recreational users of public lakes and ponds. DEM is promoting lake management planning as an appropriate tool to develop and guide the long-term strategy that is needed to manage aquatic invasive plant problems. As part of a pilot project funded by DEM and NRCS, during 2009 the Northern Rhode Island Conservation District coordinated development of lake management plans for Bowdish Reservoir and Smith and Sayles Reservoir. As one component of the plan, aquatic plant surveys of the lakes were completed in August 2009 and documented the extent of AIS in each lake. The plans assessed management options and outlined recommendations for both short and long term actions. The plans note that on-going

monitoring for AIS should be an integral part of any management strategy in order to provide data to assess effectiveness and adapt management strategies accordingly over time.

Terrestrial invasive species are also a management concern. The RINHS is currently pursuing survey and control strategies for mile-a-minute (m-a-m) vine at sites on Block Island and in Cranston and East Greenwich. The URI Biocontrol Lab has been a good partner in this work, testing a new biocontrol for m-a-m at the Cranston site. RINHS and the URI Biocontrol Lab also worked on a project over the last year to release beetles to combat purple loosestrife at 8 sites. In both the water chestnut and m-a-m vine cases, RINHS is using the community-based rapid response strategy piloted in the water chestnut infestation of Belleville Pond in North Kingstown. RINHS is working with a science teacher at East Greenwich High School to involve students in mapping and controlling the outbreak.

Another project related to invasives monitoring is RINHS's Forest Health Works Project. This project is to survey and eradicate invasive plants that threaten forest health in priority forests of Rhode Island. It began in November 2009 and will run until late spring 2011. It is funded by a $673,000 grant of Federal stimulus funds from the US Forest Service. RIDEM is the main project partner, though other stakeholders are participating on a steering committee. This is a significant amount of money for invasive species work and a boon to RI.

An important statewide invasives monitoring project is now underway: RITree got a $61,000 grant from the USDA-Animal & Plant Health Inspection Service (APHIS) to increase the public's awareness of the Asian longhorned beetle (ALB) and the Emerald Ash Borer (EAB) over the past summer. Numerous instructional workshops were held across the state. Also, trained volunteers helped to conduct pest surveys in Warwick and Cranston during the month of August 2009.

While there has been clear progress in monitoring for invasives, stable funding to sustain an effective surveillance, preparedness and rapid response program is still lacking. Outside of restricted federal grants, the state agencies, RIDEM and CRMC, have little funding dedicated to aquatic invasive program activities. The work by RINHS is supported with its own limited general funds as part of invasives survey contracts with USFWS Coastal Program, and through a small grant from the RI Conservation Stewardship Collaborative. As in past years, RINHS has been very fortunate to have money available for invasive species preparedness. However, it is not enough to allow for allocation of permanent staff, resulting in a reliance on temporary staff and contractors, as well as Coastal Fellows from URI, that have fortunately been available when they were needed. Further investment in RI's invasive species preparedness and coordination is a continuing critical need.

Unassessed Lakes and Ponds
provided by Linda Green, URI Watershed Watch

Rhode Island has 305 named lakes and ponds covering about 15% of the state, the highest percentage inland lake area in New England. In 2009 URI Watershed Watch (URI-WW) volunteers monitored 64 of RI's lakes and ponds, about one-third of which were sponsored by RI DEM with a grant. These data are the foundation of RI's freshwater monitoring program for lakes and serves environmental managers, watershed organizations, researchers, and policy makers. By utilizing URI–WW lake data and some other sources, the DEM Office of Water Resources was able to report on water quality conditions in about 75% of the total lake acreage in the state. Some lakes have been monitored by trained volunteers for over twenty years, an invaluable resource for documenting change, and unavailable in any other RI monitoring program. Plans to expand the URI-WW Program to monitor lakes which lack volunteer participation have not been funded as yet. Without continued funding, URI Watershed Watch cannot maintain its level of activity and will be forced to reduce the number of monitoring sites, leaving the state with less data available from which to make the informed decisions necessary to protect and improve water quality.

Upper Bay Dissolved Oxygen (DO) Surveys
provided by Christopher Deacutis, Narragansett Bay Estuary Program and Thomas Uva, Narragansett Bay Commission

Dissolved oxygen (DO) surveys were continued during 2009 by the Narragansett Bay Estuary Program (NBEP), Brown University and the Narragansett Bay Commission. These monitoring programs provide a spatial dataset that complements the time-series dataset generated by the fixed-site network described above. The NBEP/Brown survey conducted full water column profiles at about 75 stations covering the Providence-Seekonk Rivers, Greenwich Bay, and the East and West Passages of Narragansett Bay. At each station, depth profiles of temperature, salinity, and DO were measured. Six surveys were completed in summer 2009.[1] NBC regularly monitored five sites (Bullock's Reach, Conimicut Point, Edgewood Yacht Club, Pomham Rocks, and India Point) using a SeaBird Profiler. Sampling was conducted year round, twice per month, weather permitting.[1] In addition to DO concentration and % saturation, the SeaBird profiler records temperature, salinity, density, depth, and photosynthetic active radiation (PAR).

[1] NBEP/Brown surveys were conducted on 6/18, 7/15, 7/23, 8/04, 8/13, and 9/01. NBC surveys were conducted on 3/18, 4/1, 4/15, 5/6, 5/21, 5/27, 6/24, 7/29, 8/12, 10/14, 11/18, 12/2 and 12/15. In June and July the davit and winch aboard the NBC research vessel was being repaired resulting in fewer sampling dates than intended during these two months. Also data from the two sampling dates in September were considered erroneous due to equipment issues.

The NBC monitoring program differs from the NBEP/Brown monitoring program in that NBEP generally targets their surveys on neap tides when the bay is believed to be at greater risk for hypoxia. The NBC conducts its profiles every two weeks as an element of the NBC nutrient sampling program regardless of tidal dynamics. Due to the inherent differences in sampling design, the resulting data collected by the two organizations can be used in a complementary manner to generate an overall picture of water quality conditions in the bay over the course of the year and at the most critical times expected for hypoxic conditions.

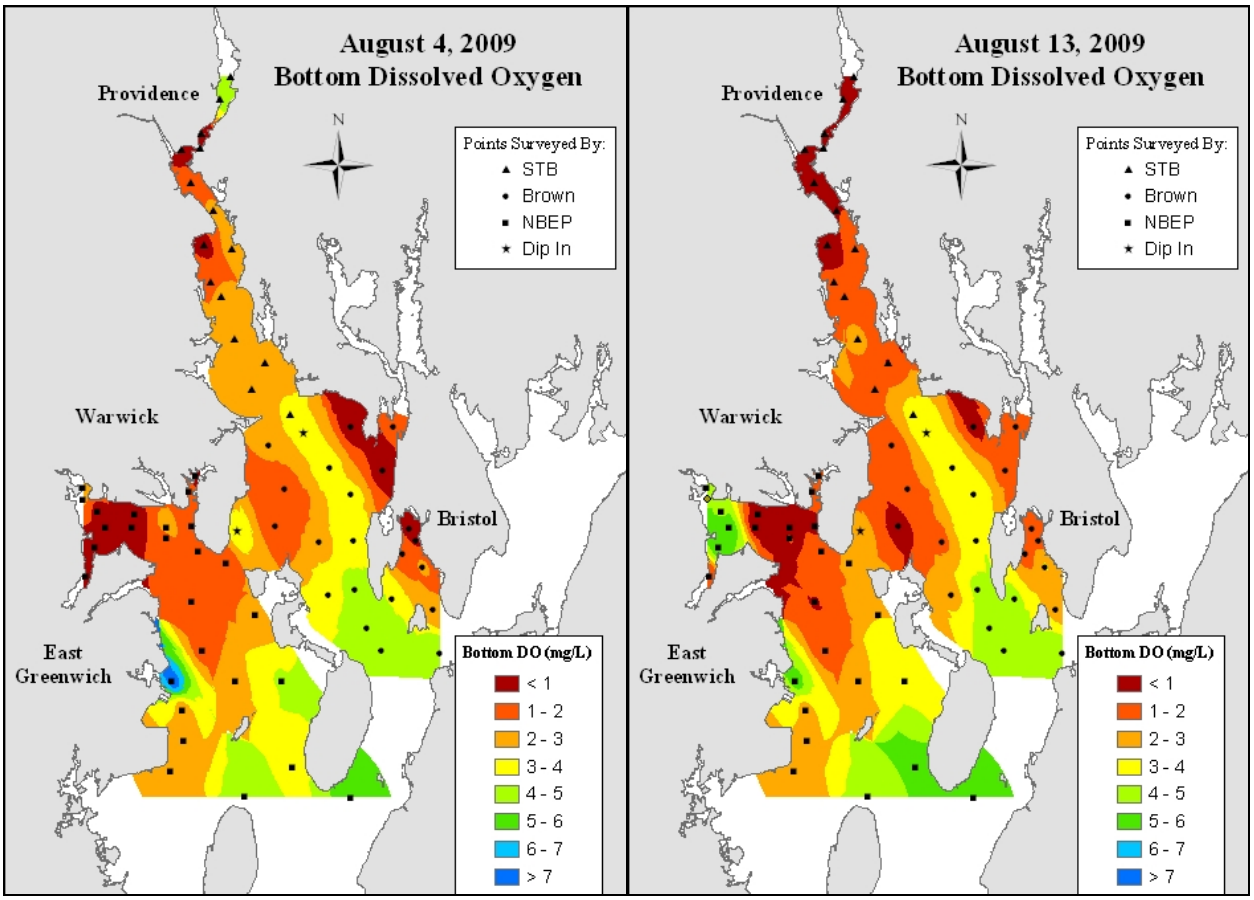
Funded from a number of sources over the years, the NBEP/Brown Survey has recently relied on the support of federal funds provided via the NOAA Bay Window Project. These funds are expected to be fully expended by early summer 2011. As a result, the NBEP/Brown DO survey is a program identified as at risk in summer 2011 due to reductions in available funding.

The DO surveys documented similar patterns of hypoxia in 2009. NBC documented acceptable levels of DO in both the spring (Mar – May) and late fall (Nov – Dec). In early summer 2009 (June and July), both programs found DO levels were good to fair, with hypoxia limited to western Greenwich Bay and the Providence River. However, the record-breaking rainfalls of July 2009, along with warming waters, brought strong stratification to the Bay. The NBEP/Brown survey indicated that by August 4 a hypoxic zone had formed and extended down-Bay to at least Quonset Point, although the most severe hypoxia was confined to areas north of Quonset (Fig. 7). Low dissolved oxygen conditions continued through the second August DO survey (8/13), with parts of western Greenwich Bay mixed and reaerated at this point (Fig. 7). On August 12, NBC found bottom DO concentrations at all its sites in the Upper Bay to be <2.0 mg/L, with the Pomham Rocks and India Point Sites having the lowest levels (DO <1.0 mg/L). By September, the water quality was improving slightly, with most areas above the hypoxic threshold of 2.9 mg/L.

These results, when considered in conjunction with the analyses of Codiga et al. (2009), indicate that very high freshwater summer river flows (>1250 cfs, Blackstone River) appear to affect the upper Bay significantly, with sustained high flows associated with both stratification and poor oxygen conditions in July and August of that year. Stratification, due to salinity and temperature differences between the surface and bottom water, prevents bottom waters and surface waters from mixing, and can lead to severe hypoxia. Once DO is depleted in the bottom waters, oxygen is not easily replenished in the absence of mixing with oxygenated surface waters.

Data and maps from the NBEP/Brown surveys are available at:
http://tinyurl.com/RIEMC-DO

Figure 7.



Bottom oxygen levels in the upper half of Narragansett Bay, August 4 & 13, 2009. Maps and data from Brown University web site http://www.geo.brown.edu/georesearch/insomniacs/

Data from the DO surveys are provided to RIDEM and taken into consideration during its assessment of water quality conditions. RIDEM will be releasing its 2010 Integrated Report summarizing water conditions statewide later this year. The data from this project continue to provide critical information on the interannual variability in extent and severity of hypoxia in Narragansett Bay. Results are being used by researchers continuing to develop models of hypoxia generation in Narragansett Bay under a nearly completed NOAA Coastal Hypoxia Research Program (CHRP) grant award.

In addition to the SeaBird profiler surveys, the NBC also performs DO monitoring on a monthly or bimonthly basis at a site just upstream of the Providence Hurricane Barrier near the Point Street Bridge. Regular sampling at this station began in September of 2007 to investigate the effect the hurricane barrier has on water quality in this low-flushing area. Profiles are taken using a YSI 600 XL sonde which records temperature, salinity, specific conductivity, depth, and pH, in addition to DO concentration and % saturation.

The Point Street Bridge location was sampled by the NBC fourteen times in 2009 between the months of February and November. Analysis of the data revealed relatively good mixing throughout the water column at the Point Street location. This monitoring indicated varied DO results ranging from a high of 11.0 mg/L at the surface in February and November to a low of 1.02 mg/L in August at the bottom. Bottom oxygen remained above 3.5 mg/L until the end of July where it then decreased to less than 2.0 mg/L through the end of August. At the end of August bottom DO concentrations at this location increased to about 3.8 mg/L and continued to increase into the fall.

The NBC is continuing its DO survey programs in 2010 and plans to increase SeaBird sampling at its five stations to once per week during the summer months. In 2009, the NBC installed YSI sonde equipment on the NBC R/V Monitor that will enable the collection of real-time surface water quality measurements while the vessel is underway performing routine weekly sample collections on Upper Narragansett Bay. The NBC intends to utilize this equipment throughout 2010 to evaluate surface water quality. Some sample days will be coordinated with the Narragansett Bay National Estuarine Research Reserve, who initiated a similar project in 2007. This joint agency monitoring initiative will provide a larger bay-wide picture of surface water quality conditions.

Beach Water Quality Monitoring
provided by Amie Parris, RI DOH

The Rhode Island Department of Health Beach Monitoring Program licenses and oversees monitoring at 50 freshwater beaches and 68 saltwater beaches throughout the state. Using a federal grant provided by the Environmental Protection Agency (EPA), the HEALTH Beach Program has developed and applied a risk-based monitoring schedule for saltwater beaches that is applied from May through September. This schedule results in more frequent monitoring at beaches with higher risks of pollution. Partnerships with volunteer-based organizations provide data from saltwater beaches in the off- season as well. As the federal grant is restricted to monitoring at saltwater beaches from May through September, the risk-based approach has not yet been applied to freshwater beach monitoring. Due to the lack of funding, most freshwater beaches are only monitored once a month by the operating facility (e.g., beach manager). Operating facility sampling is minimal due to the expense of laboratory analysis and the short beach season. The HEALTH Beach Program is also unable to conduct surveys of the beach areas or work with beach owners to address possible sources of contamination due to constraints in funding. The current monitoring limit of these beaches puts beach-goers at risk of illness due to water contamination.

Substantial evidence exists to support the importance of monitoring freshwater beaches. 50 out of 118 licensed beaches in Rhode Island are freshwater. Though there is limited

sampling of freshwater beaches, they accounted for 22% of closure days in 2009. While this is a slight decrease from 24% in 2008, freshwater beaches still account for a significant amount of contamination. The stagnant nature of many freshwater sites leads to irregular and problematic bacterial contamination. Additionally, many freshwater beaches serve as campgrounds to thousands of children who are extremely susceptible to swallowing water and becoming ill from harmful bacteria or other pathogens. Infection may also occur through cuts and scrapes.

The Beach Program tests for Enterococci bacteria that come from the intestines of all warm-blooded animals. When sewage is present in the water, Enterococci will also be present. In addition to Enterococci, many other water-borne pathogens may also be present in untreated sewage. These pathogens can cause a wide range of health problems including ear, nose, and throat infections, gastroenteritis, hepatitis, and respiratory illness. Because there are so many potential pathogens and testing for all of them is not feasible, Enterococci are used as an indicator of the potential presence of these pathogens.

If freshwater beach monitoring is not conducted, there is the potential for large numbers of children, campers, and others to become ill. Illness associated with water contamination may be very serious and should not be taken lightly. Insufficient monitoring not only jeopardizes public health, it also threatens Rhode Island's multi-billion dollar tourism industry.

RI Beach Program 2009 Monitoring Activities

Sand Study
Sand sample collection took place at 10 of Rhode Island's highest risk beaches that exhibit unsafe fecal bacteria levels. In addition, two beaches that do not experience elevated bacteria levels in the water were used as control sites. The twelve collection sites incorporated varying wave intensities including low (upper Bay beaches), medium (Warwick beaches) and high (open ocean beaches).

With the information from the study, the Beach Program hopes to make more health conscious and proactive decisions when closing beach facilities and to evaluate the current closure methods already in place. The Program will attempt to answer the following question: Is there is a need to implement more stringent policies when closing a beach to swimming based on sand sample data?

Program Staff collected 338 sand samples from August 11 through September 3, 2009. Sample results ranged from <0.28 MPN/gram through >968.43 MPN/gram of sand. The lowest sample result was taken from the dry sand of Barrington Town Beach (high risk facility) and the highest sample was taken from the wet sand of Galilee Beach Club

(control beach). Based on this observation no direct correlation can be made between bacterial contamination in sand and water.

Beach sand does not have a federally approved standard. Sampling and investigation of fecal bacteria in beach sand is new field of study and therefore cannot be used as a method to measure pollutants. Beach Sand data is collected for research purposes with the intent to one day be used as an additional environmental health factor regarding coastal beaches.

Note: Further project details can be found in the EPA approved Quality Assurance Project Plan (QAPP) for the Beaches Environmental Assessment and Coastal Health (BEACH) Grant: Investigating Potential Fecal Bacteria in Rhode Island Beach Sand and Its Effect on Beach Closures.

Easton's Beach Preemptive Closure Protocol
In the summer of 2008 the Beach Program implemented a closure protocol for Easton's Beach in Newport. The model was based on past sample history, rainfall analysis and tidal circulation rates. For two consecutive summers (2008 and 2009) the protocol has proven successful and allowed the Program to close the beach prior to risk of contamination.

Database Capacity
provided by Chuck LaBash, URI EDC and Sue Kiernan, RI DEM

Effective data management continues to be a challenge as well as an area of incremental progress for RI state mangers. While funding has not been made available to assess the overall data management and dissemination capacity among RI's environmental agencies, some improvements to data management systems have been achieved via specific projects.

In spring 2009, RI joined a consortium of Northeastern states in pursuing a multi-phased project to develop region-wide high resolution topographic data. The focus of Phase I is to acquire LiDAR (**Li**ght **D**etection **a**nd **R**anging) for coastal areas. On October 27, 2009 USGS issued a funding opportunity (10HQPA0014) under the National Map initiative of the National Geospatial Program: Imagery and Elevation Maps under ARRA (American Recovery and Reinvestment Act of 2009). The purpose of the funding opportunity is to maximize the revision of existing national elevation and imagery databases while stimulating local economies through the creation and retention of jobs. The Northeast Consortium responded with a regional proposal to USGS on December 1, 2009 aimed at covering the coastal Phase I Consortium goal. In the proposal, $1.4M in ARRA funds were requested to be coupled with $1.3M in contributing funds from NGO, State, and Federal partners. On April 1, 2010 the Northeast Consortium received notice that the project would be awarded for the full amount -- $1.4M.

RI is fortunate to have received pledges for contributing funds through the RI Division of Planning, The Nature Conservancy, and Natural Resource Conservation Service to buy-up LiDAR coverage and enhanced specifications from the coastal towns (acquisition funded through ARRA) to the remaining inland areas or the state. Although final details are still being worked out, we anticipate the entire state of RI will be flown at an average horizontal sampling density of 1m and a vertical $RMSE_v$ of 15cm. Areas of the coastline will be flown during mean sea level tidal conditions or lower.

We anticipate that the LiDAR acquisition will take place either late fall 2010 or spring 2011. Products are expected as early as summer 2011. The project will yield elevation data suitable for developing 2m bare-earth digital elevation models (DEM's). Other products will consist of raw point cloud data in LAS v1.2 or v1.3 format containing coded first, intermediate, and last LiDAR pulse return data. LiDAR intensity data will also be included as a deliverable. A valuable addition to this project that has yet to be worked out will be performing an independent 3rd party QA/QC of the data. Digital data products are expected to be available through RIGIS and USGS.

Within DEM, continued development of an improved system for water quality data was unfortunately suspended during 2009 due to loss of staff. In the prior year, DEM completed development of a new database known as the State Water Information Management System (SWIMS) that has the capability to for first time to provide multiple water–related programs within DEM access to a central repository of water quality data. The new database system represents a major enhancement over current database capabilities. SWIMS has been designed to be linked to the HEALTH laboratory and designed to exchange data via the web with the national EPA data warehouse Storet/WQX. While DEM is able to use the system for data exchange with WQX, the migration of data and initial start up of the SWIMS for agency staff has been postponed due to the lack of a database administrator.

SWIMS will house primarily water chemistry data and is not intended to serve all data management needs related to environmental monitoring. There remains a need to assess data management capacity and needs among the state environmental agencies in order to identify the most appropriate systematic approach to making critical inventory and monitoring data available to resource managers and scientists. Until further improvements are made, the result is that key data will not be readily available to support decision- making and resource allocation associated with the health of RI's environment.

Emergency Response Data Review
provided by Sue Kiernan, RIDEM

Funding has not been made available for recommended review and inventory of data needs to support emergency response actions and assist in characterizing natural resource damage claims.

Monitoring Grants Program
provided by Peter August, URI Coastal Institute

Funding has not been made available for this activity and no progress has been made.

FY 2010 Budget Shortfalls for Priority Monitoring

Over the last year the RIEMC and its participating agencies continued to seek funding to sustain and expand priority monitoring activities. Continued investment by the RI Bays Rivers and Watershed Coordination Team was critical to sustaining important monitoring programs including the streamflow gage network relied upon during the floods this past March. The Coordination Team (CT) expended a total of $212,800 in state FY2009 contractual expenses with $156,600 allocated to large river water quality monitoring, $20,000 for the fixed-site network in Narragansett Bay and $36,200 for streamflow gages. Despite the sustained investment, the overall state fiscal condition began to negatively impact the state's monitoring capacity. For example, monitoring for fish tissue contamination was curtailed in 2009 due to staffing reductions at RIDEM and it was necessary for the Coordination Team to support a greater portion of the streamflow gage network costs in state FY2010 as a result of state general revenue budget cuts.

Fiscal concerns have brought greater urgency to the RIEMC's plans to assess the status of priority monitoring programs and identify priority gaps. Several on-going programs that have previously capitalized on federal sources of funding are considered in jeopardy of ending. As noted in the introduction, this includes dissolved oxygen surveys in the upper Bay region, monthly multi-parameter surveys of the bay conducted by the National Marine Fisheries Service (NMFS), certain commercial fisheries monitoring, nutrient and benthic sampling in the Bay, and potentially much of the fixed-site monitoring network in Narragansett Bay. The overall needed new investment in critical monitoring remains above $1.2 million and is expected to grow higher after the RIEMC considers more thoroughly needs beyond those related to water monitoring; e.g. terrestrial and fisheries topics.

Estimates of shortfalls in the priority water monitoring programs previously recommended by the RIEMC are listed below. While programs are expected to be adapted over time in response to changing management needs, many of the monitoring efforts constitute long-term commitments that require stable annual funding. The RIEMC recommends that the Coordination Team discuss further the use of its funds for long-term monitoring programs that will require annual investment. As resources allow, it may be more appropriate to ensure implementing agencies have sufficient funds in their agency budgets to support long-term monitoring and thereby free the Coordination Team funding to be invested strategically to meet short-term priority monitoring needs as well as other Coordination Team program priorities.

Funding Shortfalls for RIEMC Monitoring Priorities (Annual costs)

Monitoring Priority	**Current Status**	**Funding Shortfall – State FY2011**	**Comment**
Streamflow Gage Network	36 streamflow gages operated by United States Geological Survey (USGS)	0	CT contributing up to $108,930 to cover FY2011 costs
Bay-wide water Quality – Fixed Site Network	13 sites operated by partners (DEM, URI-GSO, NBC, NBNERR)	$225,000 (beginning October 2010)	DEM seeking alternative funding source
Large River Water Quality Monitoring	Six sites monitored monthly by USGS	0	Requires CT funding for FY2011 ($156,600)
Rotating Assessment of River and Streams	Partially implemented by DEM contractors;	$240,000	Funds for full implementation (2 FTEs & lab costs)
Rotating Assessment of Coastal Waters	Not implemented	$250,000	
Freshwater Fish Tissue Contamination	Activities suspended	$105,000	
Invasive Species Monitoring	Partially implemented	$150,000	
Unassessed Lakes and Ponds	Not implemented	$80,000	
Upper Bay Dissolved Oxygen Surveys	Fully implemented	0	Projected FY2012 shortfall -$30,000
Freshwater Bathing Beaches	Upgrade to risk – based approach; not implemented	$100,000	
Database Capacity Evaluation	Not implemented	$53,000	
Emergency Response Data Review	Not implemented	$11,350	
Total		$1,224,350	

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Appendix A.
Rhode Island Stream Gage Network – January 2010

Count	Major Basin	Gage #	Station Name	Existing Funding Source[1]
1	Ten Mile River	1109403	Ten Mile River	RIDEM
2	Blackstone River	1111300	Nipmuc River near Harrisville	RIDEM
3		1111500	Branch River @ Forestdale	RIDEM
4		1112500	Blackstone @ Woonsocket	Ocean State Power
5		1113895	Blackstone @ Roosevelt St.	RIDEM
6	Moshassuck River	1114000	Moshassuck River	RIDEM
7	Woonasquatucket	1114500	Woonasquatucket River	RIDEM
8	Pawtuxet River	1115098	Peeptoad Brook	PWSB
9		1115110	Huntinghouse Brook	PWSB
10		1115120	Unnamed Trib to Scituate Res	PWSB
11		1115170	Moswansicut Stream	PWSB
12		1115184	Spruce Brook	PWSB
13		1115187	Ponaganset River	RIDEM
14		1115190	Dolly Cole Brook	PWSB
15		1115265	Hemlock Brook	PWSB
16		1115275	Bear Tree Brook	PWSB
17		1115276	Westconnaug Brook	PWSB
18		1115280	Cork Brook	PWSB
19		1115297	Wilbur Hollow Brook	PWSB
20		1115630	Nooseneck @ Rte. 3	WRB
21		1115670	Congdon River	WRB
22		1115770	Carr River	WRB
23		1115800	Big River near Nooseneck	WRB
24		1115833	Big River – Harkney Hill	WRB
25		1116000	South Branch – Pawtuxet	WRB
26		1116500	Pawtuxet River @ Cranston	WRB
27	Hunt River	1116905	Hunt River @ Frenchtown	RIDEM
28		1117000	Hunt River	WRB
29	Pawcatuck River	1117350	Chipuxet River	WRB
30		1117370	Queen River @ Liberty Lane	RIDEM
31		1117420	Usquepaug	WRB
32		1117430	Pawcatuck River @ Kenyon	RIDEM
33		1117468	Beaver River	WRB
34		1117500	Wood River Junction	USGS
35		1117800	Wood River @ Arcadia	WRB
36		1118000	Wood River @ Hope Valley	WRB
37		1118500	Pawcatuck River @ Westerly	WRB

[1]RIDEM = Rhode Island Dept. of Environmental Management
PWSB = Providence Water Supply Board
WRB = Water Resources Board
USGS = US Geological Survey