January 7, 2011

Ms. Ann Lowery
Bureau of Resource Protection
Department of Environmental Protection
1 Winter Street
Boston, MA 02108

Mr. Stephen Perkins
U.S. Environmental Protection Agency
Water Enforcement
OES4-SMR
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Boston, MA 02109-3912

RE: Massachusetts Water Resources Authority
Permit Number MA 0103284
MWRA Contingency Plan Threshold Exceedance: Infaunal diversity for August 2010

Dear Ms. Lowery and Mr. Perkins:

In its outfall ambient monitoring program, MWRA measures the numbers and types of infaunal organisms living in sediments in western Massachusetts Bay in the vicinity of the outfall and in reference areas. Samples from 12 or 13 nearfield stations are collected every year in August. Four separate measures of infaunal community diversity in nearfield sediments are in the Contingency Plan. Other measures of the health of sediment communities in the Contingency Plan are the depth of oxygen penetration into nearfield sediments and the abundance of six opportunistic species.[1]

On January 3, 2011, MWRA completed its data quality reviews and calculations of Contingency Plan threshold values for nearfield infaunal diversity and for the abundance of opportunists for its August 2010 monitoring. Those results and results for depth of oxygen penetration (apparent RPD) are in Table 1. Two of the diversity parameters calculated, Shannon-Wiener H′ and Pielou's J′, were slightly higher (more diverse) than their upper thresholds. Those results are a "Caution level" threshold exceedance requiring regulatory and public notification. This letter constitutes that notification. MWRA is evaluating the 2010 data in more detail, however, there are currently no indications that this threshold exceedance was influenced by the outfall discharge, nor are there any indications of a decline in the health of sediment communities.

The two other diversity parameters calculated for August 2010 samples, log-series alpha and total species richness, were well within their threshold ranges. The six opportunistic taxa made up less than 1% of the animals collected from nearfield sediments (the caution level is 10%). The apparent RPD was 2.25 cm, nearly twice as deep as the minimum threshold.

[1] *Massachusetts Water Resources Authority Contingency Plan Revision 1*. 2001. Report ENQUAD ms-071. Retrieved from http://www.mwra.state.ma.us/harbor/enquad/trlist.html

Table 1. Infaunal monitoring threshold results, August 2010 Samples

Parameter	Threshold range		Result	Exceedance?
	Low	High		
Total species	48.4	82	65.1	No
Log-series Alpha	9.99	16.47	14.37	No
Shannon-Weiner H'	3.37	4.14	4.23	Yes, Caution Level
Pielou's J'	0.58	0.68	0.7	Yes, Caution Level
Apparent RPD	1.18	NA	2.25	No
Percent opportunists		10%	0.60%	No

Background

Sediment monitoring in the vicinity of the outfall was designed to address questions raised about potential effects of the relocated discharge on the offshore seafloor. These questions focused on three issues: eutrophication and related low levels of dissolved oxygen, accumulation of toxic contaminants in depositional areas, and smothering of animals by particulate matter.

Monitoring design. Soft sediment samples are collected for the identification and enumeration of the benthic infaunal community. Samples are also collected for the analysis of grain size, total organic carbon (TOC), and the effluent solids tracer bacterium *Clostridium perfringens* spores. Sediment profile imaging, done with a camera, is performed at all 23 nearfield stations each year.

The design of MWRA's infaunal monitoring has been changed several times since baseline monitoring began in 1992. Beginning in 2004, the 23 nearfield stations in western Massachusetts Bay within 7 km of the outfall were split into "even year" and "odd-year" bins, with 12 or 13 of the stations sampled every August (Figure 1).

Infaunal thresholds. The Contingency Plan defines the Caution Level as "appreciable change;" measures of appreciable change for soft-sediment monitoring were developed in discussions with EPA's Outfall Monitoring Science Advisory Panel (OMSAP) in 1998 and 1999. The four biodiversity parameters selected were chosen to reflect different aspects of biodiversity.

The number of species identified (total species) is the simplest measure of how many species are present. Log-series alpha is another measure of species richness whose use has theoretical advantages over total species. Pielou's J′ measures how evenly individuals are distributed among species.[2] Shannon-Wiener H′ is one of the most-used diversity indices; H′ is affected by both species richness and evenness.

Infaunal diversity thresholds were chosen so they would be triggered by results outside of the conditions sampled during baseline monitoring in 1992-2000. Many studies of the effects of organic enrichment on infaunal communities have shown that low levels of enrichment can fertilize communities, increasing diversity, while higher levels cause stress, leading to lower species richness, lower evenness, and lower biodiversity. Over-enrichment of infaunal communities can lead to the increases in the abundance of opportunistic species, which are able to persist in degraded environments.

[2] Communities with a similar number of individuals from a number of different species, (for example a temperate forest with similar numbers of oak, maple, elm, etc.) are more diverse than ecosystems with the same number of species but with the overwhelming majority made up of one species (for example a wheat field where 99% of the plants are wheat but a few different types of weeds are growing among the crop).

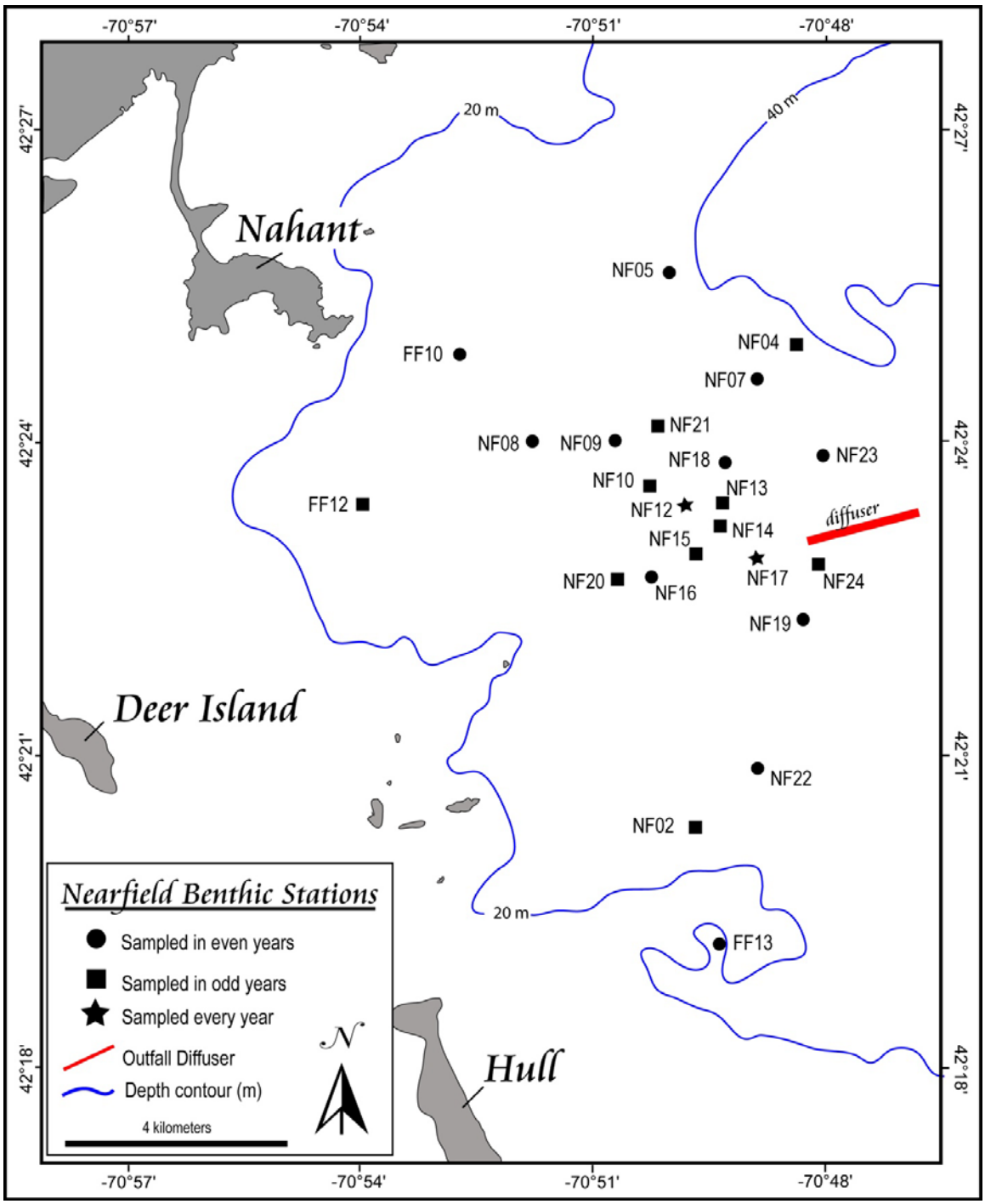

Figure 1. Map of nearfield soft-sediment stations. Stations marked with a filled circle or star were sampled in August 2010.

The infaunal thresholds were chosen to be triggered if the nearfield mean diversity for a discharge year was *lower* than the 2.5th percentile of the distribution of baseline means, or *higher* than the 97.5th percentile. The August 2010 results for Shannon-Wiener H′ and Pielou's J′ are slightly higher than the upper threshold for those parameters (Table 1) triggering the exceedance.

In addition to the biodiversity indices, two additional thresholds were established to detect possible impacts of effluent discharge. MWRA reviewed infaunal data collected both in its Boston harbor monitoring and its outfall monitoring through 1998 and identified six species[3] which have been documented as opportunistic taxa that can increase in abundance as a result of an increase in organic solids depositing in soft-sediment environments. The caution threshold for the abundance of these six species was set at 10% of total nearfield infaunal abundances, roughly 20% of their abundance in Boston Harbor monitoring in 1991-1998.

The final soft-sediment threshold related to the deposition of organic material[4] is the depth of penetration of oxygen into nearfield sediments. The depth below the sediment-water interface where sediments change from light-colored, oxygenated mud to black anoxic mud is called the depth of the apparent redox potential discontinuity (RPD). As deposition of organic matter increases, microbial breakdown of that organic material uses up more oxygen in the sediment porewaters, decreasing the thickness of the RPD. Other factors associated with pollution also act to decrease the thickness of oxygenated sediments, so tracking RPD can help identify potential pollutant impacts. The RPD threshold was set at half the average RPD measured during baseline.

2010 results

It is important to note that the evaluation of the 2010 infaunal results is just beginning, and samples relevant to the review of this threshold exceedance are still being analyzed. For example, data from four farfield reference stations sampled in August 2010 are not due to MWRA until the end of January, so we cannot yet compare the nearfield results to those at reference stations.

Sediment conditions. All indications available at this time are that conditions in nearfield sediments in 2010 were normal. Preliminary review of the sediment profile image results from all 23 nearfield stations in August 2010 suggested that conditions were similar to observations made in 2009, with relatively deep oxygen penetration into the sediments (Figure 2) and evidence for robust biological reworking of sediments at many sites (for example burrows and subsurface feeding voids).

Supporting the observations available from sediment profile imaging (SPI) study, a preliminary review of available 2010 results from MWRA's study of sediment metabolism suggests that the rates of sediment oxygen demand and nutrient release from nearfield sediments in summer 2010 are low in comparison to rates measured in Boston Harbor, and are well within the ranges measured during baseline monitoring and previous discharge years.

Total organic carbon and grain size measured at the nearfield stations in 2010 were also well within baseline and outfall discharge ranges for these stations, as was the effluent solids tracer, spores of the bacterium *Clostridium perfringens* (Figure 3).

[3] The six species include the polychaete worms *Capitella capitata* species complex, *Streblospio benedicti*, and *Polydora cornuta*, the amphipod crustaceans *Ampelisca abdita* and *A. vadorum*, and the bivalve mollusk *Mulinia lateralis*.

[4] In addition to the thresholds discussed here, MWRA tests the average concentrations of 26 organic and heavy metal contaminants in nearfield sediments. Samples for contaminants are collected at all stations every third year, and will next be sampled in August 2011.

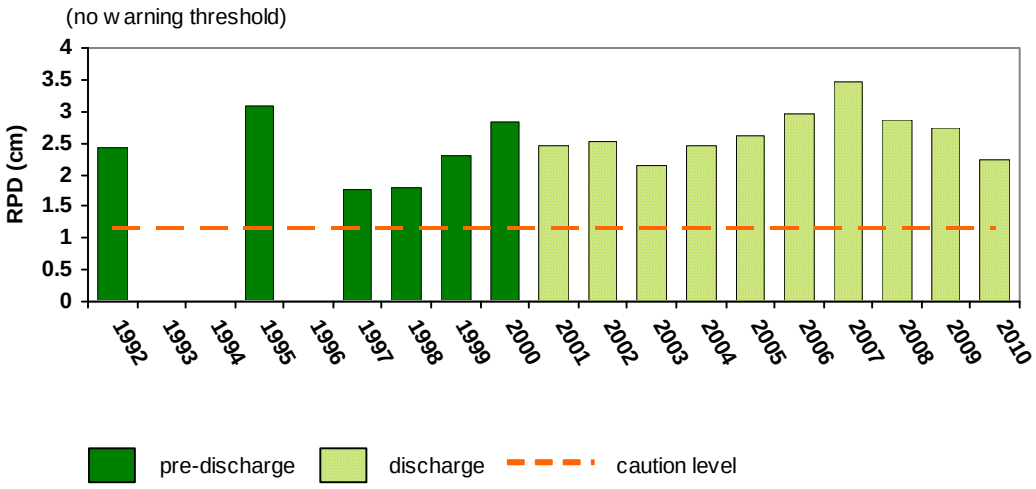

Figure 2. Depth of the average redox potential discontinuity (RPD) in nearfield sediments as measured from sediment profile images, 1992-2010.

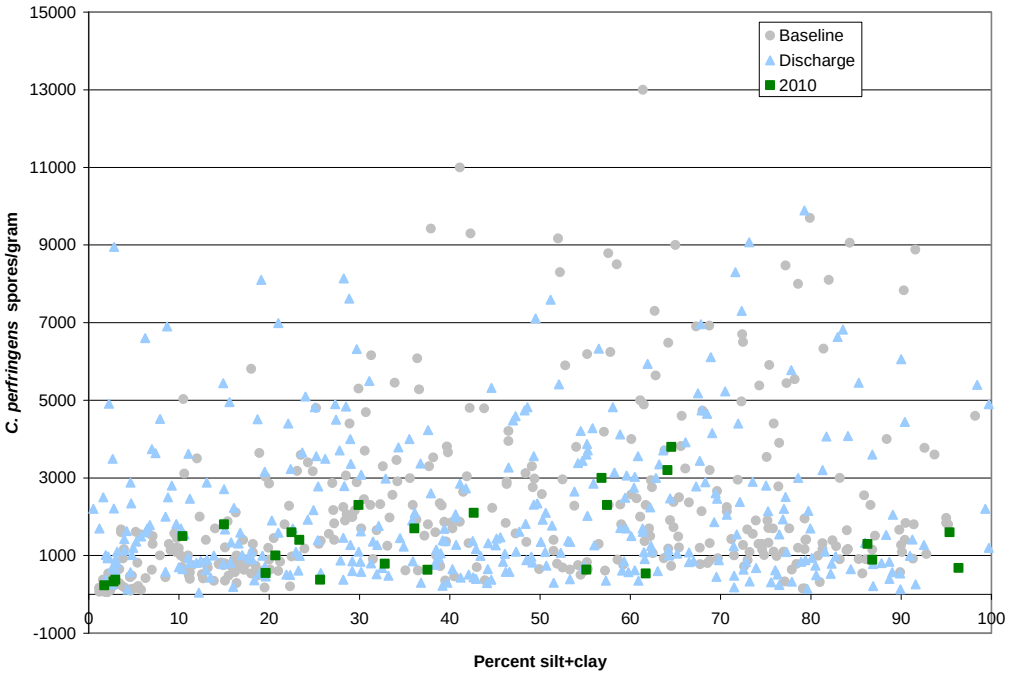

Figure 3. Scatterplot of *Clostridium perfringens* spores and percent silt/clay in sediments, 1992-2010. 2010 data are well within previous measurements.

In addition to the RPD and *Clostridium* spore results discussed above, MWRA's August 2010 monitoring included collection of contaminant samples at two nearfield stations, NF12 and NF17. Review of these data (which are not yet finalized) suggests contaminants at these sites were well within the ranges observed during baseline and previous discharge monitoring.

So far, MWRA's review of the 2010 nearfield infaunal results provides no indications that the slightly elevated Pielou's J′ and Shannon-Wiener H′ diversities (Figure 4) reflect a response to

the outfall discharge. The fact that both of the diversity indices sensitive to species richness were high in 2010 but slightly lower than observed in 2008 (Figure 5) suggests that increased species evenness is responsible for the threshold exceedance, both for J′, a measure of evenness, and H′, affected both by species richness and by evenness in samples. Infaunal densities in 2010 were slightly lower than previously observed, but were quite robust, averaging over 30,000 animals/m^2. High evenness in abundant, species-rich samples is not typical of stressed communities, therefore it is likely that the results observed represent a natural fluctuation in the nearfield infaunal communities. The continued very low abundances of opportunistic taxa (Figure 6) also supports this.

Evaluation of the 2010 sediment nearfield monitoring data is continuing; when the farfield data become available, similar analyses will be done and compared to the nearfield data.

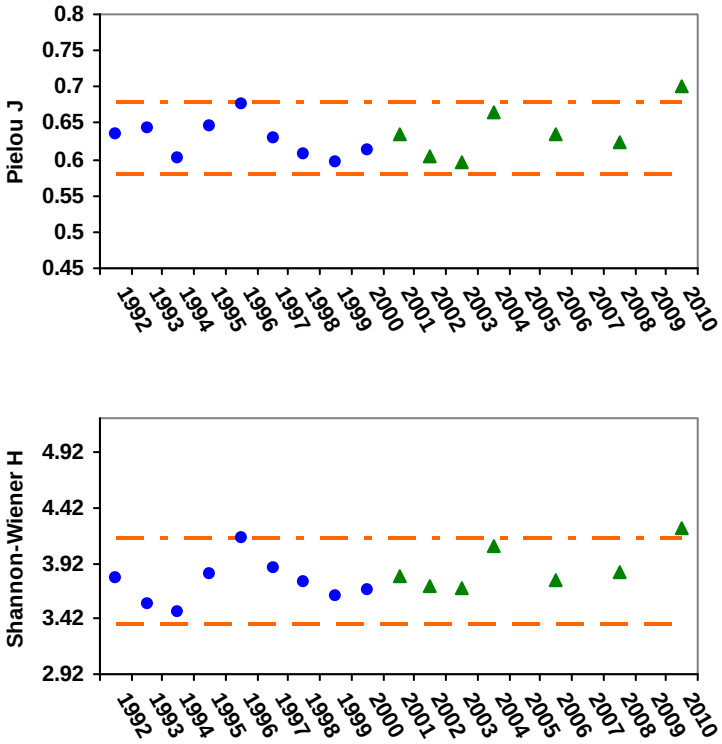

Figure 4. Pielou's J′ evenness (top) and Shannon-Wiener H′ diversity (bottom) measured at even-year monitoring stations, 1992-2010. Dotted lines are upper and lower thresholds, blue points are baseline data, and green triangles reflect outfall discharge data.

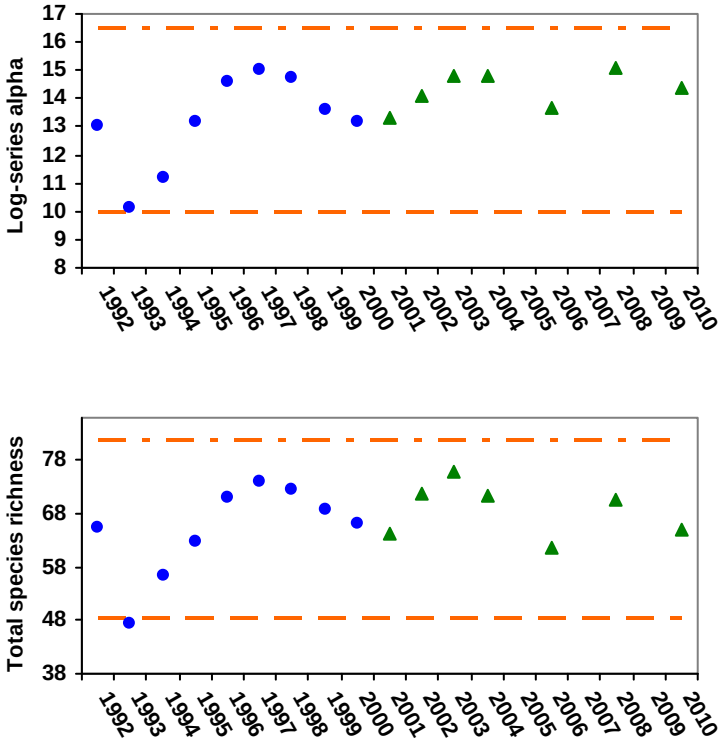

Figure 5. Log-series alpha and total species richness measured at even-year monitoring stations, 1992-2010.

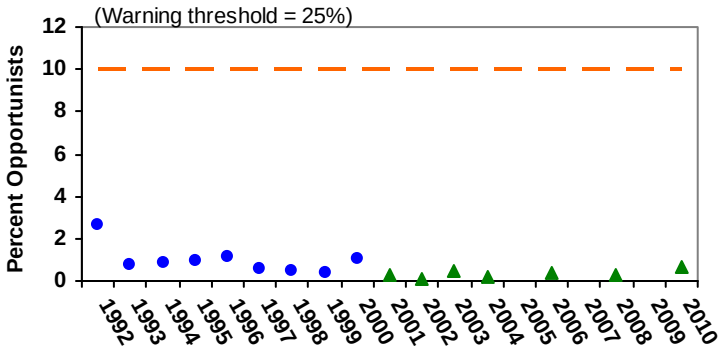

Figure 6. Abundance of opportunist taxa measured at even-year nearfield monitoring stations, 1992-2010. The dotted line reflects the 10% caution threshold.

MWRA will discuss this threshold exceedance at the next Outfall Monitoring Science Advisory Panel meeting.

If you have questions or need additional information, please feel free to call Dr. Andrea Rex at (617) 788-4940.

Sincerely,

Michael J. Hornbrook

Chief Operating Officer

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