EXHIBIT 38 (AR H.22)

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Subject: Macroalgal problems within the Great Bay Estuary System

Nutrients and Macroalgal problems within the Great Bay Estuary System

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Background and personal observations

I have worked at the Jackson Estuarine Laboratory (JEL) since its dedication in 1967 and studied the ecology of the Great Bay Estuarine System (GBES) and its seaweed populations for over 4.5 decades. I was also responsible for directing the nutrient monitoring program for JEL (1970-1981), which was the primary "bench-mark" characterizing earlier hydrographic/nutrient conditions. It is in this context that I comment regarding the macroalgal problems within the Bay. Prior to the 1980s no major algal blooms were apparent and the nutrient levels were much lower than today (cf. Mathieson and Hehre, 1981). During the past 2-3 decades the following macroalgal patterns have occurred along with increased nutrients:

(1) Extensive ulvoid green algae (*Ulva* spp.) or "green tides (Fletcher, 1996) have begun to dominate many of these estuarine areas during the past 15-20 years, particularly within Great Bay proper (Nettleton et al. 2011). Such massive blooms of foliose green algae can entangle, smother and cause the death of eelgrass (*Zostera marina*) within the low intertidal/shallow subtidal zones (pers. obs. A C Mathieson). They primarily represent annual populations that can also regenerate from residual fragments buried in muddy habitats.

(2) The introduced Asiatic green alga *Ulva pertusa* has recently contributed and exacerbated these "green tide" events, along with the dominant species *U. lactuca* (sea lettuce) and *U. compressa* (Hofmann et al., 2010).

(3) The"guanotrophic" green alga *Prasiola stipitata* suddenly appeared in the upper intertidal zone near Dover Point. It represents a disjunct open coastal taxon that is usually found in high intertidal bird roockeries with large quantities of guano. During the mid 1980's it was not recorded inland from Fort Constitution on the Piscataqua River (Mathieson and Hehre, 1986; Mathieson and Penniman, 1986), and its sudden appearance correlates with the "recent" transfer of Dover's sewage discharges from the Cocheco River to the Piscataqua River/Little Bay area.

(4) The Asiatic red alga *Gracilaria vermiculophylla* was recently introduced to the GBES (Nettleton et al. submmitted) and is causing even greater macroalgal blooms than the "green tide" seaweeds. In contrast to *Ulva* it is a perennial, long-lived taxon that is more tolerant to desiccation than the native species *G. tikvahiae*. As a consequence it now forms extensive wind rows 1-2 feet deep within the low intertidal and subtidal zones of many Little and Great Bay sites (pers. obs. A C Mathieson). Like *Ulva* spp. its massive blooms can entangle, smother and cause the death of eelgrass within the low intertidal/shallow subtidal zones.

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(5) Extensive epiphytic growths of seaweeds on eelgrass (*Zostera marina*) have also occurred during the past 15-20 years, particularly within Great Bay proper (pers. obs. A C Mathieson). These epiphytes, which are mostly filamentous red algae and colonial diatoms, may completely cover the fronds of eelgrass, limiting the host's growth and photosynthesis and compromising its viability.

Supportive scientific studies

Schubert (1984) states that macroalgae are good indicators of nutrient levels, as they lack roots, their tissues absorb nutrients directly, and they closely reflect water column contents (cf. Lapointe et al., 1992; Horrock et al., 1995). Goshorn et al. (2001) summarized several studies indicating that a large increase in macroalgal biomass is most often associated with eutrophication. Valiela et al. (1992, 1997) found that a rise in nutrients increased algal biomass 3-4 levels of magnitude, shading out eelgrass, creating more anoxic events, and changing benthic faunal communities. Hauxwell et al. (1998) found that as nitrogen loading increased macroalgal biomass increased by as much as 300%. Microcosm experiments by Fong et al. (1993) showed that nitrogen levels directly controlled macroalgal biomass, which in turn controlled levels of phytoplankton that were subsequently documented by enhanced chlorophyll levels.

Summary comments

Based upon the above observations and scientific data, eutrophication is creating an unstable and negative situation within the GBES, which needs to be quickly rectified. In retrospect these green and red (*Gracilaria*) algal blooms are typical of stressed estuarine systems like those found within Waquoit Bay, MA, Narragansett Bay, RI, and the middle Atlantic coastal estuaries within Delaware, Maryland, and Virginia.

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