Proposed Diversion of Brookhaven National Laboratory's Sewage Treatment Plant Effluent from the Peconic River to Nearby Groundwater Recharge Basins

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Introduction

The New York State Department of Environmental Conservation (NYSDEC) issued Brookhaven National Laboratory (BNL) an updated State Pollutant Discharge Elimination System (SPDES) permit in June 2009 that proposed significant reductions in the allowable concentrations of metals in BNL's Sewage Treatment Plant (STP) effluent discharge to the Peconic River. Because of these more stringent discharge limitations and public concerns about potential environmental impacts from these discharges, BNL evaluated a full range of options to meet the new standards and provide the best environmental outcome.

In addition to evaluating possible source minimization and alternative effluent treatment techniques (BNL, 2010b,c), BNL made a recommendation to the NYSDEC to eliminate all effluent discharges to the Peconic River and to utilize a nearby upland recharge area to return the treated water directly to the groundwater system (BNL 2010a). The potential impacts that such a modification may have on stream flow, vegetation and fish in the on site segments of the Peconic River were evaluated. In late 2010, the NYSDEC concurred with BNL's recommendation to redirect the STP effluent to nearby on-site recharge basins. BNL is currently performing a National Environmental Policy Act (NEPA) Environmental Assessment to evaluate the recharge option (preferred alternative) and an enhanced treatment alternative with continued discharge to the Peconic River.

BNL Sewage Treatment Plant Operations

The STP processes sanitary wastewater originating from the research and support facilities. **Figure 1** is a schematic of the STP facility and its associated monitoring locations. Treated effluent from the STP is discharged to the nearby Peconic River, and since 1978 these discharges have been regulated under a SPDES permit. The STP is located on the same site as the original plant constructed by the US Army with the establishment of Camp Upton during WW I. It is unknown whether the STP was used when the Civilian Conservation Corps occupied Camp Upton in the 1930's. The STP facility was upgraded and placed back into service when Camp Upton was reactivated in 1941, just prior to the start of US involvement in WW II. In 1947, the property was transferred to the US Atomic Energy Commission for the establishment of BNL, and the STP has been in continuous use since that time.

The STP processes an average of 0.3 million gallons per day (MGD) during non-summer months and approximately 0.5 MGD during the summer. Until 2006, treatment of the sanitary waste stream included primary clarification to remove settleable solids and floatable materials; aerobic oxidation for secondary removal of the biological matter and nitrification of ammonia; secondary clarification; sand filtration for final effluent polishing; and ultraviolet light disinfection for bacterial control prior to discharge into the Peconic River. Biological removal of nitrogen is accomplished by regulating the oxygen levels during the treatment process, and forcing the bacteria to use nitrate-bound oxygen for respiration. Wastewater from the STP secondary clarifier is released in rotation to one of four sand filter beds, where the water percolates through three feet of sand and gravel before being recovered by an underlying clay tile pipe drain system. Approximately 20 percent of the water released to the filter beds is lost either to evaporation or to direct groundwater recharge. Groundwater quality is routinely monitored using wells that are positioned around the filter bed area.

In 2006 the primary clarifier was removed from the treatment process to improve the nitrate removal efficiency of the treatment process. The process of de-nitrification is energy intensive and the microorganisms responsible for this action require nutrients for efficient oxygen removal. However, the nutrient load of the STP influent is extremely low and inadequate to support the biomass resulting in high total nitrogen levels (> 10 mg/L). By bypassing the primary clarifier, all biological matter in the influent is sent to the aeration process which should have resulted in a higher nutrient availability to the microorganisms. Even with the primary clarifier removed from the process, nutrient loading was still low. In 2008, cafeteria wastes were collected and added directly to the STP influent as a direct nutrient source. Since this addition, nitrogen removal rates have improved and total nitrogen concentrations have remained below the 10 mg/L SPDES limit.

There are two emergency hold-up ponds east of the sand filter bed area. They are used for the emergency storage of sanitary waste in the event of an upset condition or if the influent contains contaminants in concentrations exceeding BNL administrative limits or SPDES permit effluent release criteria. With a combined capacity of nearly 8 million gallons, the hold-up ponds provide BNL with the ability to divert all sanitary system effluent for approximately 18 days. Each holding pond is lined, consisting of double-wall construction - with a geotextile mesh placed between two layers of impermeable geomembrane fabric. The secondary liners are sloped to a low point that is equipped with a liquid sensor, which would detect leakage of the outer (or primary) liner.

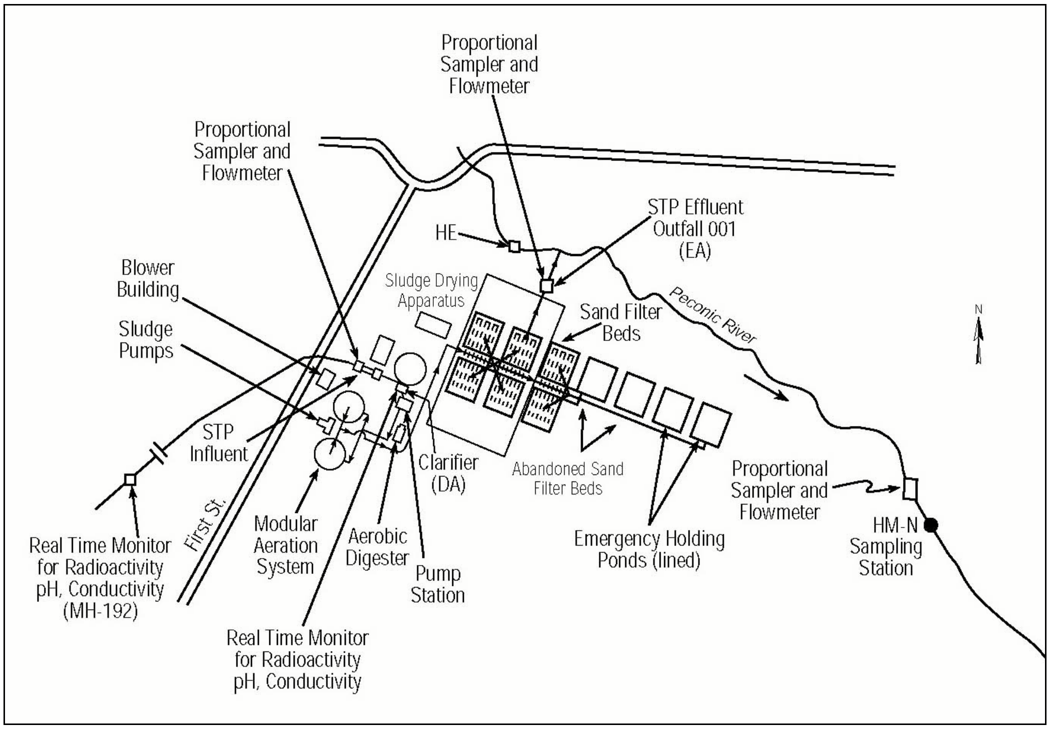

Figure 1. Schematic of the Sewage Treatment Plant.

Remediation of the STP and Peconic River

Historical discharges from the STP have resulted in elevated concentrations of heavy metals, polychlorinated biphenyls (PCBs) and radionuclides in the Peconic River sediments. Remediation of contaminated river sediments took place in two phases (2004-2005 and in 2010-2011), and removed approximately 21,800 cubic yards of river sediments from the BNL property and adjacent Suffolk County parklands. BNL has extensive sediment, surface water, and fish monitoring programs that are designed to verify the long-term effectiveness of the remediation work (see BNL 2008 for details on this monitoring program).

Monitoring of the STP process showed that sludge being stored at the facility contained high concentrations of metals. Decant from the sludge, which was directed to the STP influent, was identified as a contributing source of metals in the STP effluent. In addition, the sand media within the plant’s filter beds was also identified as a source of metal contaminants. During 2007-2009, the sludge was processed by the addition of coagulants and polymers to improve the sludge dewatering characteristics, and then mixed with excavated sand filter media and disposed offsite.

History of Peconic River on the BNL Site

The west branch of the Peconic River originates just to the west of the William Floyd Parkway. It then flows northward and eastward under the parkway onto the BNL property, where it begins a southeasterly flow to the east boundary of BNL at North

Street. Shortly after it flows off the BNL site, the river turns north until it joins the north branch of the Peconic River. From this point the entire river begins flowing eastward toward the Peconic Bay. The west branch of the river was not always so clearly evident in maps produced prior to the creation of Camp Upton in 1917. Probably the most accurate of the pre-World War I maps is that produced by the USGS in the 1904/1905 time frame which shows the western branch of the Peconic River as an intermittent stream flowing from the Ridge, NY area southeastward toward the current day Zeke's Pond.

As we know it today, the Peconic River on the BNL site is largely a result of drainage modification activities conducted by the Army in 1917. Mosquitoes caused such extensive health problems that significant work was done to control mosquito breeding areas. These efforts included the digging of drainage ditches and the oiling of ponds. The ditch system was further modified by the CCC beginning in 1934, when the property became the Upton National Forest and was enhanced for wildlife and forestry management.

The original Camp Upton ditching is still evident along the stretch of the river from the STP to an area about 2,600 feet downstream (near BNL's east firebreak), where the ditching then becomes more intermittent to connect and drain wetlands as the river proceeds to the southeast corner of the BNL property. The ditching continues to serve as a drainage mechanism, and adjacent low lying areas function as seasonal wetlands. Depending upon weather patterns, standing water can persist in these wetland areas year round. River flows upstream of the STP are intermittent, but are routinely observed in both spring and fall during most years.

The Peconic River east of the STP outfall has changed somewhat since 1941 when the flows became more or less continuous due to the routine discharges from the STP. Over the years the wetlands east of BNL's east firebreak began silting in, so that by the time the river was first remediated in 2004 there were significant stands of cattail and common reed within the wetlands.

Since the early-1990s water conservation efforts at BNL have resulted in reduced discharges from the STP and in most years the river does not flow off the BNL site, especially during periods of low precipitation (July – November). The estimated average historical STP effluent discharges to the Peconic River are summarized in **Figure 2**. The annual average discharges from the STP have decreased from a high of nearly 1.4 million gallons per day (MGD) in the mid 1970s to less than 0.4 MGD by 2003. Even with decreased flows, deeper streambed areas created during the Peconic River cleanup project maintain more persistent open water throughout the year.

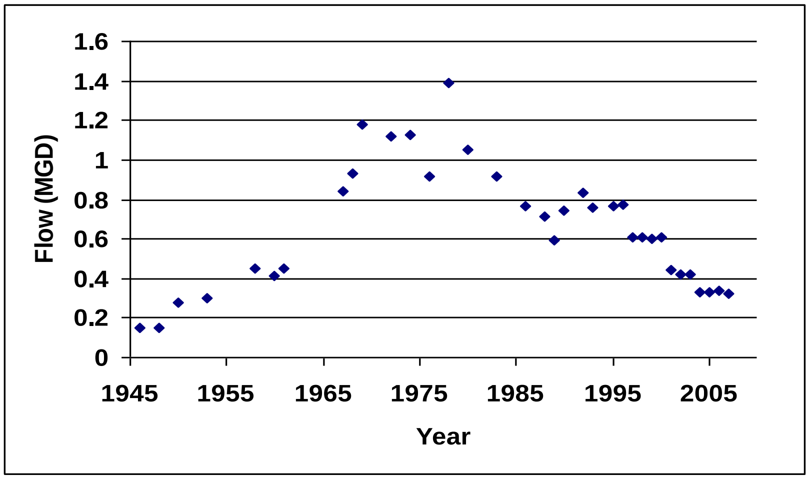

Figure 2. 1947-2008 STP effluent discharge amounts, in millions of gallons per day (MGD).

Hydrogeology of the STP Area

Shallow, discontinuous clay and silt deposits are present in the STP area, and are commonly referred to as the Peconic River clays. These low permeability deposits reduce rainfall infiltration and subsequent groundwater recharge, and promotes ponding and more lateral interflow and overland flow to the Peconic River. Detailed soil borings in the STP filter bed area determined that the currently utilized filter beds are underlain by these shallow clay and silt deposits. The direct infiltration of approximately 20% of the water released to the sand filter beds results in perched water table conditions and associated groundwater mounding below part of the facility (**Figure 3**). Depth to groundwater in the STP area varies between 5 to 15 feet below land surface, and the general direction of groundwater flow is to the east.

River Flow

Under natural conditions, Long Island streams derive 95% of their total flow from groundwater discharge and only 5% from storm water runoff (Frank and McClymonds, 1972). Typically, stream flow begins where the water table intersects the stream channel, causing water to enter the stream as base flow. The water table rises in response to recharge and typically undergoes a net rise in years when precipitation is notably higher than the preceding year. This rise results in increased groundwater discharge to the streams. In the vicinity of BNL, the Peconic River is an intermittent gaining and losing stream, where flow is highly dependent on groundwater baseflow during periods of high water table, precipitation, and contributions from the STP. "Start of flow" observations conducted by the USGS from 1966 through the 1990s indicates that the start of flow in the Peconic is highly variable (**Figure 4**). The first USGS measurement of start of flow in the BNL area was in October 1966, at the end of the 1962-1966 drought (Scorca *et al*., 1999). At that time, the start of flow was approximately 2 miles east of BNL. In 1995, also a dry period, the start of flow was approximately 1.2 miles east of BNL. During wetter periods (such as during the spring of 2010), start of flow has been observed to the west of BNL, in Ridge. Schubert *et al*. (2005) performed a detailed evaluation of stream flow in the area of BNL's east boundary monitoring station HQ. They determined that stream flow at station HQ was predominantly associated with low-stage conditions, where large sections of the stream channel upstream of station HQ are dry (approximately 79% of the time during 1993-2003). Typically, the start of continuous flow in the Peconic occurs to the east of station HQ.

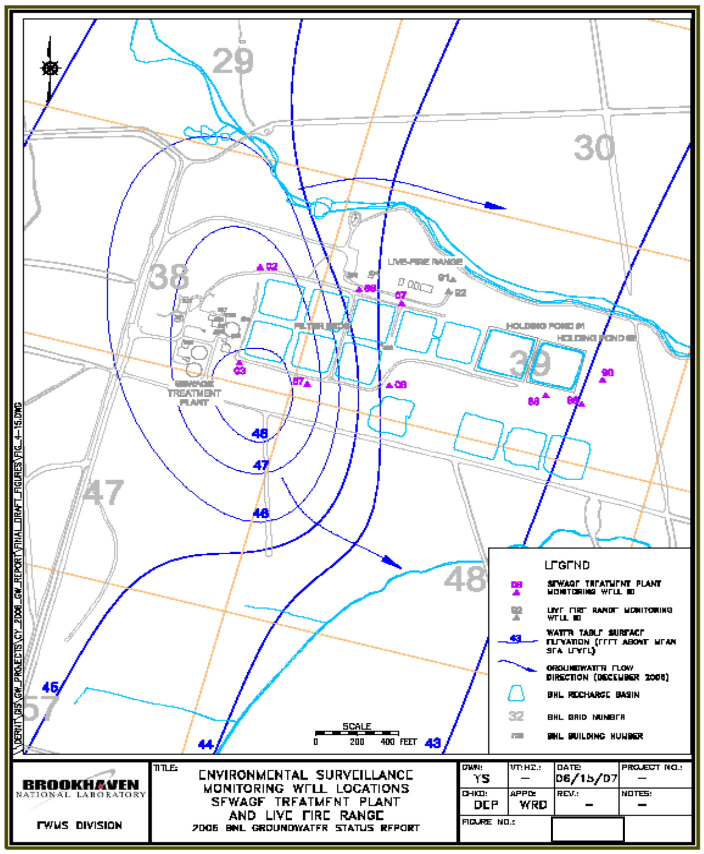

Figure 3. Groundwater flow directions near the Sewage Treatment Plant.

The nearly continuous discharge of STP effluent to the river changed the nearly 2,600 foot segment downstream of the STP outfall from an intermittent gaining and losing stream segment to a predominantly losing stream segment. **Figure 5** shows the channelized section of the river near the STP outfall, which maintains year round flow from STP effluent and groundwater baseflow during high water table periods. During dry periods, the STP effluent water seeps out of the channel, and totally infiltrates by the time the flow reaches the eastern BNL property boundary. **Figures 6a and 6b** show seasonal variations in stream conditions in a section of the river located between BNL's east firebreak and eastern boundary. Even with continuous discharges of STP effluent, this section of the river does not sustain flows during dry seasons.

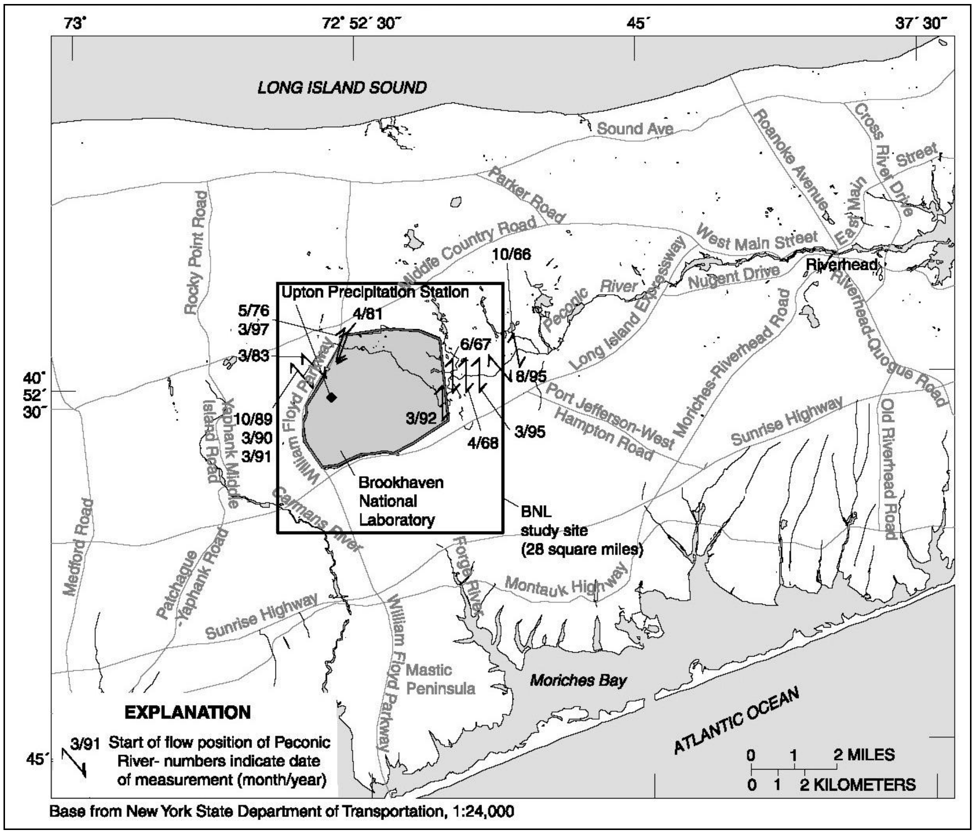

Figure 4. Approximate start of flow locations along the Peconic River based upon USGS field observations during the 1960s – 1990s (Scorca *et al*., 1999).

Figure 5. Trenched section of the Peconic River near the STP outfall (August 2004). STP discharges allow this section of the river to maintain year round flow.

Figures 6a and 6b. Comparison of water levels in the Peconic River between BNL's east firebreak and eastern boundary. October 2007 (high water levels) and September 2008 (low water levels).

Groundwater Modeling

Groundwater model simulations were performed to understand the potential impacts that the elimination of STP discharges could have to the onsite segment of the Peconic River, and determine the best location to recharge the STP effluent (BNL, 2010a). The BNL Regional Groundwater Model (Geraghty & Miller, 1996; Arcadis Geraghty & Miller, 1999) was used for this task. Groundwater flow model scenarios were created for relocating the BNL STP effluent discharges to three nearby upland recharge areas - the current STP filter bed area, an adjacent abandoned WWI-era filter bed area, and an open space area located approximately 2,700 feet southwest of the STP. The model simulations were used to predict changes in groundwater levels in the vicinity of the river and potential upland recharge areas, and to evaluate the potential impact to groundwater baseflow in the river.

Of the three upland recharge areas evaluated, the WWI era filter bed area was determined to be the best location to recharge the STP effluent. Available geological data indicates that near surface clays are not significant in this area, and that infiltration and recharge of the STP effluent can occur at the required rates. An engineering study will be conducted to provide detailed soil/percolation analyses, design of the recharge beds, and develop operational parameters for the discharges.

The water that will be recharged at the new basin is not expected to enter the nearby section of the Peconic River as groundwater baseflow. Furthermore, the water table is predicted to be 0.5 to 1 foot below the streambed until the start of continuous groundwater baseflow, which is predicted to occur approximately 800 feet upstream of river monitoring station HQ. Therefore, the downstream section of the river from the STP outfall to the east firebreak will return to intermittent stream conditions, with flow restricted to periods of high rainfall. The close proximity of the water table to the base of the stream will provide wet antecedent stream bed conditions which will allow for quick flow in wet weather.

Conclusions

Our analysis indicates that if the STP outfall is relocated away from the river to the proposed recharge area, surface water flow will no longer be continuous along the 2,600 foot on-site segment of the Peconic River stretching from the STP outfall to BNL's east firebreak. Therefore, this segment of the river will return to being an intermittent stream like the adjacent upstream and downstream areas, with flow returning to conditions similar to what existed prior to the government's use of the property. Even during dry periods, some isolated areas of standing water may be present in this section of the river due to impounded baseflow into natural or disturbed stream bed depressions. The close proximity of the water table to the base of the stream provides wet antecedent stream bed conditions which will allow for quick flow in wet weather. No significant changes to stream flow would occur east of BNL, where the river has nearly continuous year-round flow.

If effluent discharges to the Peconic River are suspended, the affects are expected to be minimal to many of the wetland species, and may result in improved habitat for banded sunfish. As water levels in open water ponds fluctuate on a more natural seasonal basis, emergent and submergent plant species may develop more along the banks of the river. As the plants develop into denser stands, they would provide suitable habitat for the banded sunfish to feed and hide from larger prey fish. The mixed habitats developing on the shoreline should also be beneficial for migratory shorebirds utilizing the area for feeding.

Discontinuing STP discharges to the Peconic River will eliminate the continued release of low levels of heavy metals (e.g., mercury) present in the treated effluent. Following BNL's extensive remediation of contaminated river sediments, eliminating the discharge of STP effluent will prevent the potential accumulation of additional heavy metals in river sediment and reduce their potential uptake by fish and other aquatic organisms.

Acknowledgements

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