Section 11
Hydrogeologic Evaluations of Effluent Recharge Sites

11.1 Introduction

One of the most significant aspects of developing a CWMP is to find suitable effluent recharge sites to incorporate into the overall recommended program. Section 9 screened the whole town to identify the best available sites for this purpose and Section 10 evaluated the nitrogen balance issues associated with adding more nitrogen to a given watershed as a result of recharging effluent. This section evaluates the ability of the sites to accept the highly treated effluent from a hydrogeologic perspective. Thus, the three highest rated effluent recharge sites are evaluated herein.

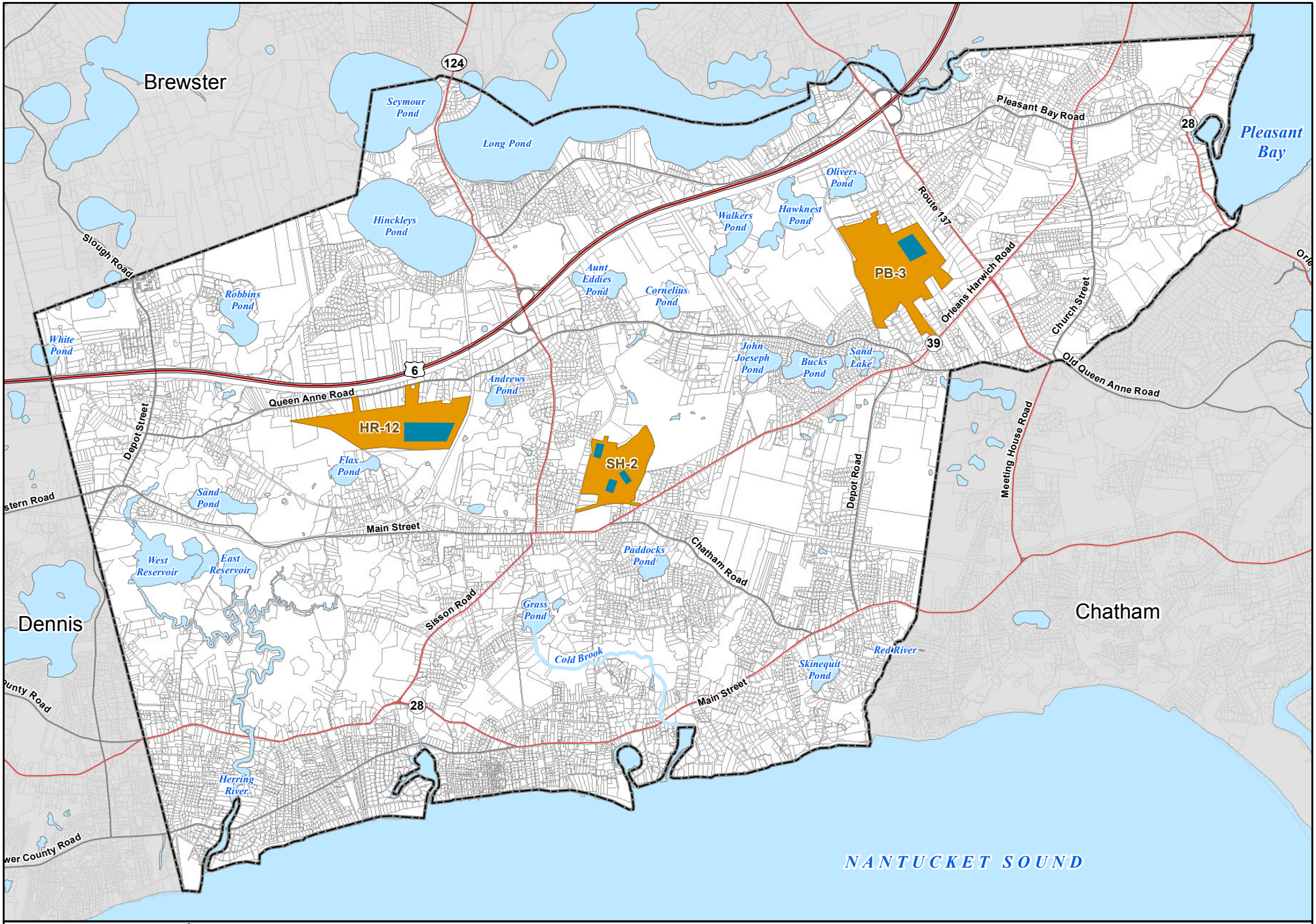
A complete hydrogeologic evaluation is presented in the Hydrogeologic Evaluation of Effluent Recharge Sites in Harwich, Massachusetts, dated July 2012, attached in Appendix C. The work plan and findings for this evaluation were coordinated with representatives of the MassDEP and Cape Cod Commission. The purpose of this section is to summarize the findings from that report.

11.2 Overview of Work

As part of the Harwich CWMP, a program for hydrogeologic data-collection and groundwater flow modeling was conducted to predict the impacts of effluent recharge to groundwater at three potential sites in Harwich, Massachusetts. The sites include an area near the capped Harwich Landfill off of Queen Anne Road (Site HR-12) within the Herring River Watershed, sports fields at the Harwich High School (now Monomoy Regional) on Oak Street (Site SH-2)within the Saquatucket Harbor Watershed, and a privately owned parcel identified off of the Orleans-Harwich Road (Site PB-3) within the Pleasant Bay watershed. The three sites are shown in Figure11-1.

The Harwich Landfill site, HR-12, is a large municipally owned parcel which consists of a capped landfill area in the western end of the site with recycling and waste transfer facilities, and former sludge/septage disposal beds located to the south but north of Flax Pond which is south of the overall site. Coy Brook is located east of the site near the bike path. The stream flow is controlled by structures in the cranberry bogs located southeast of the site. Additional cranberry bogs located south and east and west of Flax Pond are fed by surface water pumped from the pond. Groundwater and surface water levels in the area are heavily influenced and controlled by operations of the cranberry bogs. Recharge would be via infiltration basins located in the existing wooded southeastern portion of the site. Flow from this site would ultimately surface in the Herring River.

Subsurface recharge beneath playing fields is proposed for the municipally owned Harwich High School (future Monomoy Regional High School) site, SH-2. Surface water features near the site are primarily kettle ponds which reflect the groundwater table and likely have little impact on the overall flow patterns. Flow from this site would ultimately surface in Saquatucket Harbor.



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- Effluent Recharge Area
- Effluent Recharge Parcel

Town of Harwich
Comprehensive Wastewater
Management Plan

1 inch = 4,000 feet

0 1,000 2,000 4,000 Feet

Figure 11-1
Effluent Recharge Sites

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The third site, PB-3, is privately owned and located within the Pleasant Bay watershed. The site is primarily uplands adjacent to a former gravel pit with no nearby surface water features. It is located within a Zone II area to municipal wells. Recharge would be via infiltration basins located in the northeast portion of the overall site. Flow from this would ultimately surface in Pleasant Bay.

The appended hydrogeologic report describes the data-collection efforts and the groundwater modeling performed to predict impacts from the proposed effluent recharge. Hydrogeologic data review and fieldwork, including USGS data, previous landfill site investigations (Site HR-12), 2011 supplemental CWMP investigations at sites HR-12 and PB-3, and other data are discussed in Section 2 of that report. Test analysis and results from the 2011 CWMP data collection efforts include boring logs, grain size analysis, infiltration test analysis, groundwater quality results, and a summary of site visits with cranberry bog owners located south of HR-12. The hydrogeologic data review and fieldwork further identified a clay layer at HR-12 which impacts groundwater flow rates and direction.

Based on the data review and fieldwork, revisions were made to an existing regional USGS groundwater flow model which had been calibrated for 2003 conditions. Section 3 of the hydrogeologic report provides information on the MODFLOW model and calibration, including the USGS model used as a basis for the groundwater model, grid and model refinements and adjustments to recharge, clay extent, hydraulic properties, and stream updates.

The model was calibrated to regional groundwater elevations and 2003 groundwater data from Site HR-12. Recent surface water and groundwater data from 2011 was used to refine the model near HR-12. The revised and recalibrated model was used to assess the flow direction and mounding for recharge flows at the three locations based on the CWMP scenarios.

11.3 Groundwater Model Simulations

Three model simulations were completed to assess groundwater recharge scenarios developed for the CWMP. Model simulations and results are thoroughly discussed in Section 4 of the appended report.

- Simulation 1 is based on the upper end flow loadings for all scenarios (presented earlier in Section 10 of this CWMP) for effluent recharge proposed in the CWMP and utilizes all three sites:
  - HR-12: 800,000 gpd at a loading rate of 3 gpd/ft^2,
  - PB-3: 400,000 gpd at a loading rate of 5 gpd/ft^2, and
  - SH-2: 210,000 gpd at a loading rate of 1 gpd/ft^2.
- Simulation 2 is the maximum loading over a 10-acre area at HR-12 which maintains a minimum four foot depth to the top of the groundwater mound from the infiltration basin surface, per MassDEP regulatory guidance.
- Simulation 3 is the same as Simulation 2, but with revisions to the simulation of water levels in the cranberry bogs and Flax Pond south of HR-12.

Model simulation results, shown in Table 11-1, indicate that the selected sites should be able to recharge the proposed CWMP scenario flows in an acceptable manner. Increased flow to Coy Brook near HR-12 would result in enhanced stream flow and would help to maintain a more reliable base flow beneficial for the local cranberry bog agricultural operations, especially during dry weather conditions.

Table 11-1
Simulation Results Summary

Site	Total Recharge (MGD)	Loading Rate (gpd/ft^2)	Basin Area (acres)	Model Sim. Head (ft NGVD29)	Est. Basin Elev. (ft NGVD29)	Est. Depth to GW Mound (ft)	Est. Mound Height (ft)	Est. Stream Inc. (cfs)	% Est. Stream Inc.
Simulation 1 (Upper End of Flow Loading)									
HR-12	0.8	3.0	6.1	36	40	4	10	1	59%
PB-3	0.4	5.0	1.8	34	50	16	3.2		
SH-2	0.21	1.0	4.8	30	46	16	1.9		
Simulation 2 (Maximum Loading)									
HR-12	1.2	2.7	10	36	40	4	10	1.2	69%
Simulation 3 (Maximum Loading With Revisions near Cranberry Bogs)									
HR-12	1.4	3.0	10	36	40	4	10		

These results are shown in Figures 11-2 thru 11-4.

11.4 Effluent Recharge

All of the effluent recharge sites analyzed herein are located in the Monomoy Lens which is one of six groundwater flow lenses under Cape Cod. The Monomoy Lens is located under the towns of Dennis, Brewster, Harwich and Chatham. The 14 drinking water wells that provide the municipal water supply to Harwich are located in the Monomoy lens. This lense can be thought of as a mound of groundwater bordered by marine waters at the edge and bedrock on the bottom. Surface features defined watersheds that create different recharge points to the groundwater table within the lense area. The entire layer of fresh groundwater beneath the Cap is known as the Cape Code Sole Source Aquifer and consists of the sex separate lenses.

Recharge from various forms of precipitation is the sole source of water to the aquifer system. On the Cape, about 45 inches of precipitation falls during an average year (LeBlanc and others, 1986) with over half reaching the groundwater table. The rest is lost to evapotranspiration and some minor runoff (generally minimal on Cape Cod due to sandy soils). The results I about 27 inches per year of recharge to the aquifer or about 137 Mgal/d in the Monomoy lens (USGS,2004). Some have estimated that 5 to 10 percent of the water recharging the Cape Cod aquifer system is removed for water supply (Materson and others, 1997) but that most of the water is recharged back in the form of disposed wastewater from septic systems or point discharges.

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Mounding Simulation 1
Height of Groundwater Mound

Effluent Recharge Parcel

Town of Harwich
Comprehensive Wastewater
Management Plan

1 inch = 2,500 feet

0 1,000 2,000 4,000 Feet

Figure 11-2
Mounding Simulation 1

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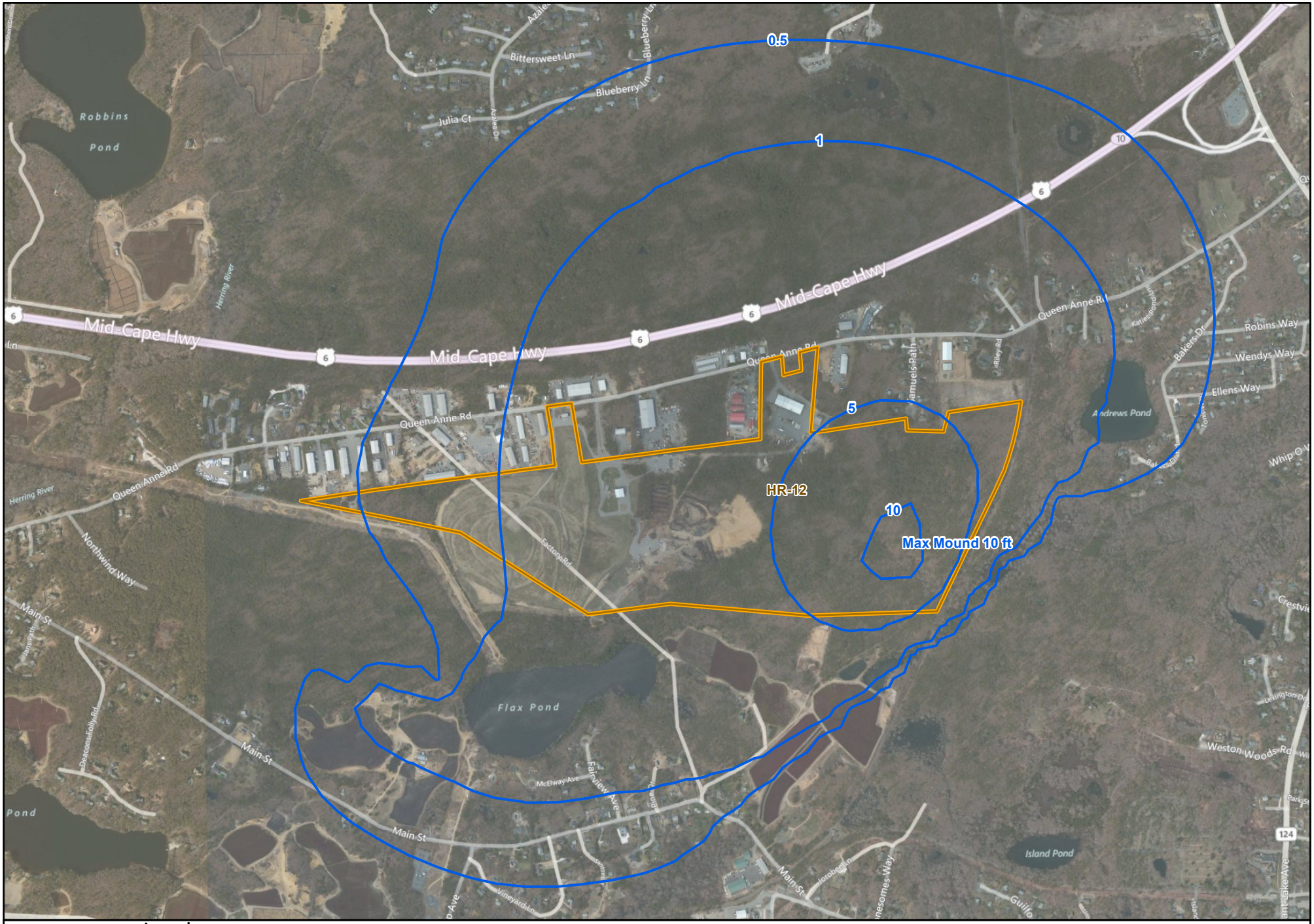

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Mounding Simulation 2
Height of Groundwater Mound

Effluent Recharge Parcel

Town of Harwich
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Management Plan

1 inch = 1,000 feet

0 500 1,000 Feet

Figure 11-3
Mounding Simulation 2

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Mounding Simulation 3
Height of Groundwater Mound

Effluent Recharge Parcel

Town of Harwich
Comprehensive Wastewater
Management Plan

1 inch = 1,000 feet

0 500 1,000 Feet

Figure 11-4
Mounding Simulation 3

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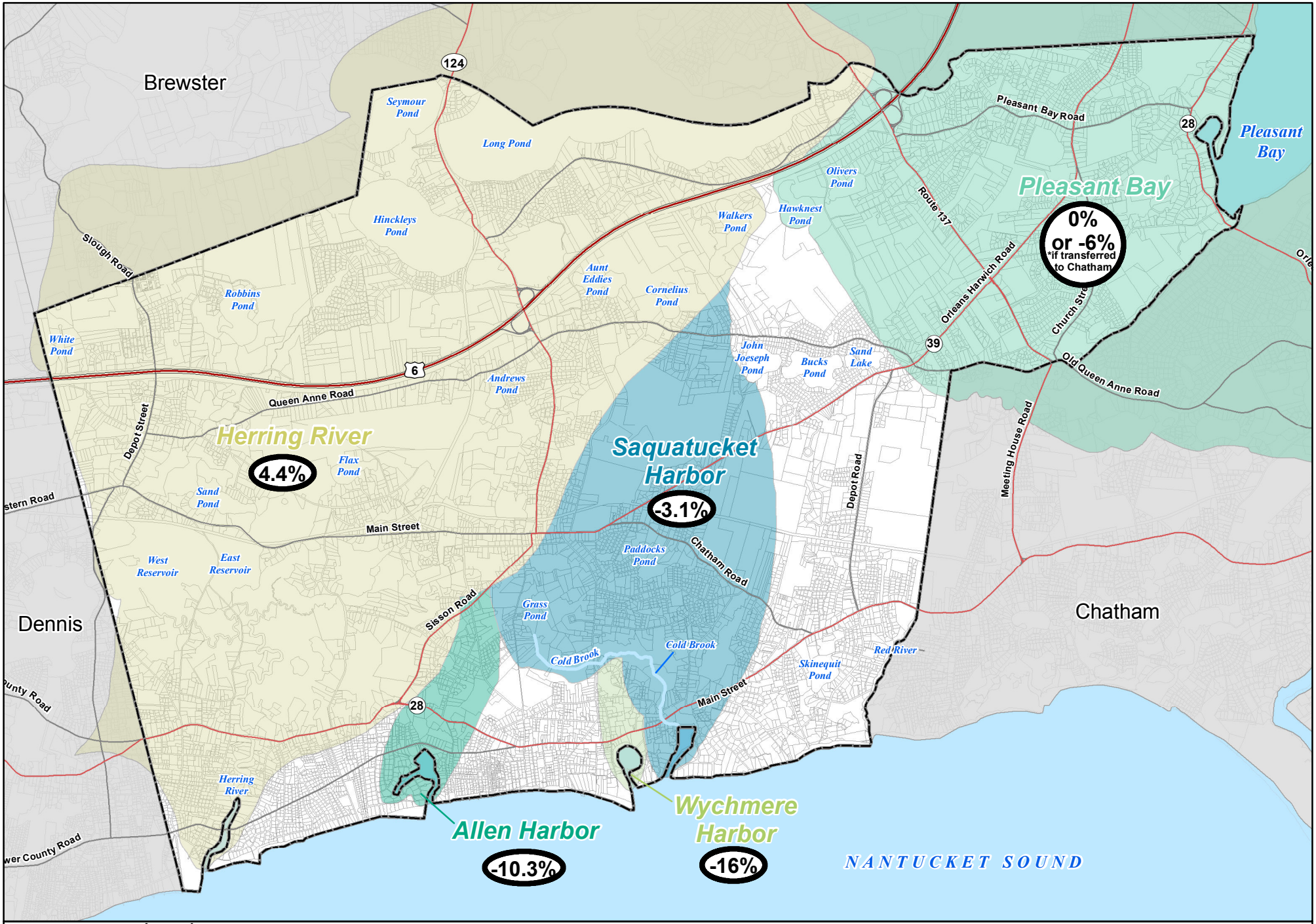
The five MEP watersheds in Harwich are all within the Monomoy Lens. Table 11-2 shows the amount of estimated average daily recharge per MEP watershed, the amount of wastewater proposed to be collected and transferred out of a given watershed and the amount of wastewater effluent transferred into a give watershed based on the recommended plan presented in Section 13. The resultant percent change for each watershed is then shown. The two smallest watersheds, Allen and Wychmere Harbor, have the projected larges change since these are densely developed and all wastewater is removed from the watershed. Saquatuckt Harbor shows an export of wastewater out of the watershed but at less than 5 percent. Herring River watershed shows a net import due to the location of the largest effluent recharge site (HR-12) being there. The Pleasant Bay watershed shows two values since the recommended plan calls for wastewater from that area to also be recharged there (0 percent change) or potentially recharged at the Chatham WPCF site (-6 percent). Overall the impact from this recharge is expected to be minimal on the towns water supply wells since the amount of wastewater/effluent being moved among the watersheds is small.

Under this CWMP, the Town of Harwich is proposing a recommended plan that falls well below the one million gallon per day threshold. The highest flow in Harwich that could be considered an interbasin transfer is for a 0.63 mgd. In the strictest sense of the regulation, however, an interbasin does not exist because the flow is below the one MGD threshold and it does not cross a town line in the Allen, Wychmere, Saquatucket and Herring River watersheds. For the Pleasant Bay, the possibility exists to cross a town line, but the proposed wastewater flow is 0.33 mgd, also well below the one mgd threshold. It is important to note that under the recommended plan, the wastewater generated in the Pleasant Bay may be recharged in Chatham in the first years of the wastewater plan. Ultimately, when Chatham's' capacity to recharge wastewater flow becomes limited, the flow from the Pleasant Bay will be recharged back in the watershed. Wastewater flow from the Great Sand Lakes, the Campground Areas and small part of Route 28 outside of the MEP watersheds are considered to be negligible (0.025-0.035 gpd) when compared to the flow generated within the MEP Watersheds. Table 11-2 and Figure 11-5 present the wastewater flow that will be transferred in and out of the MEP watersheds in the recommended plan. The percent change in the watershed based on average annual rainfall is also shown on the table and the figure.

Table 11-2
Water Use Data for Five MEP Watersheds

MEP Watershed	Estimated Daily Recharge (MGD)	Wastewater Flow Transferred Out of the Watershed (MGD)	Wastewater Flow Transferred into the Watershed (MGD)	Percent Change in the Watershed
Allen Harbor	0.6	0.062	0.0	-10.3%
Wychmere Harbor	0.2	0.032	0.0	-16%
Saquatucket Harbor	3.6	0.113	0.0	-3.1%
Pleasant Bay*	5.3	0.33	0.33	0% / -6% *
Herring River	19.2	0.0	0.63	4.4%

*The first number represents the percent change if the effluent remains within the Pleasant Bay Watershed. The second number represents the percent change if the effluent is recharged at the Chatham WPCF.



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Watersheds

- Allens Harbor
- Herring River
- Pleasant Bay
- Saquatucket Harbor
- Wychmere Harbor
- 6% Percent Recharge Change within Watershed

Town of Harwich
Comprehensive Wastewater Management Plan

1 inch = 4,000 feet

0 1,000 2,000 4,000 Feet

Figure 11-5
Percent Recharge Change

CDM Smith

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Table 11-2 shows that the flow transferred outside of the MEP watersheds is very low and does not trigger any threshold for an interbasin transfer. More importantly, the MEP watersheds are not considered to be separate basins under this rule since all of the MEP watersheds are part of the Monomoy lens which is located under the Towns of Dennis, Harwich, Brewster, Chatham, Orleans and a section of Yarmouth. Since the CWMP is already being reviewed by MEPA, these threshold are likely to be reviewed but are not expected to trigger a determination from 313 CMR 4.00.

11.5 Summary and Conclusions

In summary, the modeling results indicate that the three potential effluent recharge sites can accept the flows applied in the scenarios identified. The flow applied to HR-12 would result in enhanced flows to the cranberry bogs downgradient providing beneficial impacts to their operations. The flow applied to PB-3 while in a Zone II water supply protection area would be outside of a five-year travel time to any municipal well and thus, is not likely to require increased treatment levels. The flow applied to SH-2 would need to be coordinated with the construction of the new Monomoy Regional High School but application areas could be located beneath new or restored ballfields.

Based on the hydrogeologic findings and the meeting with the MassDEP and CCC, the following items are recommended as part of the implementation phase of the recommended CWMP program.

- Continue monitoring of surface water and groundwater locations to determine seasonal impacts to groundwater, surface water levels and cranberry bogs.
- Develop an adaptive management approach which utilized initial wastewater effluent flow as a loading test at the selected effluent recharge sites.
- Assess the flow capacity of existing hydraulic structures in Coy Brook, Flax Pond and the downstream cranberry bogs near HR-12 during the design phase to identify and mitigate the potential for blockages or limitations in flow. This analysis should include the culvert which carries Coy Brook under Great Western Road as it has been reported to have problems carrying existing flows at high groundwater periods.
- Based on groundwater modeling and preliminary discussions with MassDEP, it is expected that additional treatment for removal of Total Organic Carbon (TOC) will not be required at this site as the time of travel to the nearest municipal is estimated to be over five years.
- The movement among MEP watersheds from wastewater collection and effluent recharge will have minimal impact on the town's municipal water supply.