III. DELINEATION OF WATERSHEDS

III.1 BACKGROUND

The Massachusetts Estuaries Project team includes technical staff from the United States Geological Survey (USGS). These USGS groundwater modelers were central to the development of the groundwater modeling approach used by the Estuaries Project. Martha's Vineyard has not been extensively modeled by the USGS, but a satisfactory revision of a pre-existing sub-regional model was completed by the MEP technical staff with review by the USGS in order to delineate a watershed to Edgartown Great Pond and its sub-embayments (coves).

Martha's Vineyard Island is located along the southern edge of late Wisconsinan glaciation (Oldale and Barlow, 1986). As such, the geology of the island is largely composed of outwash plain and morainal deposits. Re-working of these geologic structures by the ocean since the retreat of the glaciers has significantly affected the physiography of the Island. The main portion of the island was located between the Cape Cod Bay and Buzzards Bay lobes of the Laurentide ice sheet. As such, the areas where the glacial ice lobes moved back and forth with warming and cooling of the climate are moraine areas and these are located along the Nantucket Sound and Vineyard Sound sides of the island. These moraines generally consist of unsorted sand, clay, silt, and gravel. The middle portion of the island is generally outwash plain and is composed of stratified sands and gravel deposited by glacial meltwater. Edgartown Great Pond and its watershed are located within this outwash plain.

The relatively transmissive sand and gravel deposits that comprise most of the Vineyard outwash plain create a hydrologic environment where watershed boundaries are usually better defined by elevation of the groundwater and its direction of flow, rather than by land surface topography (Cambareri and Eichner 1998, Millham and Howes 1994a,b). Freshwater discharge to estuaries is usually composed of surface water inflow from streams, which receive much of their water from groundwater base flow, and direct groundwater discharge. For a given estuary, differentiating between these two water inputs and tracking the sources of nitrogen that they carry requires determination of the portion of the watershed that contributes directly to a stream and the portion of the groundwater system that discharges directly into an estuary as groundwater seepage. In the case of the Edgartown Great Pond system, there were no significant surface water features requiring delineation or stream gauging as is typical of other embayments in the MEP study region. As such, freshwater flux to the systems was exclusively driven by groundwater conditions and direct precipitation on the embayment water surface.

The groundwater system of Martha's Vineyard is generally characterized by a shallow, unconfined aquifer generally situated less than 160 feet below NGVD (1929) throughout the majority of the outwash plain (Delaney, 1980). The groundwater system in the western moraine has not been well characterized and its mix of clay, till, sand and peat produces both unconfined and confined aquifer conditions. Regional studies of groundwater within the outwash plain have refined the understanding of the geology and hydrology in the area (MVC, 1999) and further information has been provided by regular monthly monitoring of 14 long-term monitoring wells by the Martha's Vineyard Commission. All of this information has been useful for subsequent activities, including the delineation of estuary watersheds completed by the Massachusetts Estuaries Project Technical Team.

III.2 EDGARTOWN GREAT POND CONTRIBUTORY AREAS

MEP technical staff reviewed a sub-regional groundwater model originally prepared by Whitman Howard (1994) and subsequently updated by Earth Tech. This model organized much

of the historic geologic data collected on the Vineyard and provided a satisfactory basis for incorporating the refinements necessary to complete the Edgartown Great Pond watershed delineation.

The MEP Technical Team with assistance from the USGS revised the model grid to match orthophotographs of the island, which resulted in a grid with 126 rows oriented southwest and 167 columns oriented southeast. Hydraulic conductivities were reworked to match the revised grid. Outputs from the revised model were compared with water table elevations generated for previously approved MassDEP Zone II drinking water well contributing area delineations and the match was acceptable. The MEP Technical Team then used the revised model to define the watershed or contributing area to Edgartown Great Pond and its sub-embayments. The Edgartown Great Pond watershed is situated along the southern edge of Martha's Vineyard and is bounded by the Atlantic Ocean to the south (Figure III-1).

The MEP Technical Team utilized the Edgartown Great Pond watershed to develop daily discharge volumes for various sub-watersheds as calculated from the watershed areas and an island-specific recharge rate. In order to develop the groundwater discharge volumes, MEP Technical Team members determined a recharge rate of 28.7 inches per year for Martha's Vineyard. In order to develop this recharge rate estimate, the MEP Technical Team reviewed the recharge and precipitation rates used on Cape Cod. In the preparation of the Cape Cod groundwater models, the USGS used a recharge rate of 27.25 in/y for calibration of the models to measured water levels (Walter and Whealan, 2005). The Cape Cod recharge rate is 61% of the estimated 44.5 in/yr of precipitation on the Cape. Precipitation data collected by the National Weather Service at Edgartown since 1947 yields a 20 year average precipitation of 46.9 in/yr (http://www.mass.gov/dcr/waterSupply/rainfall/precipdb.htm). If the Cape Cod relationship between precipitation and recharge is applied to the average Vineyard precipitation rate, the estimated recharge rate on Martha's Vineyard is 28.7 in/yr. This rate was used to estimate groundwater flow to Edgartown Great Pond and its various sub-watersheds (Table III-1). The discharge volumes developed for the sub-watersheds were used to assist in the salinity calibration of the tidal hydrodynamic models. The overall estimated groundwater flow into Edgartown Great Pond from the MEP delineated watershed is 36,437 m3/d.

The area and estimated discharge for the MEP watershed delineation are similar to previous delineations. Gaines (1993) estimated a 4,200-acre groundwater watershed to Edgartown Great Pond based on Delaney's (1980) water table map. The watershed delineation based on Whitman and Howard's (1994) modeled water table map resulted in a watershed area of 3,854 acres (MVC, 1999). The Martha's Vineyard Commission refinement of water table contours in selected areas along Gaines' historical watershed boundary resulted in some reassessment of the boundaries and the subsequent watershed area increased to 5,100 acres (MVC, 1999). Given the additional groundwater well water level data provided by the MVC as well as the model grid refinements completed by the MEP Technical Team with assistance from the USGS, the current delineation being utilized by the MEP in this analysis (as presented in Figure III-1) is likely most reflective of actual groundwater fluxes to the Edgartown Great Pond systems in comparison to historical delineations. As such, the MEP and the USGS determined that the current version of the delineations presented herein serve as an appropriate basis for completion of the Linked Watershed-Embayment Model for the Edgartown Great Pond system.

Table III-1. Daily groundwater discharge from each of the sub-watersheds to the Edgartown Great Pond Estuary.

Watershed	Watershed #	Watershed Area (acres)	Discharge	
			m^3/day	ft^3/day
Jobs Point	1	13	106	3,739
Jobs Neck Cove	2	340	2,749	97,089
Pocketapaces	3	435	3,519	124,265
Wintucket Cove	4	1,084	8,771	309,753
Janes Cove	5	367	2,965	104,715
Kanomika Neck	6	50	407	14,362
Mashacket Cove	7	890	7,195	254,092
Turkeyland Cove	8	239	1,936	68,372
King Point	9	255	2,066	72,945
Slough Cove	10	648	5,241	185,092
Butler Neck	11	142	1,145	40,443
South Beach	12	42	337	11,910
TOTAL		4,505	36,437	1,286,777

NOTE: Discharge rates are based on 28.7 inches per year of recharge.

Review of watershed delineations for Edgartown Great Pond allows new hydrologic data to be reviewed and the watershed delineation to be reassessed. The evaluation of older data and incorporation of new data during the development of the MEP watershed model is important as it decreases the level of uncertainty in the final calibrated and validated Linked Watershed-Embayment Model used for the evaluation of nitrogen management alternatives. Errors in watershed delineations do not necessarily result in proportional errors in nitrogen loading as errors in loading depend upon the land-uses that are included/excluded within the contributing areas. Small errors in watershed area can result in large errors in loading if a large source is counted in or out. Conversely, large errors in watershed area that involve only natural woodlands have little effect on nitrogen inputs to the down gradient estuary. The MEP watershed delineation was used to develop the watershed nitrogen loads to each of the aquatic systems and ultimately to the estuarine waters of the Edgartown Great Pond system (Section V.1).

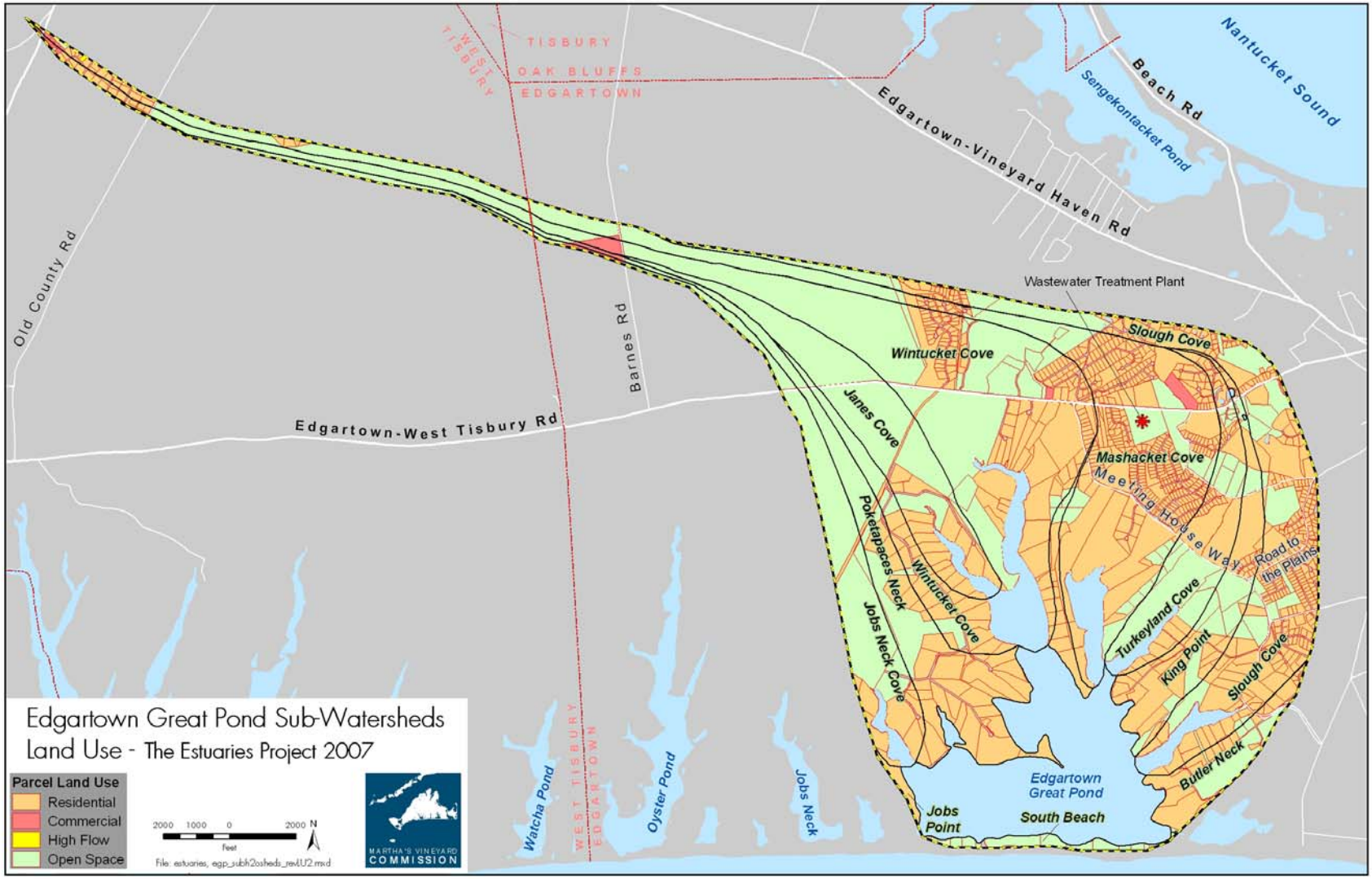

Figure III-1. Watershed and sub-watershed delineations for the Edgartown Great Pond estuary system. Sub-watersheds to embayments were selected based upon the functional estuarine sub-units in the water quality model (see section VI).