



BRISTOL ENGINEERING ADVISORS, INC.
Infrastructure and Water Resources Engineering

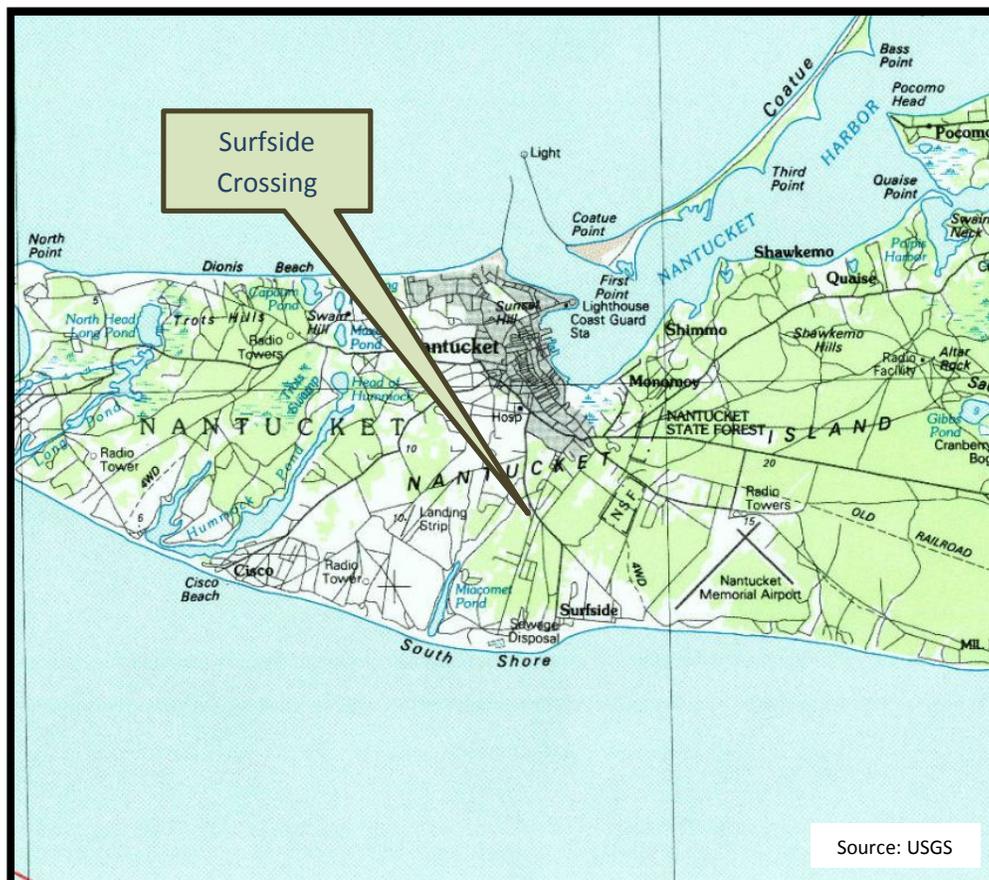
September 19, 2018

Mr. Jason Bridges, Chair
Board of Selectmen
16 Broad Street
Nantucket, MA 02554

Re: Hydrogeologic Assessment of proposed Surfside Crossing Development
Nantucket, MA

Dear Mr. Bridges:

Bristol Engineering Advisors, Inc. (Bristol) is pleased to provide the Board of Selectmen (Board) this letter report detailing our findings pursuant to the geology and hydrogeology of the proposed Surfside Crossing project. Our review was undertaken in an effort to determine whether the Project has a reasonable potential to adversely impact the island's water resources



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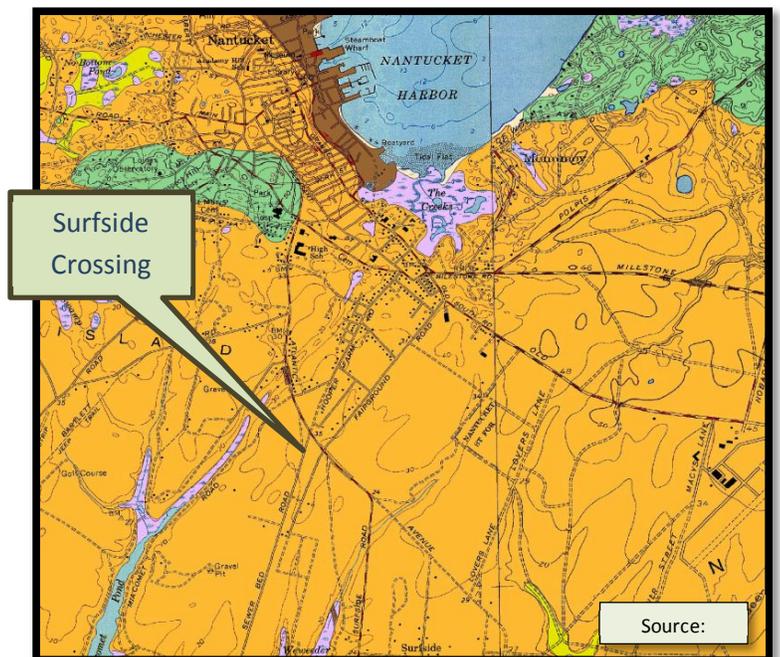
This letter report has been prepared based on data and records obtained from the Wannacomet Water Co., the Town of Nantucket and a MassDEP file review conducted on September 4, 2018. No independent data collection or field work was performed. This document represents a collation and interpretation of existing information and is, therefore, entirely dependent upon the integrity of the data reviewed.

The Surfside Commons Project seeks to build 156 units of residential housing, totaling 389 bedrooms, at a currently undeveloped site outside of the Town Center along South Shore Road, south of its intersection with Surfside Road. There are concerns about the Town's ability to accommodate the additional water supply and wastewater demands this project will create. Additionally, because the site is located within the Zone 2 of the Wannacomet Water Company's public water supply wells, there is increased potential for contamination and/or stormwater runoff emanating from the Project site to impair the Town's water supply.

It is common to estimate water usage by using demand estimates included in Massachusetts Title 5 regulations (310 CMR 15.00). Title 5 estimates 110 gallons per day (gpd) per bedroom. With 389 bedrooms, the Title 5 estimate for water demand and wastewater generation is 42,790 gallons per day. An independent water demand analysis commissioned by the Zoning Board of Appeals was recently performed by the Wannacomet Water Company's consultant (Haley and Ward 2018). Their analysis estimated an average day demand of 36,800 gpd, and a peak day demand of approximately 92,000 gpd. These average and peak demand values are derived from the water company's prior experience with similar projects and from system-wide averages.

Site Geology and Hydrogeology

The Project site is located in the center of the island, approximately midway between two shallow lenses of mounded groundwater to the east and west. Geologically, the soils underlying the site are of glacial origin. The island has been subject to multiple glaciations over the past 150,000 years, the most recent – the Wisconsinan – terminating at approximately the location of the Nantucket Town Center between 15,000 and 10,000 years ago. The older – Illinoian – retreated ca. 150,000 years ago and underlies the Wisconsinan deposits. The thickness of these glacial deposits is greater than 500 feet below sea level in some locations and overlies still older deposits of Cretaceous (135 MY – 65 MY before present) and possibly Triassic (225 – 190 MY before present) age.

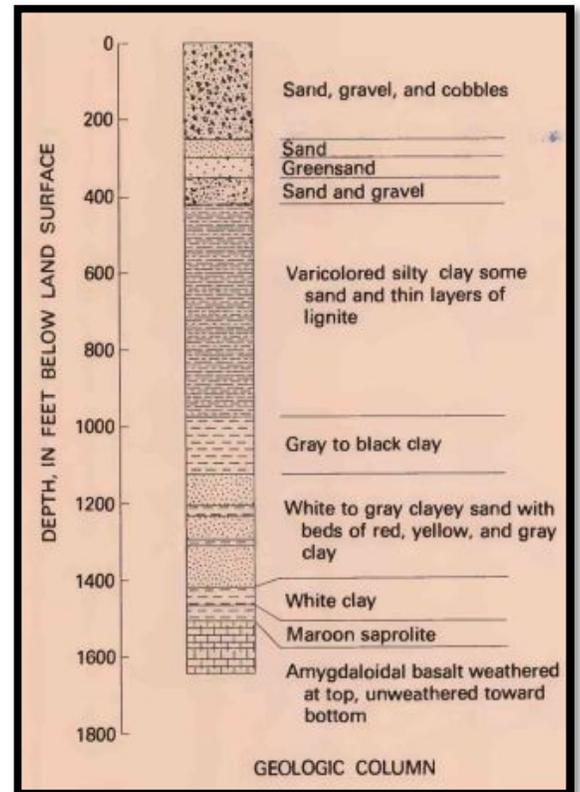


This repeated glaciation has resulted in at least two discrete aquifer complexes, the lower Illinoian aquifer partially isolated from the newer Wisconsinan aquifer by a layer of till. This middle layer of



Wisconsinan till contains substantial quantities of fossiliferous debris from the interglacial period when sea levels were comparable to present day. The debris includes shells, which are predominantly calcium carbonate. As rainwater infiltrates through to this lower aquifer, the calcium carbonate buffers its natural acidity, raising the pH considerably. This process is reflected in the rather different water quality observed in the Illinoisan compared to the Wisconsinan aquifer, as described in the Source Final Report for the State Forest well Source Final Report (Haley and Ward, 1993)

Bedrock underlying Nantucket is extremely deep, reported to be greater than 1,500 feet below ground surface, of probable Triassic age (USGS 1980). While bedrock can often influence the movement and characteristics of groundwater at sites elsewhere in New England through recharge and discharge, it is very unlikely to have any practical effect on groundwater resources on Nantucket due to its extreme depth. The following figure is from a 1980 USGS publication and presents the lithologic features of a single boring advanced to a depth of 1,686 feet below ground at the center of the island. The figure shows the permeable Wisconsinan and Illinoisan deposits in the upper 250 feet, with a third conductive zone located from about 375 feet to 410 feet below ground. Below 410 feet, the geologic materials consist largely of silts and clays, and would not be considered suitable for water supply development purposes.



The great depth to bedrock results in the islands fresh water resting atop ancient salt water that is connected to the Atlantic ocean. Fresh water is less dense than salt water and as a general rule will float on top of the salt water, with a transition zone of increasing salinity between the two due to molecular diffusion. Saltwater is approximately 2.5% more dense than fresh and according to the Ghyben-Herzberg relation, for every foot above sea level, the freshwater lense will depress the salt water approximately 40 feet (Barlow 2003). A USGS well near the center of the island has measured the lense to be about 500 feet thick, thinning out towards the shoreline and terminating a short distance offshore (USGS 1980).

Water Supply Resources

The Wannacomet Water Company operates five (5) public water supply wells, all located between the harbor and the airport. Combined, these five sources have the MassDEP approved capacity to produce nearly 6.0 million gallons per day. The recently approved Well Nos. 15 and 16 are replacements for the Milestone tubular wellfield and are located in the upper Wisconsinan aquifer. The Milestone #2, State Forest and North Pasture wells are located below the Wisconsinan till into the underlying Illinoisan aquifer. The well closest to the Project is State Forest well, located 4,700 feet east. The next closest well is the Milestone #15 well, at 5,485 feet northeast. The North Pasture well is the furthest from the site and 8,900 feet northeast.



Well	Depth	Yield
Milestone #2	180'	700 gpm
State Forest	180'	1,000 gpm
North Pasture	165'	1,000 gpm
Milestone #15	78'	800 gpm
Milestone #16	75'	600 gpm

The Wannacomet Water Company also has four million gallons of storage in two storage tanks, the 2.0 million gallon Washing Pond storage tank and the 2.0 million gallon North Pasture tank.

MassDEP has authorized the water company a total withdrawal of 613.2 million gallons per year. Of this, 222.65 million gallons is considered grandfathered withdrawal capacity and 390.55 million gallons is permitted under the Water Management Act. This equates to an average daily withdrawal of 1.68 million gallons. The water company is substantially below this amount during the fall, winter and spring months, but considerably above in the summer due to the influx of visitors and seasonal residents. To date, the water company has been able to supply the demand while remaining at or slightly above its authorized withdrawal. However, increasing demand from this project and others means the water company will be required to either implement water conservation policies or seek a permit for additional withdrawal volume in the near future.

The Haley and Ward water supply review (2018) states that the Wannacomet Water Company has sufficient supply and storage capacity to meet the additional demand the Surfside Commons project will require; however, they may have difficulty staying within their MassDEP authorized volume now and into the future. This appears to be more of a systemic issue with some aggressive demand projections provided by the regulatory agencies that may significantly underestimate the summer population on the island.

Hydrogeology

Groundwater flow is dictated by the permeability of the soils through which it flows, the pressure driving the flow as determined by the slope of the water table and by the size of the pore spaces through which the water flows. The hydraulic conductivity of an aquifer is typically represented as distance per unit time (feet per day, for example), but is more accurately represented as a volume per unit time per cross-sectional area through which it flows (gallons per day per square foot, for example). This second representation tends to be more consistent with the original equation for groundwater flow:

$$Q = kiA$$

Known as Darcy's Law, it forms the basis of virtually all hydrogeologic assessments. Q is volumetric flow within an aquifer, i is the hydraulic gradient and A is the cross-sectional area of the aquifer. From this equation one can derive many aquifer properties. It is particularly useful in estimating groundwater



flow velocity across a site and is generally calculated using data obtained by performing aquifer tests such as pump tests or slug tests. Bristol has reviewed pump tests performed on the State Forest well (Haley and Ward, 1993) and on the Milestone replacement wells 15 and 16 (Haley and Ward 2017).

The testing performed at these sites demonstrated their suitability as locations for highly productive groundwater supply wells.

The hydraulic conductivity (**k**) at the Milestone sites screened within the Wisconsin deposits ranged from 221 - 254 $\text{ft}^3/\text{d}/\text{ft}^2$, and was calculated to be as high as 456 $\text{ft}^3/\text{d}/\text{ft}^2$ at the State Forest well in the Illinoian deposits. These values are consistent with published values for coarse sands and gravels. Using a graphical representation of water table elevation provided by the USGS, an estimate of 0.000273 feet per foot (f/f) and 0.000106 f/f was derived for the hydraulic gradient (**i**) at the Milestone and State Forest well sites, respectively. Seepage velocity (**V**) is calculated according to the following formula:

$$V = \frac{ki}{n}$$

Typical porosity (**n**) values are in the range of 0.15 for poorly sorted mixed deposits to around 0.3 for well sorted sand. It is very difficult to measure actual porosity in the field, so using a value in the middle of this range is typical for real-life circumstances. Using 0.22, we arrive at a range of groundwater seepage velocity of 0.32 feet per day between the Project site and Milestone wells; and 0.215 feet per day between the Project and the State Forest well. These velocities translate to a time of travel of 47 and 60 years, respectively.

Zone 2

MassDEP defines Zone 2 (Zone II) as follows:

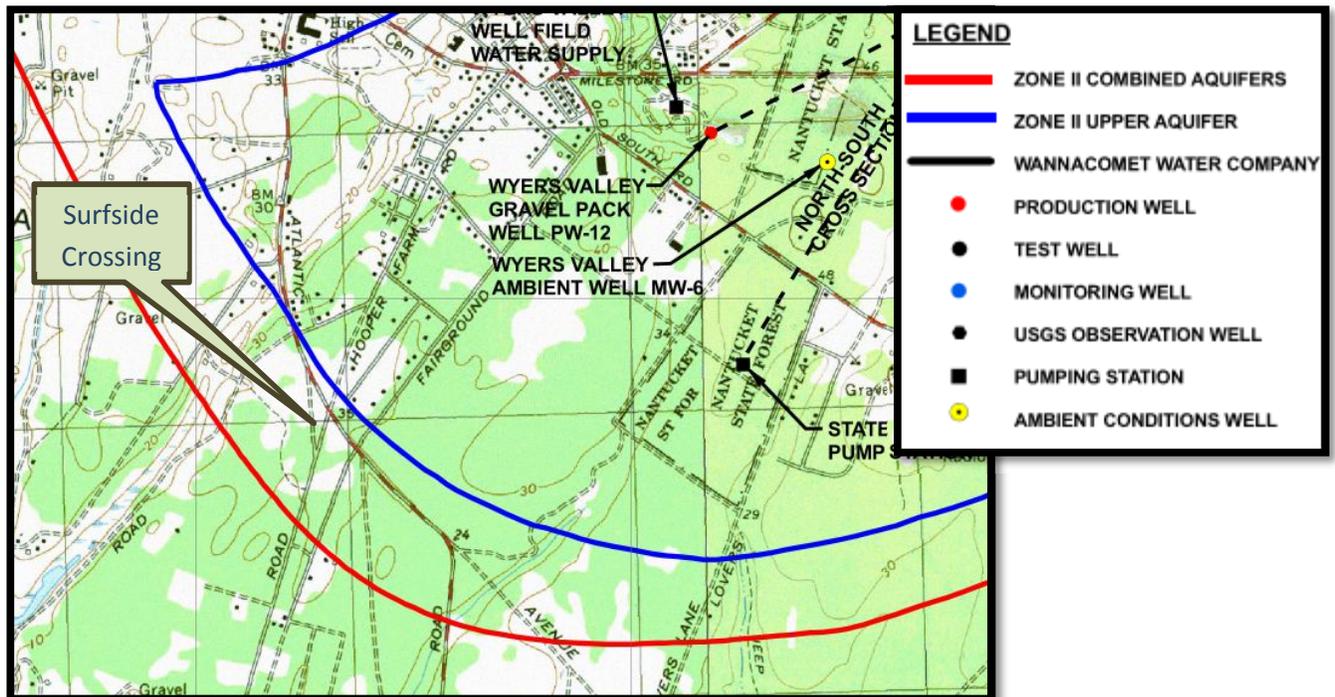
...that area of an aquifer that contributes water to a well **under the most severe pumping and recharge conditions that can be realistically anticipated** (180 days of pumping at approved yield, with no recharge from precipitation). It is bounded by the groundwater divides that result from pumping the well and by the contact of the aquifer with less permeable materials such as till or bedrock. In some cases, streams or lakes may act as recharge boundaries. In all cases, Zone II shall extend upgradient to its point of intersection with prevailing hydrogeologic boundaries (a groundwater flow divide, a contact with till or bedrock, or a recharge boundary). The Zone II must include the entire Zone I area. ...

The Zone 2 report prepared by Haley and Ward (2011) depicts two Zone 2 delineations – a shallow Zone 2 and a combined Zone 2, which includes the contributing areas to the deep wells. The “shallow” Zone 2 terminates a few hundred feet north of Atlantic Avenue in the direction of the Project site; however, the combined Zone 2 extends further south and encompasses the Surfside Crossing project site.

This delineation implies that surface discharges at the Project site would be unlikely to contribute to recharge to the Milestone wells in the shallow aquifer. However, the deeper aquifer must derive its recharge through the semi-confining layer at 120 feet below ground surface from the overlying aquifer. Therefore, under extreme circumstances it is conceivable that a major environmental release to



groundwater may migrate to the capture zone of the deep aquifer. However, even in this extremely unlikely event, the time of travel to the well site would be in excess of 60 years.



Wastewater

The Project is proposed to be serviced by public sewer and therefore is not anticipated to have any negative water quality impacts from on-site discharge of wastewater.

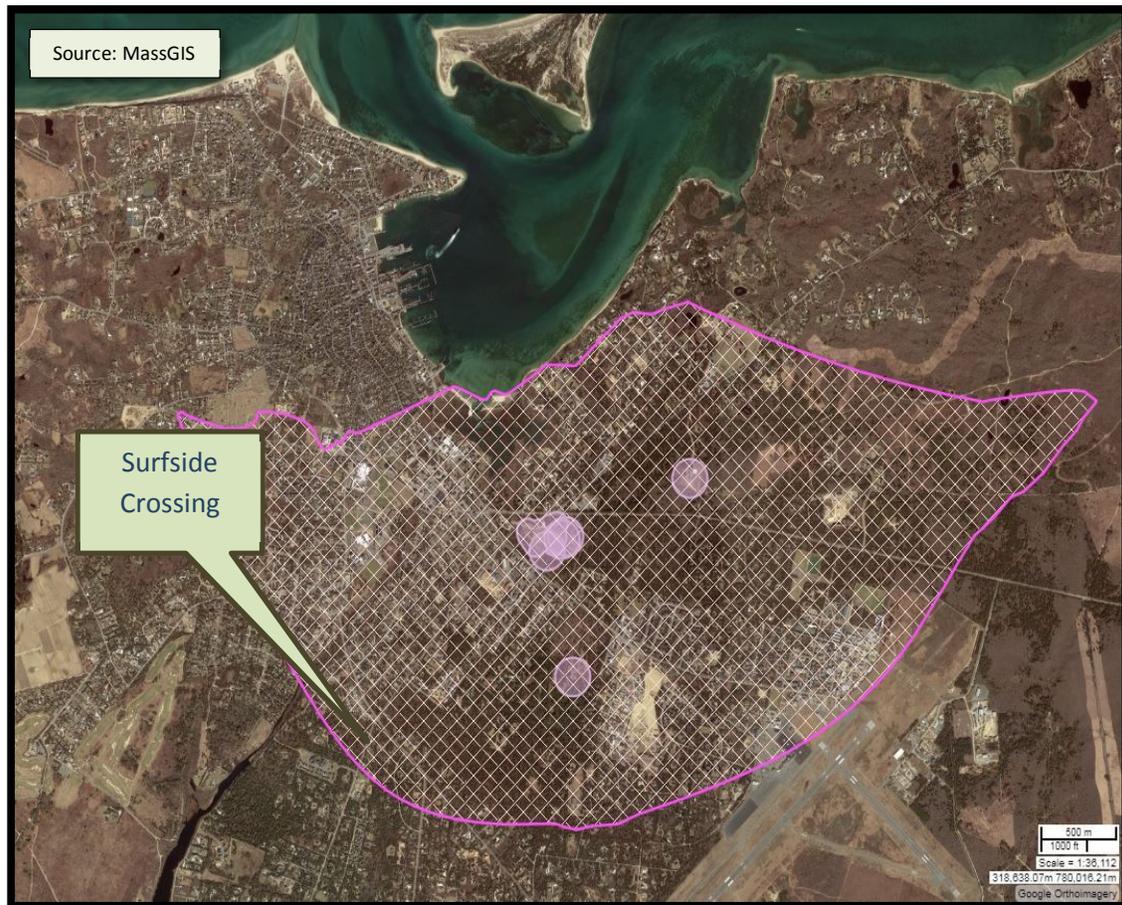
The Town's wastewater is treated and discharged into a series of infiltration beds to the west of Surfside Beach. The Town's groundwater discharge permit is capped at 4.0 million gallons per day (MGD) of treated wastewater effluent. The facilities peak design capacity is 7.7 MGD (David Gray, personal communication). Average daily winter flow is 0.85 – 1.4 MGD; and the average daily summer flow is 1.8 – 2.4 MGD. Peak flows in summer can be as high as 8,000 gallons per minute for multiple hours. Despite these peak flows, it appears that the Nantucket wastewater treatment facility has sufficient capacity available to serve the Project.

Nantucket Zoning Bylaws

The Surfside Crossing project is subject to multiple sections of the Nantucket zoning bylaws. However, for the purposes of this review there are two sections that matter, Chapter 114 – Public Water Supply and Chapter 139 Section 12.B – Public Wellhead Recharge District.



Chapter 114 – Public Water Supply Use Restrictions



Chapter 114 defines the Town’s ability to regulate water use in times of a MassDEP declared water supply emergency. Its scope is limited to this unusual circumstance and is of little relevance to this project.

Chapter 139 Section 12. B. – Public Wellhead Recharge District

The purpose of the Public Wellhead Recharge District is to “preserve the quality and quantity of the Town’s groundwater resources in order to ensure a safe and healthy public water supply.” The section further defines the overlay for the Wannacomet Water Company wells as encompassing the area defined in the 2011 Haley and Ward Zone 2 map.

To the end of preserving the quantity and quality of groundwater, the bylaw contains a list of permitted and prohibited uses, the majority of which the Project is in compliance. However, there are two items which bear mention: 12.B.(1)(b) – incidental use of fertilizers, etc. and 12.B.(2)(q) – impervious surface.



12.B.(1)(b): Incidental use of fertilizers and pest control products, while permitted in a residential setting, has the potential to contaminate groundwater through improper use and storage. It is likely that a homeowner's association (HOA) will be created to manage common services such as snow removal and landscaping. All contractors for seasonal maintenance of facilities and grounds should be required to provide an affidavit as to their knowledge and experience performing their services in environmentally sensitive areas.

12.B.(2)(q): The project site encompasses a total of 590,607 square feet. Of this, 285,309 (48.3%) is proposed to be impervious surface. This exceeds the amount permitted under the bylaw by greater than a factor of 3. While the Applicant has sought a waiver from this section of the bylaw, it does contain a provision for exceeding the 15% (or 2,500 square foot) if "a system for artificial recharge of 95% of annual precipitation is provided that will not result in the degradation of groundwater quality". The Applicant's stormwater report (Bracken 2018) states that runoff from the first 1-inch of rainfall will be treated via Stormceptor units prior to recharge. According to the Bracken Engineering report, each catchment area has been evaluated and the Stormceptor unit sized to achieve at least 80% total suspended solids (TSS) removal.

Stormceptor units have been used for many years in sensitive areas, and have proven themselves to be effective provided they are maintained and accumulated sediment removed and disposed of as needed.

A detailed review of the stormwater management plan was not performed, but it appears that it was prepared in substantial conformance with the MassDEP Stormwater Handbook. What is not included, however is a detailed discussion of the recharge ponds (which appear to be drywells) or the site's ability to infiltrate the nearly 24,000 cubic feet of runoff from a 1-inch rainfall, or the nearly 140,000 cubic feet from the 25-year storm in the 10 drywells that are proposed.

Summary

Bristol has reviewed the 40B permit application and a large quantity of additional documents pertinent to this review. Based on our extensive review, it is our professional opinion that the project, as proposed, does not present a significant threat to either the quantity or quality of groundwater available to the Town. This conclusion is based on the following:

- An independent review of water capacity by the Wannacomet Water Company's engineering consultant concluded that the Water Company has sufficient water supply capacity at present and for the foreseeable future.
- The project is to be serviced by the public sewer system and therefore will not have adverse water quality impacts to groundwater due to on-site wastewater disposal. Additionally, the Town's wastewater treatment facility has sufficient capacity for the additional wastewater flows.
- There is expected to be a substantial volume of runoff generated, but the Applicant is proposing to treat and infiltrate the entire volume on-site. This treated stormwater will infiltrate into the



shallow aquifer that serves direct recharge to the Milestone Well Nos. 15 and 16, but that it is outside of capture zone for these shallow wells. The shallow aquifer serves as a source of recharge to the deeper aquifer from which the balance of the Water Company's wells draw. However, the estimated travel time from beneath the Project site to the nearest Water Company well is approximately 60 years.

Despite our opinion that the Project does not present a viable threat to groundwater resources, Bristol has the following recommendations to further assess and/or minimize concerns:

- The Applicant should provide additional information regarding the stormwater infiltration capacity and an analysis for evaluating the ability of the drywells to infiltrate the 25-year storm.
- Bristol recommends that the ZBA require the establishment of a Homeowner's Association (HOA) to manage facilities and grounds maintenance. The HOA documents should require the use of organic and/or non-toxic fertilizers and pesticides, as well as documented training of professional applicators.

We appreciate the opportunity to be of service to you. If you have any questions, please do not hesitate to contact me (508)758-8270 or at peter.newton@bristolea.com.

Respectfully,

BRISTOL ENGINEERING ADVISORS, INC.

A handwritten signature in blue ink that reads "Peter L. Newton". The signature is fluid and cursive.

Peter Newton, PG



References and Citations

- Bracken Engineering, Inc., Stormwater Report for Surfside Crossing, LLC, February 15, 2018.
- Comprehensive Permit Application to the Nantucket Zoning Board of Appeals, Surfside Crossing, LLC, March 2018.
- Haines Hydrogeologic Consulting, Hydrogeologic Assessment Report, Westender Restaurant, October 1992.
- Haley and Ward, Inc., Report of the Groundwater Exploration Program and Request for Site Approval at Nantucket State Forest, October 1991.
- Haley and Ward, Inc., Proposal for Conducting a Prolonged Pumping Test at Nantucket State Forest, April 1992.
- Haley and Ward, Inc., Source Final Report: Nantucket State Forest Public Water Supply Well, December 1993.
- Haley and Ward, Inc., Request for Site Exam at 00 North Pasture new Source Location, Nantucket, MA, October 2005.
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- Haley and Ward, Inc., Source Final Report: North Pasture Public Water Supply Well, Nantucket, Massachusetts, January 2011.
- Haley and Ward, Inc., "Narrative to Accompany BRP WS-20: Approval to Construct Milestone Well 15 and 16", April 7, 2017.
- Haley and Ward, Inc., Letter to Mr. Edward Toole, Chairman, Nantucket Zoning Board of Appeals, Peer Review of Water Supply Issues, August 20, 2018.
- Horsley Witten Hegemann, Inc., Water Resources Protection Plan, Nantucket, Massachusetts, January 1990.
- MassDEP, BRP WS-20: Approval to Construct Milestone Replacement Wells 15 and 16, June 21, 2018.
- MassDEP, BRP WS-32: Distribution Modification: Chlorination at Washing Pond Storage Tank, June 28, 2012.



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Walker, Eugene H., 1980, "Water Resources of Nantucket Island, Massachusetts", USGS Hydrologic Investigations Atlas, HA-615.

Wannacomet Water Company, Annual Statistical Reports to MassDEP. 2015, 2016, 2017.

Town of Nantucket Zoning Bylaws.