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October 24, 2017

Via Federal Express/Electronic Mail

Todd Anthony Bianco, PhD, EFSB Coordinator
RI Energy Facilities Siting Board
89 Jefferson Blvd.
Warwick, RI 02888

Re: Invenergy Docket No. SB-2015-06

Dear Dr. Bianco:

On behalf of Invenergy Thermal Development LLC and the Clear River Energy Center Project ("Invenergy"), enclosed please find an original and three (3) copies of a report entitled "CREC's Proposed Water Use from the Lower Wood Watershed," prepared by ESS Group, Inc., dated Oct. 23, 2017.

The information provided to the Board in this report relates to Invenergy's additional contingent/redundant water supply source, the Narragansett Indian Tribe and the Lower Wood Aquifer.

Please let me know if you have any questions.

Very truly yours,

ALAN M. SHOER
ashoer@apslaw.com

Enclosures

cc: Service List

405180\003\875730.v1

CREC's Proposed Water Use from the Lower Wood Watershed

Clear River Energy Center
Burrillville, Rhode Island

PREPARED FOR:
Invenergy Thermal Development LLC
One South Wacker Drive, Suite 1900
Chicago, Illinois 60606

FOR SUBMITTAL TO:
State of Rhode Island Energy Facility Siting Board
89 Jefferson Boulevard
Warwick, Rhode Island 02888

PREPARED BY:
ESS Group, Inc.
10 Hemingway Drive, 2nd Floor
East Providence, Rhode Island 02915

ESS Project No. I108

October 23, 2017

CREC'S PROPOSED WATER USE FROM THE LOWER WOOD WATERSHED
Clear River Energy Center
Burrillville, Rhode Island

Prepared for:

Invenergy Thermal Development LLC
One South Wacker Drive, Suite 1900
Chicago, Illinois 60606

For Submittal to:

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October 23, 2017

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1.0 BACKGROUND

On October 28, 2015 Invenergy Thermal Development LLC (Invenergy) requested approval from the Rhode Island Energy Facility Siting Board (EFSB) to construct and operate the Clear River Energy Center (CREC or Facility), a combined-cycle electric generating facility to be located on Wallum Lake Road (State Route 100) in Burrillville, Rhode Island (the Project or the Facility).

The Facility will have a nominal power output at base load of approximately 850-1,000 megawatts (MW) while firing natural gas. The Facility will be configured as a two-unit one-on-one (1x1), combined-cycle generation station. Each unit will consist of an advanced class combustion turbine operated in a combined-cycle configuration with a heat recovery steam generator (HRSG), a steam turbine and an air cooled condenser (ACC) for each train. Each gas turbine will fire natural gas as a primary fuel and ultra-low sulfur distillate (ULSD) fuel as a backup fuel. The Facility will be equipped with state-of-the art air emission controls and sound abatement systems and has been designed to minimize and avoid impacts to the environment to the greatest extent technologically and economically feasible. The Facility incorporates various features that support load following and fast start operation to balance the variable electrical output of current and future renewable generation in the region.

The utilization of air cooled condensers to remove waste heat from the Facility reduces the overall water consumption of the Facility by *more than 90 percent* of that required to cool electric generating plants using more traditional wet cooling tower systems. Process water use by the Facility has been further reduced by selected water recycling features to an overall level that allows trucking of water to the Facility from off-site sources.

On January 11, 2017, Invenergy filed a revised Water Supply Plan for the Facility that identified that water to support operation of the Facility will normally be supplied from the Town of Johnston, Rhode Island under a long term water supply agreement and delivered to the Facility via state roads by trucks contracted by the Facility. Since the Facility would contract its own water supply trucks, other municipal or private water suppliers could operate as redundant/contingent water suppliers should water from the Town of Johnston water supply system not be available to the Facility. The Town of Johnston water supply will fully meet the water requirements of the Facility under all conditions of operation. The Town of Johnston purchases its municipal water from the Providence Water supply system which has its own water reservoirs and water treatment facility. A long term agreement with the Town of Johnston has been signed, with approval from the Johnston Town Council on January 10, 2017, to meet the needs of the Facility.

Subsequently, CREC issued a Supplement to the Water Supply Plan that identified that CREC has secured commitments from a private trucking company, Benn Water & Heavy Transport (Benn Water) to transport water to the Facility and act as a back-up or contingent water supply. The Benn Water Transport Agreement identifies municipal water systems that Benn Water has the ability to and routinely uses to supply water for its everyday business needs.

CREC has also secured a commitment from the Narragansett Indian Tribe (Tribe or NIT) to supply water to the Facility as an additional back-up or contingent water supply. The Tribe has developed, owns and operates its own wells to meet its public supply requirements. The Tribal wells obtain water from within the southern portion of the Lower Wood Aquifer, located within the Pawcatuck Basin. The Tribe has agreed to supply water, as an additional contingent water supplier, to the Facility. CREC has sampled the water from one of the existing Tribe wells and the analytical results support that it will meet the water quality requirements of the Facility. The water from the Tribe will also be delivered to the Facility by Benn Water under the terms of the Benn Water Transport Agreement.

This study provides an assessment of the potential effect of the Facility's proposed water use from the Tribe's well located in the Lower Wood sub-watershed on the overall availability of groundwater within this watershed. Although the primary water supply to the Facility remains with the Town of Johnston, and other contingent water supplies have been made available to the Facility through the Benn Water Transport Agreement, Invenergy has undertaken this evaluation based on its intent to use this water source as an additional contingent water supply for the CREC and in response to written concerns by the Town of Charlestown as detailed in its Motion to Intervene.

2.0 CREC'S PROJECTED WATER USE

A modern energy efficient gas fired combined cycle electric generating facility is not the classical power plant of the past. The overall efficiency of the generation processes has significantly increased over recent years, and as a result, the amount of fuel used, air emissions produced, water used and wastewater produced have been significantly reduced, compared to older generation technologies. The Facility has been configured as a nominal 850-1,000 MW, energy efficient, dual-fuel combined cycle power plant that will utilize dry cooling to conserve water use.

In a combined cycle power plant, the majority of the electricity (approximately two-thirds) is generated by a gas fired combustion turbine, which is tied to an electrical generator. Waste exhaust heat from the combustion turbine is recovered and used to generate steam in a "Heat Recovery Steam Generator" (HRSG) that uses the waste heat to generate high pressure steam used to spin a more conventional steam turbine which is also tied to an electrical generator. In some combined cycle generation facilities such as the proposed Facility, the steam turbine and the gas turbines share the same shaft saving space in the overall plant configuration. The term "combined cycle" is derived from the two types of turbines involved (gas and steam turbines).

After passing through the steam turbine the exhaust steam, now devoid of its useful energy, must be condensed back into water in a steam condenser and the condensed water is then reused in the cycle and pumped back to the HRSG. To condense the steam, the Facility features a dry cooling system, which is similar to the cooling provided by a typical automobile radiator, which cools by the use of ambient air supplied by fans.

The use of a dry cooling system by the proposed Facility reduces the amount of water and wastewater generation by more than 90% from that which would have otherwise been required if a more conventional wet cooling tower had been selected. Most power plants in New England use wet cooling and as a result consume considerably more water per megawatt of electricity generated. Although dry cooling costs more than wet cooling, Invenergy has selected the dry cooling system for this site to minimize water use.

The use of dry cooling, as compared to more conventional wet cooling, is increasing in New England to reduce demands on available water supplies.

The Facility's overall daily water demand will vary with plant load, the ambient air temperature and the fuel used in firing the Facility. Modern combined cycle electric generating facilities in New England are primarily fueled by natural gas, and at times, during unusually cold winters when natural gas supplies could become under severe stress, some electric generation plants are required by the Independent

System Operator New England (ISO-NE) to fire distillate oil to conserve the natural gas supplies for home heating and commercial use. Water use by combined cycle electric generating facilities increases when distillate oil is fired, as water is used in the combustion process to control the temperature of the combustion flame significantly reducing emissions that otherwise would have occurred. Conditions that lead to a need to fire distillate oil are typically infrequent and short in duration in New England.

The Facility's normal daily water demand with both combustion turbines firing natural gas under a full-load normal condition will be approximately 15,840 gallons per day (gpd) for the spring, fall and winter seasons (while firing natural gas) and for the summer condition (approximately 3 months per year) will be approximately 18,720 gpd (while firing natural gas). CREC has significant on-site water storage in two tanks, the Fire Water/Service Water storage tank whose capacity is 1,050,000 gallons and the Demineralized Water storage tank whose capacity is 1,850,000 gallons. To put this in perspective, if the Demineralized Water storage tank was full, the Facility could run on natural gas for more than 3 months without any water deliveries.

During the summer months, in order to increase power output of the Facility when conditions allow it may be desirable at times to operate a device called an evaporative cooler that uses water evaporation to cool the inlet air to the combustion turbines increasing their overall electric generation output; although this mode of operation is discretionary, the frequency of operation can be selected to only that required to maximize electricity generation from the Facility as the on-site water supply tanks capacity may permit. Evaporative coolers are only effective when air temperatures are high and the relative humidity is low which occurs during many hot summer days but are ineffective during the night when humidity levels rise and ambient air temperatures fall.

Operation of the evaporative coolers requires an additional water use of up to approximately 4,600 gallons per hour (this is the amount of water used when the air temperature is 90^{o}F and the relative humidity is low like 45% relative humidity (RH). At lower air temperatures or higher relative humidity, the amount of water used will be less for each hour the evaporative coolers are operated. The use of the evaporative coolers is discretionary and Invenergy believes that it could be operated on average 4 to 6 hours per day[1] during the summer months; approximately mid-June to mid-September.

The natural gas supply to New England is delivered via pipeline from outside of the region. Historically, expansion of the natural gas supply into the region was not pursued because natural gas was more expensive than distillate oil. With the major expansion of the natural gas supply in the U.S., there has been a reduction in the price of natural gas, and as a result, many major gas pipeline companies are undergoing and/or pursuing projects to expand their delivery capacity into the region. As a result, once these natural gas pipeline expansions are complete, the pressures on the regional natural gas distribution system that historically have forced the use of distillate oil firing in some winters should be lessened.

To put the above in perspective, over the last five years in New England with the current limited natural gas pipeline capacity into the region, there has been an average of only five days per year when gas fired electric generation were asked to switch to distillate oil. Five days per year means, if the Facility had existed for the last five years, the Facility would have fired natural gas 98.6% of the time. Given the facilities locations and being connected to both of the Algonquin pipeline mainlines (24" and 30"), it has excellent access to natural gas and, as such, would be one of the last dual fuel units called upon to switch

[1] Invenergy Thermal Development LLC Response 22-31 to the Town of Burrillville (dated February 14, 2017)

to oil. For the last two winters, there has been no scarcity or emergency events that may have caused the Facility, if it had existed, to have been called upon to operate on distillate fuel oil. Not all of the electric generating facilities in New England have the capability of firing oil; and most, if not all are limited in the number of days they can operate on oil (i.e., oil firing) by the amount of oil and/or water stored on site.

Projecting forward with the natural gas pipeline expansions underway and the growth of renewables throughout New England, whose output is not tied to the natural gas supply, the total annual days of oil firing should lessen with the increasing supplies of natural gas and renewables helping to reduce winter shortages of this critical fuel to the region.

If the Facility is requested by ISO-NE to fire one of the gas turbines on distillate oil (the other gas turbine will remain on natural gas), the water consumption from on-site storage by the Facility will increase by approximately 724,320 gpd for each full day of oil firing. The on-site water and distillate oil storage tanks have been sized to provide a total of 3 days of oil firing operation (the Facility's on-site storage tanks are as follows; Distillate Oil 2,000,000 gallons, Fire Water/Service Water 1,050,000 gallons and the Demineralized Water 1,850,000 gallons). Given that both oil and water are delivered by truck, it is not possible for the Facility to operate on oil beyond the storage capacity of the onsite oil and water storage tanks. Invenergy has requested a 15-day annual limit on distillate oil firing, which if it were to occur, could not be continuous due to the volume limitations of the on-site water and oil storage tanks. Refilling of these water tanks will occur only on an extended trucking schedule and the re-filling will be limited by the number of truck trips per day (13) as outlined in the water plan filed with the EFSB in January 2017.

Although the water use by the Facility will vary with each season, and can increase in the coldest of winters should the Facility be called upon to fire distillate oil, a conservative estimate of the total annual water quantity expected to support the Facility is provided below in **Table 1**.

Table 1

CREC's Projected Water Draw from its Water Source

Operating Condition and Use	Days	Gallons Per Day	Total Gallons
Base Water Demand for Facility			
Ambient Spring/Fall/Winter Natural Gas Firing	250	15,840	3,960,000
Summer Natural Gas Firing	90	18,720	1,684,800
Additional Water Demands (as needed; in addition to Base Water Demand)			
Optional Summer Evaporative Cooler Conservatively Assumed at 8 hours/day at 4,600 GPH *	90	36,800	3,312,000
Distillate Oil Firing – One Gas Turbine ** (3 Days of Oil Firing)	**25*** **	**104,000********	**2,600,000**
Total		**GPY**	**11,556,800**

NOTES

GPD – Gallons Per Day

GPY – Gallons Per Year

*Evaporative cooling Summer water demand is 4,600 additional gallons per hour, when used
Although 8 hours per day is assumed, the actual expected is only 4-6 hours per day

**Additional water consumption – Oil Firing – 724,320 gpd will be provided by drawing down on-site storage tanks and refilling these tanks by truck deliveries to the facility

Gallons Per Day values previously reported in Water Supply Plan (ESS, 2017a)

Gallons Per Year (GPY) estimate previously noted in response to Town of Burrillville Data Request 27-12

*** - Number of days to complete a refill event following a 3-day oil firing event

**** - Equates to Base Water Demand (15,840 gallons) plus Additional Water Demand (88,160 gallons) to refill storage tanks

Table 1 presents a conservative estimate of the total annual water use by the Facility through a typical operating year assuming the Facility, operated at full load output, stayed on-line 100% of the year, was required to operate on distillate oil for a total of 3 full days in the winter and the Facility operated its optional evaporative coolers for as much as 8 hours per day for a full 90 days (typically mid-June to mid-September). The above is also conservative in that the Facility will not likely operate at full load 100% of the time; most gas fired combined cycle electric generating facilities do not operate continuously at 100% load and more typically operate closer to 60% to 65% of the time which then proportionally will reduce the above total annual water demand.

If and only if the Facility were required to fire distillate oil in the winter there will be a need to re-fill or replenish the on-site water tanks. This re-fill or replenishment event has been planned to occur if needed over an approximately 30 day period to reduce traffic impacts on the local community and limit the daily water demand required by the Facility. If and only if the Facility has been required to fire distillate oil in the winter will there be a need to truck an approximate total of 2.2 million gallons of water to the Facility to re-fill the on-site water tanks depleted by a winter oil firing event.

The water supply to meet this re-fill event will be sourced from the Town of Johnston but if for any reason the Town of Johnston water supply is not available to the Facility, water for this re-fill event will be provided through the Benn Water Transport Agreement and sourced from one or possibly a number of the contingent water suppliers.

Although there are a number of water supplies available through Benn Water, it is possible that the water required to meet this re-fill event could be sourced from the Narragansett Tribe's proposed water well or their existing water sources. If this occurs, the total amount of water that would be needed is approximately 2.2 million gallons (to refill the water storage tanks) plus the normal daily requirements of the Facility over the approximately 25 to 30-day event. As a result, this re-fill event would require approximately 13 trucks per day each carrying 8,000 gallons or a total of approximately 104,000 gallons per day.

From **Table 1** and the above analysis CREC's daily water draw on the NIT well to support plant operations is 15,840 gpd in the spring, fall and winter months, 18,720 gpd in the summer months (mid-June to mid-September), increases to a maximum total of 55,520 gpd (18,720 gpd + 36,800 gpd = 55,520 gpd) in the summer months if the Facility utilizes its evaporative coolers and rises to a maximum of 104,000 gpd (total of 13 trucks per day each at 8,000 gallons per truck) during a winter/spring replenishment event (completed over a timeframe less than 30 days/event) if and only if the CREC Facility was required to operate on distillate oil.

3.0 WATER QUALITY

Water to support operation of the Facility will normally be supplied from the Town of Johnston, Rhode Island under a long term water supply agreement and delivered to the Facility via public roads by trucks contracted by the Facility. The Town of Johnston water supply will fully meet the water requirements of the Facility under all conditions of operation. The Town of Johnston purchases its municipal water from the Providence Water supply system which has its own water reservoirs and water treatment facility. As a result the water quality available to the Facility from the Town of Johnston is sourced from a surface water supply (Scituate Reservoir) and treated by Providence Water in its water treatment facilities before delivery.

All of the contingent water supplies available to the Facility under the Benn Water Transport Agreement are high quality municipal drinking sources fully meeting state and federal drinking water standards and as such these water supplies are excellent sources to provide process water makeup to the Facility. The Narragansett Tribe well water will be an additional contingent water supply for the Facility and based on sampling is a high quality water that does have a higher concentration of Total Dissolved Solids (TDS) (as compared to the surface water sources) that can easily be treated with the Project's on site demineralized water treatment system. All of the contingent water supplies can be treated by the Facility's proposed water treatment systems to produce high quality demineralized water needed by the Facility.

4.0 CREC'S WATER USE AND THE LOWER WOOD SUB-WATERSHED

An evaluation of the potential effect of sourcing the Facility's proposed water demand from the Narragansett Tribe well located within the Lower Wood sub-watershed was performed using readily available information from the following sources:

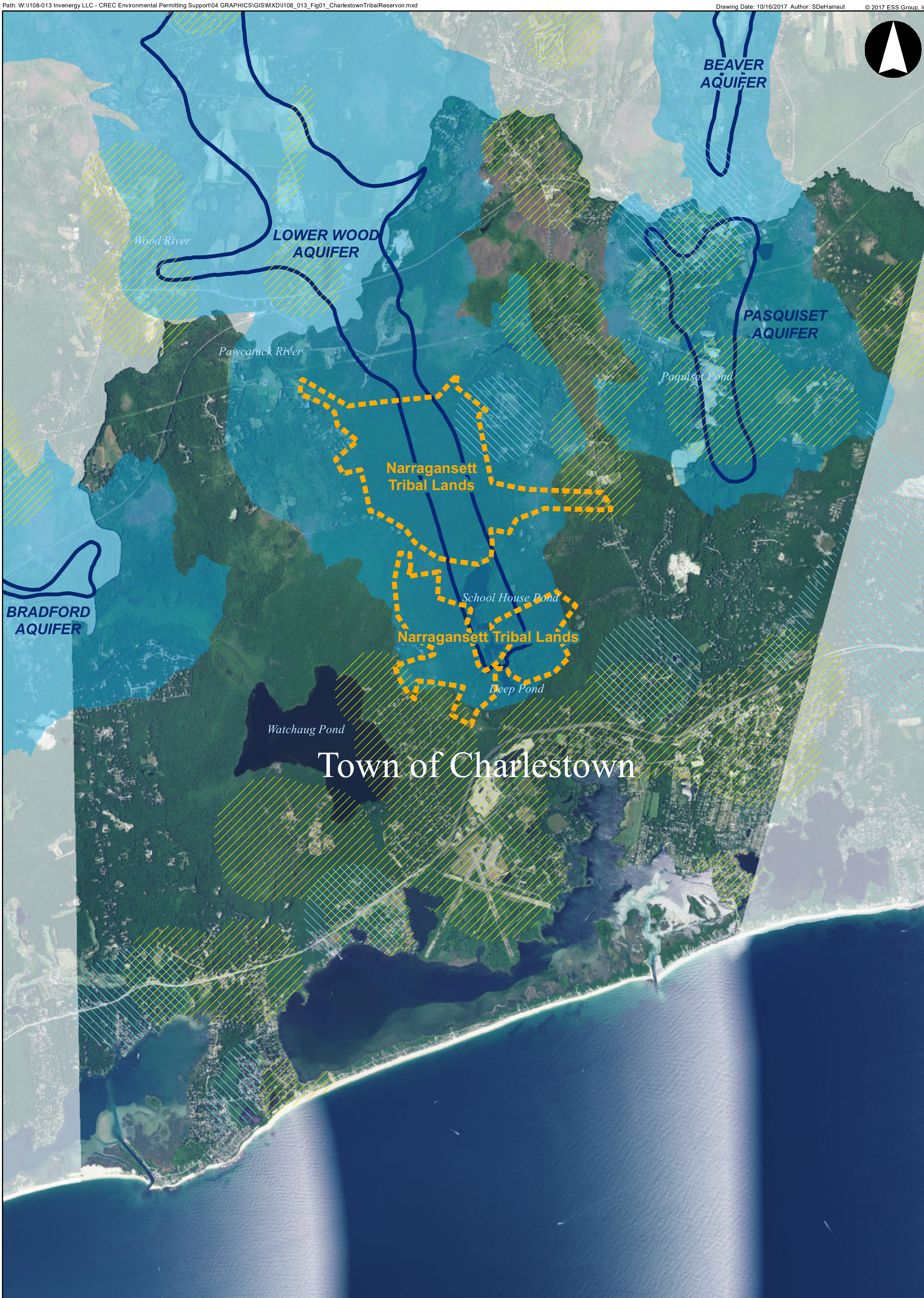
- USGS Water Supply Papers
- USGS Water Resources Investigations Reports
- USGS Open File Reports
- USGS Water Use and Availability Reports
- USGS Scientific Investigations Reports
- Town of Charlestown Potable Water Working Group
- Town of Charlestown Comprehensive Plan and Updates
- Source Water Protection Plan (SWPP) for the Town of Charlestown
- Rhode Island Geographic Information System

Significant geologic features of the Charlestown ("Charlestown" or "Town") area include:

- Coastal outwash plain located to the south of the Charlestown Moraine
- Charlestown Moraine, which separates the northern portion of the town within the Pawcatuck River Basin from the South Coastal Basin, which includes the Salt Pond Region
- Three significant aquifer areas, at least partially occurring within the Town of Charlestown (Refer to **Figure 1** for the locations of these aquifers), which are located within pre-glacial river channels
  - Bradford Aquifer
  - Lower Wood Aquifer
  - Beaver-Pasquiset Aquifer
- Bedrock underlying the area of the Town of Charlestown is predominantly crystalline granite and gneiss

Path: W:\I108-013 Invenergy LLC - CREC Environmental Permitting Support\04 GRAPHICS\GIS\MXD\I108_013_Fig01_CharlestownTribalReservoir.mxd

Drawing Date: 10/16/2017 Author: SDeHainaut



ESS group
environmental consulting & engineering services

0 0.25 0.5 Miles

Clear River Energy Center

Burrillville, Rhode Island

1 inch = 3,833 feet

Source: 1) ESRI, World Imagery, 2016
2) Tribal Boundaries, USGS, 2014
3) RIGIS, Recharge Areas, 2011
4) RIGIS, Reservoirs, 2017
5) RIGIS, Wellhead Protection, 2014

Legend

Tribal Lands
Community Wellhead Protection Areas
Non-Community Wellhead Protection Areas
Groundwater Reservoirs
Groundwater Recharge Areas

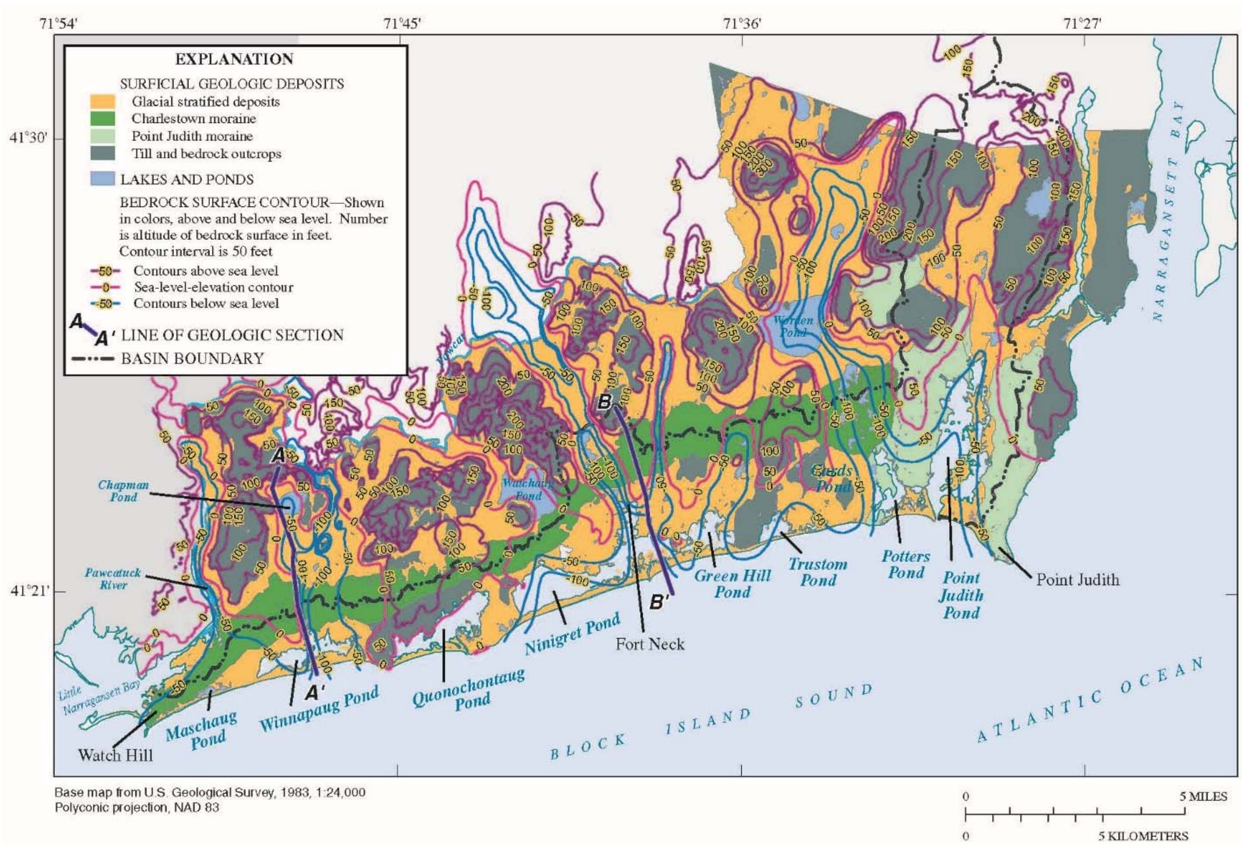
Area of Detail

Groundwater Reservoirs and Groundwater Reservoir Recharge Areas Charlestown, Rhode Island

Figure 1

The majority of the significant geologic features within the town were developed as a result of the most recent glacial activity in the region.

This information was reviewed to develop a conceptual understanding of the hydrogeologic setting in the area of the Town of Charlestown, focusing on the Pawcatuck River Basin, within which the proposed contingent water source for the CREC is located. Given the location of the proposed contingent water source within the Pawcatuck River Basin, and in particular, the Lower Wood sub-watershed, the potential water usage for CREC will have no impact on the groundwater resources within the South Coastal Basin, located to the south of the Charlestown Moraine. Refer to the figure below for the mapped location of the Charlestown Moraine, shown in green (Masterson, et. al., 2006; Figure 3). The two existing Tribe water supply wells are also located within the Lower Wood sub-watershed.



In particular, the USGS report, Estimated Water Use and Availability in the Pawcatuck Basin, Southern Rhode Island and Connecticut, 1995-1999 (herein referred to as the USGS Water Use and Availability Report or 2004 USGS report), provided valuable information into the water availability in the Lower Wood Aquifer. The following text focuses on the information contained in this report. Refer to **Figure 1** for the location of the portion of the Lower Wood Aquifer located within the Town of Charlestown and extending northward into the towns of Richmond and Hopkinton.

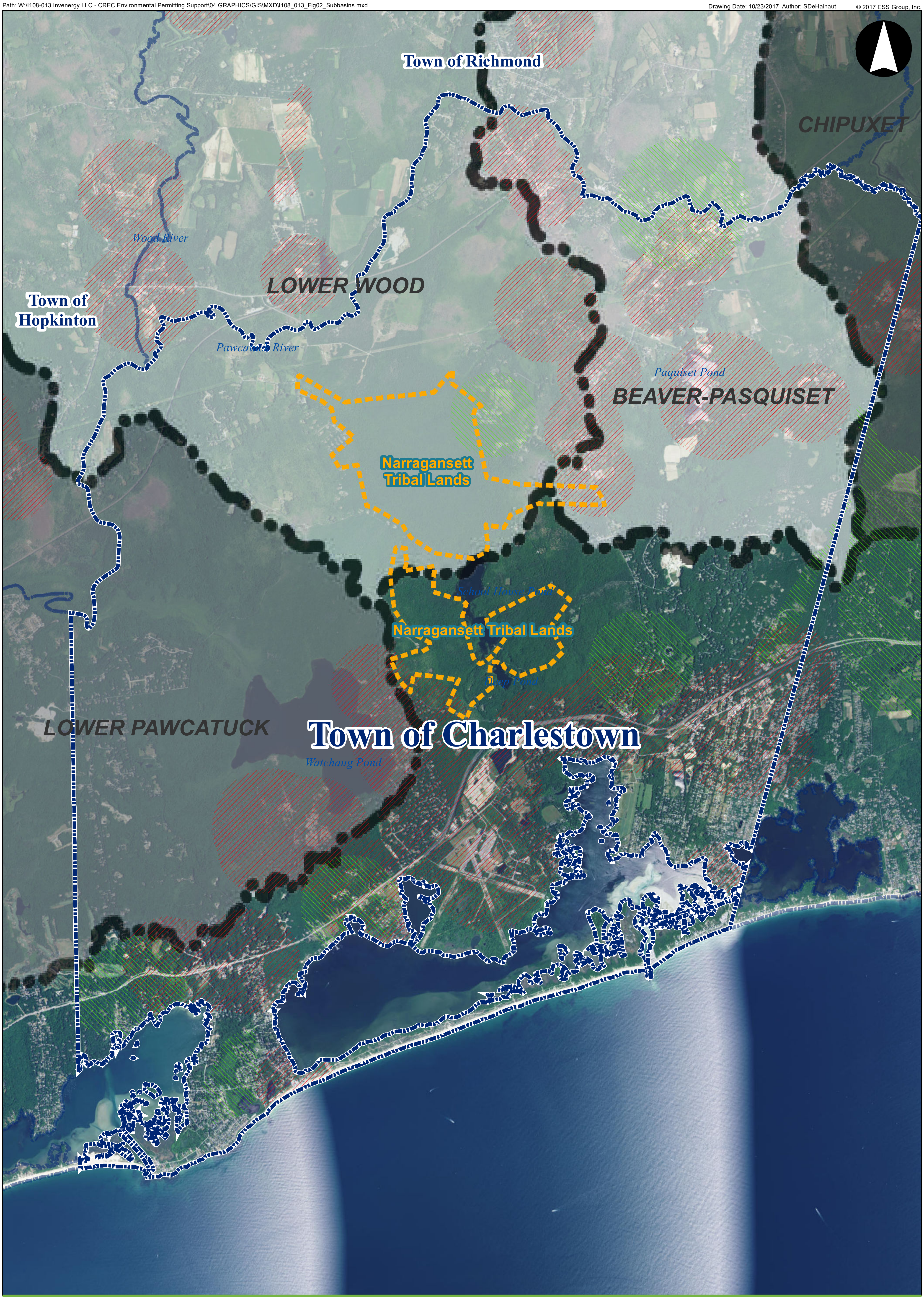
As detailed in the Town of Charlestown Comprehensive Plan and associated updates and the Town's Motion to Intervene, the water supply for the area comprising Charlestown, including the NIT, is through a variety of private, public and quasi-municipal wells. Reportedly, and based on information contained in the various USGS reports, some of these wells are completed in the overburden materials (including both stratified drift deposits and till deposits) and some are completed in the underlying bedrock. Till deposits and bedrock typically do not yield adequate water for large-scale well development but do yield adequate water for individual residential water supply wells. The SWPP (2010) notes the presence of 67 public water systems and over 4,000 private water supply wells and also notes that all drinking water systems in Charlestown, whether public or private, are dependent on groundwater. The approximate locations of community wellhead protection areas and non-community wellhead protection areas are shown on **Figure 1**, as provided by RIGIS. There are no large-scale municipal water or wastewater systems in the Town of Charlestown. It is our understanding that these various private, public and quasi-municipal well water sources occur throughout the Town of Charlestown and obtain water from one of the five watersheds (Chipuxet, Beaver-Pasquiset, Lower Wood, Lower Pawcatuck and South Coastal) that encompass the Town. Refer to **Figure 2** for the locations of these sub-watersheds.

The vast majority of the water used in the Town is recharged back into the underlying overburden materials through on-site wastewater treatment systems (OWTSs). The USGS Water Use and Availability Report notes that 85% of the water used by domestic populations on septic systems (i.e., OWTSs) was returned to the groundwater, based on the estimate that 15% of the water was consumed. This report also estimates that only approximately 10% of typical commercial and industrial water use is consumptive. This limits the consumptive use of groundwater under these conditions but could result in the degradation of groundwater quality over time, but as communities are diligent in monitoring and maintaining OWTSs and monitoring groundwater quality, the degradation can be minimized or limited.

The USGS Water Use and Availability Report is the most recent, comprehensive accounting of water uses within the Pawcatuck Basin, a significant portion of which is located within the Town of Charlestown. This document provides a thorough evaluation of the nature and magnitude of the existing water uses within the various sub-watersheds of the Pawcatuck River Basin, including the Beaver-Pasquiset, Lower Wood and Lower Pawcatuck sub-watersheds which contain the majority of the town land north of the Charlestown Moraine. This document comprehensively summarizes the water uses within the Pawcatuck River Basin, including the Lower Wood sub-watershed, associated with the following land use types.

- Domestic
- Commercial
- Industrial
- Agricultural (generally consisting of irrigation of croplands, including turf farms, and golf courses and provision of water for livestock)

The accounting of the water usage within the Pawcatuck River Basin, as documented in the 2004 USGS report, covered the period from 1995 to 1999. The following assessment focuses on the water usage as summarized in the USGS Water Use and Availability Report within the Lower Wood sub-watershed, which contains the Lower Wood Aquifer. This is the proposed location of the groundwater withdrawal that will be the source of the NIT's contingent water supply. In order to be able to assess the potential effect of the proposed contingent water source for the CREC within the Lower Wood Aquifer, the water use data contained in this report was augmented by population data available from the U.S. Census and



ess group
environmental consulting & engineering services

Clear River Energy Center
Burrillville, Rhode Island

1 inch = 3,833 feet

Source: 1) ESRI, World Imagery, 2016
2) Tribal Boundaries, USGS, 2014
3) RIGIS, Wellhead Protection, 2014
4) USGS, Sub-Basins, 2004

0 0.25 0.5 Miles

Legend
- Town Boundaries
- Tribal Lands
- Community Wellhead Protection Areas
- Non-Community Wellhead Protection Areas

Area of Detail

USGS Sub-watersheds
Pawcatuck River Basin
Charlestown, Rhode Island

Figure 2

population projections by the Rhode Island Statewide Planning Office (2013) for the three towns that currently obtain water from this sub-watershed (Charlestown, Hopkinton, Richmond). **Table 2** summarizes this information.

TABLE 2

Population - Community Total and Lower Wood Sub-watershed Allocation

	TOTAL			PROJECTED TOTAL		
	1990	**2000**	**2010**	**2020**	**2030**	**2040**
Charlestown	6,381	7,859	7,827	8,319	8,915	9,329
% change		*23%*	*-0.4%*	*6%*	*7%*	*5%*
Hopkinton	6,871	7,836	8,188	8,570	9,146	9,537
% change		*14%*	*4%*	*5%*	*7%*	*4%*
Richmond	5,350	7,222	7,708	8,687	9,842	10,855
% change		*35%*	*7%*	*13%*	*13%*	*10%*
Projected Population Allocation Within Lower Wood Sub-watershed						
	TOTAL			PROJECTED TOTAL		
	1990	**2000**	**2010**	**2020**	**2030**	**2040**
Charlestown	1,223	1,506	1,500	1,594	1,709	1,788
Hopkinton	1,460	1,665	1,740	1,821	1,943	2,026
Richmond	1,650	2,227	2,377	2,679	3,035	3,348
TOTAL	4,333	5,399	5,617	6,095	6,687	7,162
% change		*25%*	*4%*	*8%*	*10%*	*7%*

NOTES:

Community Totals based on US Census data

Projected Totals based on Rhode Island Statewide Planning Program (April 2013)

The allocation of population to the Lower Wood watershed (1990) is as presented in the USGS Estimated Water Use and Availability in the Pawcatuck Basin (2004)

Projected Lower Wood Population Allocations (2000-2040)are based on % change for Community Totals and Projected Totals

It is assumed that the Population Totals include the Narragansett Tribe

The population allocation in the Lower Wood sub-watershed was presented in the 2004 USGS report. The Projected Totals within the Lower Wood sub-watershed were based on the % changes in the Community Total populations for each of the three towns.

In order to project the potential effect of the CREC contingent water source on the water availability in the Lower Wood sub-watershed, these population projections were applied to the water usage summarized in the 2004 USGS report (1995-1999) as shown below on **Table 3** to project the water usage into the future.

TABLE 3

Average Water Withdrawals (MGD) - Lower Wood Sub-watershed

Year/Use Category	Month			
	June	July	August	September
1995-1999	**0.932**	**1.155**	**1.353**	**0.709**
Domestic (43%)	0.40	0.50	0.58	0.30
Commercial (1%)	0.01	0.01	0.01	0.01
Industrial (7%)	0.07	0.08	0.09	0.05
Agricultural (49%)	0.46	0.57	0.66	0.35
2010	**0.948**	**1.175**	**1.376**	**0.721**
Domestic	0.42	0.52	0.61	0.32
Commercial	0.01	0.01	0.01	0.01
Industrial	0.07	0.08	0.09	0.05
Agricultural	0.46	0.57	0.66	0.35
2020	**0.981**	**1.216**	**1.425**	**0.747**
Domestic	0.45	0.56	0.65	0.34
Commercial	0.01	0.01	0.01	0.01
Industrial	0.07	0.08	0.09	0.05
Agricultural	0.46	0.57	0.66	0.35
2030	**1.026**	**1.272**	**1.490**	**0.781**
Domestic	0.50	0.61	0.72	0.38
Commercial	0.01	0.01	0.01	0.01
Industrial	0.07	0.08	0.09	0.05
Agricultural	0.46	0.57	0.66	0.35
2040	**1.061**	**1.315**	**1.540**	**0.807**
Domestic	0.53	0.66	0.77	0.40
Commercial	0.01	0.01	0.01	0.01
Industrial	0.07	0.08	0.09	0.05
Agricultural	0.46	0.57	0.66	0.35

NOTES:

Average Water Withdrawals (June, July, August, September) for 1995-1999 from Table 22 in USGS Water Use and Availability Report (2004)

Domestic Water Use escalated based on average population increase projected in Table 2

Commercial, Industrial and Agriculatural water use not projected to increase significantly

The water usage information for the Lower Wood sub-watershed obtained from the 2004 USGS report (shown above for the period 1995-1999) was subdivided into water usage associated with domestic, commercial, industrial and agricultural land uses within the report. As shown above, 92% of the water usage for the Town of Charlestown, within the Lower Wood sub-watershed is from domestic and agricultural uses. Industrial and commercial water uses only account for a total of 7% of the water use. The water usage information, as presented in the 2004 USGS report, also demonstrates that the Town of Charlestown's water usage within the Pawcatuck River Basin (exclusive of the town's water usage in the South Coastal watershed) is distributed amongst the four sub-watersheds, as shown on **Table 4**.

TABLE 4
Town of Charlestown % Water Usage per Sub-watershed

Sub-watershed	% of Total Water Usage within the Pawcatuck River Basin
Chipuxet	6%
Beaver-Pasquiset	39%
Lower Wood	33%
Lower Pawcatuck	23%

In order to forecast the water usage into the future and allow for the incorporation of the contingent water source for the CREC into the evaluation, the portion of the Lower Wood sub-watershed water usage assigned to domestic land uses was escalated using the population projections presented in **Table 2**. The commercial, industrial and agricultural water usage was assumed to remain constant. This assumption is supported by the Town of Charlestown 1991 Comprehensive Plan which states “to reflect a desire to conserve open space and rural resources and to protect community character” and the regional lack of any significant expansion in agricultural land uses (i.e., livestock farming, turf farms, golf courses).

The USGS Water Use and Availability Report develops estimates of water availability within the sub-watersheds of the Pawcatuck River Basin based on actual streamflow data available for a number of long-term USGS gauging stations located in the Pawcatuck River Basin. The water availability estimates developed by the USGS ranged from 26.83 MGD (June) to 8.13 MGD (September) for the Lower Wood sub-watershed. This scenario uses the 50th Percentile Estimated Gross Yield Minus the 7-Day, 10-Year Low Flow (7Q10) as the basis for the water availability. This is the same criterion that was the basis of the water availability conclusions in the 2004 USGS report. This analysis is conservative in that the 50th percentile of the Estimated Gross Yield is used and the total 7Q10 estimated for that gauging station is subtracted in order to develop a reasonable and environmentally protective estimate of water availability. The 7Q10 is a low-flow characteristic defined as the annual minimum average stream/river discharge for a selected consecutive-day period (7 days) for a given recurrence interval in years (10 years).

In order to assess the relative degree of water usage within each of the sub-watersheds of the Pawcatuck River Basin, the USGS developed ratios of water withdrawal to water availability for the months of June, July, August and September when streamflow conditions are typically the lowest. As previously noted and shown in **Table 3**, the historical water use estimates for the period 1995-1999, for the months of June through September ranged from 0.709 MGD (September) to 1.353 MGD (August) for the Lower Wood sub-watershed. **Table 5** summarizes these ratios for the Lower Wood sub-watershed as presented in the 2004 USGS report and as projected into the future, both with and without the proposed contingent water source for the CREC.

TABLE 5

Water Withdrawal to Water Availability Ratios - Lower Wood Sub-watershed

	June	July	August	September
1995-1999	0.035	0.092	0.148	0.087
2010	0.035	0.094	0.151	0.089
2020	0.037	0.097	0.156	0.092
w/ CREC	***0.039***	***0.101***	***0.162***	***0.099***
2030	0.038	0.102	0.163	0.096
w/ CREC	***0.040***	***0.106***	***0.169***	***0.103***
2040	0.040	0.105	0.168	0.099
w/ CREC	***0.042***	***0.109***	***0.175***	***0.106***

NOTES:

Water Use Information is based on Table 3

Water Availability data is from Table 21 from the Water Use and Availability Report (2004)

Water Availability data is based on the 50th Percentile Estimated Gross Yield minus 7Q10

The Water Withdrawal to Water Availability Ratios summarized above demonstrate that there is significant additional available water within the Lower Wood sub-watershed. For example, for the period 1995-1999, the highest water use ratio (0.148; August) means that under these evaluation criteria, approximately 15% of the available water is being withdrawn and approximately 85% of the available water was unused. In general, low ratios for sub-watersheds demonstrate that more water is available for future uses.

The Water Withdrawal to Water Availability Ratios summarized in **Table 5** also clearly demonstrate that the addition of the proposed CREC water usage (based on the Summer Maximum – 55,520 gpd) does not significantly affect these ratios and therefore does not have a significant effect on water availability in the Lower Wood sub-watershed.

Another way to look at the proposed CREC water usage and the water availability for the Lower Wood sub-watershed, as estimated in the 2004 USGS report, is to compare the proposed CREC Summer Maximum water demand (55,520 gpd) to the water availability (50^{th} Estimated Gross Yield Minus 7Q10) for the months of June, July, August and September. This comparison shows that the proposed CREC Summer Maximum water demand would account for between 0.21% (June) to 0.68% (September) of the available water within the Lower Wood sub-watershed.

5.0 TOWN OF CHARLESTOWN GROUNDWATER RESOURCES

As noted previously, at least portions of the three significant groundwater reservoirs (i.e., aquifers) are present within the Town of Charlestown. These aquifers are the following:

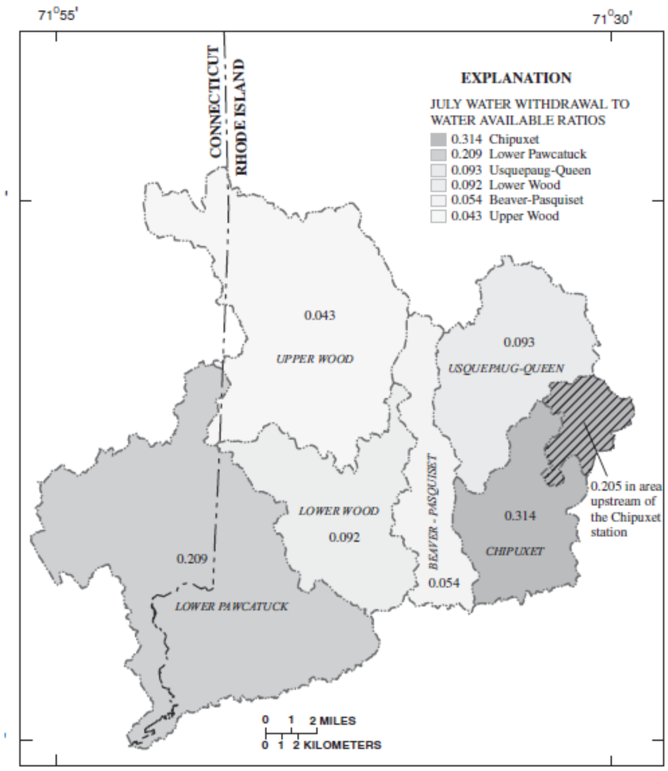
- Bradford Aquifer
- Lower Wood Aquifer
- Beaver-Pasquiset Aquifer

The USGS has performed an evaluation into the nature of these aquifers and provided estimates of the potential yields to groundwater wells to support water supply planning by the communities and the State of Rhode Island. Based on our review of these documents, the information is consistent with the statement in Natural Resources section of the Town of Charlestown's 1991 Comprehensive Plan that "the reservoirs could support a population of 20,000 people, supplying 2 to 3 million gallons per day". Also, as noted in this plan and the various USGS reports, development of these resources would need to consider the potential for adverse impacts to other surrounding water resources, such as freshwater wetlands and surface water bodies, during the design of the water acquisition systems (e.g., wells, infiltration galleries, etc.). Assuming that the current annual average water demand for the Town is between approximately 700,000 and 900,000 gpd would support that significant additional capacity (approximately 1.0 MGD or more) is available for the development of future water sources. It should also be noted that the consumptive water use is only estimated to be approximately 15% for domestic water uses and approximately 10% for commercial and industrial uses as noted in the 2004 USGS report. Therefore, a majority of this water is returned to the subsurface through the OWTSs.

Additional water capacity exists in the Town of Charlestown outside of these three aquifer areas within the other less extensive and other thinner stratified drift deposits, till deposits and within the underlying crystalline bedrock which typically have adequate yield for individual domestic water wells.

The following figures from the USGS Water Use and Availability Report (2004; Figure 17) further demonstrate that additional water is available for development within the portions of the Pawcatuck River Basin (Beaver-Pasquiset, Lower Wood and Lower Pawcatuck sub-watersheds) located within the Town of Charlestown as the water use to availability ratios are significantly less than 1.0. Of these three sub-watersheds, the Lower Pawcatuck sub-watershed is characterized by the highest ratios of water use to availability and the Beaver-Pasquiset the lowest ratios.

A.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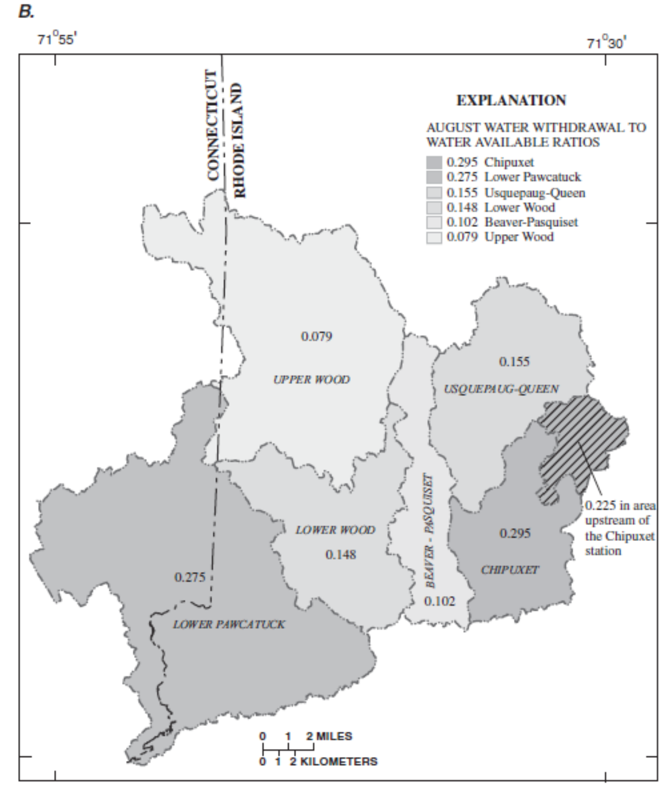
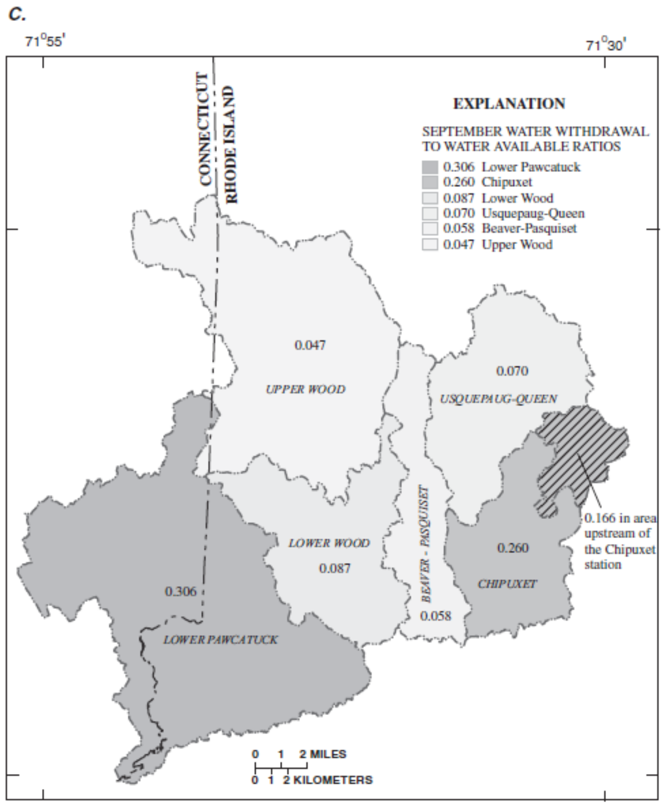
CONNECTICUT
RHODE ISLAND
EXPLANATION
JULY WATER WITHDRAWAL TO WATER AVAILABLE RATIOS
0.314 Chipuxet
0.209 Lower Pawcatuck
0.093 Usquepaug-Queen
0.092 Lower Wood
0.054 Beaver-Pasquiset
0.043 Upper Wood
0.043
UPPER WOOD
0.093
USQUEPAUG-QUEEN
0.205 in area upstream of the Chipuxet station
LOWER WOOD
0.092
BEAVER - PASQUISET
0.054
0.314
CHIPUXET
0.209
LOWER PAWCATUCK
0 1 2 MILES
0 1 2 KILOMETERS

B.


71°55'
71°30'
CONNECTICUT
RHODE ISLAND
EXPLANATION
AUGUST WATER WITHDRAWAL TO WATER AVAILABLE RATIOS
0.295 Chipuxet
0.275 Lower Pawcatuck
0.155 Usquepaug-Queen
0.148 Lower Wood
0.102 Beaver-Pasquiset
0.079 Upper Wood
0.079
UPPER WOOD
0.155
USQUEPAUG-QUEEN
0.225 in area upstream of the Chipuxet station
LOWER WOOD
0.148
BEAVER - PASQUISET
0.102
0.295
CHIPUXET
0.275
LOWER PAWCATUCK
0 1 2 MILES
0 1 2 KILOMETERS



5.1 Potential for Adverse Impacts to Contaminated Sites

During the hearing on Tuesday, October 17, the Town of Charlestown expressed concern regarding the potential for the proposed groundwater withdrawal on the Narragansett Tribal Lands within the Lower Wood Aquifer to adversely impact conditions on two contaminated properties, United Nuclear and Kenyon Piece Landfill, both located within the Town of Charlestown. Refer to **Figure 3** for the approximate locations of these sites on a figure provided by the Town of Charlestown.

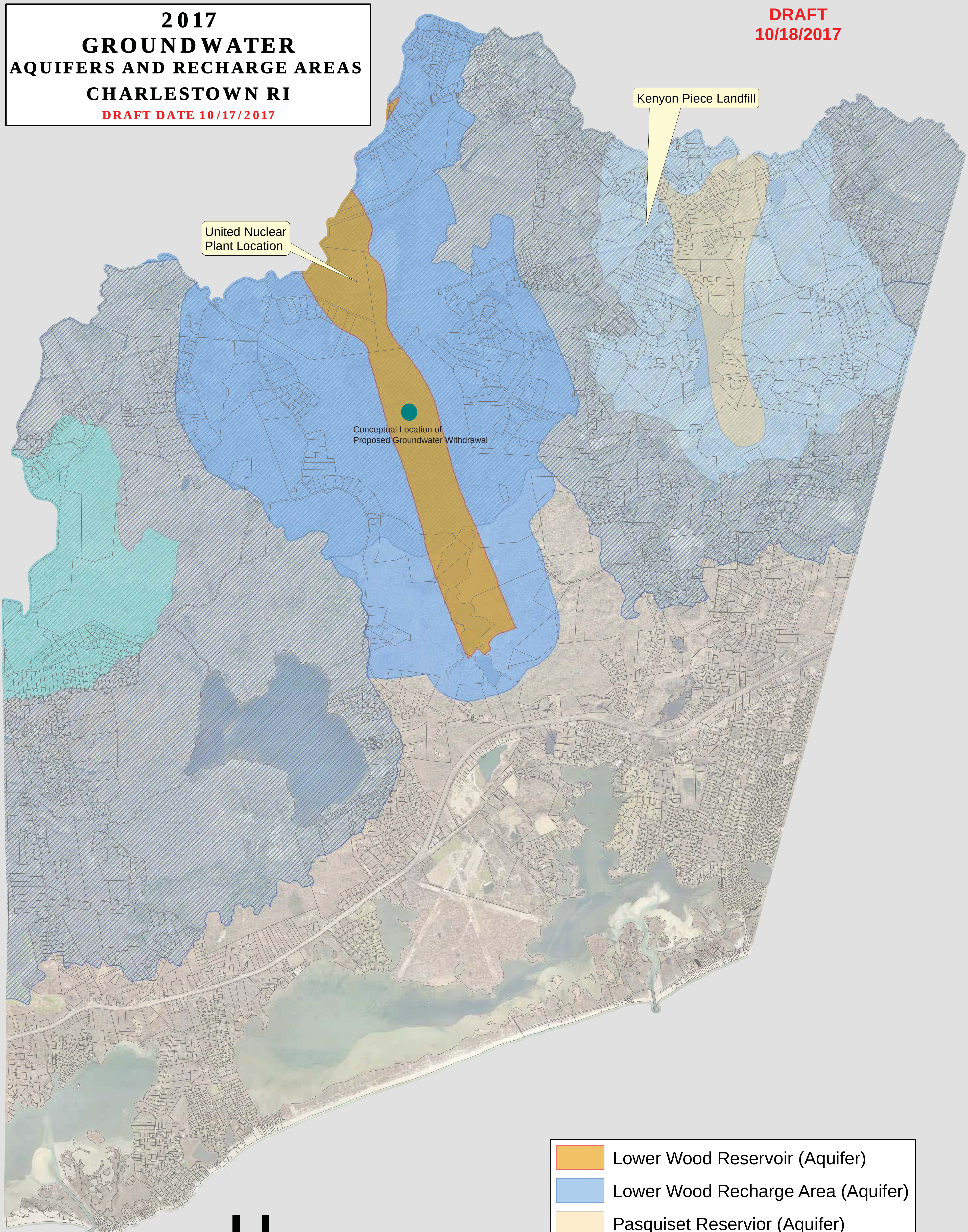
Kenyon Piece Landfill is a CERCLIS-listed site located within the Beaver Pasquiset sub-watershed. Based on information available from CERCLIS, site investigations and removal actions (i.e., remediation) have been completed at the site. The current status of the Kenyon Piece Landfill on the CERCLIS website (https://cumulis.epa.gov/supercpad/cursites/srchrslt.cfm?start=1) is NF (defined as No Further Remedial Action Proposed). The Kenyon Piece Landfill is not listed on the National Priority List (NPL). Groundwater flow on the Kenyon Piece Landfill site is anticipated to be towards the northwest and the Pawcatuck River. The Removal Program Preliminary Assessment/Site Investigation Report (Weston Solutions, Inc., 2008) included statements that concurred with this assumed groundwater flow direction. The Kenyon Piece site is located approximately 0.5 miles from the river and 2.25 miles from the proposed NIT well.

The United Nuclear site is a state-listed (RIDEM) site located within the Lower Wood sub-watershed. Groundwater flow on the United Nuclear site is documented to be towards the west/northwest and the Pawcatuck River (USGS, 1997). The United Nuclear site is located approximately 0.25 miles from the river.

2017
GROUNDWATER
AQUIFERS AND RECHARGE AREAS
CHARLESTOWN RI

DRAFT DATE 10/17/2017

DRAFT
10/18/2017



- Lower Wood Reservoir (Aquifer)
- Lower Wood Recharge Area (Aquifer)
- Pasquiset Reservior (Aquifer)
- Pasquiset Recharge Area (Aquifer)
- Bradford Recharge Area (Aquifer)
- Pawcatuck River Basin

0 2,000 4,000 8,000 Feet

THIS MAP IS FOR PLANNING PURPOSES ONLY. IT IS NOT VALID FOR LEGAL DESCRIPTION OR CONVEYANCE

While the Town makes every attempt to ensure the accuracy and completeness of the data, the Town of Charlestown provides this data as is, with all faults. The Town of Charlestown makes no claims, no representations and no warranties, regarding the reliability, completeness or the accuracy of the GIS data and GIS data products furnished by the Town. In no event shall the Town be liable for any indirect or consequential damages incurred from the use or inability to use the data.

Pictometry Image
Flown Spring Dec. 2016
Town of Charlestown
4 inch pixel resolution.

RIGIS

DRAFT
10/18/2017

FIGURE 3

The anticipated location of the proposed groundwater well on the Tribal Lands (Refer to **Figure 3**) is approximately 5,000 feet (0.95 miles) to the south/southeast of the United Nuclear site and approximately 12,000 feet (2.25 miles) from the Kenyon Piece Landfill. Given the distance to the site and the location of the Kenyon Piece Landfill within a different sub-watershed and the anticipated pumping rate to meet the water demands of the CREC, the proposed groundwater withdrawal will not have any impact on conditions on the Kenyon Piece Landfill.

Given the distance to the United Nuclear site and the location of this site hydraulically downgradient of the proposed groundwater withdrawal, the proposed groundwater withdrawal should not have any impact on groundwater conditions on the United Nuclear site. To further support this assertion, a simple analysis of the potential capture zone, in particular the downgradient stagnation point of the capture zone, was performed using conventional capture zone analysis (EPA, 2008; Figure 14). These calculations support that the downgradient stagnation point, the furthest downgradient point where the well will capture groundwater by reversing groundwater flow towards the well, is less than 100 feet. The hydraulic assumptions used to support this analysis were based on the 1974 USGS Availability of Ground Water in the Lower Pawcatuck River Basin, Rhode Island, in particular Plate 2 (Map Showing Approximate Saturated Thickness of the Sand and Gravel Aquifer) and Plate 4 (Transmissivity of the Sand and Gravel Aquifer), as assumed groundwater flow gradient of 0.02 feet/foot and a withdrawal rate of 104,000 gpd (maximum draw following an oil firing event). The results of the capture zone analysis support that the proposed groundwater withdrawal will not have any impact on the conditions on the United Nuclear site.

The USGS assessed the movement of contamination at this site during a 3½-year study of this ground-water contamination near Wood River Junction, R.I. as part of the Low-Level Radioactive Waste Program. The objectives of the study were to

(1) identify chemical and radiochemical constituents in the plume;

(2) assess the interaction of solutes with the aquifer materials;

(3) determine the location, movement, and fate of constituents in the plume; and

(4) estimate the effects of ground-water contamination on future ground-water development adjacent to the site.

Objective 4 of the Study was to estimate the effects of ground-water contamination on the future ground-water development adjacent to the site. The USGS report stated that "*According to the simulation results using a two-dimensional areal-flow model developed for the site, ground-water development in the Wood River Junction area would be influenced by the contaminated ground water but probably not enough to preclude development. If pumping rates of new water-supply wells were limited to about 0.25 Mgal/d, excessive intake of contamination ground water could be avoided."*

The above conclusion was reached by USGS related to the future development of new water supply wells adjacent to the site in Wood River Junction; as such the USGS report further supports the above conclusions relative to the United Nuclear site and the proposed groundwater withdrawal on the Tribal Lands.

5.2 Potential for Adverse Impacts to Existing Wells

During the hearing on Tuesday, October 17, the Town of Charlestown expressed concern regarding the potential for the proposed groundwater withdrawal to impact other existing water supply wells in the area.

In order to perform a conceptual assessment of the proposed withdrawal and the potential for adverse impacts to nearby individual water supply wells, the following evaluation was performed. The 1974 USGS Availability of Ground Water in the Lower Pawcatuck River Basin, Rhode Island report, in particular Plate 2 (Map Showing Approximate Saturated Thickness of the Sand and Gravel Aquifer) and Plate 4 (Transmissivity of the Sand and Gravel Aquifer) were used to support estimates of the hydraulic characteristics of the Lower Wood Aquifer in the vicinity of the proposed well based as the basis for the assumptions for the analysis.

- Transmissivity: 1,250 to 2,500 ft^2/day
- Saturated Thickness: 20 feet
- Groundwater Gradient: 0.02 feet/foot
- Specific Yield: 0.2 (dimensionless)

Using these hydraulic parameters, an initial analysis of the predicted drawdown associated with the proposed groundwater withdrawal was conservatively developed using the proposed Summer Peak Water Demand (55,520 gpd) over a 90-day continuous pumping period. Using this information, estimates were developed for the approximate distance from the proposed water withdrawal well to the extent of the one foot drawdown of the groundwater table resulting from the proposed pumping. These estimates were developed with the Cooper-Jacob Approximation of the Theis equation using the GroundwaterSoftware.com on-line calculator (see References). Drawdowns less than one foot would not be expected to have a significant impact on surrounding supply wells. The resultant distances generated by these calculations ranged from approximately 525 feet to 1,075 feet.

Looking at the conceptual location for the proposed water withdrawal well, as shown on **Figure 3**, and readily available aerial photography for the proposed well area, it appears that all of the existing residential wells, based on the locations of homes or other structures in the area, are at least 2,500 feet from the conceptual well location. Given the results of the calculations described above and the estimated distances to the nearby residences and structures, the proposed water withdrawal should not have an impact on the existing supply wells in the area under the conditions assumed for this evaluation as noted below.

- Approximate location of the well as noted on **Figure 3**
- Minimum distance from any surrounding existing supply well of at least 1,500 feet

6.0 CONCLUSIONS

Based on this review of readily available information, the Town of Charlestown's water sources can be characterized as follows.

- Town water sources rely solely on groundwater
- Town water sources draw water from a variety of subsurface materials including stratified drift, till deposits and bedrock, not just the three major groundwater reservoirs (aquifers) mapped within the town.
- Town water sources occur throughout the town and draw water from one of the five sub-watersheds and not just the Lower Wood sub-watershed

Based on the documented water usage proposed for the CREC facility and the evaluations documented in this report, the following conclusions have been drawn.

- The proposed operating scenario for the CREC facility requires a water source or sources capable of providing 15,840 gpd in the spring, fall and winter months and 18,720 gpd in the summer months (mid-June to mid-September). Water demand from the source increases to a Summer Maximum total of 55,520 gpd (18,720 gpd + 36,800 gpd = 55,520 gpd) in the summer months if the Facility utilizes its evaporative coolers and rises to a daily maximum of 104,000 gpd (total of 13 trucks per day each at 8,000 gallons per truck) during any oil firing refill event .
- At the proposed water usage rates identified above for the NIT contingent water source, any effect on water availability would be limited to the Lower Wood sub-watershed
- Potential use of the proposed contingent water source for the CREC, located within the Lower Wood sub-watershed, will not have a significant effect on the water availability within this watershed.
- As noted in their 1991 Comprehensive Plan and supported by various investigations and studies completed by the USGS, the Town of Charlestown has significant capacity (approximately 1.0 MGD or more) available for the development of future water sources and the proposed use of water by CREC will not significantly impact this capacity.
- Use of the proposed contingent water source will not impact groundwater conditions at either the Kenyon Piece Landfill or the United Nuclear site.
- Use of the proposed contingent water source within the Lower Wood Aquifer will not impact surrounding existing water supply wells.

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