

# Candlewood Lake Brookfield Study Area Wastewater Management Plan

## Task 1 Report – Community Profile and Data Review

**Prepared for:  
Brookfield Water Pollution Control Authority**

**October 2, 2019**



*Prepared by:*

**Environmental Engineers/Consultants**

**LOMBARDO ASSOCIATES, INC.**

188 Church Street, Newton, Massachusetts 02458

**October 2, 2019**

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Brookfield Water Pollution Control Authority  
53A Commerce Road, Unit 1  
Brookfield, CT 06804

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Louise Trojanowski-Marconi, Vice Chairman  
Loretta Donovan, Member  
Phillip Kurtz, Member  
Tulio E. Lopez, Member

Matthew Brown, Alternate  
Michael DelValle, Alternate  
James Murray, Alternate



## EXECUTIVE SUMMARY

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The Brookfield Water Pollution Control Authority (WPCA) has commissioned this Engineering Plan to address the Town's wastewater management issues and needs for the approximate 1,500 properties in the WPCA Areas of Concern (AoC) adjacent and near to Candlewood Lake and the Brookfield portion of the Candlewood Lake drainage area see Figure ES-1.

This CT Clean Water Fund initiative along with the Brookfield WPCA is due to the concern that Study Area wastewater systems may be adversely impacting the quality of Candlewood Lake – an issue that has been occurring at numerous lakes in the Northeast with devastating impacts.

The Candlewood Lake Brookfield Contributing Area Wastewater Management Plan Project consists of ten (10) tasks that in total will:

- ✓ Evaluate existing conditions, in particular wastewater management practices
- ✓ Determine wastewater systems public health and environmental impacts (in particular on Candlewood Lake's water quality)
- ✓ Develop cost effective, technically reliable solutions to address problem systems
- ✓ Develop an Implementation Plan to mitigate any negative impacts

This Task 1 Community Profile and Data Review Report contains three sections:

- Study Area Profile - land use, property, and population data; water supply and water quality information; and current wastewater management practices.
- Description of Natural Resources - descriptions of soils and bedrock, topography, floodplains and wetlands, and water resources.
- History and water quality conditions of Candlewood Lake summary

Some key project findings to date that are included in this Task 1 report are:

- 87% of properties are residential; 73% are more than 50 years old, most with the original septic system.
- More than 28% of lots are less than 10,000 square feet.
- Drinking water quality data strongly suggests that septic discharges are adversely influencing drinking water quality of Arrowhead and Candlewood Shores – which serve 60% of the AoC parcels.

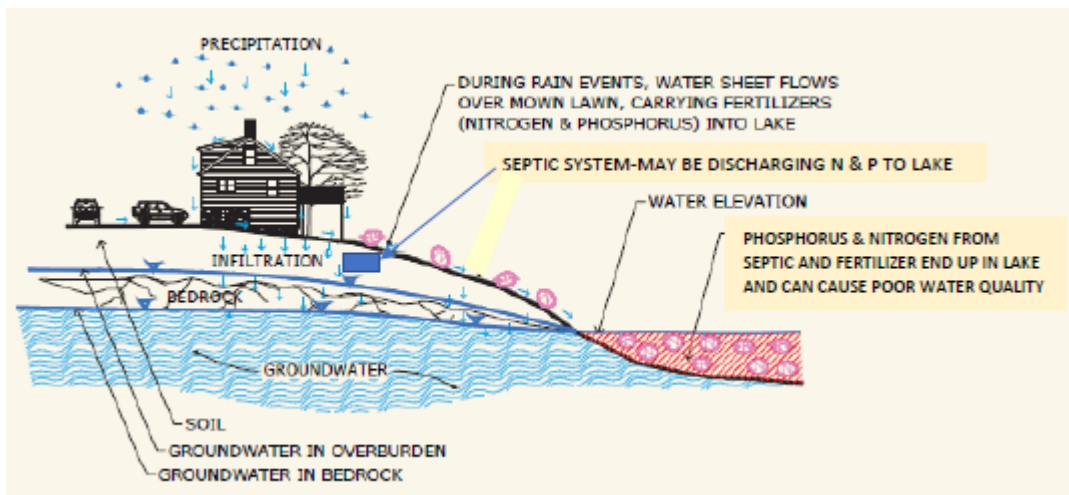
Figure ES-2 illustrates how wastewater from septic systems infiltrates to the groundwater/water supply wells and a body of water such as Candlewood Lake.

- Nitrate nitrogen levels in the Arrowhead and Candlewood Shores (CS) water supplies are very close to violating the US EPA drinking water standard of 10 parts per million (ppm) for nitrate-nitrogen. As of 2018, Arrowhead was 7.9 ppm and Candlewood Shores was 7.5 ppm. In 2017, CS violated the nitrate-N drinking water public health limit.
- Wastewater design conditions in the study area are challenging due to steep slopes and shallow bedrock.
- Candlewood Lake is phosphorus limited – i.e. phosphorus levels controls water quality.
- Candlewood Lake has recently experienced cyanobacteria/blue-green algae blooms that can be a health hazard to pets and humans.



**1 Project Study Area within Brookfield**

Figure ES-



**Figure ES-2 Study Area Geohydrology Cross-Section**

The Task 1 information lays the groundwork for next step of the study in which:

- ✚ phosphorus removal in septic systems will be field tested at three septic drainfields and three groundwater wells
- ✚ wastewater needs will be defined on a property by property basis



# 1 INTRODUCTION

---

The Brookfield Water Pollution Control Authority (WPCA) has commissioned this Engineering Plan to address the Town's wastewater management issues/needs in the WPCA Areas of Concern (AoC) adjacent/near to Candlewood Lake and the Town's portion of the Candlewood Lake drainage area. The WPCA's initiative is in part due to the concern that wastewater systems may be significantly adversely affecting the quality of Candlewood Lake, as has been occurring at numerous Lakes in the Northeast.

- Figure 1-1 presents a regional location map of the project Study Area within the Candlewood Lake / Housatonic River watersheds.
- Figure 1-2 presents the Study Area within Brookfield.

The primary objective of this Engineering Plan is to evaluate wastewater management practices, determine their public health and environmental impacts (in particular on Candlewood Lake's water quality) and develop cost effective, technically reliable solutions to mitigate any negative impacts.

This Candlewood Lake Brookfield Contributing Area Wastewater Management Plan Project consists of the following activities:

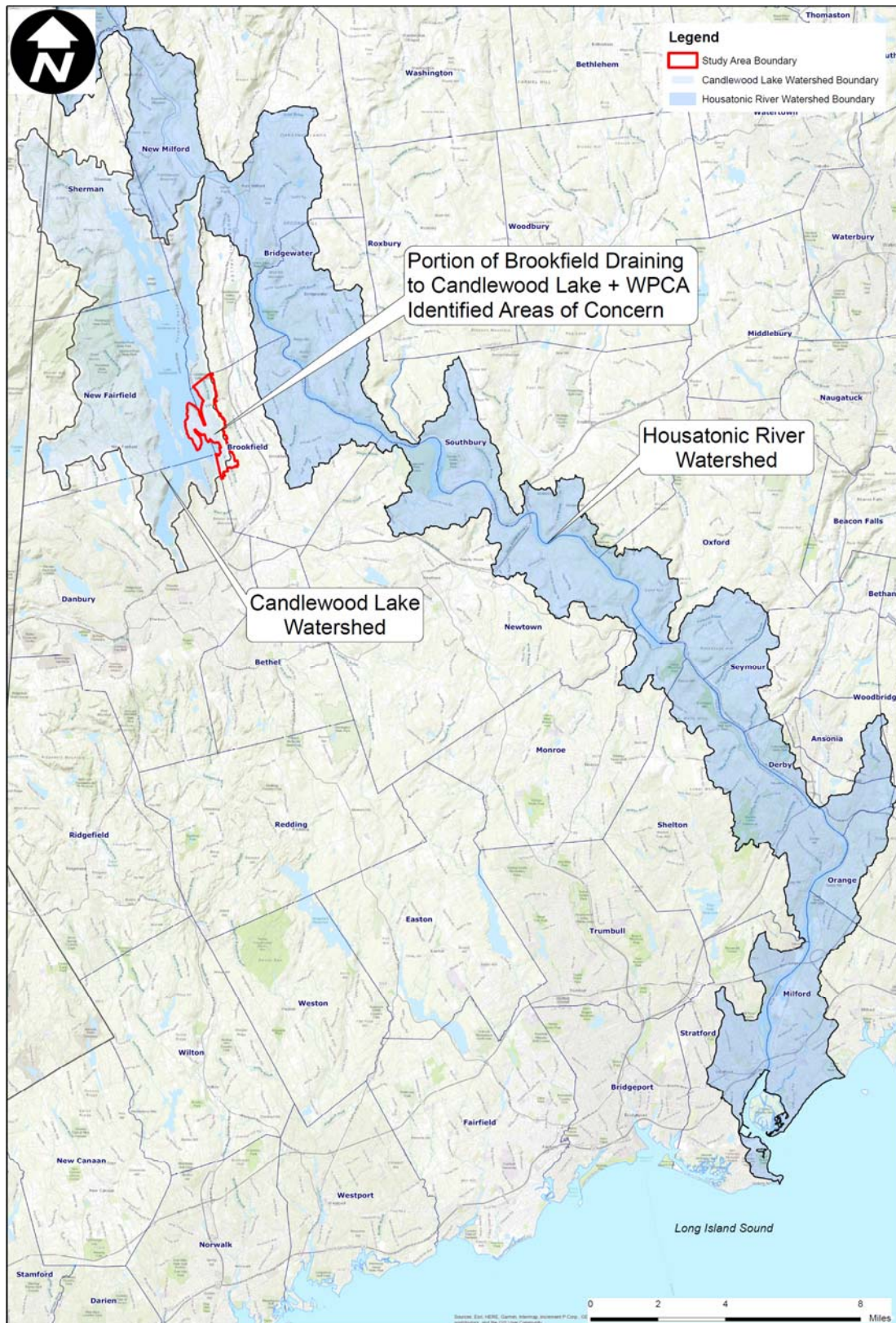
1. **Assess impact of Brookfield wastewater practices on Candlewood Lake's water quality.** On a lot-by-lot basis, determine phosphorus, nitrogen and pathogenic bacteria contributions due to wastewater management practices of using individual onsite wastewater treatment systems (OWTS).
2. **Determine Need for improved wastewater practices** due to the adverse impacts of current/historical wastewater practices. Property-by-property Needs are to be categorized as:
  - a. **Functional Need** – defined as wastewater systems that are not providing bacterial purification and are thereby a public health problem. Lots having inadequate space for a CT Department of Health (DoH) code-compliant wastewater system in the future when the current system fails, is also included as a Functional Need.
  - b. **Performance Need** – defined as wastewater systems not providing sufficient nitrogen and phosphorus removal and thereby causing groundwater and/or surface waters to not meet their water quality standards and are therefore impaired.

The Needs analysis will also determine, on a lot-by-lot basis, which properties:

- Are able to upgraded with an on-site solution
  - Due to insufficient space and/or site conditions, require an off-site solution
3. **Identify and evaluate alternative wastewater management options** (i.e. collection, treatment and disposal/reuse-either on-site or off-site) to address the determined Needs.
  4. **Identify and evaluate wastewater treatment and disposal locations** and their associated capacities to address the off-site solution Needs.

5. **Develop Wastewater Solution Scenarios, i.e. 3 +/-, to address the Study Area-wide** wastewater management Needs. Perform Preliminary Engineering layouts and prepare Capital/Annual O&M Budgets of the Scenarios.
6. **Develop Preferred Solution Scenario** - with WPCA and stakeholders.
7. **Identify Potential Grants//Loans for the Preferred Scenario**
8. Develop a **Preliminary Financing Plan, Projected User Charges & Implementation Plan** with permitting timeline.
9. **Prepare Engineering Plan Report** that presents the above Findings and provides sufficient detail for project funding.
10. **Facilitate and maintain open communication** process with the Brookfield WPCA and stakeholders on the project efforts and findings.

This Wastewater Management Plan addresses each of the above items - prefaced by the next chapter on Study Area profile.



**Figure 1-1 Project Study Area within Regional Watershed**





**Figure 1-2 Project Study Area within Brookfield**

## 2 STUDY AREA PROFILE

### 2.1 STUDY AREA DEFINITION

The Study Area is defined as the:

- ✓ 1,053 parcels within the WPCA Areas of Concern (AoC) adjacent/near to Candlewood Lake, which includes 72 parcels in the southeastern end of the AoC that are not in the Candlewood Lake drainage area – rather in the East Brook drainage area.
- ✓ 473 additional parcels within Town's portion of the Candlewood Lake drainage area.
- ✓ 1,526 total parcels of which 1,454 are within Candlewood Lake drainage area

The entire Study Area is approximately 1,200 acres in size and consists of 1,526 parcels.

### 2.2 LAND USE

Land Use data was obtained from the Town Assessor's Database, via an export from Vision Systems. Table 2-1 presents the Study Area Land Use designations and the number of parcels within each designation. Table 2-1 also contains condensed categories that show that residential development represents 87% of the 1,526 parcels in the Study Area. Figure 2-1 presents Study Area Land Use on a parcel-by-parcel basis based upon the 2019 Assessors data.

Associated with creation of Candlewood Lake, FirstLight (formerly Connecticut Light & Power-CL&P) owns lands below Rocky River Project Boundary - formerly known as the 440' elevation, it is elevation 438.1 NGVD-1929. Current survey reference is NAVD 1988. With the appropriate elevation adjustment from NGVD-1929 to NAVD 1988 for the Lake location, the Project Boundary is ~ 437.2 NAVD-1988. All activities below the Project Boundary elevation require permits from FirstLight.

**Table 2-2 Study Area**

First Light Candlewood Lake Boundary & Operating Range Elevations (ft)					
Season	CL&P Datum	NGVD*	Project Boundary CL&P	Project Boundary NGVD-29	Project Boundary NAVD-88
Summer (Memorial Day - Oct. 15)	427.0-429.5	425.1-427.6	440	438.1	437.2
Winter	418.0-425.9	416.1-424.0			

\*National Geodetic Vertical Datum-1929

### 2.3 DEVELOPMENT, POPULATION AND HOUSING

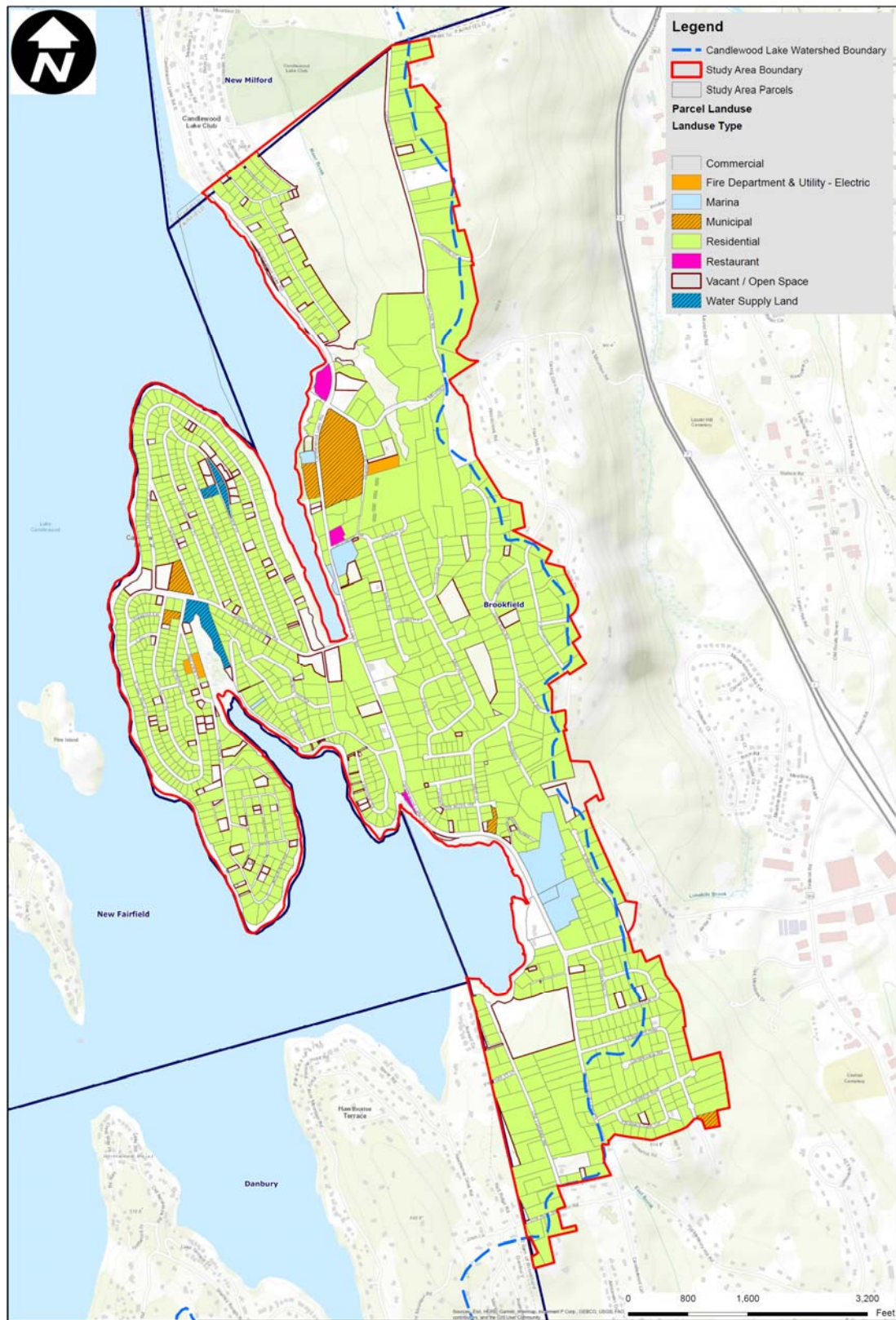
Tables 2-3a and b and Figures 2-2a and b present the age of the AoC and non AoC developed property stock, respectively, and illustrates their age distribution. Of note is that only 11% of the AoC developed properties are less than 30 years old and 74% are greater than 50 years old. Similar statistics apply to the non AoC area. Tables 2-3c presents the

age of the all Study Area developed properties. A comparison of Tables 2-3 a, b and c indicates that there is little age distribution change among the three property sorts.

**Table 2-1 Number of Parcel in Land Use Categories**

Land Use ID	Land Use Category	Parcels in Study Area	Land Use Category	Parcels in Study Area	% of Total
Accessory Bldgs	Commercial	3	Non Residential	15	1.0%
Apartments	Residential	1	Fire Department	2	0.1%
Auto Repair	Commercial	1	Marina	7	0.5%
Cell Site	Commercial	1	Municipal	6	0.4%
Charitable Res	Commercial	2	Residential	1,322	86.6%
Com Ld Dv	Commercial	3	Restaurant	3	0.2%
Comm Garage	Commercial	1	Utility - Electric	1	0.1%
Community Well Ld	Water Supply Land	6	Vacant / Open Space	164	10.7%
Country Club	Commercial	1	Water Supply Land	6	0.4%
Elecsubsta	Utility - Electric	1	<b>Total</b>	<b>1,526</b>	
Forest	Vacant / Open Space	1			
Four Family	Residential	1			
Fratnl Org	Commercial	1			
Marinas Lnd	Marina	2			
Marinas Md 94	Marina	3			
Marinas Md 96	Marina	1			
Mun Bldg Com	Municipal	2			
Mun Lnd Res	Municipal	2			
Mun Park Bld	Municipal	1			
Mun Park Ind	Municipal	1			
Nbhd Ctr	Commercial	1			
Office Bldg	Commercial	1			
Res. Condo	Residential	25			
Rest/Club	Restaurant	3			
SFR w/Acc Apt	Residential	39			
SFR w/Lake Access	Residential	28			
Single Family	Residential	1,058			
Single Family WF	Residential	170			
Unbuildable Res Lnd	Vacant / Open Space	3			
Vac Lnd/OBs	Vacant / Open Space	4			
Vac Lnd	Vacant / Open Space	8			
Vac Res Ld WF	Vacant / Open Space	30			
Vacant Res Land	Vacant / Open Space	118			
Vol Fire Dep	Fire Department	1			
Vol Fire Dep Ln	Fire Department	1			
Water Access	Marina	1			
<b>Total</b>		<b>1,526</b>			





**Figure 2-1 Study Area Land Use**

**Table 2-3a AoC Area Developed Property Age Distribution**

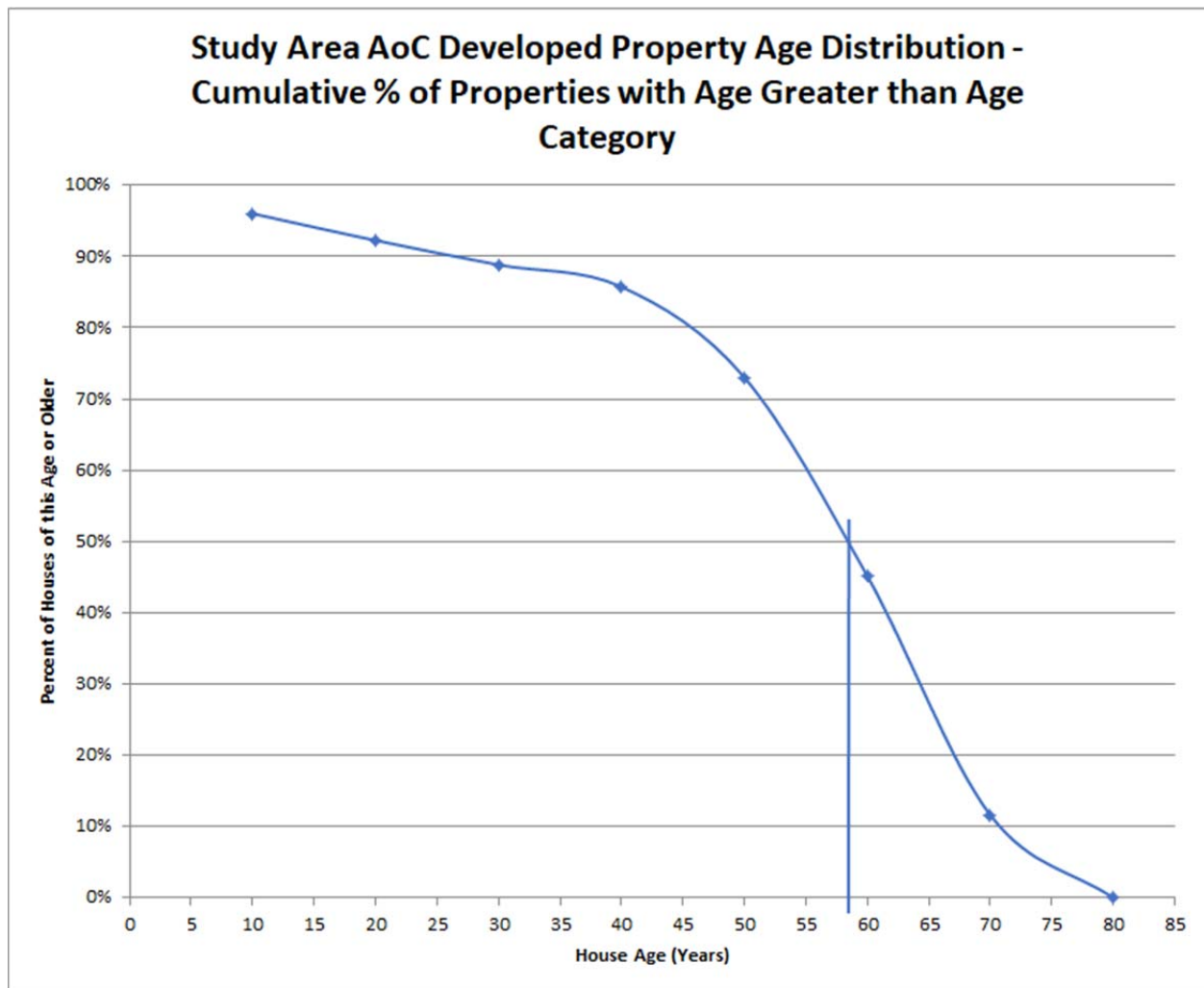
Candlewood Lake AOC House Age Distribution												
Category	Total # of Properties	Total Props w/ Housing Age	0-10 Yrs	11-20 Yrs	21-30 Yrs	31-40 Yrs	41-50 Yrs	51-60 Yrs	61-70 Yrs	71+ Yrs	Totals (with Data)	Total Props w/o Housing Age
Total	1,023	904	36	34	31	28	115	252	303	105	904	119
% of Total Props w/ Data			4%	4%	3%	3%	13%	28%	34%	12%	100%	
Cululative % of Props w/ Data			4%	8%	11%	14%	27%	55%	88%	100%		

**Table 2-3b Non-AoC Area Developed Property Age Distribution**

Candlewood Lake Outside of AOC House Age Distribution												
Category of Properties with Age Data	Total # of Properties	Total Props w/ Housing Age	0-10 Yrs	11-20 Yrs	21-30 Yrs	31-40 Yrs	41-50 Yrs	51-60 Yrs	61-70 Yrs	71+ Yrs	Totals (with Data)	No Data
Total	497	435	10	16	25	36	77	158	67	46	435	62
% of Total Props		88%	2%	3%	5%	7%	15%	32%	13%	9%	88%	
Cum. % of Props/Age Greater than Category			98%	95%	90%	82%	67%	35%	22%	12%		

**Table 2-3c Entire Study Area Developed Property Age Distribution**

Candlewood Lake Study Area House Age Distribution													
Category	Total # of Properties	Total Props w/ Housing Age	0-10 Yrs	11-20 Yrs	21-30 Yrs	31-40 Yrs	41-50 Yrs	51-60 Yrs	61-70 Yrs	71+ Yrs	Totals (with Data)	No Data	Sum Totals
Total	1,518	1,346	46	50	56	64	199	410	370	151	1,346	172	1,518
% of Total Properties		89%	3%	3%	4%	4%	13%	27%	24%	10%	88%	11%	100%
Cum. % of Props/Age Greater than Category			86%	82%	79%	75%	61%	35%	10%	0%			



**Figure 2-2a AoC Developed Property Age Distribution**

According to the 2015 Brookfield Plan of Conservation and Development, Brookfield's 2013 population, housing and median household income are presented below.

Population: 16,547  
Households: 6,160  
Percent Owner-Occupied Housing: 60%  
Median Household Income: \$103,615

**Therefore, the Study Area represents ~ 25% of the households in Brookfield.**

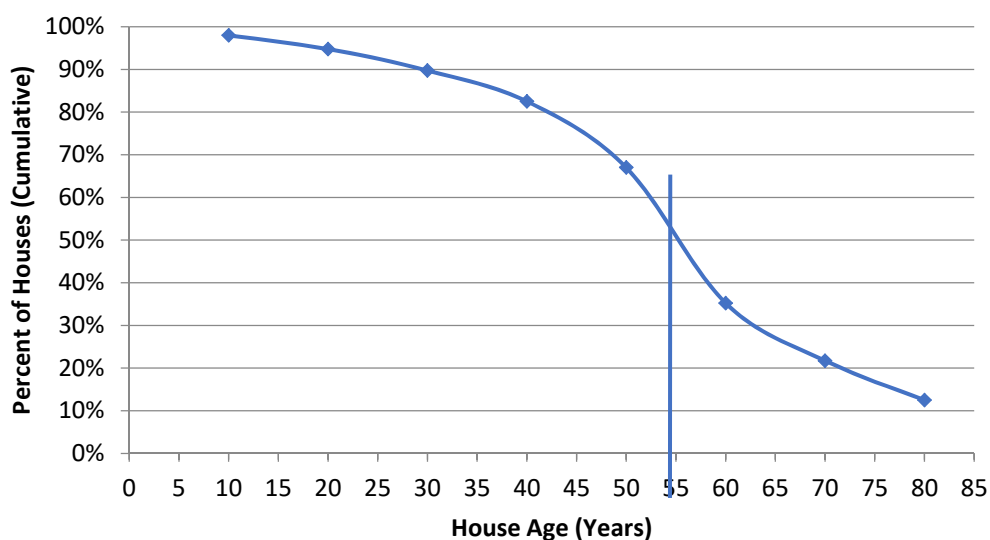
**Photos of Study Area development follow.**







### Non AoC Study Area Developed Property Age Distribution - Cumulative % of Properties with Age Greater than Age Category



**Figure 2-2b Non-AoC developed Property Age Distribution**

## 2.4 ZONING & PROPERTY APPRAISALS

Table 2-4a presents the Town zoning categories within the Study Area. Figure 2-3 presents the zoning districts within the Study Area. As shown on Table 2-4, the Peninsula Area R7 zoning, 7,000 square foot minimum, has 795 parcels in that zoning category.

**Table 2-4a Study Area Zoning Categories & Districts**

Zoning Code	Description	# in Study Area	% of Total
R100	Residential - Minimum Lot Size 100,000-ft <sup>2</sup>	27	1.8%
R40	Residential - Minimum Lot Size 40,000-ft <sup>2</sup>	636	41.7%
R60	Residential - Minimum Lot Size 60,000-ft <sup>4</sup>	5	0.3%
R7	Residential - Minimum Lot Size 7,000-ft <sup>2</sup>	795	52.1%
R80	Residential - Minimum Lot Size 80,000-ft <sup>2</sup>	24	1.6%
RC41	Restricted Commercial District	6	0.4%
RS40	Recreational Services District	20	1.3%
Blank	Unknown	13	0.9%
Total		1,526	100%

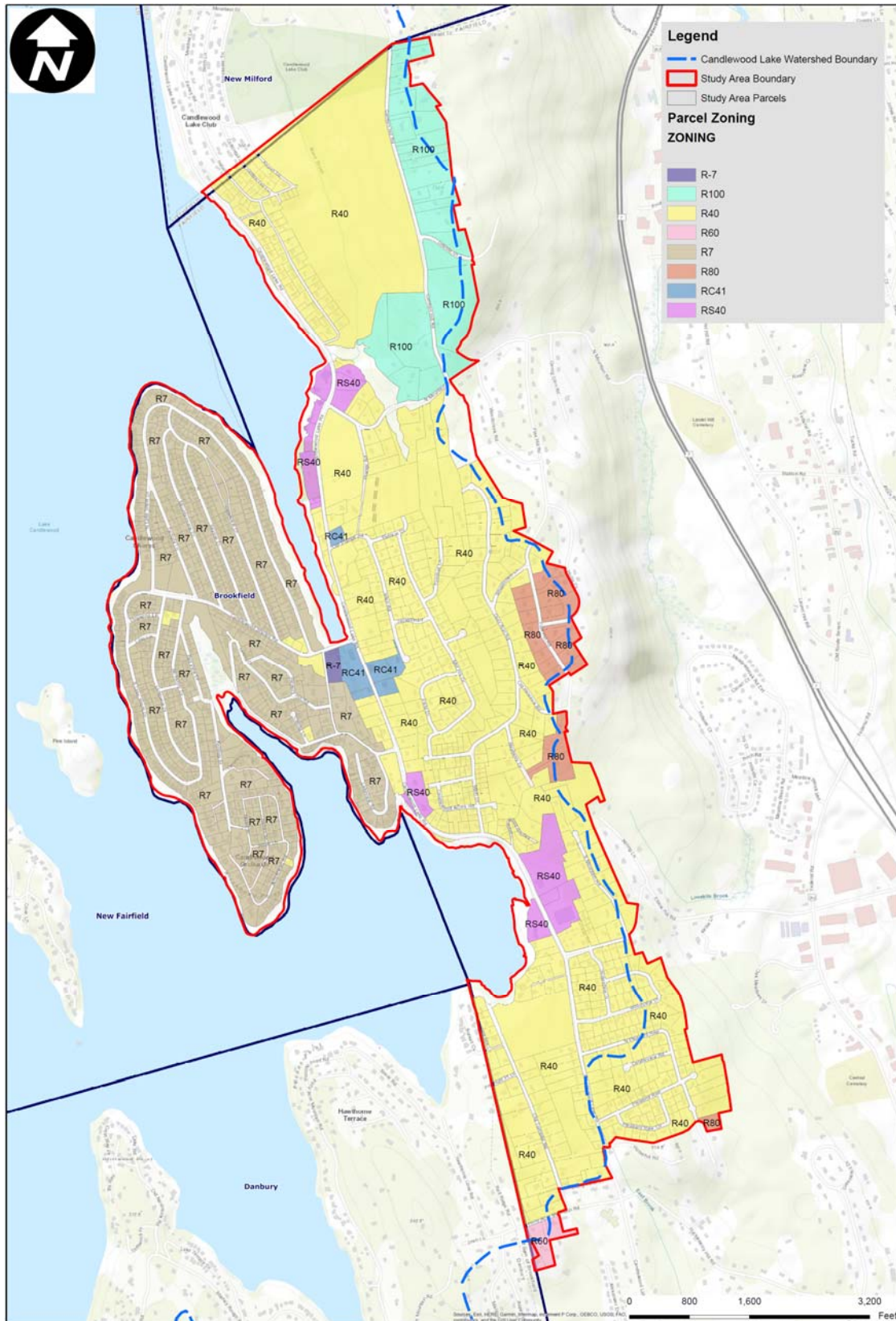
Based upon the Assessors database, Table 2-4b presents the distribution of property assessed values in the AoC.

**Table 2-4b Study Area 2019 Property Appraised Valuations**

Subdivision	Total Properties	Assessed Value <sup>(1)</sup>
Candlewood Lake Road	109	\$ 214,169
Candlewood Shores	577	\$ 262,106
Arrowhead Point	246	\$ 273,521
Pleasant Rise	121	\$ 232,756
Total	1,053	\$ 256,438

<sup>(1)</sup> Assessed Value = 70% of Appraised Value





**Figure 2-3 Study Area Zoning Map**

## 2.5 LOT SIZES

Table 2-5 presents the number of Study Area parcels which are developed or undeveloped within each lot size range. As indicated, 28% of the lots are less than 10,000 sf and 50% of the lots are less than 15,000 sf.

Lot Size Range (ft <sup>2</sup> )	# of Dev. Parcels	% of total	Cum % of total	# of Vac. Parcels	Total
0 - 5,000	27	2%	2%	42	69
5,001 - 7,500	126	9%	11%	32	158
7,501 - 10,000	222	16%	28%	24	246
10,001 - 15,000	292	22%	50%	27	319
15,001 - 20,000	157	12%	61%	9	166
20,001 - 25,000	150	11%	72%	15	165
25,000 - 50,000	262	19%	92%	10	272
>50,000	110	8%	100%	21	131
	1,346	100%		180	1,526

**Table 2-5 Study Area Lot Sizes**

## 2.6 WATER SUPPLY & USE

### 2.6.1 WATER SUPPLY

**Table 2-6 Water Supply Districts & Number of Parcels**

Water System Owner	# of Parcels
Aquarion - Candlewood Acres	27
Aquarion of Western Brookfield	210
Arrowhead Point HO Ass'n	100
Candlewood Lake Club	64
Candlewood Orchards	34
Candlewood Shores Tax District	539
Food establishments on well -TNC	1
Hickory Hills	62
Woodcreek Village Condo Ass'n	25

**Total 1,062**

Table 2-6 presents the Study Area water supply districts, which are illustrated on Figure 2-4.

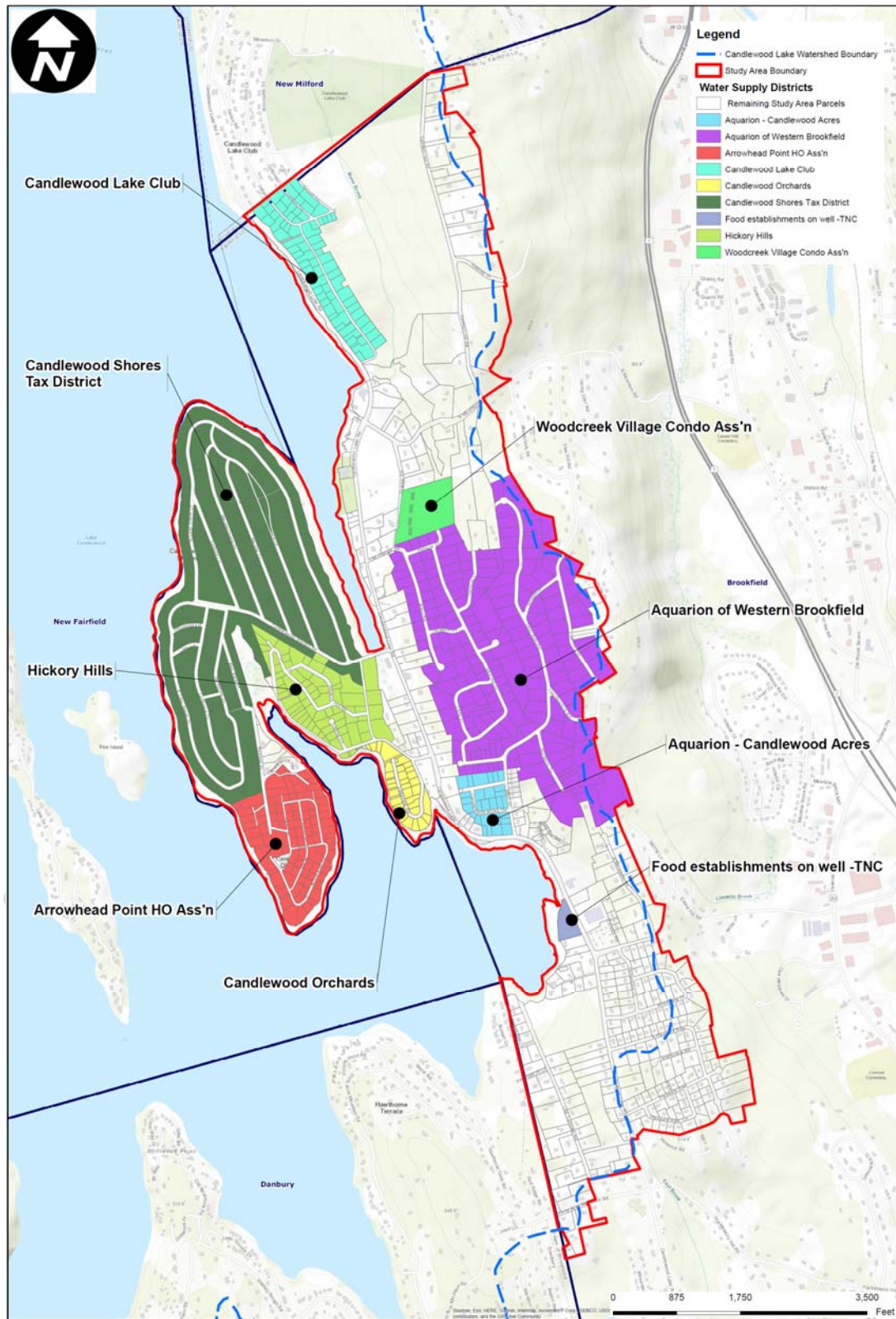
Water supply for the non-water districts properties is supplied by individual wells.

Figure 2-5 presents Study Area groundwater quality designations.

Table 2-7a presents a summary of study area drinking water wells information, which was obtained from the CT DoH Source Water Assessment Reports. The water source is from bedrock wells. Tables 2-7b and 2-7b present information on Candlewood Shores

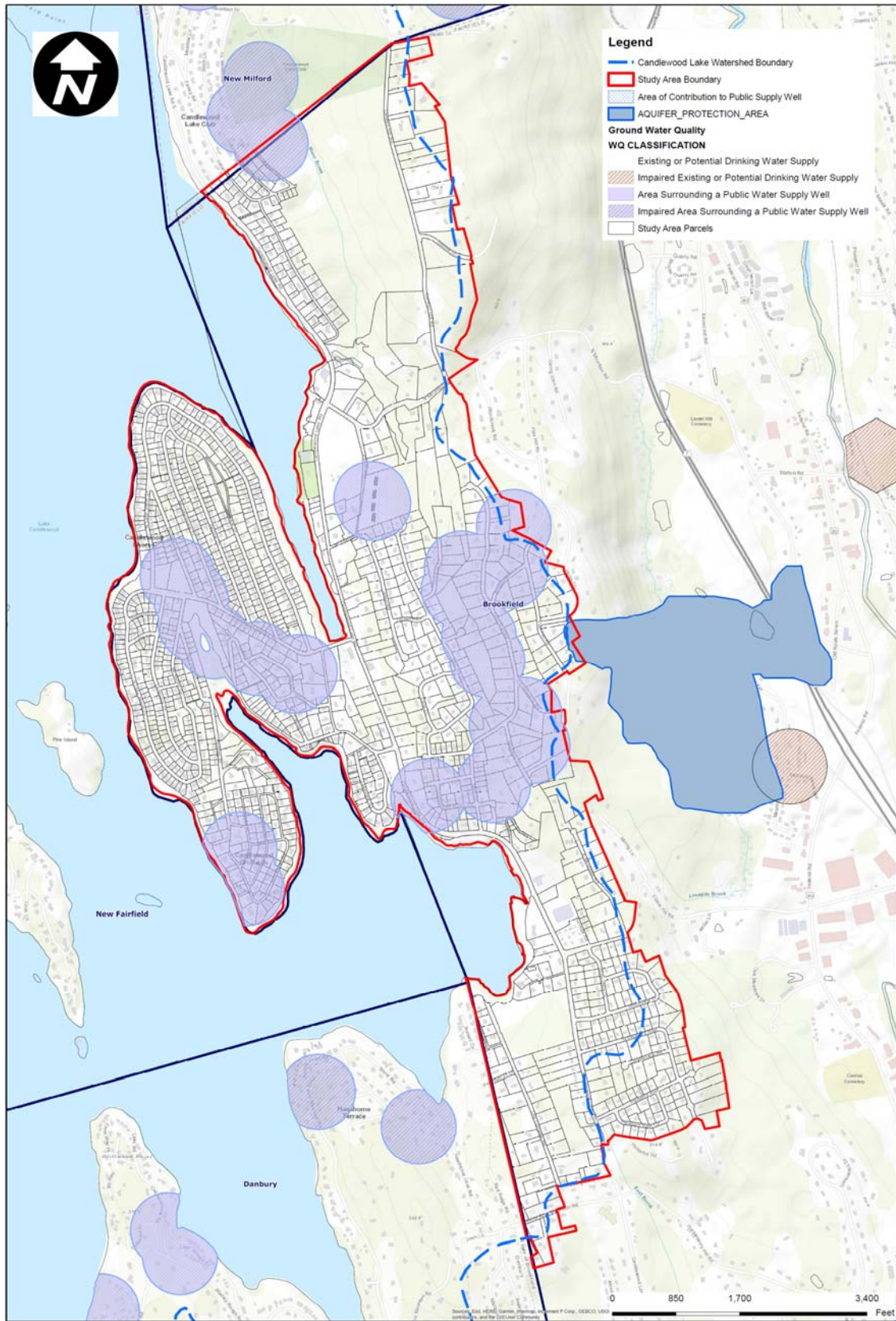
well logs and yield tests.

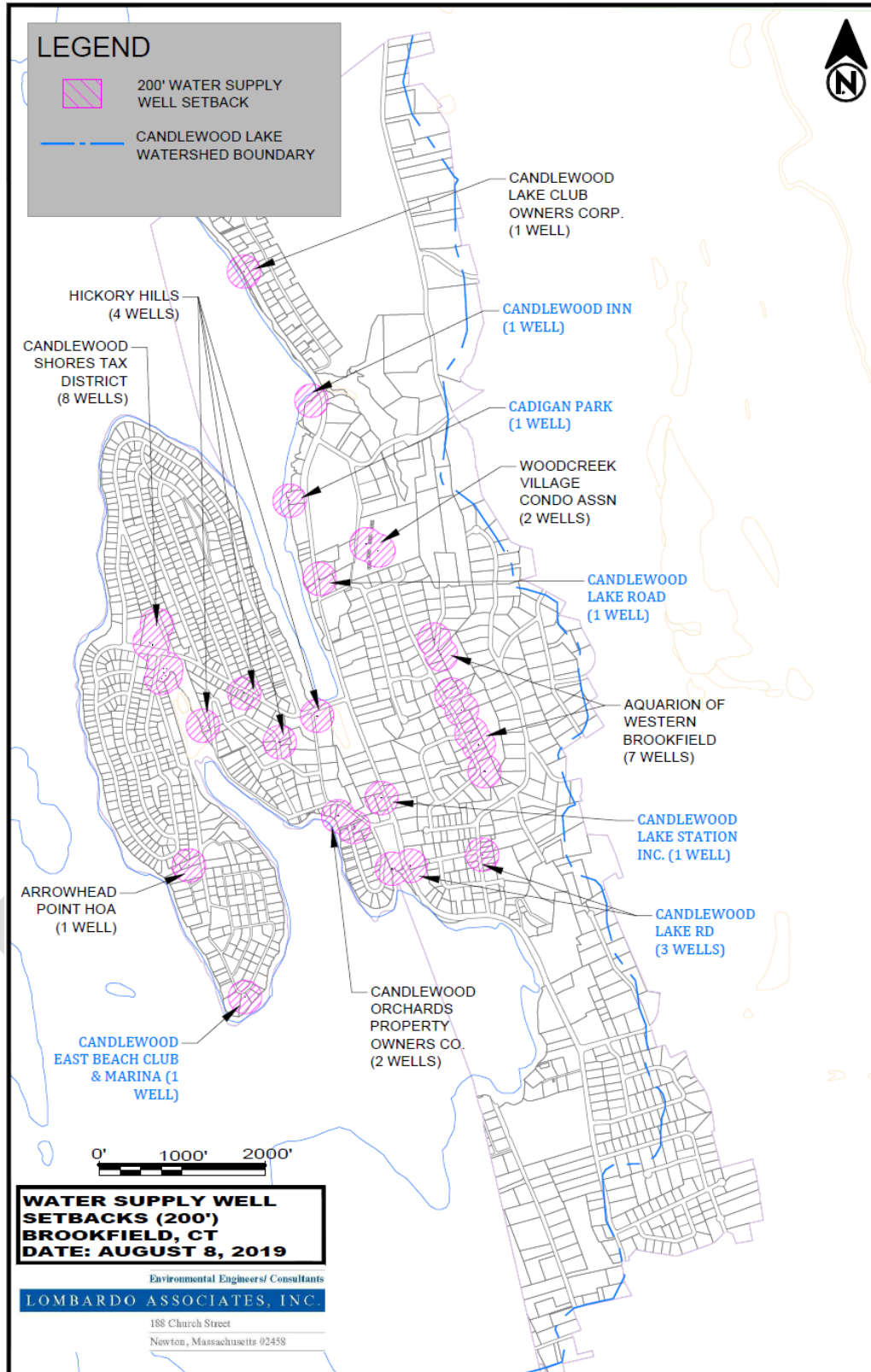




**Figure 2-4 Study Area Water Supply Districts**







**Figure 2-5 Study Area Water Supply Wells & Setback Areas**

**Table 2-7a Summary of Study Area Drinking Water Wells**

Study Area Source Water Protection Inventory Summary									
Subdivision	CT DPH #	Name of Drinking Water Source(s)	Well Type	Classification	Source Water Area (acres)	Source Water Assessment Ratings For This Well			
						I Environmental Sensitivity	II Potential Risk Factors	III Source Protection Need	
Candlewood Shores Taxing District	CT0180061	Well 1	Bedrock	GAA-Well	65	Low	Low	High	PWS should provide information about the amount of land it owns or controls within a 200 foot radius around this well and increase ownership or control of these lands
		Well 2	Bedrock	GAA-Well	50	Low	Low	High	
		Well 3	Bedrock	GAA-Well	76	Low	Low	High	
		Well 6	Bedrock	GAA-Well	50	Low	Low	High	
		Well 7	Bedrock	GAA-Well	18	Low	Low	High	
		Well 8	Bedrock	GAA-Well	58	Low	Low	High	
		Well 9	Bedrock	GAA-Well	36	Low	Low	High	
Candlewood Orchards Property Owners Corp	CT0180181	Well 2	Bedrock	GA	18	Low	Low	High	
Arrowhead Point Homeowners Association	CT0180091	Well 1	Bedrock	GAA-Well	18	Low	Low	High	
		Well 2	Bedrock	GAA-Well	18	Low	Low	High	
Woodcreek Village Condominium	CT0180201	Well 1	Bedrock	GAA-Well	18	Low	Low	High	
		Well 2	Bedrock	GAA-Well	18	Low	Low	High	
Hickory Hills - Aquarion	CT0180101	Well 1	Bedrock	GAA-Well	22	Low	Low	High	
		Well 2	Bedrock	GAA-Well	18	Low	Low	High	
		Well 3	Gravel	GAA-Well	18	Low	Low	High	
Candlewood Acres	CT0180081	Well 1	Bedrock	GAA-Well	45	Low	Low	High	
		Well 2	Bedrock	GAA-Well	36	Low	Low	High	
GA = Existing or Potential Drinking Water supply suitable for drinking without treatment									
GAA-Well = existing or potential public supply of water suitable for drinking without treatment									



**Table 2-7b Candlewood Shores Drinking Water Well Details & Yields**

Candlewood Shores Tax District Well Characteristics											
Well #	Registration #	Permit #	Date of Completion	Static Water Level below surface (ft)	Compacted Depth (ft)	Casing Length (ft)	Casing Diameter (in)	Casing Weight/ft (lbs)	Yield Test Water Level (ft)	Stabilized Drawdown (ft)	Yield (GPM)
3	303	137852	6/6/1989	6	355	N/A	N/A	N/A	330	55	40
5	1	106536	8/6/1986	50	455	N/A	N/A	N/A	435	N/A	1.5
6	303	114185	8/15/1986	10	405	40	6	17.5	380	N/A	20
7	303	114190	8/25/1986	30	305	103	6	17.5	280	115	15
8	303	114191	8/22/1986	10	305	120	6	17.5	180	N/A	45
9	303	114225	10/11/1986	40	455	160	6	17.5	430	160	15

**Table 2-7c Candlewood Shores Drinking Water Well Logs**

## 2.6.2 POTABLE WATER USE & QUALITY

The Study Area's groundwater is its water supply, as well as recipient of some of its wastewater discharges. Table 2-8 presents water use for the water districts for which data was available. Table 2-9 presents 2018 data on potable water quality for nitrate nitrogen, sodium and chloride.

**Table 2-8 Potable Water Use in Districts & Parcels / Population Served**

Water System	# of Parcels Served	Est. No. Users	Water Demand		
			gpd	gpd/parcel	gpcd
Aquarion - Candlewood Acres	27				
Aquarion of Western Brookfield	210	840	46,200	220	55
Arrowhead Point HO Ass'n	100				
Candlewood Lake Club	64				
Candlewood Orchards	34	144			
Candlewood Shores Tax District	539	1,305			
Food establishments on well -TNC	1				
Hickory Hills - Aquarion	62	132	3,700	60	28
Woodcreek Village Condo Ass'n	25	72			
Total	1,062	2,493			

**Table 2-9 Potable Water Quality by District**

Table 2-6 Potable Water Quality by District						
Water System	Nitrate (NO <sub>3</sub> -N) Conc. (mg/L)		Sodium (Na) Conc. (mg/L)		Chloride (Cl) Conc. (mg/L)	
	MCL	Latest Actual	NL	Latest Actual	NL	Latest Actual
Aquarion - Candlewood Acres	10	0.7	28	16.2	250	7
Aquarion of Western Brookfield		3.5		53		53
Arrowhead Point HO Ass'n		7.9		24.8		100
Candlewood Lake Club		1.3		6.46		8.4
Candlewood Orchards		0		9.9		3.4
Candlewood Shores Tax District		7.5		31		31
Food establishments on well -TNC						
Hickory Hills - Aquarion		0.5		8.1		7.1
Woodcreek Village Condo Ass'n		0.7		18.7		129
MCL = Maximum Contaminant Level						
NL = State of Connecticut customer notification level. Elevated levels of sodium, coupled with dietary intake, can potentially affect those on a sodium-restricted diet.						

Candlewood Shores provided water use data for each of their 511 customers for the period July 1, 2018 through June 30, 2019 on a 4 -month billing basis. Water use averaged approximately 100 gallons per day per parcel during the non-summer period and 117 gpd/parcel for the summer period. Wastewater generation is typically 85% - 95% of winter time or non-irrigation periods water use. This wastewater generation value of 85 – 95 gpd/parcel is comparable to the Brookfield sewered area rate of 75.6 gpd/unit, further discussed in Section 2.6.

The Table 2-9 water quality data strongly suggests that septic discharges influences well water quality of Arrowhead and Candlewood Shores – which serve 60% of the AoC parcels. Nitrate nitrogen levels in the Arrowhead and Candlewood Shores water supplies are very close to violating the US EPA drinking water standard.

## 2.7 WATER RESOURCES – SURFACE AND GROUNDWATER

Water resources in the Study Area consists of stormwater and groundwater – all fed by rainwater. Monthly normal and 2018 totals for Danbury Airport rainfall is presented on Table 2-10 and shows a fairly consistent normal monthly precipitation of 4+/- inches.

Rainfall (inches) at Danbury Airport		
Month	Normal	2018
January	3.36	2.26
February	2.77	4.60
March	4.10	2.77
April	4.24	4.45
May	4.44	2.37
June	4.88	5.13
July	4.58	6.79
August	4.54	5.02
September	4.30	5.64
October	4.71	3.80
November	4.25	7.05
December	4.10	5.96
Total	50.27	55.84

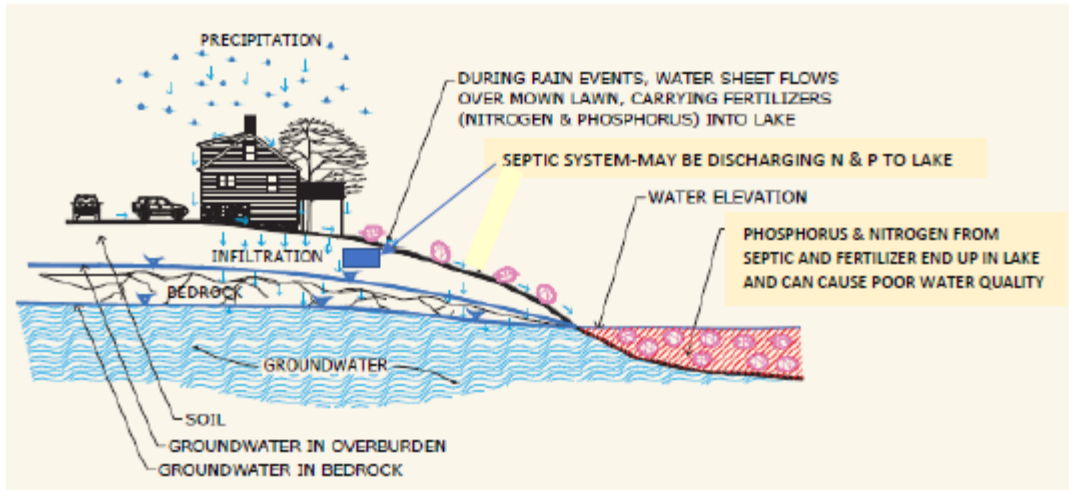
**Table 2-10 Danbury Rainfall Monthly Normal and 2018 Totals**

### Groundwater

While there are no known studies on the Study Area's groundwater, it is understood to exist in the overburden and bedrock as depicted by Milone & MacBroom, Inc. (2014) (used with permission) with modifications by LAI and shown on Figure 2-6. There are no known instances of perched groundwater or data that suggest that perched groundwater would exist. There are no known documents presenting area-wide depth to groundwater data for the Study Area.

Without data, it will be assumed that groundwater is slightly above (we will use 1 foot) Lake elevation and that groundwater sub-watershed divides match surface water sub-watershed divides, which are dictated by surface topography. Further discussion on surface water and groundwater sub-watersheds and flow paths is presented in Section 3.7.





**Figure 2-6 Hydrology Cross Section**

## Stormwater Management

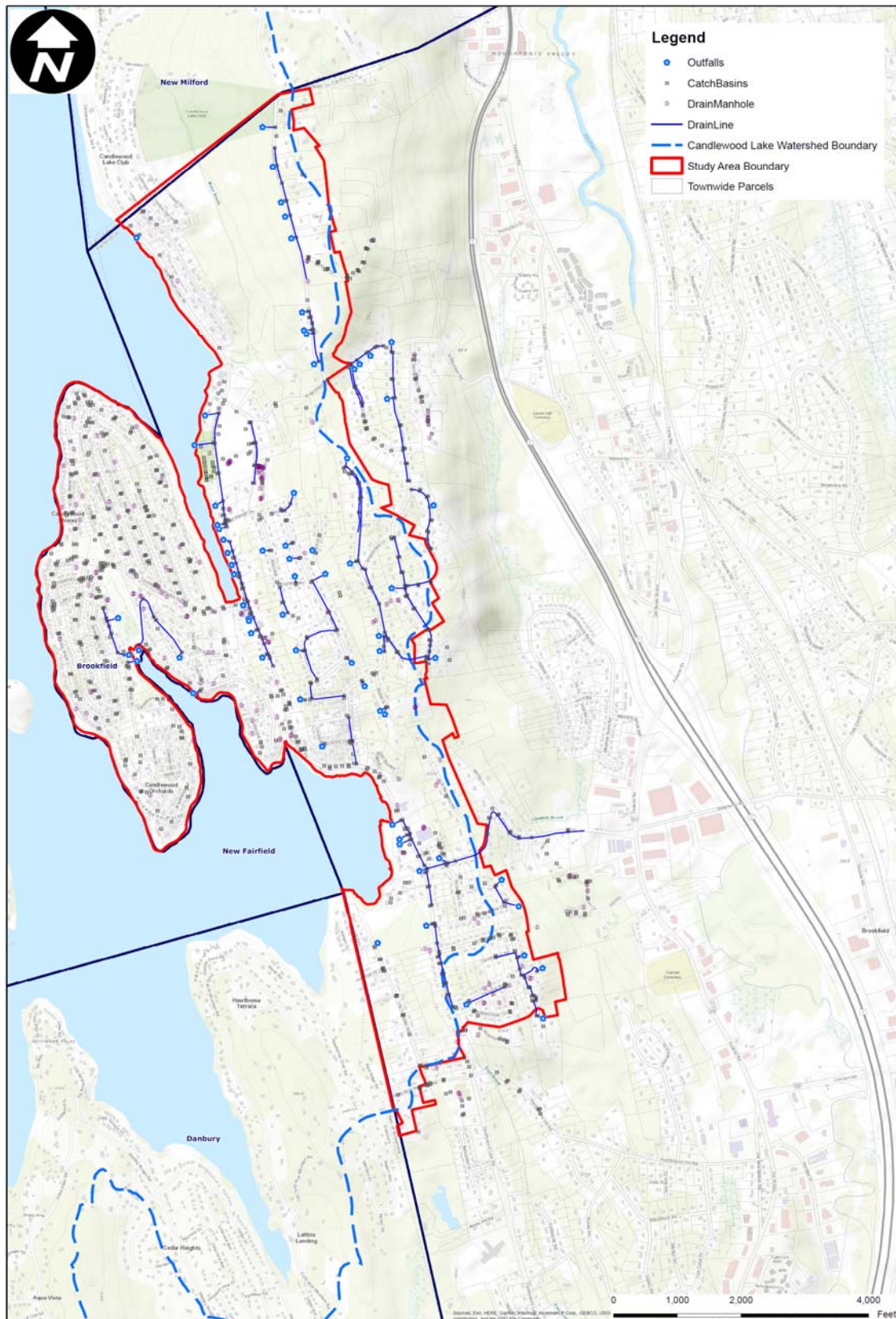
Study area stormwater management is a concern as improper stormwater management can adversely impact an OWTS. Also, stormwater conveyance systems can be conduits for discharges of failing OWTS.

CT DoH OWTS code requirements include minimum separation distances from stormwater structures, drains and infiltration systems of typically 25 – 50 feet depending on site conditions.

The stormwater management systems in the Study Area are presented on Figure 2-7 and illustrate the locations of drain manholes, catch basins, drain lines and outfalls. The Town's Municipal Separate Storm Sewer System Permit (MS4) Permit Number GSM 000006 requires an [Annual Report](#) from the Town, which is viewable at [Annual Report](#). <https://www.brookfieldct.gov/public-works/news/stormwater-management-2107-annual-report-draft-public-review-and-comment>

As much of the Study Area has private roads owned by Associations/Districts, stormwater management in those Association areas are the responsibility of the Associations/Districts. No reports have been identified that address stormwater management in the private Associations / Districts.

According to the [CT DEEP Water Quality Factsheets](#), Brookfield stormwater quality for total nitrogen and phosphorus averages approximately 1.5 mg/L and 0.10 mg/L respectively.



**Figure 2-7 Brookfield Stormwater System Map**

## 2.8 WASTEWATER MANAGEMENT PRACTICES

It is understood that all wastewater systems in the Study Area rely predominately upon septic tank drainfields as shown on Figure 2-8, from the [Bay Journal](#) (July-August 2019). While there may be cesspools on some properties due to their age and practices at the time, it is expected to be an insignificant number as CT DoH banned cesspools in the 1950s and Study Area site conditions are not conducive to the use of cesspools.

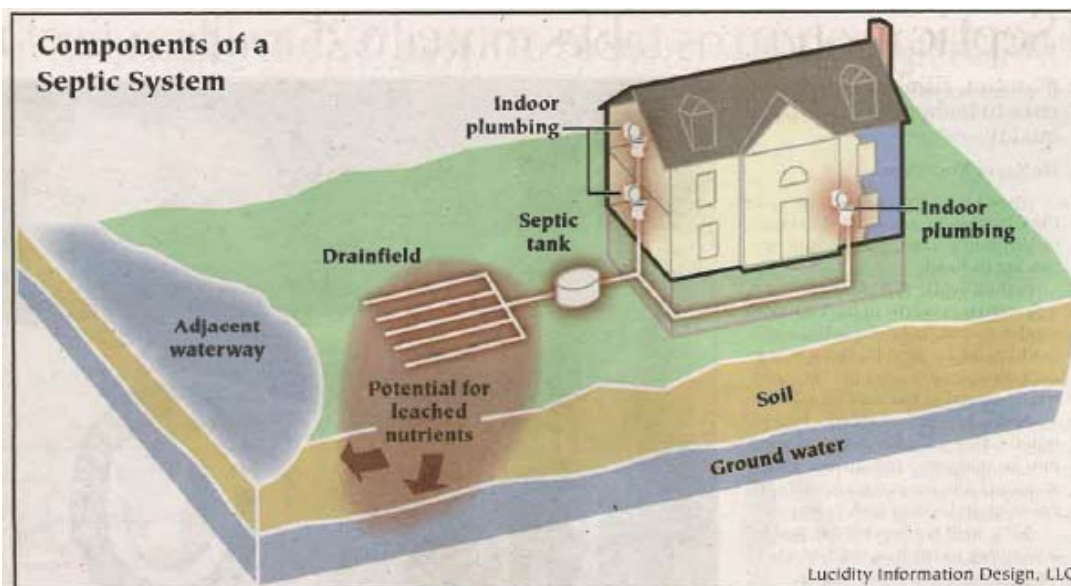
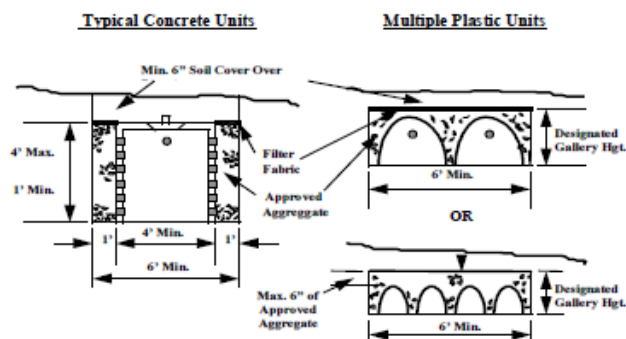


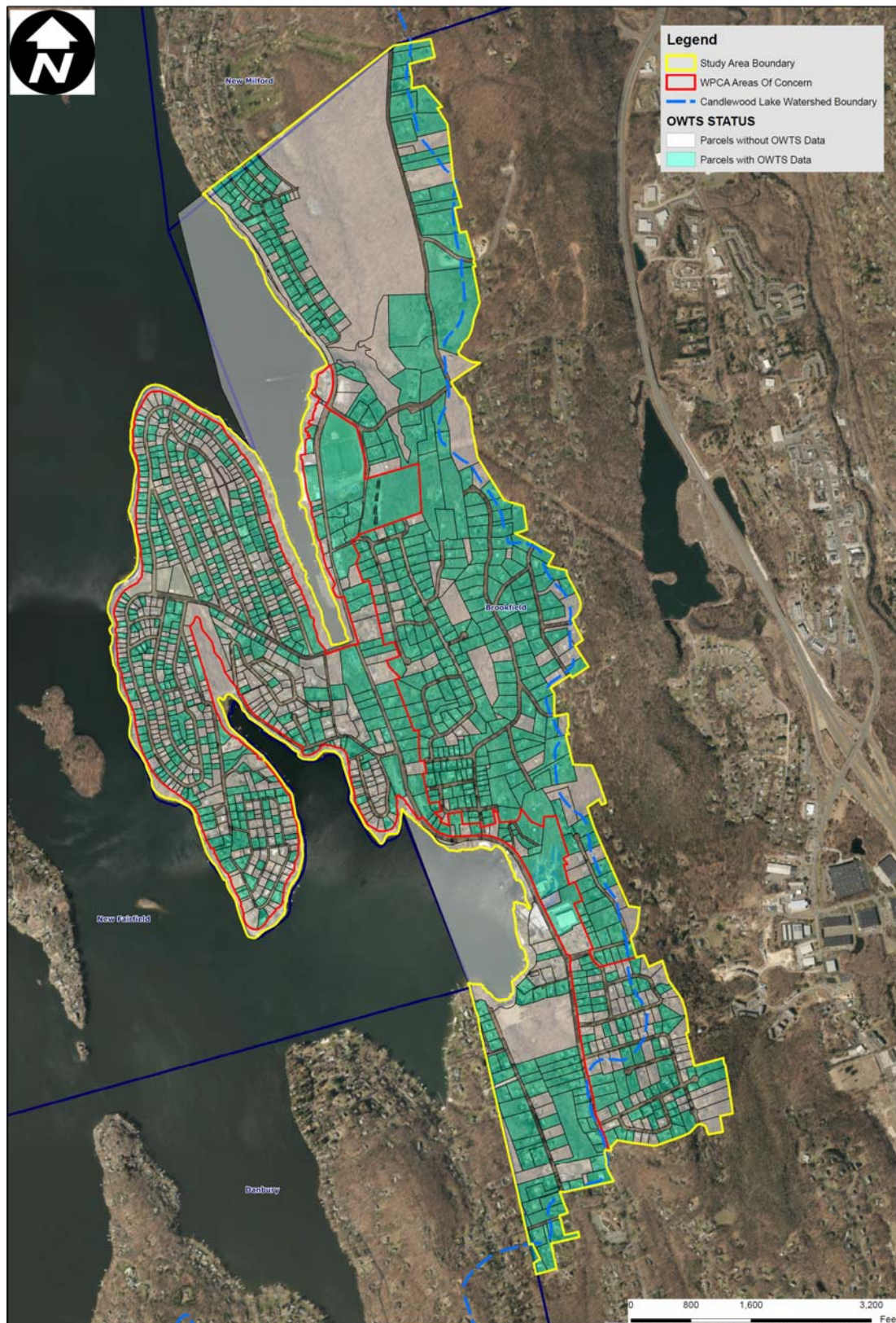
Figure 2-8 Residential OWTS Schematic

For the properties in the WPCA Areas of Concern, the WPCA scanned OWTS Plans/Record Drawings (RD) from the Brookfield Health Department files. Figures 2-9a and 2-9b illustrate the location of the scanned septic Plans/RD in the AoC. Table 2-11 presents statistics on the number of parcels within the WPCA Areas of Concern, number with Plans/RD and number of parcels with soils percolation rate, soils texture and slope data, along with perc and slope data summary. Of the 1,053 parcels, 413 have Plans/RD, 278 have perc data and 123 have slope data. The max, mean and minimum values for percolation rate and slope are presented on Table 2-12. The mean percolation rate of ~ 20 minutes per inch (mpi) is consistent with percolation rates expected with the area soil types of fine sandy loams as described in Section 3.1 and soil texture data presented on Table 2-13. Typical Leaching Gallery Structures from CT DoH OWTS Code is presented on Figure 2-10.

Figure 2-10 Typical Leaching Gallery Structures

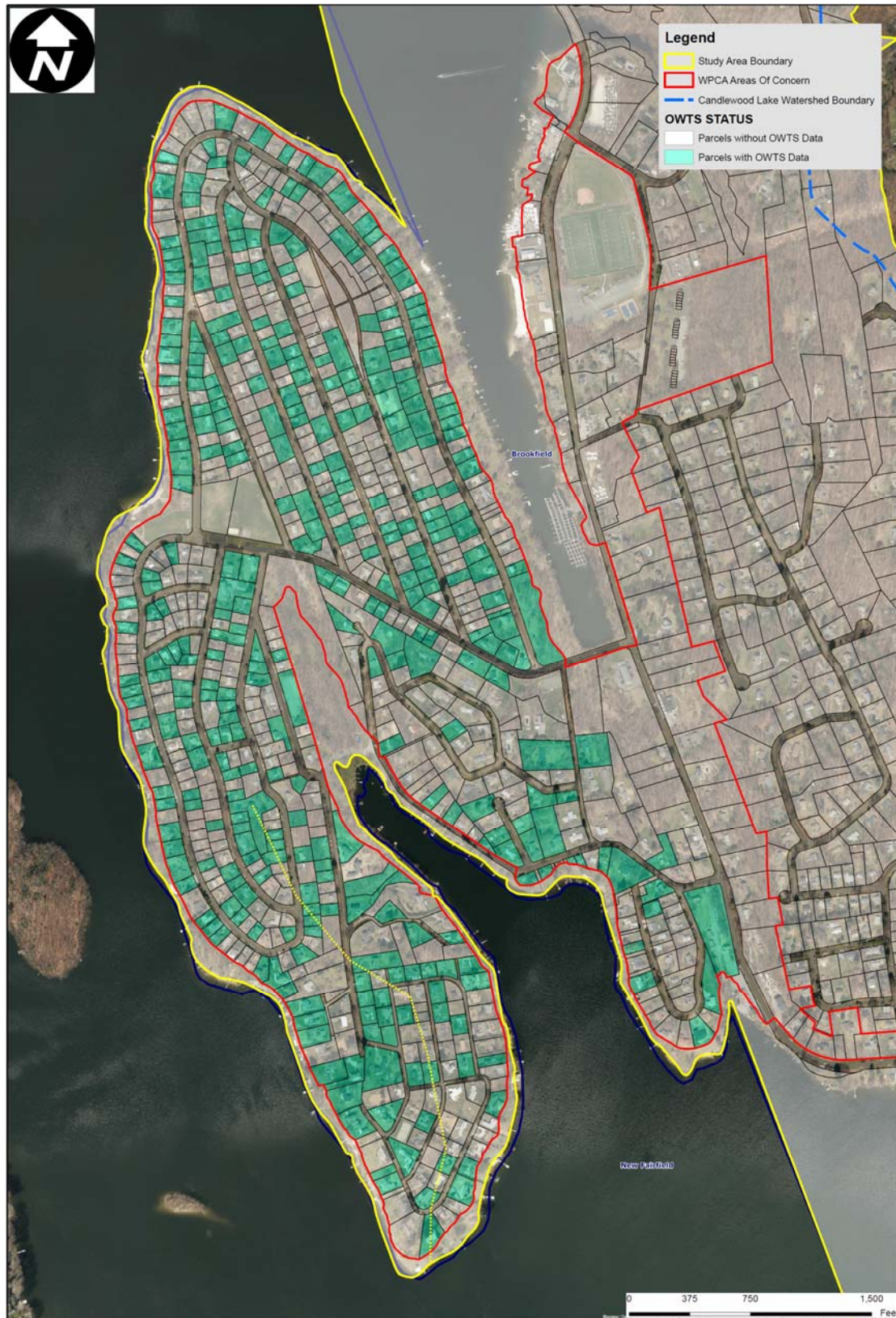






**Figure 2-9a Properties with Scanned OWTS Plans**





**Figure 2-9b Properties with Scanned OWTS Plans**

**Table 2-11 AoC Septic System Data Inventory & Perc/Slope Data**

Candlewood Lake Study Area - Property Listing by Subdivision, Septic Plans, Design Data, Site Soils Texture & Perc Rate								
Subdivision	Master Listing					Perc	Soils Texture	Slope
	Total Properties	With Plans		Without Plans		No. Properties w/ Perc Data	No. Properties w/ Soil Data	No. Properties w/ Slope Data
		No.	% of Total	No.	% of Total			
Candlewood Lake Road	109	0	0%	109	100%	0	0	0
Candlewood Shores	577	269	47%	308	53%	182	86	84
Arrowhead Point	246	88	36%	158	64%	72	32	29
Pleasant Rise	121	56	46%	65	54%	24	10	10
<b>Total</b>	<b>1,053</b>	<b>413</b>	<b>39%</b>	<b>640</b>	<b>61%</b>	<b>278</b>	<b>128</b>	<b>123</b>

**Table 2-12 AoC Septic System Data Inventory & Perc/Slope Data**

Candlewood Lake Study Area Soils Perc Rate & Slope								
Subdivision	Perc (min. per inch)				Slope (%)			
	No. Properties w/Perc Data	Max	Mean	Min	No. Properties w/Slope Data	Max	Mean	Min
Candlewood Lake Road	0				0			
Candlewood Shores	182	60	17	2	84	59	18	3
Arrowhead Point	72	75	20	4	29	30	13	5
Pleasant Rise	24	45	20	10	0	0	0	0
<b>Total</b>	<b>278</b>				<b>113</b>			
<b>% of Plans</b>	<b>67%</b>				<b>27%</b>			

Table 2-13 presents soil texture data at > 30" below ground surface and septic system technology type with number installed. Table 2-14 presents statistics on the number of WPCA Area of Concern (AOC) parcels with septic system plan dates and system ages. Tables 2-15 and 2-16 present WPCA AOC Septic System Age using housing age for septic age for parcels when no septic age data exists and using Plan/RD date, respectively.

**Table 2-13 WPCA AoC Septic System Plan Dates Statistics**

Candlewood Lake Study Area Septic System Date Inventory						
Subdivision	Total Plans	Plans w/ Dates	Plans w/o Dates	Totals	Parcels w/o Plans	Total Parcels
Candlewood Lake Road	0	0	0	0	109	109
Candlewood Shores	269	230	39	269	308	577
Arrowhead Point	88	80	8	88	158	246
Pleasant Rise	56	40	16	56	65	121
<b>Total</b>	<b>413</b>	<b>350</b>	<b>63</b>	<b>413</b>	<b>640</b>	<b>1053</b>
<b>% of Total Plans</b>		<b>85%</b>	<b>15%</b>	<b>100%</b>		
<b>% of Total Parcels</b>		<b>33%</b>	<b>6%</b>	<b>39%</b>	<b>61%</b>	



**Table 2-14 AoC Septic Systems – Soil Texture and Technology Type**

Candlewood Lake Study Area Soils Texture Data at Elevation > 30"													
Subdivision	Total No. Properties w/Soils	Fill	Sandy Loam	Fine Sandy Loam	Silty Sandy Loam	Sand	Silty Sand	Fine Silty Sand	Silty Loam	Clay Loam	Clay	Hardpan	Totals
Candlewood Lake Road	0	0	0	0	0	0	0	0	0	0	0	0	0
Candlewood Shores	86	5	13	3	5	3	17	12	11	1	0	16	86
Arrowhead Point	32	0	5	0	4	3	9	0	2	0	2	7	25
Pleasant Rise	1	0	0	0	1	0	0	0	0	0	0	0	1
<b>Total</b>	<b>119</b>	<b>5</b>	<b>18</b>	<b>3</b>	<b>10</b>	<b>6</b>	<b>26</b>	<b>12</b>	<b>13</b>	<b>1</b>	<b>2</b>	<b>23</b>	<b>112</b>
<b>% of Total</b>		<b>4%</b>	<b>15%</b>	<b>3%</b>	<b>8%</b>	<b>5%</b>	<b>22%</b>	<b>10%</b>	<b>11%</b>	<b>1%</b>	<b>2%</b>	<b>19%</b>	<b>100%</b>

Candlewood Lake Study Area Septic System Types															
Subdivision	Total Systems	Trench	Gallery	Eljen	GeoMat	Living Filter	Infil	GreenL each Drainfi	Trench + Gallery	Trench + Eljen	Gallery + Eljen	Infil + Gallery	Leaching Pool	Tank Replace.	Totals
Candlewood Lake Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Candlewood Shores	269	26	123	35	15	10	25	5	7	0	1	5	2	15	269
Arrowhead Point	88	15	46	7	8	1	7	0	0	1	1	0	0	2	88
Pleasant Rise	56	21	22	6	3	0	2	0	0	0	0	0	0	2	56
<b>Total</b>	<b>413</b>	<b>62</b>	<b>191</b>	<b>48</b>	<b>26</b>	<b>11</b>	<b>34</b>	<b>5</b>	<b>7</b>	<b>1</b>	<b>2</b>	<b>5</b>	<b>2</b>	<b>19</b>	<b>413</b>
<b>% of Total</b>		<b>15%</b>	<b>46%</b>	<b>12%</b>	<b>6%</b>	<b>3%</b>	<b>8%</b>	<b>1%</b>	<b>2%</b>	<b>0%</b>	<b>0%</b>	<b>1%</b>	<b>0%</b>	<b>5%</b>	<b>100%</b>

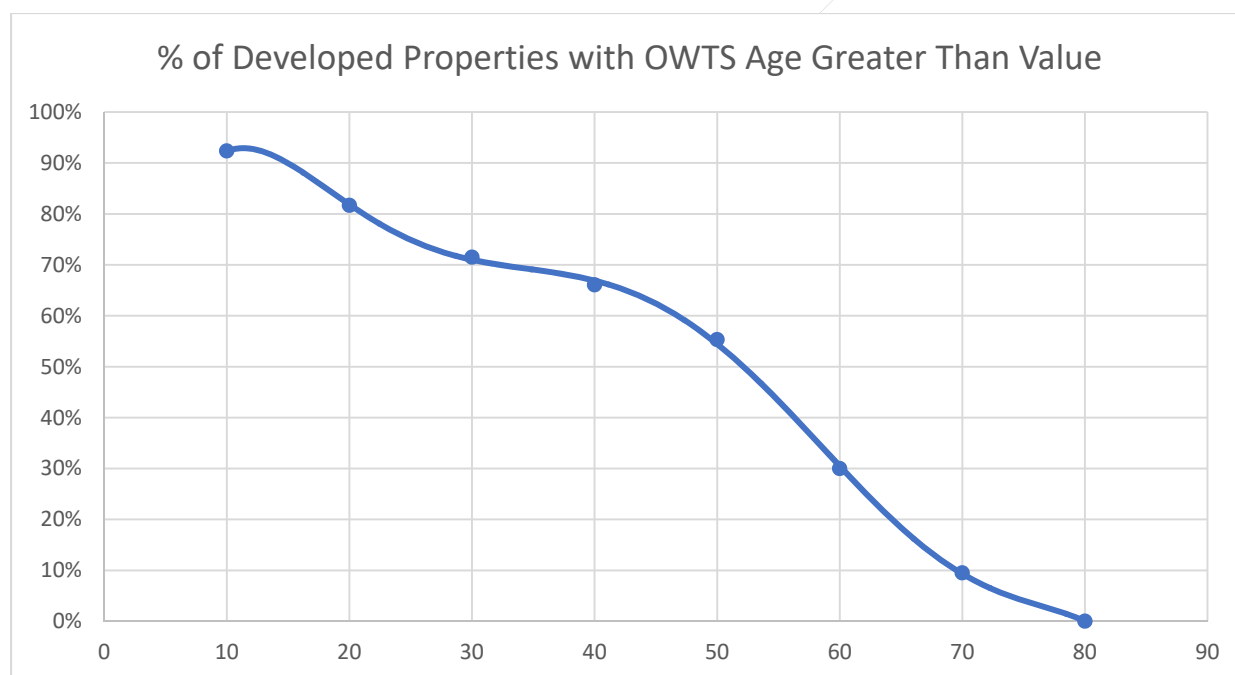
**Table 2-15 Study Area OWTS System Age Distribution – Using Housing Age when no OWTS Plan Age**

Study Area Septic Age Distribution												
Category	Total # of Parcels	Total Parcels w/ Septic Age	0-10 Yrs	11-20 Yrs	21-30 Yrs	31-40 Yrs	41-50 Yrs	51-60 Yrs	61-70 Yrs	71+ Yrs	Total	
<b>Total</b>	<b>1,526</b>	<b>1,358</b>	<b>104</b>	<b>145</b>	<b>138</b>	<b>74</b>	<b>146</b>	<b>344</b>	<b>278</b>	<b>129</b>	<b>1,358</b>	
<b>% of Total Properties</b>		<b>89%</b>	<b>8%</b>	<b>11%</b>	<b>10%</b>	<b>5%</b>	<b>11%</b>	<b>25%</b>	<b>20%</b>	<b>9%</b>	<b>100%</b>	
<b>Cum. % of Prop w/Age Greater than Category</b>			<b>92%</b>	<b>82%</b>	<b>72%</b>	<b>66%</b>	<b>55%</b>	<b>30%</b>	<b>9%</b>	<b>0%</b>		

Table 2-15 and Figure 2-11 present the estimated OWTS Age distribution in the Study Area. Per Table 2-15, 29% of OWTS are less than 30 years old and 55% are greater than 50 years old.

**Table 2-16 AoC Septic System Plan Dates Distribution**

Candlewood Lake AOC Septic System Age - Plan Dates Only							
Subdivision	Total Plans w/ System Age	0-10 Yrs	11-20 Yrs	21-30 Yrs	31-40 Yrs	41-50 Yrs	Totals
Candlewood Lake Road	0	0	0	0	0	0	0
Candlewood Shores	230	62	87	60	15	6	230
Arrowhead Point	80	17	35	17	9	2	80
Pleasant Rise	40	13	11	14	1	1	40
<b>Total</b>	<b>350</b>	<b>92</b>	<b>133</b>	<b>91</b>	<b>25</b>	<b>9</b>	<b>350</b>
<b>% of Total Plans</b>		<b>26%</b>	<b>38%</b>	<b>26%</b>	<b>7%</b>	<b>3%</b>	<b>100%</b>
<b>Cum % of Total Plans</b>		<b>26%</b>	<b>64%</b>	<b>90%</b>	<b>97%</b>	<b>100%</b>	
<b>% of Total Properties</b>		<b>9%</b>	<b>13%</b>	<b>9%</b>	<b>2%</b>	<b>1%</b>	<b>33%</b>



**Figure 2-11 OWTS Age Distribution**

## **ANALYSIS**

Per Table 2-12, during the past 30 years there have been a total of 316 septic system plans for either new construction or repairs in the AoC. Per Table 2-3a, there have been 101 new homes (i.e. property development) in the AoC during the past 30 years. Therefore, there were ~215 repairs during that time or an average of 7 repairs per year. Using a developed parcel quantity of 904, **the OWTS repair rate averaged 0.77% per year.**

## 2.9 EXISTING SEWER SYSTEM

There is no municipal wastewater treatment facility in Brookfield. The Brookfield existing sewer system, shown on Figure 2-12, discharges to the Danbury Wastewater Treatment Facility (WWTF). According to the WPCA, the existing sewer system consists of 23 miles of gravity sewers and force mains and 14 pump stations. The sewer system serves approximately 1,650 connections and contributes approximately 310,000 gallons per day (gpd) of wastewater to the Danbury WWTF, which is about 3% of the flow to the Danbury WWTF.

According to the WPCA Operating and Capital Budgets (Budget) for the Year Ended June 30, 2020, at the end of 2018 there were 4,102 units producing approximately 310,000 gpd or 75.6 gpd/unit. Each residential household is one unit. Based on WPCA Rules and Regulations, commercial establishments use a formula to determine their unit usage rate. An October 2015 water use analysis prepared for the WPCA found average winter water use at 102 gpd. With wastewater generation typically 90+/-% of winter water use, the data suggest a continuing impact of water conserving practices in the sewer area.

Per the Budget, "all Brookfield sanitary wastewater flow is sent to the Regional Danbury Waste Treatment plant under the supervision of the CT DEEP and by an Interlocal Agreement with Danbury. The agreement allows a flow from Brookfield of up to 500,000 gallons per day. But this is slated to be reduced to 380,000 gallons per day in 2022 with new phosphorous mitigation requirements imposed on the Danbury Waste Treatment Plant. Brookfield is currently sending wastewater at an average rate of 86% of the new allowable flow". WPCA annual sewer fee is \$420/unit, which is \$15.23 per 1,000 gallons of wastewater.

## 2.10 WASTEWATER MANAGEMENT REGULATIONS AND RULES

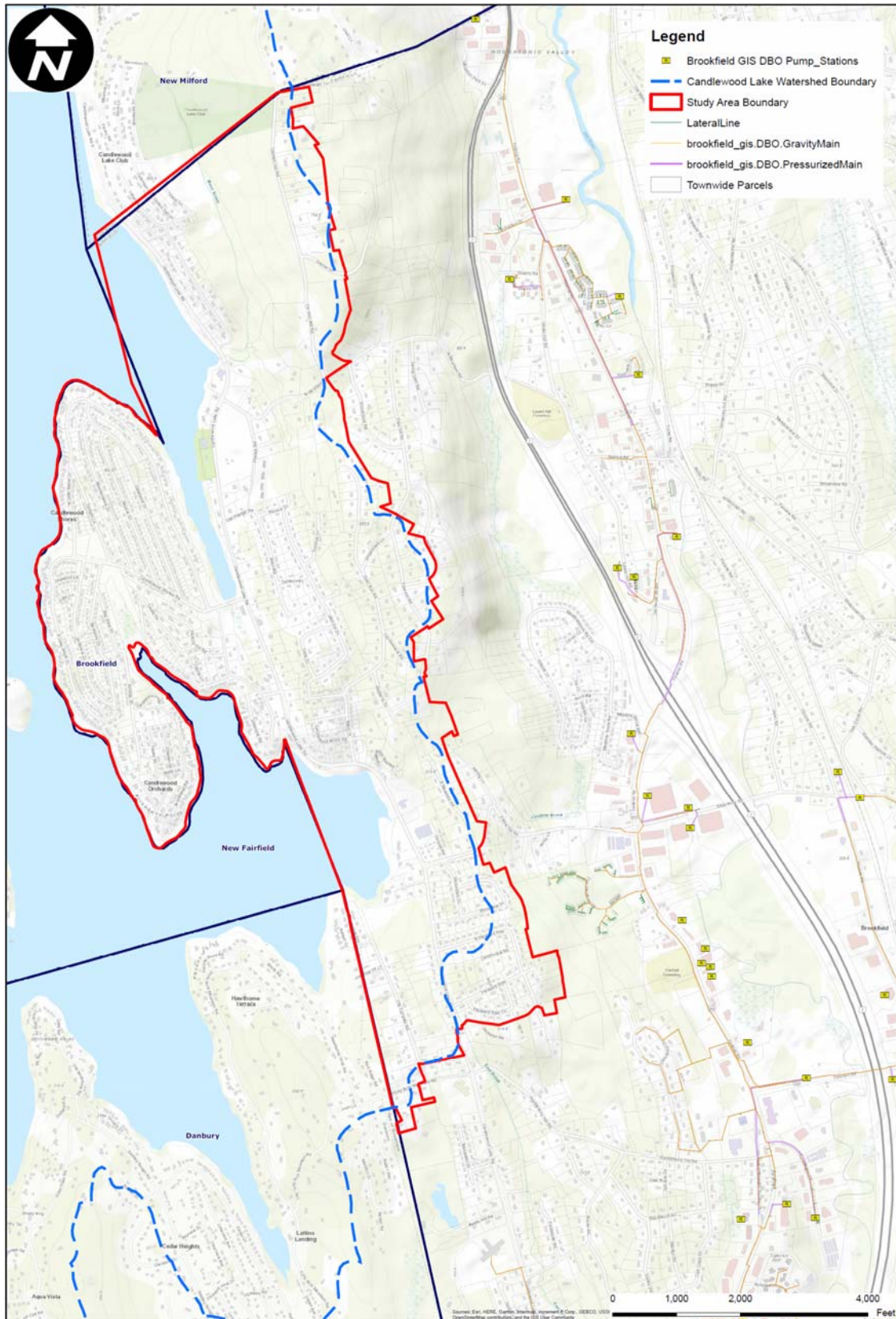
### 2.10.1 PERMITTING JURISDICTION AND CODES

Table 2-17 presents a summary of the CT Regulations and Rules that govern permitting of wastewater management systems in the Study Area.

**Table 2-17 CT Wastewater Permitting Rules**

Wastewater Flow	Technology Type	Jurisdiction	Code	Permit Type
Less than 7,500 gpd	Septic Tank - Drainfield	CT DoH	CT Public Health Code On-site Sewage Disposal Regulations and Technical Standards for Subsurface Sewage Disposal Systems - Jan. 2018	New construction or repair
Greater than 7,500 gpd	Any	CT DEEP	Guidance for Design of Large Scale On-Site Wastewater Renovation Systems - February 2006	
Any flow	Any	CT DEEP	2018 On-Site Code and 2006 Guidance	General Permit to Discharge from Subsurface Sewage Disposal Systems Serving Existing Facilities - expires 2002
Any flow	Alternative Technology*	CT DEEP / CT DoH	Guidance for Design of Large Scale On-Site Wastewater Renovation Systems - February 2006	New construction or repair
*Per C.G.S. § 19-a-35a pertaining to Alternative On-Site Sewage Treatment Systems, CT DPH has the statutory authority to categorize and permit discharges of < 7,500 gpd from alternative OWTs but has not done so due to the lack of the appropriations. In the interim, DEEP has authority.				





**Figure 2-12 Study Area & Town Sewer System**

## 2.10.2 WPCA AUTHORITY

Per C.G.S. § 7-246 Water Pollution Control Authority, the WPCA has the authority to establish a Decentralized Wastewater Management Districts (DWMD) as follows:

- ✓ Following approval of an engineering report by the Commissioner of Energy and Environmental Protection that includes concurrence with such approval by the Commissioner of Public Health, and in consultation with the local director of health, a municipality, acting in conjunction with its water pollution control authority may, by ordinance, establish geographical areas of decentralized wastewater management districts within such municipality.
- ✓ Such ordinance shall include remediation standards for the design, construction and installation of alternative sewage treatment systems and standards for the effective supervision, management, control, operation and maintenance of alternative sewage treatment systems within such decentralized wastewater management districts that are consistent with any permit, order or recommendation of the Commissioner of Energy and Environmental Protection.
- ✓ Notwithstanding any provision of the general statutes, an area that is designated by ordinance of a municipality as a decentralized wastewater management district shall not be a public sewer for purposes of the Public Health Code.

The advantages / disadvantages of a DWMD for the Study Area will be considered and evaluated in the development of a Project Implementation Plan. If a DWMD is desired by the WPCA, consultation with CT DEEP and CT DoH will be needed to work through details.

## 2.10.3 OWTS PERMITTING REQUIREMENTS & DISPOSAL AREA REQUIREMENTS

### 2.10.3.1 SETBACKS

OWTS are required meet a number of minimum separation requirements as listed below.

#### **CT DoH Code Requirements**

Groundwater	1.5' (increases when perc rate is < 5mpi)
Bedrock	4.0'
Open Water Course	50' For lots in existence prior to 8/16/82 that are not on a public water supply watershed, the distance shall be reduced to not less than 25 feet
Property line	10'
Building	10'
Groundwater Drain	25' upgradient; 50' downgradient
Stormwater Catch Basin/MH	25'
Stormwater infiltration systems	25' – 75' depending on site conditions; 10' for rain gardens

**Brookfield Inland Wetlands Commission** has jurisdiction over and **permits are required** for activities within these distances to a wetland, stream or watercourse (i.e. creek at Indian Trails).

Candlewood Lake shoreline	200'
Wetlands*	75'
Stream*	100'

Watercourse\* 100'

\*For slopes > 5%, up to 200' is the jurisdictional distance.

The Inland Wetlands Commission does not have setback requirements – rather, the Commission works with property owners to achieve best achievable setbacks.

### 2.10.3.2 LEACHING AREA REQUIREMENTS

OWTS are required meet minimum leaching areas, which is calculated by:

Required Leaching Area = Design Flow / Hydraulic Application Rate

#### 1. Depth to Limiting Layer >60"

For Residential OWTS:

- Design Flow = 150 GPD/bedroom
- Hydraulic Application Rate (HAR) is based on soil percolation rate
- Area requirements presented on Table 2-18.

For Commercial OWTS:

- Design flows for user types are on Section IV.B, Table 4 of CT DoH OWTS Code
- HAR for problematic sewerage users Section VII.F.2-3, Table 7 of OWTS Code – i.e. restaurant, bakery, food service establishment, residential institution
- HAR for users not covered by Table 7 of OWTS Code, use Section VII.F.2-3, Table 8

Footprint requirement for any specific system are Technology Specific as different technologies are assigned different SF area credits/areal foot.

**Table 2-18 Residential OWTS Leaching Area Requirements**

CT DoH Code Req'd Leaching Area (SF) - Residential						
Perc. Rate (min./in.)	LTAR Rate (GPD/ft <sup>2</sup> )	# of Bedrooms (150 GPD/BR)				
		1	2	3	>3 (Per added BR)	
					Single family	Multi - family
0-10	0.55	187.5	375	495	82.5	165
10.1-20	0.40	250	500	675	112.5	225
20.1-30	0.36	282.5	565	750	125	250
30.1-45	0.30	337.5	675	900	150	300
45.1-60	0.27	372.5	745	990	165	330

LTAR = Long-Term Acceptance Rate

#### 2. Depth to Limiting Layer ≤60"

CT DoH requires systems built in soils with less than 60" to limiting layer be subject to calculation of Minimum Leaching System Spread (MLSS). The MLSS defines the minimum length of dispersal area required by OWTS Code and is calculated as follows:



$$\text{MLSS (ft)} = \text{HF} \times \text{FF} \times \text{PF}$$

- Hydraulic Factor (HF) – based on hydraulic gradient approximated by topography-based slopes, and receiving soil depth to limiting layer
- Flow Factor (FF) – based on design flow of building served
- Percolation Factor (PF) – based on percolation rate of receiving soil

MLSS Factor Calculation Tables are presented on Tables 2-19 through 2-21.

**Table 2-19 CT DPH Hydraulic Factor Calculation Table**

		Hydraulic Gradient (% Slope)								
		<1.0	1.0-2.0	2.1-3.0	3.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-15.0	>15.0
Receiving Soil Depth (Inches)	0.1 - 17.9	See Comments in Section VIII A								
	18.0 - 22.0	72	62	54	48	42	34	30	28	26
	22.1 - 26.0	66	56	48	42	34	30	28	26	24
	26.1 - 30.0	56	49	42	34	30	28	26	24	20
	30.1 - 36.0	48	42	34	30	28	26	24	20	18
	36.1 - 42.0	42	36	30	28	26	24	20	18	16
	42.1 - 48.0	36	32	28	26	24	20	18	16	14
	48.1 - 60.0	30	28	24	22	20	18	16	14	10
	>60.0	MLSS Need Not be Considered								

**Table 2-20 CT DPH Flow Factor Calculation Table**

Flow Factor = Design Flow/300	
<b>Residential:</b> Design Flow for each bedroom is 150 GPD except for bedrooms beyond 3 in single-family residential buildings, which have a 75 GPD per bedroom design flow.	
<u>Single-family lots:</u>	<u>FF</u>
1 Bedroom = 150/300	0.5
2 Bedroom = 300/300	1.0
3 Bedroom = 450/300	1.5
4 Bedroom = 525/300	1.75    Increase FF by 0.25 for each additional bedroom
<u>Multi-family buildings:</u> Minimum FF is 2.0 (4 bedrooms) and each additional bedroom increases FF by 0.5.	
<u>Non-Residential:</u>	Design Flow (GPD) / 300

**Table 2-21 CT DPH Hydraulic Factor Calculation Table**

Percolation Rate	Percolation Factor (PF)
Up to 10.0 Minutes/Inch	1.0
10.1 to 20.0 Minutes/Inch	1.25
20.1 to 30.0 Minutes/Inch	1.5
30.1 to 45.0 Minutes/Inch	3.0, or 2.0*
45.1 to 60.0 Minutes/Inch	5.0, or 3.0*

\*If leaching system is entirely in select fill and the bottom of system is above existing grade and at least 24 inches above maximum groundwater.

### **2.10.3.3 OTHER REQUIREMENTS**

#### **Slope**

It is noted that areas with excessive slope (>25%) has special State Department of Health permitting regulations for on-site disposal of treated wastewater.

## 3 NATURAL RESOURCES

### 3.1 SOILS

The Study Area soil types were obtained from the USDA Natural Resources Conservation Service (NRCS) [Soils Web Site](#) and are presented on Figure 3-1. Tables 3-1 through Table 3-3 list the Study Area Soil Type and their associated texture, slope and depth to bedrock, respectively, based upon NRCS each soil type's characteristics. Of the 14 soil types, there are a total of 34 soils with different slopes. Depth to bedrock for the soil type, i.e. no slope consideration, is presented on Table 3-3 as 89% of the soils have depth to bedrock of  $\leq 3.5$ . In summary, the Study Area soils have the following characteristics:

**Texture:** predominantly **fine sandy loams** and represent 74% of the Study Area.  
**Depth to Bedrock:** **shallow (less than 4-ft)** for approximately 90% of the Study Area.  
**Slopes:** predominately moderate to steep  
    < 8%                      35% of Study Area  
    8% - 15%                35% of Study Area  
    > 15%                    40% of Study Area

As shown on Table 2-12 and 2-13, the 278, 119 and 113 properties in the AoC have data on percolation rate, depth to rock and slope, respectively. The percolation data with a mean of 20 mpi is consistent with expectations of the soil texture of fine sandy loams. Mean slopes of 13% – 18% are consistent with soil types as described above and on Table 3-2. Table 3-4 presents a comparison of the OWTS field collected data and the NRCS soil types descriptions for depth to bedrock.

### 3.2 SURFICIAL GEOLOGY

Surficial geology coverages were obtained from the CT DEEP GIS website, in the [Geoscience category](#). The surficial geology, Figure 3-2, of the Study Area is exclusively Till (areas where Till is < 10 – 15 feet thick) and Thick Till (areas where Till is > 10 – 15 feet thick).

Range of Difference Between Observed Depth to BR & Soil-Based Depth to BR (ft)*	# Parcels	% of Total
(-4) - (-1)	13	10%
(-1) to 0	5	4%
0 - 1	5	4%
1 - 3	49	39%
3 - 5	46	36%
5 - 7	7	6%
7 - 10	2	2%

Total 127

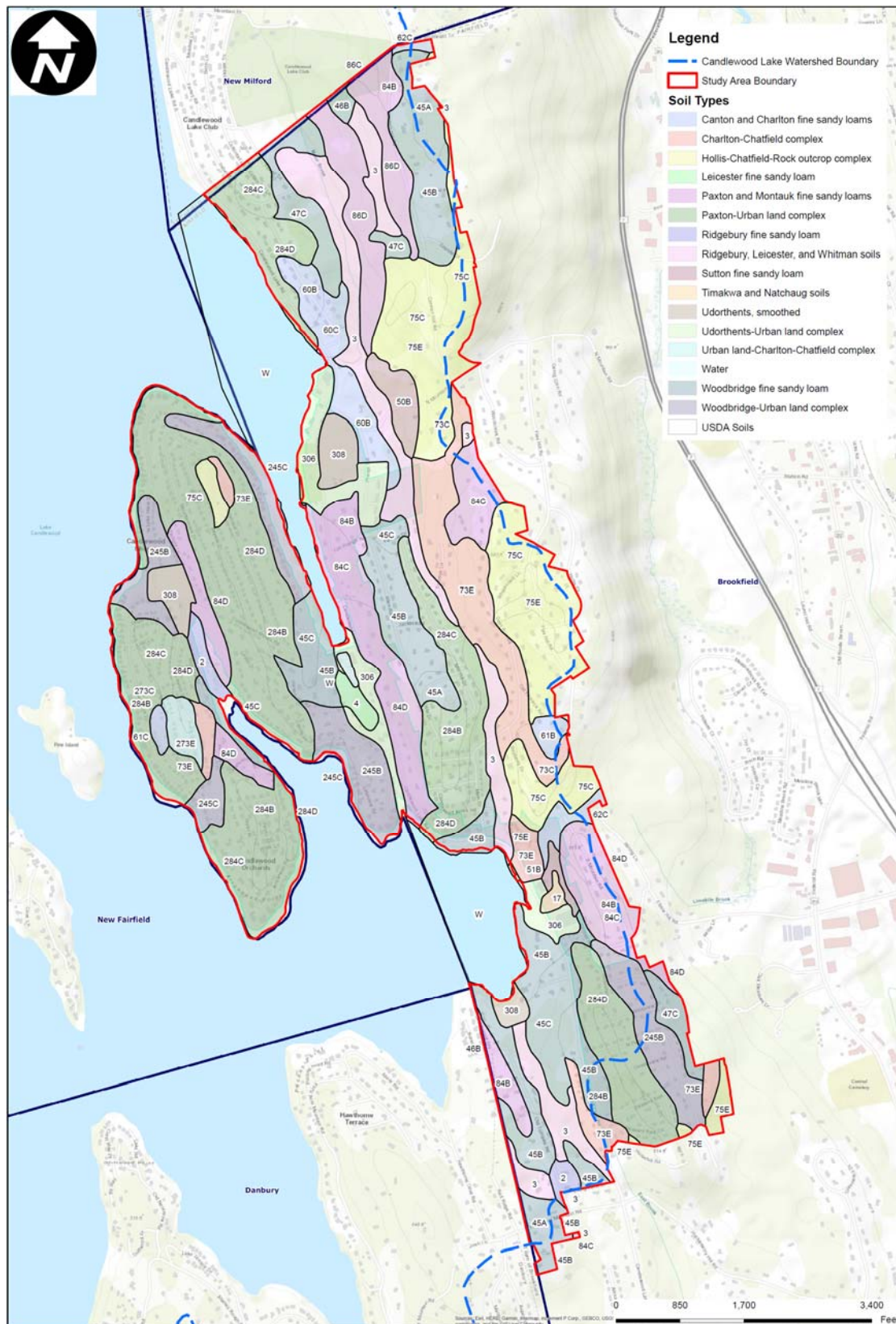
\*Negative value means observed depth to Bedrock (BR) was shallower than soils-based value

**Table 3-4 Comparison of Study Area Soils Depth to Bedrock Characteristics with Field Data**

### 3.3 BEDROCK

Depth to bedrock data is available for properties where WPCA data mining efforts located actual field-testing results. Depth to bedrock is also available on a very general scale from the soil type, as listed in the Soil Survey data. Depth to bedrock defines the thickness of the soil mantle between the surface and bedrock.





**Figure 3-1 Study Area Soils**

**Table 3-1 Study Area Soils Information**

Soil Code	% of SA	Cum. % of SA	Soil Type	Degree of Stoniness	Texture
284B	5.41%	24.0%	Paxton-Urban land complex		Gravelly Fine Sandy Loam
284C	5.67%				
284D	13%				
45A	1.94%	16.7%	Woodbridge fine sandy loam		Gravelly Fine Loamy Sand
45B	8.31%				
45C	2.95%				
46B	0.88%			Very Stony	
47C	2.67%			Extremely Stony	
84B	2.42%	13.9%	Paxton and Montauk fine sandy loams		Gravelly Sandy Loam
84C	2.99%				
84D	4.63%				
86C	0.18%			Extremely Stony	
86D	3.66%			Extremely Stony	
75C	6.13%	11.83%	Hollis-Chatfield-Rock outcrop complex		Bedrock
75E	5.70%				
2	0.81%	8.26%	Ridgebury fine sandy loam		Gravelly Sandy Loam
3	7.45%			Extremely Stony	Fine Sandy Loam
245B	4.74%	7.30%	Woodbridge-Urban land complex		Gravelly Fine Sandy Loam
245C	2.57%				
73C	0.87%	6.65%	Charlton-Chatfield complex	Very Rocky	Gravelly Fine Sandy Loam / Bedrock
73E	5.78%				
60B	1.71%	3.71%	Canton and Charlton fine sandy loams		Gravelly Fine Sandy Loam
60C	0.66%				
61B	0.40%			Very Stony	
61C	0.25%			Very Stony	
62C	0.70%			Extremely Stony	
306	3.36%	3.36%	Udorthents-Urban land complex		Very Gravelly Sandy Loam / Fill
308	1.83%	1.83%	Udorthents, smoothed		Very Gravelly Sandy Loam
50B	0.93%	1.23%	Sutton fine sandy loam		Gravelly Sandy Loam
51B	0.30%			Very Stony	
273C	0.13%	0.52%	Urban land-Charlton-Chatfield complex	Rocky	Gravel Fine Sandy Loam / Unweathered Bedrock
273E	0.39%			Rocky	
4	0.44%	0.44%	Leicester fine sandy loam		Gravelly Fine Sandy Loam
17	0.21%	0.21%	Timakwa and Natchaug soils		Gravelly Sandy Loam

**Table 3-2 Study Area Soils Slopes**

<b>Soil Code</b>	<b>Soil Type</b>	<b>% of SA</b>	<b>Cum. % of SA</b>	<b>Slope</b>
17	Timakwa and Natchaug soils	0.2%	0.2%	0 - 2%
45A	Woodbridge fine sandy loam	1.9%	2.1%	0 - 3%
2	Ridgebury fine sandy loam	0.8%	3.0%	0 - 3%
46B	Woodbridge fine sandy loam	0.9%	3.8%	0 - 8%
51B	Sutton fine sandy loam	0.3%	4.1%	0 - 8%
245B	Woodbridge-Urban land complex	4.7%	8.9%	0 - 8%
3	Ridgebury, Leicester, and Whitman soils	7.4%	16.3%	0 - 8%
61B	Canton and Charlton fine sandy loams	0.4%	16.7%	0 - 8%
73C	Charlton-Chatfield complex	0.9%	17.6%	0 - 15%
60B	Canton and Charlton fine sandy loams	1.7%	19.3%	3 - 8%
284B	Paxton-Urban land complex	5.4%	24.7%	3 - 8%
45B	Woodbridge fine sandy loam	8.3%	33.0%	3 - 8%
84B	Paxton and Montauk fine sandy loams	2.4%	35.4%	3 - 8%
50B	Sutton fine sandy loam	0.9%	36.4%	3 - 8%
75C	Hollis-Chatfield-Rock outcrop complex	6.1%	42.5%	3 - 15%
86C	Paxton and Montauk fine sandy loams	0.2%	42.7%	3 - 15%
62C	Canton and Charlton fine sandy loams	0.7%	43.4%	3 - 15%
273C	Urban land-Charlton-Chatfield complex	0.1%	43.5%	3 - 15%
284C	Paxton-Urban land complex	5.7%	49.2%	8 - 15%
45C	Woodbridge fine sandy loam	3.0%	52.1%	8 - 15%
47C	Woodbridge fine sandy loam	2.7%	54.8%	8 - 15%
84C	Paxton and Montauk fine sandy loams	3.0%	57.8%	8 - 15%
245C	Woodbridge-Urban land complex	2.6%	60.3%	8 - 15%
60C	Canton and Charlton fine sandy loams	0.7%	61.0%	8 - 15%
61C	Canton and Charlton fine sandy loams	0.2%	61.3%	8 - 15%
284D	Paxton-Urban land complex	13.0%	74.2%	15 - 25%
84D	Paxton and Montauk fine sandy loams	4.6%	78.8%	15 - 25%
86D	Paxton and Montauk fine sandy loams	3.7%	82.5%	15 - 35%
75E	Hollis-Chatfield-Rock outcrop complex	5.7%	88.2%	15 - 45%
73E	Charlton-Chatfield complex	5.8%	94.0%	15 - 45%
273E	Urban land-Charlton-Chatfield complex	0.4%	94.4%	15 - 45%
306	Udorthents-Urban land complex	3.4%	97.7%	
308	Udorthents, smoothed	1.8%	99.6%	
4	Leicester fine sandy loam	0.4%	100.0%	



**Table 3-3 Study Area Soils Depth to Bedrock**

Soil Code	% of SA	Cum. % of SA	Soil Type	Depth to Bedrock (ft)
284B	24.0%	24.0%	Paxton-Urban land complex	0 - 3.25
245B	16.74%	40.8%	Woodbridge-Urban land complex	0 - 3.25
273C	13.88%	54.7%	Urban land-Charlton-Chatfield complex	0 - 3.5
75C	7.30%	62.0%	Hollis-Chatfield-Rock outcrop complex	.8 - 3.5
2	11.83%	73.8%	Ridgebury fine sandy loam	1.25 - 3
45A	8.3%	82.0%	Woodbridge fine sandy loam	1.67 - 3.25
84B	6.7%	88.7%	Paxton and Montauk fine sandy loams	1.67 - 3.25
306	3.71%	92.4%	Udorthents-Urban land complex	0 - >6
73C	3.36%	95.8%	Charlton-Chatfield complex	1.67 - >6
60B	1.83%	97.6%	Canton and Charlton fine sandy loams	1.67 - >6
308	1.23%	98.8%	Udorthents, smoothed	>6
50B	0.52%	99.4%	Sutton fine sandy loam	>6
4	0.44%	99.8%	Leicester fine sandy loam	>6
17	0.21%	100.0%	Timakwa and Natchaug soils	>6

### 3.4 TOPOGRAPHY AND SLOPE

A Digital Elevation Model (DEM), obtained from CT DEEP's GIS website, was used to generate 20-ft contours, as presented on Figure 3-3. 2-foot contours were also generated for use in site-specific analysis. Surface elevations in the Study Area range from 740-feet to the water surface elevation in Candlewood Lake, approximately 427-ft. Figure 3-4 presents the slopes in the Study Area which were generated using ARCVIEW Spatial Analyst software.

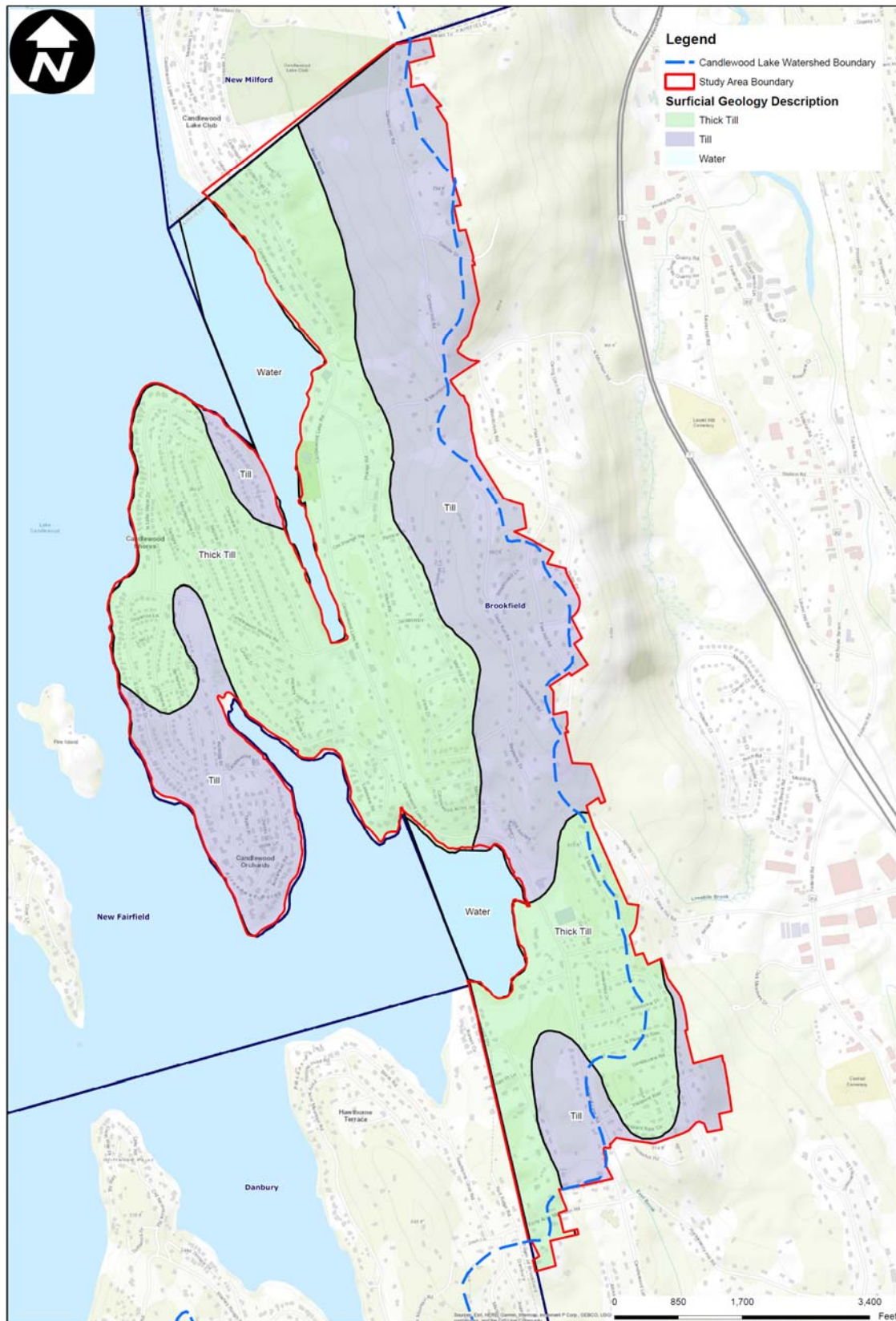
### 3.5 FLOODPLAINS

Figure 3-5 presents the US Federal Emergency Management Agency (FEMA) floodplains within the Study Area. Due to the steep topography in the Study Area, there are no significant flood plains beyond the immediate shoreline areas.

### 3.6 WETLANDS

Figure 3-6 illustrates the types and locations of wetlands within the Study Area. The wetland areas are defined by the National Wetland Inventory maps. Similar to the floodplains, there are no significant wetlands within the Study area.

Many activities within 200 feet of Candlewood Lake, within 100 feet of any other watercourse and within 75 feet of a wetland require a permit from the Brookfield Inland-Wetlands Commission. Figure 3-7 illustrates these jurisdictional areas in the Study Area along with the DoH setback requirement of 50 feet from an Open Water Course.



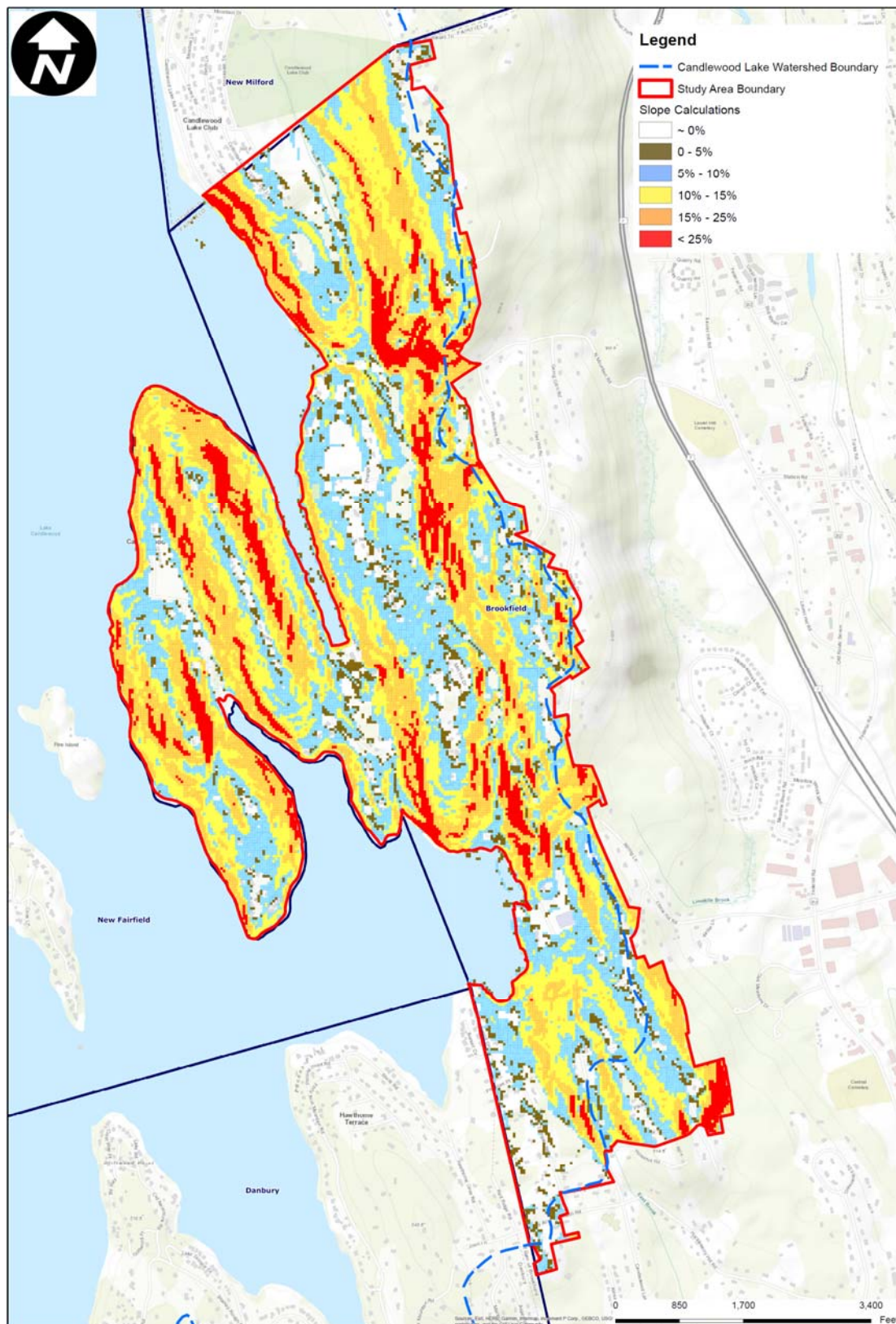
**Figure 3-2 Study Area Surficial Geology Map**



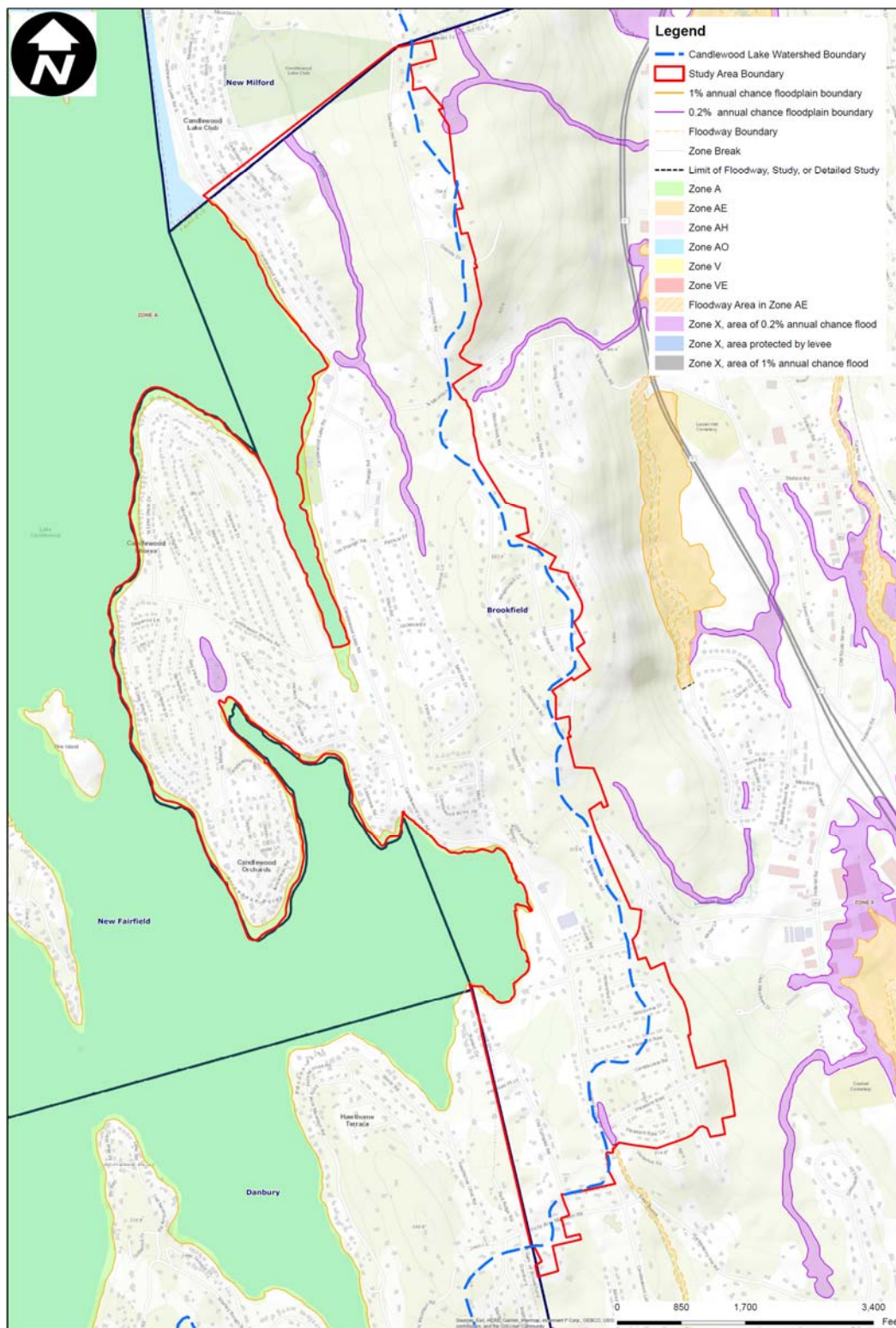


**Figure 3-3 Study Area Topography**



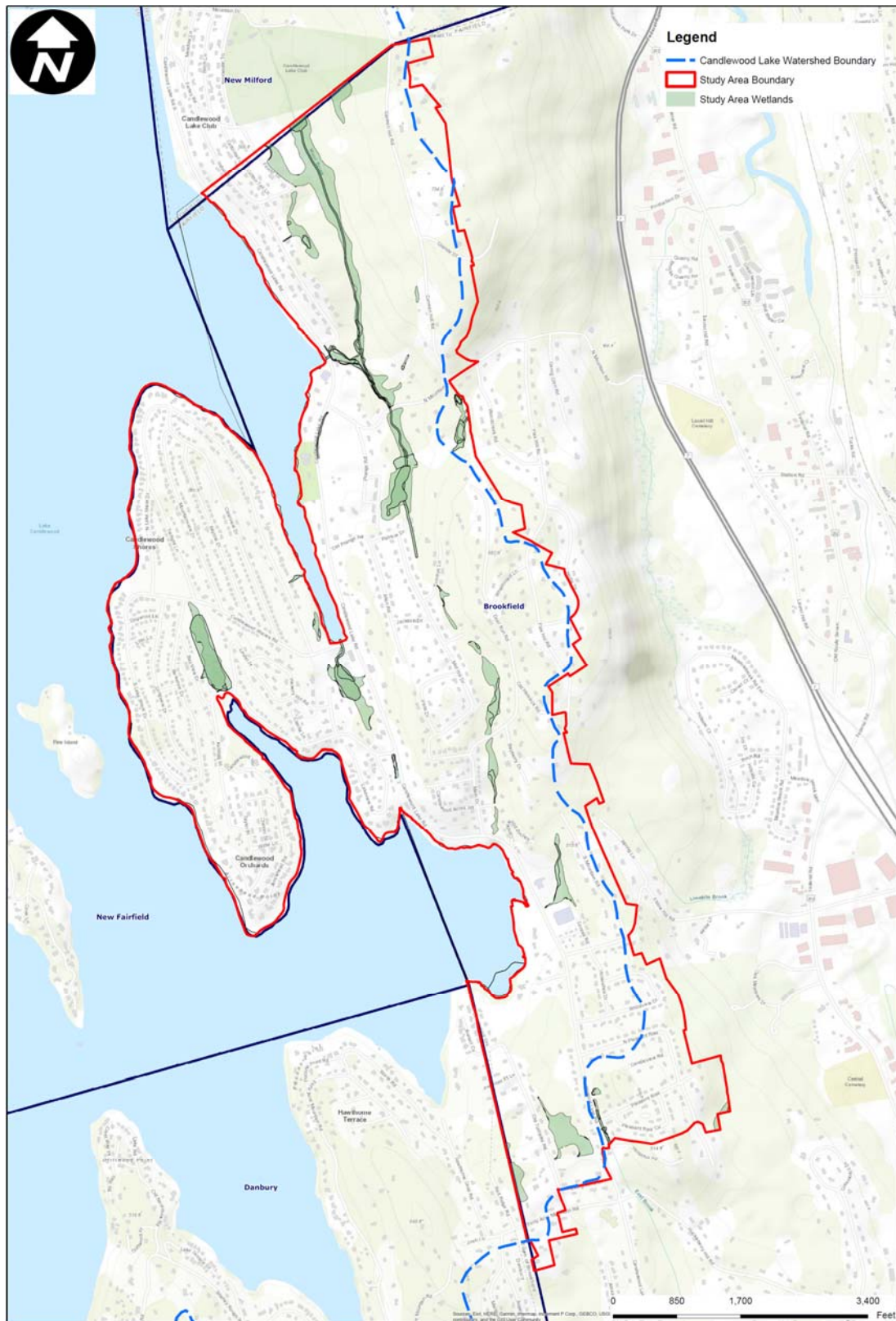


**Figure 3-4 Study Area Slopes**



**Figure 3-5 FEMA Floodplains in Study Area**





**Figure 3-6 Wetlands in Study Area**





**Figure 3-7 Inlands-Wetlands Comm. Jurisdictional Areas & DoH Setback Areas**

### 3.7 WATER RESOURCES

Water resources in the Study Area are composed of:

- Groundwater which is fed by rainfall infiltration and then discharges to surface waters;
- Storm water
- Surface water bodies – Candlewood Lake and streams which receives rainfall directly on its surface, surface runoff and groundwater

Figure 3-8 presents Sub-watershed Boundaries & Estimated Surface/Groundwater Flow Paths. Lacking any data to the contrary, it is assumed that groundwater flow direction is the same as surface water. Table 3-5 presents the surface area, number of developed parcels, average slope and estimated annual groundwater and surface water flow of each sub-watershed assuming groundwater infiltration is 50% and surface water is 25% of annual rainfall of 50 inches. The balance of rain is assumed to be evapotranspired.

#### 3.7.1 GROUNDWATER

Study Area depth to groundwater data has not been identified. Per Figure 2-6, groundwater elevations are expected to be below the bedrock elevation, with potential perched elevations on top of the bedrock.

To obtain an understanding of potential Study Area groundwater flow velocities, Darcy's Law is used to calculate the aquifer thickness that may result on top of bedrock from rain infiltration and wastewater disposal. Darcy's Law disposal capacity of the drainfield zones and groundwater travel times were estimated at the downgradient face of the zone as follows, see Figure 3-9.

$$\begin{aligned} Q &= K \cdot A \cdot i, \text{ where} & Q &= \text{volumetric flow (cf/day),} \\ & & K &= \text{Hydraulic conductivity (ft/day) of unsaturated zone,} \\ & & A &= \text{cross sectional area (sf) of discharge cross sectional area} \\ & & i &= \text{groundwater slope} \\ \text{Darcy Velocity (Q/A)} &= K \cdot i \\ \text{Linear velocity (V)} &= \text{Darcy Velocity/porosity (n)} \end{aligned}$$

Hydraulic conductivity (K) of soils estimated based upon NCRS soils data are 6 +/- feet/day. Assuming  $i = 0.10$  and  $n = .33$ , then  $V = 1.8$  feet / day.

Groundwater travel time from a point = groundwater flow length / travel time

Groundwater travel time is important to know as it indicates how long a septic plume would take from its initiation to receipt by the water body. This is important for design and evaluation of field data collection efforts. Additionally, along with the Lake's turnover time of 3.3 years (see Section 4), groundwater travel time is used to determine the length of time it would take for the Lake to reflect water quality improvements resulting from wastewater systems improvements.

For perched groundwater, with groundwater flow paths to the Lake ranging from 50 feet (for shoreline properties) to 250–500 feet (properties at the top of the subwatershed), groundwater

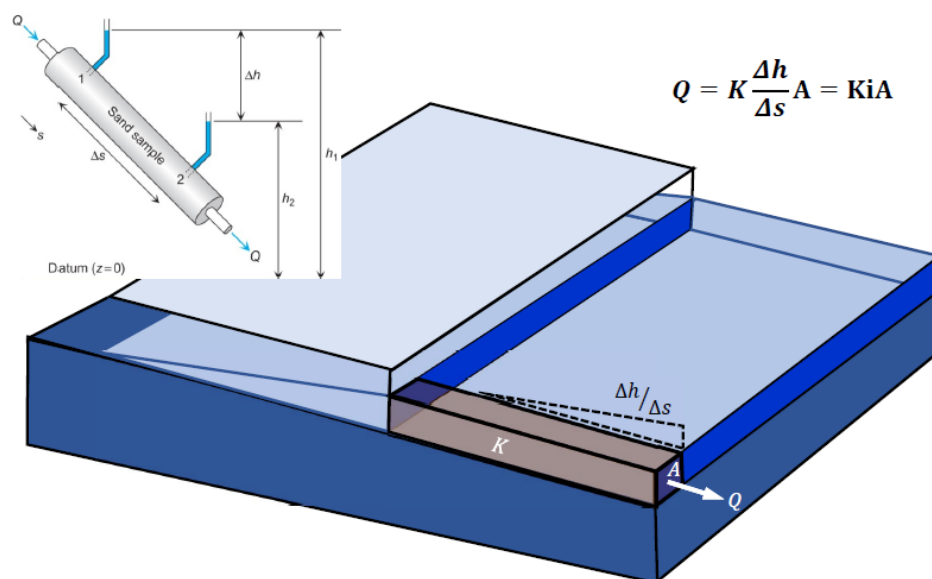


travel times to the Lake could be approximately 30 days (shoreline properties) to 125-250 days (top of the subwatershed). Groundwater in the bedrock would travel at a significantly lower rate.



**Figure 3-8 Sub-watershed Boundaries & Estimated Surface/Groundwater Flow Paths**





**Figure 3-9 Simplified Darcy's Law Applied to Mounding Analysis**  
From Bradley et al, 2019

## 4 CANDLEWOOD LAKE – HISTORY, PHYSICAL, BIOLOGICAL AND CHEMICAL FEATURES

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### 4.1 HISTORY

Candlewood Lake, Figure 4-1 from Kohli et al, 2017, is a 29 MW capacity pumped-storage reservoir along the Housatonic River created in the 1920s for hydropower generation. Completed in 1928, the project was the first pumped-storage station in the US. Candlewood Lake water discharges to the Housatonic River via a 10-foot diameter penstock that descends from the Lake approximately 200 feet to the Rocky River Powerhouse located on the Housatonic River in New Milford. The system is a peaking station, producing power primarily when demand is high and energy markets favorable and pumping water from the Housatonic River to Candlewood Lake when electricity to run the pumps is least expensive. Approximately 3 times more water is released from the lake for power generation per year than is pumped to the lake from the Housatonic River (Marsicano et al. 1995).

### 4.2 WATERSHED - LAKE PHYSICAL FEATURES

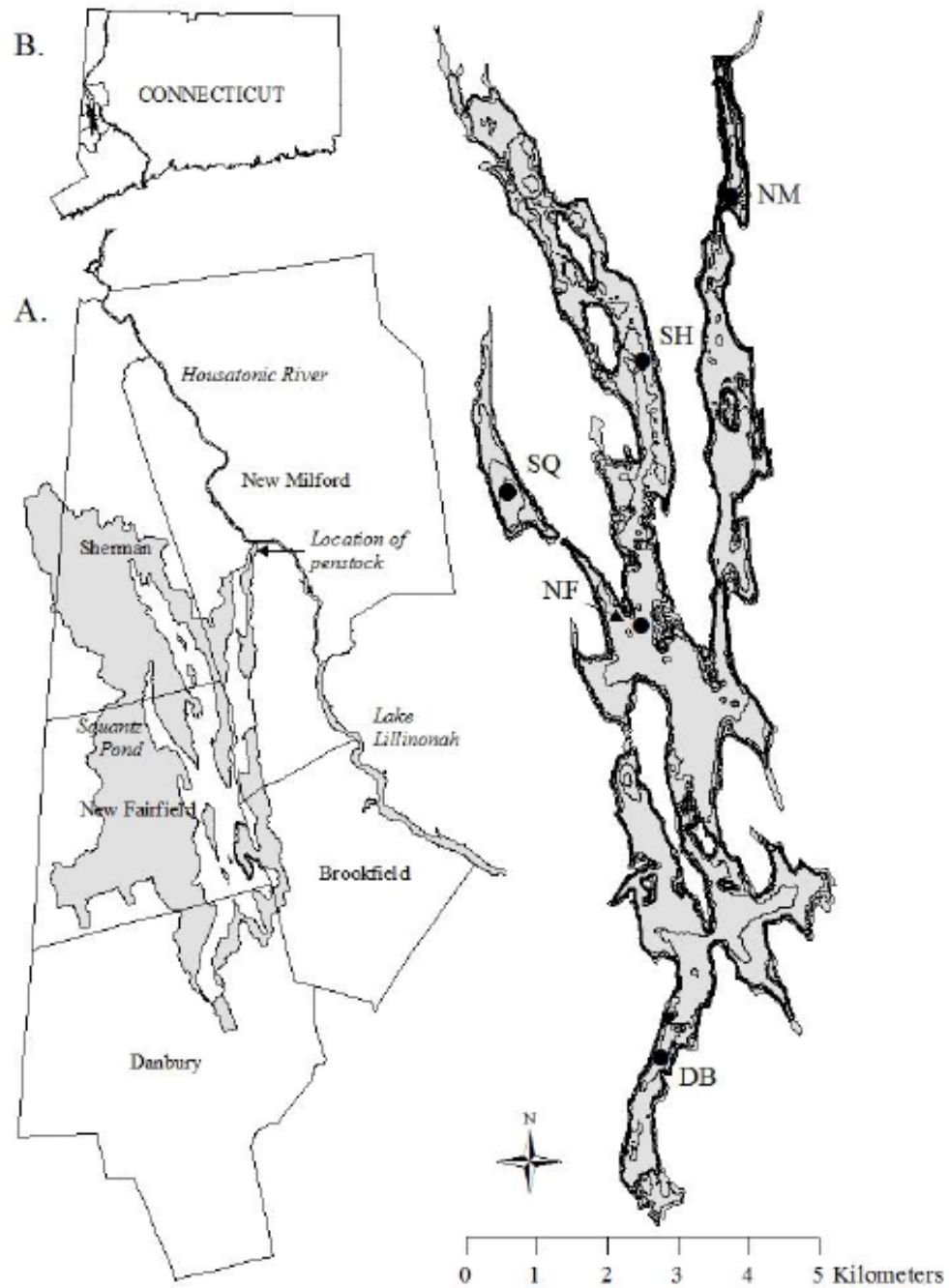
All but 3% of the 40.5 miles<sup>2</sup> (25,920 acres) Candlewood Lake watershed lies within the Connecticut municipalities of Brookfield, New Fairfield, New Milford, Sherman, and Danbury, with 3% being located in eastern New York State. The Lake's watershed is part of the 1,948 miles<sup>2</sup> Housatonic River watershed. The Lake is approximately 11,500 feet at its widest point, 11.2 miles long and includes 3 north-to-south running arms which range in length from 2.49 miles to 4.97 miles, Figure 4-1. According to the Aquatic Ecosystem Research (AER) 2018 Candlewood Lake Water Quality Report (2019) and previous studies (Marsicano et al, 1995; Kohli et al, 2017), Table 4-1 presents a summary of the physical features of Candlewood Lake, its contributing watershed and a water balance for the Lake. Figure 4-2 presents the Candlewood Lake bathymetry, from Jacobs and O'Donnell 2002, adjacent to the Study Area.

The Rocky River Generating Station, Figure 4-3, is a three-unit hydroelectric station with a capacity of 29 MW using 2 GE 3.5 MW turbines and 1 GE 23 MW turbine and is operated by [First Light Power Resources](#) subject to Federal Energy Regulatory Commission (FERC) permitting requirements.



**Figure 4-3 Rocky River Generating Station**





**Figure 4-1 Candlewood Lake and Study Area – Location Map**

**Primary Monitoring Stations:**

DB Danbury Bay  
 NF Center of Lake  
 SH Sherman Arm  
 NM New Milford Arm

**Other Monitoring Station:**

SQ Squantz Pond



**Table 4-1 Candlewood Lake / Watershed Physical Features and Water Balance**

Watershed Area (sq. miles)	41
Lake Surface Area (sq. miles)	8.46
Width (feet at widest point)	11,500
Length (miles)	11.20
Mean Lake Depth (feet)	29
Max Lake Depth (feet)	85
Typical Lake Volume (billions gallons)	51.78
Average Rainfall in watershed (inches/year)	50
Shoreline (miles)	65.2

Average Hydraulic Retention Time (Years)	3.30
Average Annual Net Lake Discharge <sup>(1)</sup> (billions gallons/year)	15.69
Estimated average Housatonic River water discharged to Lake (billion gallons/year)	5.23
(1) without consideration of discharge of pumped Housatonic River water	

Net Rainfall on Lake <sup>(2)</sup> (billions gallons/year)	3.68
Net Watershed Rainfall-runoff/groundwater to Lake <sup>(2)</sup> (billions gallons/year)	12.01
(2) Net incorporates evapotranspiration estimates	

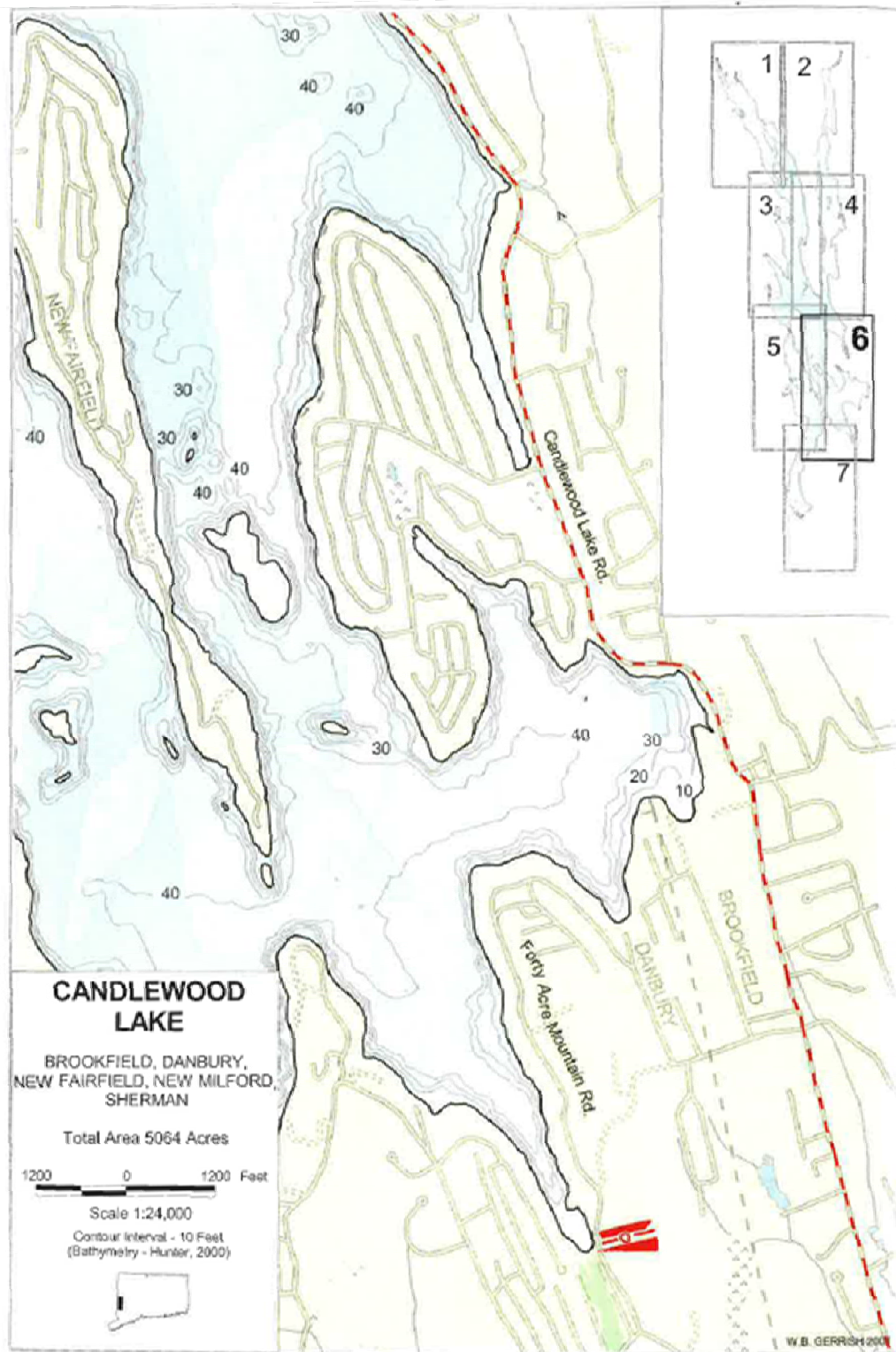


Figure 4-2 Candlewood Lake Bathymetry

### 4.3 LAKE WATER QUALITY CONDITIONS

Appendix A presents a brief description of the hydrologic cycle and lake terminology. Table 4-2 presents the State of Connecticut's criteria used to define a Lake's trophic level (i.e. biological activity).

**Table 4-2 CT Criteria for Lake Trophic Levels**

CT DEEP Trophic Level	Total Phosphorus	Total Nitrogen	Chlorophyll-a	Secchi Disk Transparency
Measurement Period	spring and summer	spring and summer	mid-summer	mid-summer
Oligotrophic	0-10 ug/l	0-200 ug/l	0-2 ug/l	6 + meters
Mesotrophic	10-30 ug/l	200-600 ug/l	2-15 ug/l	2-6 meters
Eutrophic	30-50 ug/l	600-1000 ug/l	15-30- ug/l	1-2 meters
Highly Eutrophic	50+ ug/l	1000+ ug/l	30+ ug/l	0-1 meters

A long-term monitoring program was established in 1983 to track changes in the physical, chemical and biological characteristics of Candlewood Lake after the Lake was classified as mid-mesotrophic to eutrophic and undergoing accelerated eutrophication by CT DEEP (Marsicano, 1995). AER (2019) recently categorized Candlewood Lake as a late mesotrophic – eutrophic Lake. Four (4) monitoring stations have been sampled since 1985.

Per AER (2018), despite the water quality improvements detected from 1985 through 2012, Candlewood Lake, Squantz Pond, and other water bodies in Connecticut have experienced increased frequency and intensity of blue-green algae (also called cyanobacteria) blooms in recent years. Also, per AER (2018), in 2015 and 2017 the Connecticut Department of Energy and Environmental Protection (CT DEEP) issued permits for the import and liberation of triploid grass carp (*Ctenopharyngodon idella*) into Candlewood Lake. A permit was also issued in 2017 for the liberation of triploid grass carp into Squantz Pond. Permit conditions required that specific monitoring of water quality parameters be conducted throughout the duration of this project. Additionally, the State required yearly reporting as a condition of the permit.

AER (2019) stated that “since circa 2010 Candlewood Lake has experienced more frequent and intense cyanobacteria algae blooms”. Furthermore, AER (2019) states that “It is important to note that the internal loading does not appear to be the driving force behind the increases in the frequency or intensity of cyanobacteria algal blooms in the last decade. Also, it is important to note that cyanobacteria can produce cyanotoxins which – at high concentrations – pose significant, even lethal, human and pet health risks.

AER (2019) states that “it is now known that historical phosphorus levels, which at 1m depth are indicative of mesotrophic productivity, can support bloom formations under the right climatological and water column stratification conditions. Candlewood Lake clearly exhibits a pattern of late season phosphorus loading from the sediments late in the season that impact epilimnetic phosphorus concentrations.”

#### **Phosphorus Limiting Nutrient**

AER (2018) used the Redfield ratio 16:1 of total nitrogen to total phosphorus to determine whether phosphorus or nitrogen is the limiting nutrient for algae growth. Ratios below 16



indicate nitrogen limitation while ratios above 16 indicate phosphorus. AER (2019) calculated the N:P ratios for both epilimnetic and metalimnetic samples where both total nitrogen and total phosphorus data was available. In the epilimnion, ratios ranged from 15 to 53 and averaged 33. In the metalimnion ratios ranged from 14 to 82 and averaged 31. Redfield ratio averages for the season ranged from a low of 22 (at NM) to high of 38 (at NF). **These data clearly support that Candlewood Lake is almost always phosphorus limited (AER 2019).**

### **Lake Water Quality Data**

The following Tables and Figures present historical data on Candlewood Lake's water quality. BT = Bottom Temperature; BO = Bottom Oxygen conc.

Figure 4-4 2012 – 2018 Secchi Disc, Chl a, Epilimnetic and Hypolimnetic P conc. with comparison to longterm averages

Figure 4-5 1985 – 2012 Lake Water Quality Data Graphs

Table 4-3 1985 – 2012 Lake Water Quality Data by Month

Table 4-4 2018 Lake Water Quality Data by Month

From AER (2019),  
pH 8.3 average  
Alkalinity 65 mg/L as CaCO<sub>3</sub> average

The Candlewood Lake Authority is having data collected on microcystin, a toxin released by blue green algae, at Town beaches with the 2019 results presented on Table 4-4.

### **Table 4-4 Candlewood Lake Beaches Microcystin Data**

**Overview summary of Microcystins (ppb; µg/L)  
in Candlewood Lake, Summer 2018 (6/27 – 8/29)  
Wong Lab, Western Connecticut State University**

Date	Brookfield	Danbury	Lynn Deming	New Fairfield	Sherman	Squantz
27-Jun	0.715	0.724	0.896	0.332	0.597	0.944
4-Jul	0.440	0.474	0.730	0.722	0.534	0.435
11-Jul	0.979	0.802	0.937	0.724	0.332	0.943
18-Jul	0.937	1.285	1.235	0.716	0.773	0.739
25-Jul	0.529	0.724	0.520	0.481	0.555	0.545
1-Aug	0.565	0.556	0.328	0.491	0.344	0.470
8-Aug	0.484	0.498	0.301	0.455	0.220	0.381
15-Aug	0.821	0.826	0.680	0.380	0.436	0.528
22-Aug	0.510	0.610	0.446	0.427	0.778	1.044
29-Aug	0.656	0.575	0.696	0.715	0.724	0.672

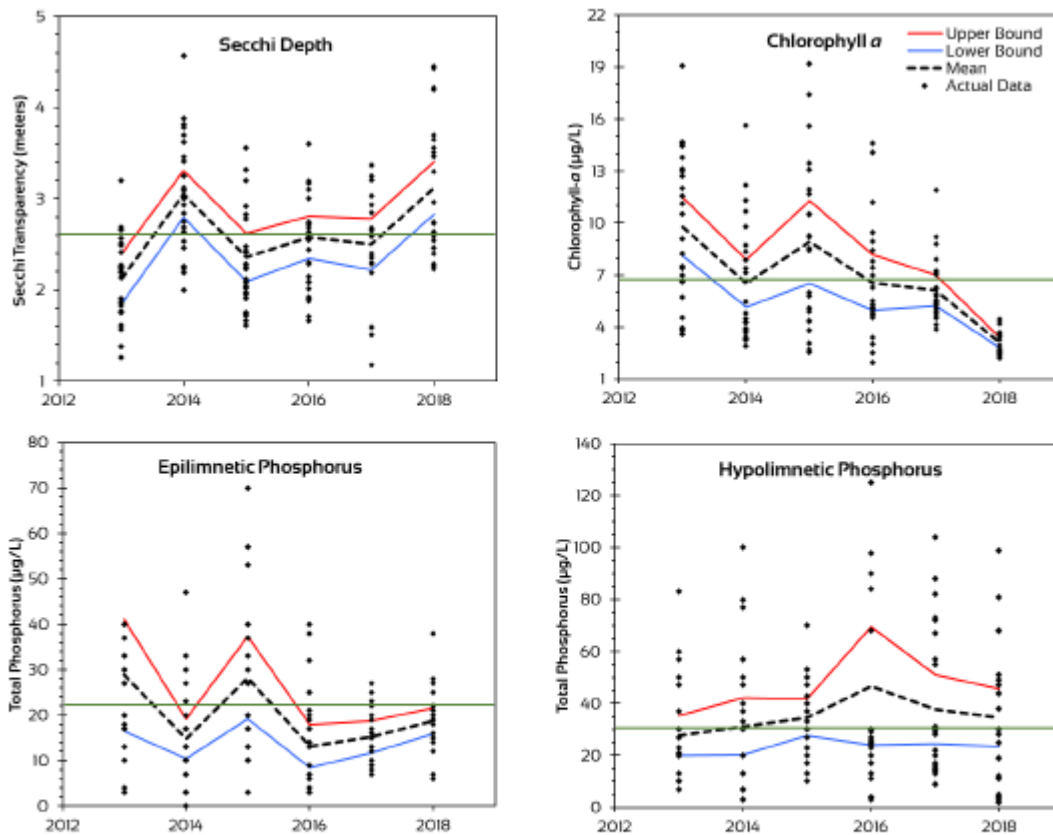


Figure 16. The 95% confidence intervals and averages for Secchi transparency, chlorophyll-a concentrations, epilimnetic and hypolimnetic total phosphorus concentrations at Candlewood Lake from 2013 to 2018 compared to 28-year averages (green lines) for each variable based on data collected from 1985 to 2012 (Kohli et al. 2017).

Figure 4-4 2012 – 2018 Secchi Disc, Chl a, Epilimnetic and Hypolimnetic P conc.

**Table 4-3 Summary of Candlewood Lake Water Quality Data 1985 - 2012**

**Table 2.** Median  $\pm$  Interquartile Range (IQR) for the 10 water quality variables in Candlewood Lake from May 1985 to October 2012 at site: DB, NF, NM, and SH.

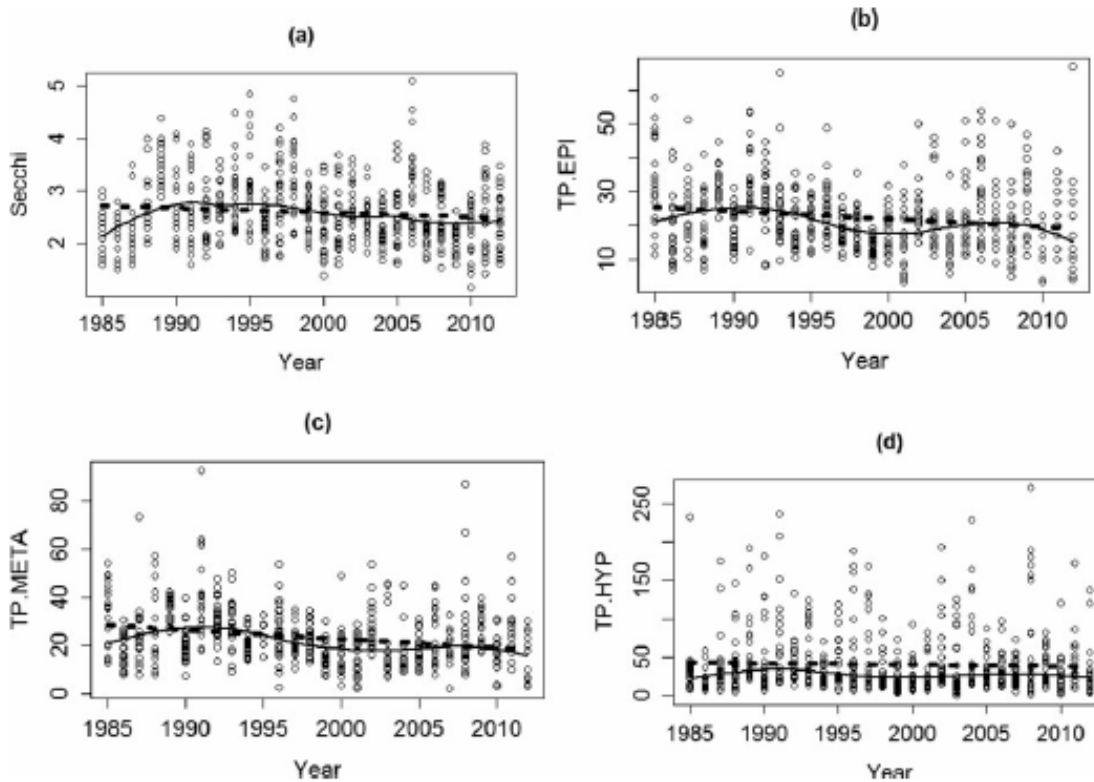
Variable (unit)	Month	Study site			
		DB	NF	NM	SH
Secchi depth (m)	May	2.44 $\pm$ 0.82	2.48 $\pm$ 0.73	2.52 $\pm$ 0.71	2.45 $\pm$ 0.53
	Jun	2.82 $\pm$ 0.68	3.06 $\pm$ 0.90	3.13 $\pm$ 0.63	3.20 $\pm$ 0.81
	Jul	2.28 $\pm$ 0.37	2.24 $\pm$ 0.67	2.25 $\pm$ 0.49	2.38 $\pm$ 0.66
	Aug	2.71 $\pm$ 0.62	2.73 $\pm$ 0.71	2.75 $\pm$ 0.91	2.51 $\pm$ 0.68
	Sep	2.40 $\pm$ 0.77	2.38 $\pm$ 0.70	2.97 $\pm$ 0.79	2.12 $\pm$ 0.71
	Oct	2.09 $\pm$ 0.39	2.00 $\pm$ 0.42	2.60 $\pm$ 0.50	2.00 $\pm$ 0.45
	All	2.40 $\pm$ 0.74	2.48 $\pm$ 0.90	2.72 $\pm$ 0.87	2.40 $\pm$ 0.82
TP <sub>EPI</sub> ( $\mu$ g/L)	May	24.00 $\pm$ 13.00	20.60 $\pm$ 9.65	21.00 $\pm$ 13.35	19.30 $\pm$ 16.80
	Jun	24.00 $\pm$ 15.70	20.00 $\pm$ 10.55	22.90 $\pm$ 11.25	18.45 $\pm$ 15.03
	Jul	22.50 $\pm$ 9.98	19.90 $\pm$ 8.68	17.45 $\pm$ 14.70	20.50 $\pm$ 11.25
	Aug	24.00 $\pm$ 9.25	21.00 $\pm$ 9.50	18.85 $\pm$ 10.78	20.00 $\pm$ 14.98
	Sep	20.20 $\pm$ 13.10	17.85 $\pm$ 11.65	17.60 $\pm$ 9.75	21.00 $\pm$ 15.25
	Oct	22.90 $\pm$ 12.75	22.00 $\pm$ 13.00	16.90 $\pm$ 12.20	25.80 $\pm$ 10.80
	All	23.00 $\pm$ 13.23	20.10 $\pm$ 11.55	19.00 $\pm$ 11.80	21.00 $\pm$ 14.23
TP <sub>META</sub> ( $\mu$ g/L)	May	25.70 $\pm$ 9.90	19.30 $\pm$ 12.70	20.35 $\pm$ 13.73	20.95 $\pm$ 15.03
	Jun	23.00 $\pm$ 13.60	21.00 $\pm$ 11.25	21.40 $\pm$ 6.10	19.80 $\pm$ 9.10
	Jul	22.70 $\pm$ 14.95	22.35 $\pm$ 12.23	21.00 $\pm$ 15.85	20.60 $\pm$ 13.05
	Aug	23.80 $\pm$ 15.08	22.15 $\pm$ 20.13	20.00 $\pm$ 16.90	23.00 $\pm$ 22.15
	Sep	22.10 $\pm$ 14.80	19.70 $\pm$ 14.25	18.80 $\pm$ 23.80	18.00 $\pm$ 13.15
	Oct	21.15 $\pm$ 14.05	20.00 $\pm$ 10.95	17.40 $\pm$ 7.00	22.00 $\pm$ 12.00
	All	23.00 $\pm$ 14.00	20.00 $\pm$ 13.40	20.00 $\pm$ 15.05	20.90 $\pm$ 13.65
TP <sub>HTP</sub> ( $\mu$ g/L)	May	22.00 $\pm$ 6.50	19.70 $\pm$ 11.70	13.70 $\pm$ 13.45	24.00 $\pm$ 6.10
	Jun	22.20 $\pm$ 16.00	20.35 $\pm$ 11.63	12.60 $\pm$ 14.30	17.00 $\pm$ 10.23
	Jul	40.85 $\pm$ 43.65	36.10 $\pm$ 26.28	22.30 $\pm$ 9.63	28.75 $\pm$ 26.78
	Aug	57.85 $\pm$ 65.93	70.85 $\pm$ 65.55	38.95 $\pm$ 52.78	56.65 $\pm$ 57.38
	Sep	39.90 $\pm$ 39.28	37.70 $\pm$ 66.90	59.95 $\pm$ 69.75	31.45 $\pm$ 35.85
	Oct	22.20 $\pm$ 12.10	19.60 $\pm$ 10.50	46.70 $\pm$ 48.50	23.20 $\pm$ 14.53
	All	28.00 $\pm$ 28.50	27.00 $\pm$ 31.25	24.00 $\pm$ 34.68	26.00 $\pm$ 25.40
Conductivity ( $\mu$ S/cm)	May	178.50 $\pm$ 28.50	172.00 $\pm$ 27.50	200.50 $\pm$ 38.25	168.00 $\pm$ 28.50
	Jun	180.50 $\pm$ 23.00	176.00 $\pm$ 24.50	187.00 $\pm$ 26.50	176.00 $\pm$ 24.00
	Jul	180.00 $\pm$ 22.00	178.50 $\pm$ 27.25	192.00 $\pm$ 29.50	177.00 $\pm$ 24.50
	Aug	181.00 $\pm$ 28.75	178.00 $\pm$ 27.00	191.00 $\pm$ 38.50	178.00 $\pm$ 29.50
	Sep	179.50 $\pm$ 28.00	178.00 $\pm$ 28.50	185.00 $\pm$ 34.50	179.00 $\pm$ 27.00
	Oct	180.00 $\pm$ 22.50	178.00 $\pm$ 23.00	179.00 $\pm$ 28.00	177.00 $\pm$ 22.00
	All	180.00 $\pm$ 25.00	178.00 $\pm$ 27.25	188.00 $\pm$ 33.00	177.00 $\pm$ 27.00
Chl-a ( $\mu$ g/L)	May	4.39 $\pm$ 2.74	4.30 $\pm$ 3.34	3.76 $\pm$ 2.23	4.10 $\pm$ 3.58
	Jun	3.90 $\pm$ 2.63	3.79 $\pm$ 2.90	3.35 $\pm$ 3.25	3.75 $\pm$ 3.40
	Jul	8.16 $\pm$ 4.61	7.12 $\pm$ 4.19	6.02 $\pm$ 4.49	6.20 $\pm$ 4.03
	Aug	6.09 $\pm$ 4.49	5.58 $\pm$ 3.81	4.80 $\pm$ 2.77	5.40 $\pm$ 4.30
	Sep	7.45 $\pm$ 2.54	7.01 $\pm$ 3.92	5.65 $\pm$ 3.02	7.95 $\pm$ 3.55
	Oct	11.90 $\pm$ 4.55	12.02 $\pm$ 47.20	7.20 $\pm$ 2.86	13.70 $\pm$ 7.40
	All	6.82 $\pm$ 5.45	5.90 $\pm$ 5.15	5.23 $\pm$ 3.74	6.60 $\pm$ 5.65
pH	May	7.75 $\pm$ 0.66	7.90 $\pm$ 0.59	8.00 $\pm$ 0.60	7.77 $\pm$ 0.50
	Jun	8.30 $\pm$ 0.80	8.04 $\pm$ 0.60	8.30 $\pm$ 0.50	8.00 $\pm$ 0.50
	Jul	8.20 $\pm$ 0.84	8.33 $\pm$ 0.55	8.40 $\pm$ 0.54	8.35 $\pm$ 0.67
	Aug	7.90 $\pm$ 0.58	7.90 $\pm$ 0.67	7.91 $\pm$ 0.50	7.89 $\pm$ 0.75
	Sep	7.50 $\pm$ 0.47	7.55 $\pm$ 0.47	7.61 $\pm$ 0.43	7.40 $\pm$ 0.35
	Oct	7.35 $\pm$ 0.30	7.45 $\pm$ 0.58	7.43 $\pm$ 0.30	7.45 $\pm$ 0.38
	All	7.72 $\pm$ 0.71	7.80 $\pm$ 0.75	7.90 $\pm$ 0.80	7.70 $\pm$ 0.64



**Table 4-5 Candlewood Lake 2018 Water Quality Data by Month**

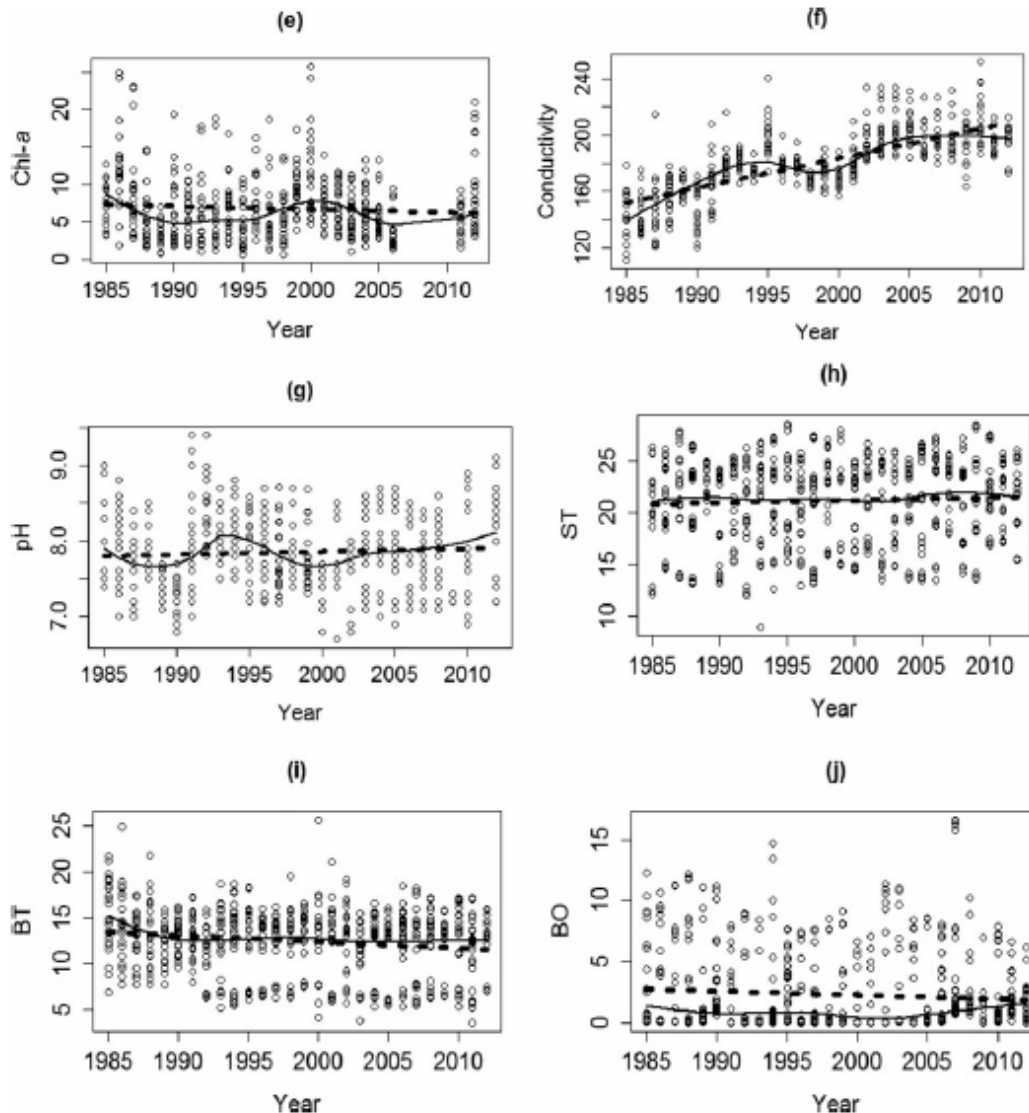
Table 6. Summary statistics (mean  $\pm$  standard deviation) of nutrient data collected at Candlewood Lake in the 2018 season by month. All data are in mg/L with the exception of TP which is in  $\mu\text{g/L}$  and TN:TP which is a ratio.  $\text{NH}_4$  = Ammonia;  $\text{NO}_3^-$  = Nitrate; TKN = Total Kjeldahl Nitrogen; TN = Total Nitrogen; TP = Total Phosphorus; and TN:TP = the Redfield ratio of Total Nitrogen to Total Phosphorus. Epi = epilimnion; Meta = metalimnion; and Hypo = hypolimnion.

$\text{NH}_4$	May	June	July	Aug	Sep	Oct	Season
Epi	0.0 $\pm$ 0.0	0.12 $\pm$ 0.01	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.02 $\pm$ 0.05
Meta	0.0 $\pm$ 0.0	0.13 $\pm$ 0.02	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.09 $\pm$ 0.18	0.04 $\pm$ 0.08
Hypo	0.0 $\pm$ 0.0	0.16 $\pm$ 0.04	0.05 $\pm$ 0.09	0.18 $\pm$ 0.12	0.36 $\pm$ 0.24	0.77 $\pm$ 0.21	0.25 $\pm$ 0.29
$\text{NO}_3^-$	May	June	July	Aug	Sep	Oct	Season
Epi	0.01 $\pm$ 0.03	0.06 $\pm$ 0.00	0.0 $\pm$ 0.0	0.03 $\pm$ 0.03	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.02 $\pm$ 0.03
Meta	0.05 $\pm$ 0.06	0.07 $\pm$ 0.01	0.01 $\pm$ 0.03	0.01 $\pm$ 0.03	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.02 $\pm$ 0.03
Hypo	0.15 $\pm$ 0.05	0.15 $\pm$ 0.15	0.08 $\pm$ 0.17	0.10 $\pm$ 0.17	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.08 $\pm$ 0.12
TKN	May	June	July	Aug	Sep	Oct	Season
Epi	0.50 $\pm$ 0.16	0.94 $\pm$ 0.34	0.44 $\pm$ 0.02	1.20 $\pm$ 0.27	0.16 $\pm$ 0.04	0.66 $\pm$ 0.16	0.65 $\pm$ 0.39
Meta	0.44 $\pm$ 0.02	0.92 $\pm$ 0.34	0.45 $\pm$ 0.08	0.89 $\pm$ 0.13	0.17 $\pm$ 0.03	0.80 $\pm$ 0.15	0.61 $\pm$ 0.32
Hypo	0.40 $\pm$ 0.04	1.11 $\pm$ 0.15	0.50 $\pm$ 0.22	1.34 $\pm$ 0.58	0.53 $\pm$ 0.04	1.20 $\pm$ 0.17	0.85 $\pm$ 0.45
TN	May	June	July	Aug	Sep	Oct	Season
Epi	0.51 $\pm$ 0.16	1.00 $\pm$ 0.34	0.44 $\pm$ 0.02	1.22 $\pm$ 0.28	0.16 $\pm$ 0.04	0.66 $\pm$ 0.16	0.66 $\pm$ 0.40
Meta	0.48 $\pm$ 0.05	0.99 $\pm$ 0.35	0.47 $\pm$ 0.06	0.90 $\pm$ 0.15	0.17 $\pm$ 0.03	0.80 $\pm$ 0.15	0.63 $\pm$ 0.33
Hypo	0.55 $\pm$ 0.06	1.26 $\pm$ 0.21	0.59 $\pm$ 0.38	1.45 $\pm$ 0.67	0.53 $\pm$ 0.04	1.20 $\pm$ 0.17	0.93 $\pm$ 0.49
TP	May	June	July	Aug	Sep	Oct	Season
Epi	16.3 $\pm$ 15.1	13.0 $\pm$ 5.0	20.0 $\pm$ 1.6	20.8 $\pm$ 2.9	23.0 $\pm$ 5.9	19.3 $\pm$ 2.4	18.7 $\pm$ 7.1
Meta	12.8 $\pm$ 5.7	7.3 $\pm$ 2.4	25.3 $\pm$ 5.0	24.8 $\pm$ 2.2	31.5 $\pm$ 3.4	20.3 $\pm$ 3.8	20.3 $\pm$ 9.0
Hypo	9.5 $\pm$ 3.7	3.0 $\pm$ 1.4	25.5 $\pm$ 4.8	40.8 $\pm$ 14.8	79.0 $\pm$ 14.7	49.3 $\pm$ 13.0	34.5 $\pm$ 27.7
TN:TP	May	June	July	Aug	Sep	Oct	Season
Epi	47 $\pm$ 25	78 $\pm$ 14	22 $\pm$ 3	60 $\pm$ 19	7 $\pm$ 1	36 $\pm$ 14	42 $\pm$ 28
Meta	43 $\pm$ 18	136 $\pm$ 10	19 $\pm$ 5	37 $\pm$ 7	5 $\pm$ 1	41 $\pm$ 15	47 $\pm$ 44
Hypo	73 $\pm$ 53	506 $\pm$ 253	26 $\pm$ 23	46 $\pm$ 42	7 $\pm$ 1	25 $\pm$ 5	114 $\pm$ 204



ST = Surface Temperature  
 BT = Bottom Temperature  
 BO = Bottom oxygen concentration

(Continued on next page)



**Figure 2.** Plot of the observed values (dots), linear regression fit (dotted line), and nonparametric fit (solid line) for (a) Secchi depth, (b)  $TP_{EPA}$ , (c)  $TP_{METS}$ , (d)  $TP_{HYP}$ , (e) Chl-*a*, (f) conductivity, (g) pH, (h) ST, (i) BT, and (j) BO for database recorded from 1985 to 2012 at DB, NF, NM, and SH. (Continued)

**Figure 4-5 1985 – 2012 Lake Water Quality Data Graphs**

#### 4.4 PRELIMINARY SEPTIC PHOSPHORUS & NITROGEN CONTRIBUTIONS TO CANDLEWOOD LAKE

Table 4-6 presents phosphorus and nitrogen loadings per property and Study Area wide along with preliminary estimates of incremental increase on Lake N and P concentrations.

For reference purposes, per US EPA (2013), each person discharges between 11 and 13 pounds (lbs.) of nitrogen (N) / year with approximately 25% removal in the drainfield as shown on Figure 4-6. Based upon the Table 4-5 household septic tank effluent N discharges and that there are minor amounts of N removal in a septic tank, there are approximately 2 people per household in the Study Area.



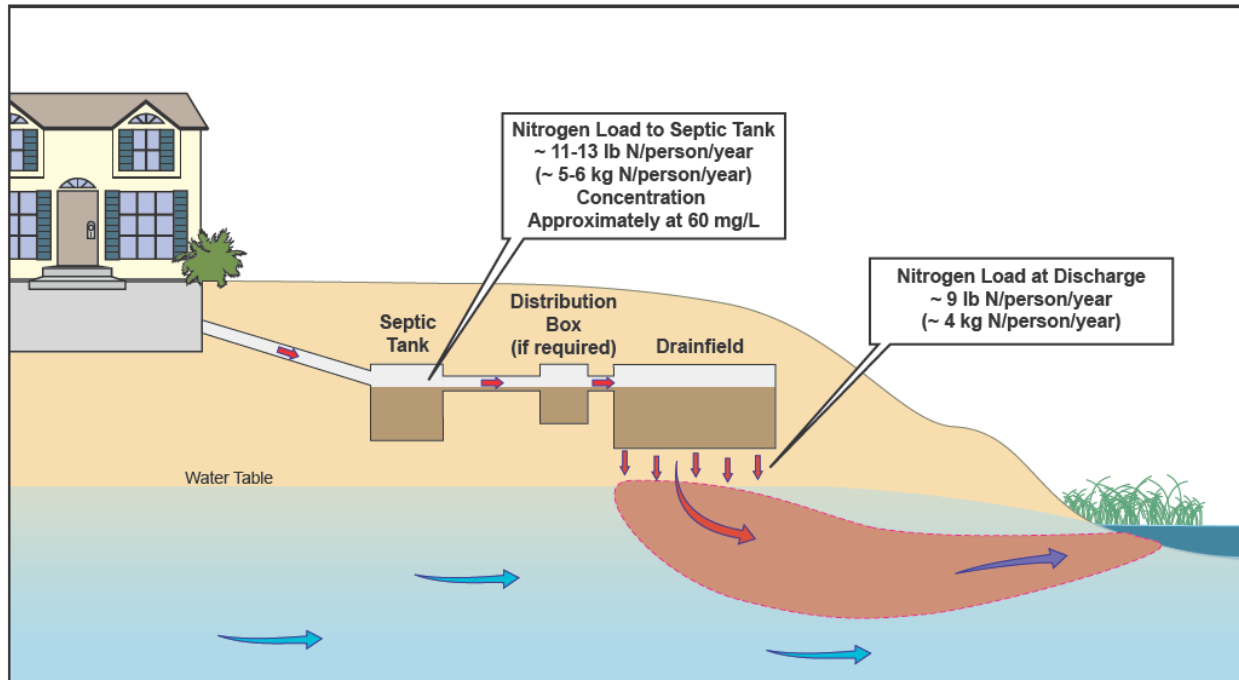
The average person excretes between 2-4 g/day of phosphorus (Etner, et al, 2005, Fewless et al, 2011). Using 3 g/day, each person therefore excretes 2.41 lbs./year. Phosphorus in laundry detergents were banned in 1973. In 2010 phosphorus in dishwasher detergents were banned. Phosphorus removal in a septic system (septic tank and drainfield) is highly complex and heavily dependent on local soils (Lombardo 2005). Phosphorus soils removal mechanisms are mineralization and sorption. While the mineralization mechanism can have an extremely large removal capacity, sorption mechanisms are limited as well as desorption can occur.

Given the criticality that soils have on septic phosphorus loadings to Candlewood Lake, a Study Area field testing program, described in the Task 2 Report, will determine the degree to which Study Area soils remove phosphorus.

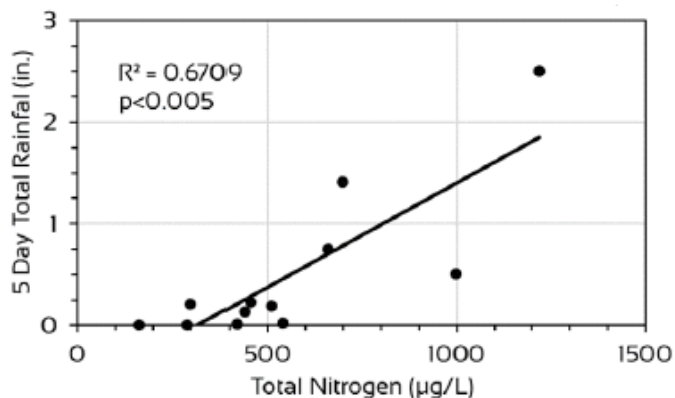
**Table 4-6 Estimates-Septic N & P Discharges to & Impact on Candlewood Lake**

<b>Typical Household N &amp; P discharges to Drainfield &amp; Groundwater</b>		
Flow (gpd)	100	
	<b>Phosphorus<sup>(1)</sup></b>	<b>Nitrogen</b>
Septic Tank Effluent Nutrient Conc. (mg/L)	7	65
Nutrient Loading (lbs/yr)	2.1	19.8
Typical Percent Removal in Drainfield Unsaturated zone	Site Specific	25%
Nutrient Loading to Groundwater (lbs/yr)		14.8
Typical Percent Removal in Surficial Geology		0%
Nutrient Loading to Lake <sup>(2)</sup> (lbs/yr)	2.1	14.8
<sup>(1)</sup> Phosphorus STE conc. average of 10 years of data for MA sites		
<sup>(2)</sup> Assuming 0% P Removal by soils		
<b>Brookfield Contributions to Candlewood Lake P &amp; N Levels</b>		
Number of Households	1,500	
Nutrient <sup>(2)</sup> Loading to Lake (lbs/yr)	3,196	22,260
Lake Volume Annual Turnover (gal)	15,690,909,000	
Incremental P <sup>(2)</sup> & N conc. (mg/L) due to septic discharges	0.024	0.170
Brookfield Septics as % of Total in Watershed	25%	
Watershed wide Incremental P <sup>(2)</sup> & N conc. (mg/L) due to septic discharges	0.098	0.680

Figure 4-7, from AER 2019, illustrates Relationship between Total Rainfall in 5 days Prior to Sampling and Lake Average TN, which suggests potential septic influence.



**Figure 4-6 Typical Septic Systems and Nitrogen Loadings**



**Figure 4-7  
Relationship  
Between Total  
Rainfall in 5 Days  
Prior to Sapling and  
Lake TN**

Figure 19. Relationship between total rainfall in the five days prior to sampling and the lake average total nitrogen concentration at Candlewood Lake in 2017 and 2018

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## APPENDIX A LAKE HYDROLOGY AND TERMINOLOGY

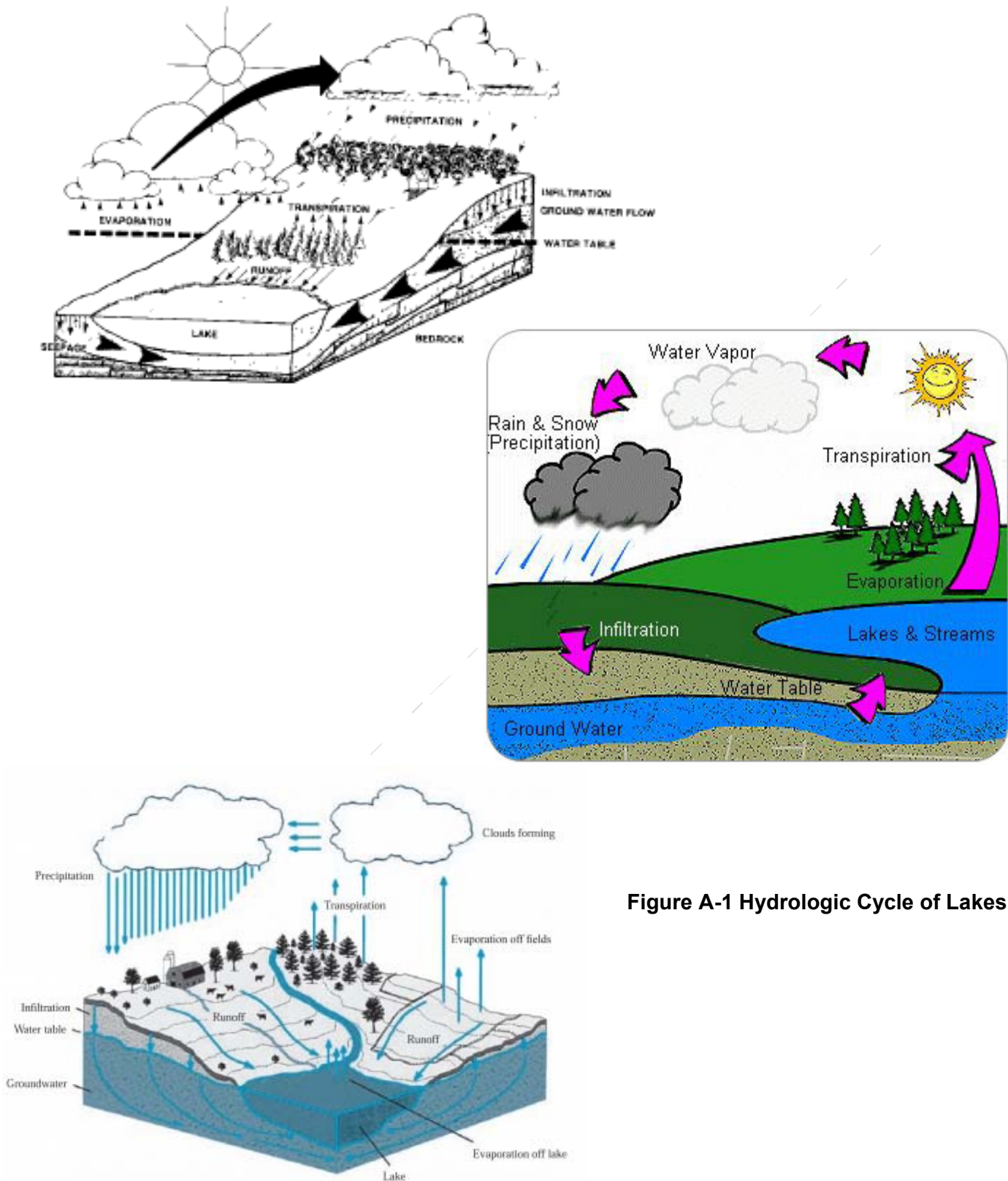
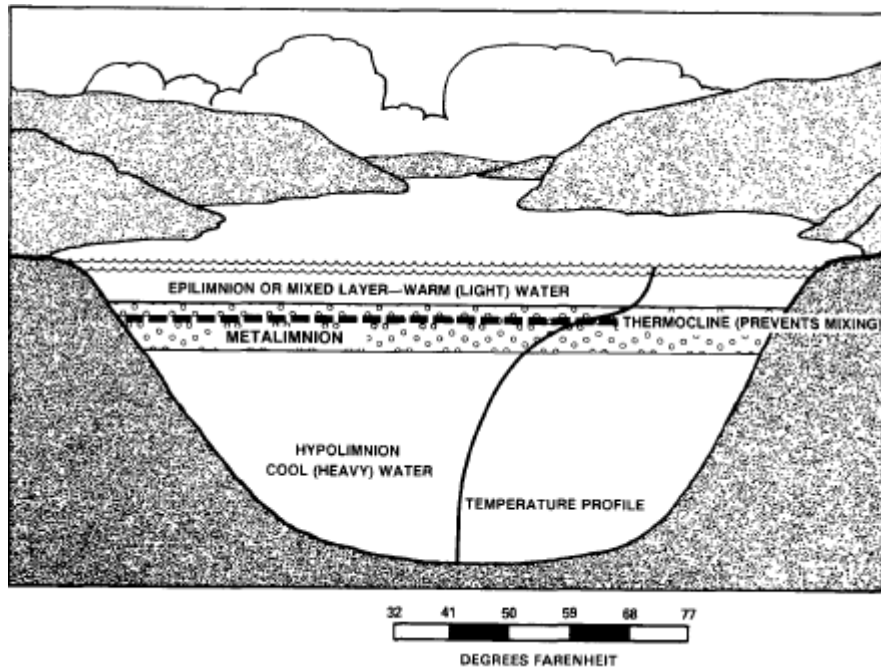


Figure A-1 Hydrologic Cycle of Lakes



**Figure A-2 Lake Stratification & Terminology**

Epilimnion top layer of Lake, warmer and less dense – uniformly warm

Metalimnion layer of water of rapid thermal change with depth

Hypolimnion cooler dense water layer, uniformly cold

Thermocline layer of water with the greatest temperature change

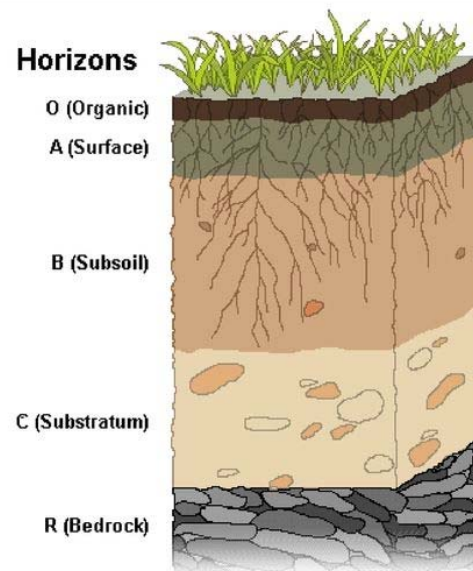
Thermal Mixing (Spring & Fall)

Caused by changing temperature of epilimnion. Water is heaviest at 39.2°F. In spring, warming water is heavier and sinks and causes mixing with metalimnion and hypolimnion. In fall, cooling water is heavier and causes mixing with lower layers.

## APPENDIX B CANDLEWOOD LAKE STUDY AREA SOILS DESCRIPTIONS

### WHAT IS A SOIL PROFILE?

- Cross section of soil layers revealing all soil horizons
- O Horizon = organic material (humus)
- A Horizon = topsoil
- B Horizon = subsoil
- C Horizon = partially weathered parent material
- R Horizon = bedrock



Horizon suffixes

- a: Highly decomposed organic matter (used only with O)
- e: Moderately decomposed organic matter (used only with O)
- g: Strong gley.
- i: Slightly decomposed organic matter (used only with O)
- p: Plow layer or other artificial disturbance
- w: Weak color or structure within B (used only with B)

See [Soils Horizons](#) for further details/descriptions.

### **2—Ridgebury fine sandy loam, 0 to 3 percent slopes**

#### **Typical profile**

*Oe - 0 to 1 inches: moderately decomposed plant material*

*A - 1 to 6 inches: fine sandy loam*

*Bw - 6 to 10 inches: sandy loam*

*Bg - 10 to 19 inches: gravelly sandy loam*

*Cd - 19 to 66 inches: gravelly sandy loam*

#### **Properties and qualities**

*Depth to restrictive feature: 15 to 35 inches to densic material*

*Natural drainage class: Poorly drained*

*Runoff class: Very high*

*Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)*

*Depth to water table: About 0 to 6 inches*

*Hydrologic Soil Group: D*



### **3—Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony**

#### ***Description of Ridgebury, Extremely Stony***

##### **Typical profile**

*Oe - 0 to 1 inches:* moderately decomposed plant material

*A - 1 to 6 inches:* fine sandy loam

*Bw - 6 to 10 inches:* sandy loam

*Bg - 10 to 19 inches:* gravelly sandy loam

*Cd - 19 to 66 inches:* gravelly sandy loam

##### **Properties and qualities**

*Depth to restrictive feature:* 15 to 35 inches to densic material

*Natural drainage class:* Poorly drained

*Runoff class:* Very high

*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately low (0.00 to 0.14 in/hr)

*Depth to water table:* About 0 to 6 inches

*Hydrologic Soil Group:* D

#### ***Description of Leicester, Extremely Stony***

##### **Typical profile**

*Oe - 0 to 1 inches:* moderately decomposed plant material

*A - 1 to 7 inches:* fine sandy loam

*Bg - 7 to 18 inches:* fine sandy loam

*BC - 18 to 24 inches:* fine sandy loam

*C1 - 24 to 39 inches:* gravelly fine sandy loam

*C2 - 39 to 65 inches:* gravelly fine sandy loam

##### **Properties and qualities**

*Percent of area covered with surface fragments:* 9.0 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Poorly drained

*Runoff class:* Very high

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to high (0.14 to 14.17 in/hr)

*Depth to water table:* About 0 to 6 inches

*Hydrologic Soil Group:* B/D

#### ***Description of Whitman, Extremely Stony***

##### **Typical profile**

*Oi - 0 to 1 inches:* peat

*A - 1 to 10 inches:* fine sandy loam

*Bg - 10 to 17 inches:* gravelly fine sandy loam

*Cdg - 17 to 61 inches:* fine sandy loam

## **Properties and qualities**

*Depth to restrictive feature:* 7 to 38 inches to densic material

*Natural drainage class:* Very poorly drained

*Runoff class:* Negligible

*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately low (0.00 to 0.14 in/hr)

*Depth to water table:* About 0 to 6 inches

*Hydrologic Soil Group:* D

### **4—Leicester fine sandy loam**

#### **Typical profile**

*Ap - 0 to 7 inches:* fine sandy loam

*Bg1 - 7 to 10 inches:* fine sandy loam

*Bg2 - 10 to 18 inches:* fine sandy loam

*BC - 18 to 24 inches:* fine sandy loam

*C1 - 24 to 43 inches:* gravelly fine sandy loam

*C2 - 43 to 65 inches:* gravelly fine sandy loam

## **Properties and qualities**

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Poorly drained

*Runoff class:* Very low

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.57 to 5.95 in/hr)

*Depth to water table:* About 0 to 18 inches

*Hydrologic Soil Group:* B/D

### **17—Timakwa and Natchaug soils, 0 to 2 percent slopes**

#### ***Description of Timakwa***

#### **Typical profile**

*Oa1 - 0 to 12 inches:* muck

*Oa2 - 12 to 37 inches:* muck

*2Cg1 - 37 to 47 inches:* very gravelly loamy coarse sand

*2Cg2 - 47 to 60 inches:* gravelly loamy very fine sand

## **Properties and qualities**

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Very poorly drained

*Runoff class:* Negligible

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to high (0.14 to 14.17 in/hr)

*Depth to water table:* About 0 to 12 inches

*Hydrologic Soil Group:* B/D

## **Description of Natchaug**

### **Typical profile**

*Oa1 - 0 to 12 inches: muck*  
*Oa2 - 12 to 31 inches: muck*  
*2Cg1 - 31 to 39 inches: silt loam*  
*2Cg2 - 39 to 79 inches: fine sandy loam*

### **Properties and qualities**

*Depth to restrictive feature: More than 80 inches*  
*Natural drainage class: Very poorly drained*  
*Runoff class: Negligible*  
*Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.01 to 14.17 in/hr)*  
*Depth to water table: About 0 to 12 inches*  
*Hydrologic Soil Group: B/D*

**45A—Woodbridge fine sandy loam, 0 to 3 percent slopes**  
**45B—Woodbridge fine sandy loam, 3 to 8 percent slopes**  
**45C—Woodbridge fine sandy loam, 8 to 15 percent slopes**

### **Typical profile**

*Ap - 0 to 7 inches: fine sandy loam*  
*Bw1 - 7 to 18 inches: fine sandy loam*  
*Bw2 - 18 to 30 inches: fine sandy loam*  
*Cd - 30 to 65 inches: gravelly fine sandy loam*

### **Properties and qualities**

*Depth to restrictive feature: 20 to 39 inches to densic material*  
*Natural drainage class: Moderately well drained*  
*Runoff class: Very high*  
*Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)*  
*Depth to water table: About 18 to 30 inches*  
*Hydrologic Soil Group: C/D*

**46B—Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony**

### **Typical profile**

*Oe - 0 to 2 inches: moderately decomposed plant material*  
*A - 2 to 9 inches: fine sandy loam*  
*Bw1 - 9 to 20 inches: fine sandy loam*  
*Bw2 - 20 to 32 inches: fine sandy loam*  
*Cd - 32 to 67 inches: gravelly fine sandy loam*

### **Properties and qualities**

*Depth to restrictive feature: 20 to 43 inches to densic material*



*Natural drainage class:* Moderately well drained  
*Runoff class:* Medium  
*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately low (0.00 to 0.14 in/hr)  
*Depth to water table:* About 19 to 27 inches  
*Hydrologic Soil Group:* C/D

**47C—Woodbridge fine sandy loam, 8 to 15 percent slopes, extremely stony**

**Typical profile**

*Oe - 0 to 2 inches:* moderately decomposed plant material  
*A - 2 to 9 inches:* fine sandy loam  
*Bw1 - 9 to 20 inches:* fine sandy loam  
*Bw2 - 20 to 32 inches:* fine sandy loam  
*Cd - 32 to 67 inches:* gravelly fine sandy loam

**Properties and qualities**

*Depth to restrictive feature:* 20 to 43 inches to densic material  
*Natural drainage class:* Moderately well drained  
*Runoff class:* Medium  
*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately low (0.00 to 0.14 in/hr)  
*Depth to water table:* About 19 to 27 inches  
*Hydrologic Soil Group:* C/D

**50B—Sutton fine sandy loam, 3 to 8 percent slopes**

**Typical profile**

*Ap - 0 to 5 inches:* fine sandy loam  
*Bw1 - 5 to 17 inches:* fine sandy loam  
*Bw2 - 17 to 25 inches:* sandy loam  
*C1 - 25 to 39 inches:* gravelly sandy loam  
*C2 - 39 to 60 inches:* gravelly sandy loam

**Properties and qualities**

*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Moderately well drained  
*Runoff class:* Very high  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to high (0.14 to 14.17 in/hr)  
*Depth to water table:* About 12 to 27 inches  
*Hydrologic Soil Group:* B/D

**51B—Sutton fine sandy loam, 0 to 8 percent slopes, very stony**

**Typical profile**

*Oi - 0 to 2 inches:* slightly decomposed plant material  
*A - 2 to 7 inches:* fine sandy loam

*Bw1 - 7 to 19 inches: fine sandy loam*  
*Bw2 - 19 to 27 inches: sandy loam*  
*C1 - 27 to 41 inches: gravelly sandy loam*  
*C2 - 41 to 62 inches: gravelly sandy loam*

#### **Properties and qualities**

*Depth to restrictive feature: More than 80 inches*  
*Natural drainage class: Moderately well drained*  
*Runoff class: Very high*  
*Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)*  
*Depth to water table: About 12 to 27 inches*  
*Hydrologic Soil Group: B/D*

#### **60B—Canton and Charlton fine sandy loams, 3 to 8 percent slopes** **60C—Canton and Charlton fine sandy loams, 8 to 15 percent slopes**

#### ***Description of Canton***

##### **Typical profile**

*Ap - 0 to 7 inches: fine sandy loam*  
*Bw1 - 7 to 15 inches: fine sandy loam*  
*Bw2 - 15 to 26 inches: gravelly fine sandy loam*  
*2C - 26 to 65 inches: gravelly loamy sand*

#### **Properties and qualities**

*Depth to restrictive feature: 19 to 39 inches to strongly contrasting textural stratification*  
*Natural drainage class: Well drained*  
*Runoff class: Low*  
*Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)*  
*Depth to water table: More than 80 inches*  
*Hydrologic Soil Group: B*

#### ***Description of Charlton***

##### **Typical profile**

*Ap - 0 to 7 inches: fine sandy loam*  
*Bw - 7 to 22 inches: gravelly fine sandy loam*  
*C - 22 to 65 inches: gravelly fine sandy loam*

#### **Properties and qualities**

*Depth to restrictive feature: More than 80 inches*  
*Natural drainage class: Well drained*  
*Runoff class: Low*  
*Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)*  
*Depth to water table: More than 80 inches*

*Hydrologic Soil Group: B*

**61B—Canton and Charlton fine sandy loams, 0 to 8 percent slopes, very stony**

**61C—Canton and Charlton fine sandy loams, 8 to 15 percent slopes, very stony**

***Description of Canton, Very Stony***

**Typical profile**

*Oi - 0 to 2 inches:* slightly decomposed plant material

*A - 2 to 5 inches:* fine sandy loam

*Bw1 - 5 to 16 inches:* fine sandy loam

*Bw2 - 16 to 22 inches:* gravelly fine sandy loam

*2C - 22 to 67 inches:* gravelly loamy sand

**Properties and qualities**

*Depth to restrictive feature:* 19 to 39 inches to strongly contrasting textural stratification

*Natural drainage class:* Well drained

*Runoff class:* Low

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to high (0.14 to 14.17 in/hr)

*Depth to water table:* More than 80 inches

*Hydrologic Soil Group: B*

***Description of Charlton, Very Stony***

**Typical profile**

*Oe - 0 to 2 inches:* moderately decomposed plant material

*A - 2 to 4 inches:* fine sandy loam

*Bw - 4 to 27 inches:* gravelly fine sandy loam

*C - 27 to 65 inches:* gravelly fine sandy loam

**Properties and qualities**

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Well drained

*Runoff class:* Low

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to high (0.14 to 14.17 in/hr)

*Depth to water table:* More than 80 inches

*Hydrologic Soil Group: B*

**62C—Canton and Charlton fine sandy loams, 3 to 15 percent slopes, extremely stony**

***Description of Canton, Extremely Stony***

**Typical profile**

*Oi - 0 to 2 inches:* slightly decomposed plant material

*A - 2 to 5 inches:* fine sandy loam



*Bw1 - 5 to 16 inches: fine sandy loam*  
*Bw2 - 16 to 22 inches: gravelly fine sandy loam*  
*2C - 22 to 67 inches: gravelly loamy sand*

**Properties and qualities**

*Depth to restrictive feature: 19 to 39 inches to strongly contrasting textural stratification*  
*Natural drainage class: Well drained*  
*Runoff class: Low*  
*Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)*  
*Depth to water table: More than 80 inches*  
*Hydrologic Soil Group: B*

**Description of Charlton, Extremely Stony**

**Typical profile**

*Oe - 0 to 2 inches: moderately decomposed plant material*  
*A - 2 to 4 inches: fine sandy loam*  
*Bw - 4 to 27 inches: gravelly fine sandy loam*  
*C - 27 to 65 inches: gravelly fine sandy loam*

**Properties and qualities**

*Depth to restrictive feature: More than 80 inches*  
*Natural drainage class: Well drained*  
*Runoff class: Low*  
*Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)*  
*Depth to water table: More than 80 inches*  
*Hydrologic Soil Group: B*

**73C—Charlton-Chatfield complex, 0 to 15 percent slopes, very rocky**  
**73E—Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky**

**Description of Charlton, Very Stony**

**Typical profile**

*Oe - 0 to 2 inches: moderately decomposed plant material*  
*A - 2 to 4 inches: fine sandy loam*  
*Bw - 4 to 27 inches: gravelly fine sandy loam*  
*C - 27 to 65 inches: gravelly fine sandy loam*

**Properties and qualities**

*Depth to restrictive feature: More than 80 inches*  
*Natural drainage class: Well drained*  
*Runoff class: Low*  
*Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)*  
*Depth to water table: More than 80 inches*

*Hydrologic Soil Group: B*

**Description of Chatfield, Very Stony**

**Typical profile**

*Oi - 0 to 1 inches: slightly decomposed plant material*

*A - 1 to 2 inches: fine sandy loam*

*Bw - 2 to 30 inches: gravelly fine sandy loam*

*2R - 30 to 40 inches: bedrock*

**Properties and qualities**

*Depth to restrictive feature: 20 to 41 inches to lithic bedrock*

*Natural drainage class: Well drained*

*Runoff class: High*

*Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)*

*Depth to water table: More than 80 inches*

*Hydrologic Soil Group: B*

**75C—Hollis-Chatfield-Rock outcrop complex, 3 to 15 percent slopes**

**75E— Hollis-Chatfield-Rock outcrop complex, 15 to 45 percent slopes**

**Description of Hollis**

**Typical profile**

*Oa - 0 to 1 inches: highly decomposed plant material*

*A - 1 to 6 inches: gravelly fine sandy loam*

*Bw1 - 6 to 9 inches: channery fine sandy loam*

*Bw2 - 9 to 15 inches: gravelly fine sandy loam*

*2R - 15 to 80 inches: bedrock*

**Properties and qualities**

*Depth to restrictive feature: 10 to 20 inches to lithic bedrock*

*Natural drainage class: Somewhat excessively drained*

*Runoff class: Low*

*Capacity of the most limiting layer to transmit water (Ksat): Low to high (0.01 to 5.95 in/hr)*

*Depth to water table: More than 80 inches*

*Hydrologic Soil Group: D*

**Description of Chatfield**

**Typical profile**

*Oa - 0 to 1 inches: highly decomposed plant material*

*A - 1 to 6 inches: gravelly fine sandy loam*

*Bw1 - 6 to 15 inches: gravelly fine sandy loam*

*Bw2 - 15 to 29 inches: gravelly fine sandy loam*

*2R - 29 to 80 inches: unweathered bedrock*

### **Properties and qualities**

*Depth to restrictive feature:* 20 to 40 inches to lithic bedrock

*Natural drainage class:* Well drained

*Runoff class:* Low

*Capacity of the most limiting layer to transmit water (Ksat):* Low to high (0.01 to 5.95 in/hr)

*Depth to water table:* More than 80 inches

*Hydrologic Soil Group:* B

### **Description of Rock outcrop**

### **Properties and qualities**

*Depth to restrictive feature:* 0 inches to lithic bedrock

*Runoff class:* Very high

*Hydrologic Soil Group:* D

**84B—Paxton and Montauk fine sandy loams, 3 to 8 percent slopes**

**84B—Paxton and Montauk fine sandy loams, 8 to 15 percent slopes**

**84B—Paxton and Montauk fine sandy loams, 15 to 25 percent slopes**

### **Description of Paxton**

### **Typical profile**

*Ap - 0 to 8 inches:* fine sandy loam

*Bw1 - 8 to 15 inches:* fine sandy loam

*Bw2 - 15 to 26 inches:* fine sandy loam

*Cd - 26 to 65 inches:* gravelly fine sandy loam

### **Properties and qualities**

*Depth to restrictive feature:* 18 to 39 inches to densic material

*Natural drainage class:* Well drained

*Runoff class:* Medium

*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderate (0.00 to 0.14 in/hr)

*Depth to water table:* About 18 to 37 inches

*Hydrologic Soil Group:* C

### **Description of Montauk**

### **Typical profile**

*A - 0 to 4 inches:* fine sandy loam

*Bw1 - 4 to 14 inches:* fine sandy loam

*Bw2 - 14 to 25 inches:* sandy loam

*2Cd1 - 25 to 39 inches:* gravelly loamy coarse sand

*2Cd2 - 39 to 60 inches:* gravelly sandy loam

### **Properties and qualities**



*Depth to restrictive feature:* 20 to 38 inches to densic material

*Natural drainage class:* Well drained

*Runoff class:* Low

*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately high (0.00 to 0.20 in/hr)

*Depth to water table:* About 24 to 30 inches

*Hydrologic Soil Group:* C

**86C—Paxton and Montauk fine sandy loams, 3 to 15 percent slopes, extremely stony**

**86D—Paxton and Montauk fine sandy loams, 15 to 35 percent slopes, extremely stony**

***Description of Paxton, Extremely Stony***

**Typical profile**

*Oe - 0 to 2 inches:* moderately decomposed plant material

*A - 2 to 10 inches:* fine sandy loam

*Bw1 - 10 to 17 inches:* fine sandy loam

*Bw2 - 17 to 28 inches:* fine sandy loam

*Cd - 28 to 67 inches:* gravelly fine sandy loam

**Properties and qualities**

*Depth to restrictive feature:* 20 to 43 inches to densic material

*Natural drainage class:* Well drained

*Runoff class:* High

*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately low (0.00 to 0.14 in/hr)

*Depth to water table:* About 18 to 37 inches

*Hydrologic Soil Group:* C

***Description of Montauk, Extremely Stony***

**Typical profile**

*Oe - 0 to 2 inches:* moderately decomposed plant material

*A - 2 to 6 inches:* fine sandy loam

*Bw1 - 6 to 28 inches:* fine sandy loam

*Bw2 - 28 to 36 inches:* sandy loam

*2Cd - 36 to 74 inches:* gravelly loamy sand

**Properties and qualities**

*Depth to restrictive feature:* 20 to 43 inches to densic material

*Natural drainage class:* Well drained

*Runoff class:* High

*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately high (0.00 to 1.42 in/hr)

*Depth to water table:* About 18 to 37 inches

*Hydrologic Soil Group:* C

**245B—Woodbridge-Urban land complex, 0 to 8 percent slopes**

## **245C—Woodbridge-Urban land complex, 8 to 15 percent slopes**

### ***Description of Woodbridge***

#### **Typical profile**

*Oe - 0 to 2 inches:* moderately decomposed plant material

*A - 2 to 9 inches:* fine sandy loam

*Bw1 - 9 to 20 inches:* fine sandy loam

*Bw2 - 20 to 32 inches:* fine sandy loam

*Cd - 32 to 67 inches:* gravelly fine sandy loam

#### **Properties and qualities**

*Depth to restrictive feature:* 20 to 43 inches to densic material

*Natural drainage class:* Moderately well drained

*Runoff class:* Medium

*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately low (0.00 to 0.14 in/hr)

*Depth to water table:* About 19 to 27 inches

*Hydrologic Soil Group:* C/D

### ***Description of Urban Land***

#### **Typical profile**

*M - 0 to 10 inches:* cemented material

#### **Properties and qualities**

*Depth to restrictive feature:* 0 inches to manufactured layer

*Runoff class:* Very high

*Capacity of the most limiting layer to transmit water (Ksat):* Very low (0.00 to 0.00 in/hr)

*Hydrologic Soil Group:* D

## **273C—Urban land-Charlton-Chatfield complex, rocky, 3 to 15 percent slopes**

## **273E—Urban land-Charlton-Chatfield complex, rocky, 15 to 45 percent slopes**

### ***Description of Urban Land***

#### **Typical profile**

*M - 0 to 10 inches:* cemented material

#### **Properties and qualities**

*Depth to restrictive feature:* 0 inches to manufactured layer

*Runoff class:* Very high

*Capacity of the most limiting layer to transmit water (Ksat):* Very low (0.00 to 0.00 in/hr)

*Hydrologic Soil Group:* D

### ***Description of Charlton***

#### **Typical profile**

*Ap - 0 to 4 inches: fine sandy loam*  
*Bw1 - 4 to 7 inches: fine sandy loam*  
*Bw2 - 7 to 19 inches: fine sandy loam*  
*Bw3 - 19 to 27 inches: gravelly fine sandy loam*  
*C - 27 to 65 inches: gravelly fine sandy loam*

**Properties and qualities**

*Depth to restrictive feature: More than 80 inches*  
*Natural drainage class: Well drained*  
*Runoff class: Low*  
*Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)*  
*Depth to water table: More than 80 inches*  
*Hydrologic Soil Group: B*

**Description of Chatfield**

**Typical profile**

*Oa - 0 to 1 inches: highly decomposed plant material*  
*A - 1 to 6 inches: gravelly fine sandy loam*  
*Bw1 - 6 to 15 inches: gravelly fine sandy loam*  
*Bw2 - 15 to 29 inches: gravelly fine sandy loam*  
*2R - 29 to 80 inches: unweathered bedrock*

**Properties and qualities**

*Depth to restrictive feature: 20 to 40 inches to lithic bedrock*  
*Natural drainage class: Well drained*  
*Runoff class: Low*  
*Capacity of the most limiting layer to transmit water (Ksat): Low to high (0.01 to 5.95 in/hr)*  
*Depth to water table: More than 80 inches*  
*Hydrologic Soil Group: B*

**284B—Paxton-Urban land complex, 3 to 8 percent slopes**  
**284C—Paxton-Urban land complex, 8 to 15 percent slopes**  
**284D—Paxton-Urban land complex, 15 to 25 percent slopes**

**Description of Paxton**

**Typical profile**

*Ap - 0 to 8 inches: fine sandy loam*  
*Bw1 - 8 to 15 inches: fine sandy loam*  
*Bw2 - 15 to 26 inches: fine sandy loam*  
*Cd - 26 to 65 inches: gravelly fine sandy loam*

**Properties and qualities**

*Depth to restrictive feature: 20 to 39 inches to densic material*



*Natural drainage class:* Well drained

*Runoff class:* Medium

*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately low (0.00 to 0.14 in/hr)

*Depth to water table:* About 18 to 37 inches

*Hydrologic Soil Group:* C

#### **Description of Urban Land**

##### **Typical profile**

*M - 0 to 10 inches:* cemented material

##### **Properties and qualities**

*Depth to restrictive feature:* 0 inches to manufactured layer

*Runoff class:* Very high

*Capacity of the most limiting layer to transmit water (Ksat):* Very low (0.00 to 0.00 in/hr)

*Hydrologic Soil Group:* D

#### **306—Udorthents-Urban land complex**

##### **Description of Udorthents**

##### **Typical profile**

*A - 0 to 5 inches:* loam

*C1 - 5 to 21 inches:* gravelly loam

*C2 - 21 to 80 inches:* very gravelly sandy loam

##### **Properties and qualities**

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Well drained

*Runoff class:* Medium

*Capacity of the most limiting layer to transmit water (Ksat):* Very low to high (0.00 to 1.98 in/hr)

*Depth to water table:* About 54 to 72 inches

*Hydrologic Soil Group:* C

#### **Description of Urban Land**

##### **Typical profile**

*M - 0 to 6 inches:* material

##### **Properties and qualities**

*Depth to restrictive feature:* 0 inches to manufactured layer

*Runoff class:* Very high

*Capacity of the most limiting layer to transmit water (Ksat):* Very low (0.00 to 0.00 in/hr)

*Hydrologic Soil Group:* D

### **308— Udorthents, smoothed**

#### **Typical profile**

*A - 0 to 5 inches:* loam

*C1 - 5 to 21 inches:* gravelly loam

*C2 - 21 to 80 inches:* very gravelly sandy loam

#### **Properties and qualities**

*Slope:* 0 to 35 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Moderately well drained

*Runoff class:* Medium

*Capacity of the most limiting layer to transmit water (Ksat):* Very low to high (0.00 to 1.98 in/hr)

*Depth to water table:* About 24 to 54 inches

*Hydrologic Soil Group:* C

## APPENDIX C CANDLEWOOD LAKE STUDY AREA PARCEL LIST - EXAMPLE

LOCATION	OWNER_NAME	W_SYS_NAM	ZONE	LU_CAT	BLDG_STYLE	AREA_SF	YR_BLT	WW_YR_BLT	WW_SY_S_AGE	DEV_S TA	AV_ARE A	WW_FLO W
1 ARROWHEAD RD	MONTALTO JAMES AND	Arrowhead Point HO Ass'n	R7	Vacant / Open Space		18,735				0	11,355	0
2 ARROWHEAD RD	SHAULSON SAMUEL SCOTT	Arrowhead Point HO Ass'n	R7	Residential	Modern/Cont emp	30,328	1927	2013	6	1	12,325	450
3 ARROWHEAD RD	MONTALTO JAMES J AND		R7	Residential	Modern/Cont emp	23,877	1960	1991	28	1	4,189	600
4 ARROWHEAD RD	SHINE KEVIN & SARAH	Arrowhead Point HO Ass'n	R7	Residential	Colonial	28,844	2002	2001	18	1	7,925	750
9 ARROWHEAD RD	LEVINE JEFFREY & ANNE	Arrowhead Point HO Ass'n	R7	Residential	Ranch	24,061	1950	2014	5	1	5,205	600
10 ARROWHEAD RD	MONTALTO JAMES J AND	Arrowhead Point HO Ass'n	R7	Vacant / Open Space		8,522				0	3,137	0
12 ARROWHEAD RD	JARKOW KENNETH S	Arrowhead Point HO Ass'n	R7	Residential	Cape Cod	28,641	1945	1945	74	1	12,126	600
13 ARROWHEAD RD	POLIZZI STEPHEN C 50% AND DEL BENE	Arrowhead Point HO Ass'n	R7	Residential	Ranch	14,174	1958	2007	12	1	1,997	450
15 ARROWHEAD RD	KELLY NANCY J	Arrowhead Point HO Ass'n	R7	Residential	Ranch	12,000	1965	1965	54	1	2,266	450
16 ARROWHEAD RD	LEVINE JEFFREY & ANNE	Arrowhead Point HO Ass'n	R7	Vacant / Open Space		8,597		2005	14	0	3,028	0
18 ARROWHEAD RD	VOVES JOSEPH J & LUCIE H	Arrowhead Point HO Ass'n	R7	Residential	Conventional	15,470	1961	2005	14	1	3,170	450
19 ARROWHEAD RD	TRAVIS MARY ELLEN	Arrowhead Point HO Ass'n	R7	Residential	Ranch	12,000	1953	2000	19	1	1,949	450
20 ARROWHEAD RD	MELLAS STEPHEN J & PATRICIA M	Arrowhead Point HO Ass'n	R7	Vacant / Open Space		4,531				0	1	0
22 ARROWHEAD RD	TIMMONS BRUCE & ELAINE	Arrowhead Point HO Ass'n	R7	Residential	Cape Cod	25,054	1946	1946	73	1	9,096	600
23 ARROWHEAD RD	HOWELLS ROBERTA A	Arrowhead Point HO Ass'n	R7	Residential	Ranch	9,000	1958	1958	61	1	683	450
24 ARROWHEAD RD	HARTMAN SCOTT & LINDA	Arrowhead Point HO Ass'n	R7	Residential	Cape Cod	45,413	1945	1945	74	1	23,239	600
27 ARROWHEAD RD	THOMPSON ALEXANDER J & CALVO RICHARD	Arrowhead Point HO Ass'n	R7	Residential	Cape Cod	15,000	1945	1945	74	1	3,101	450
28 ARROWHEAD RD	REDDEN ROBERTA PUNZI	Arrowhead Point HO Ass'n	R7	Residential	Ranch	25,615	1965	2001	18	1	9,002	600
30 ARROWHEAD RD	SOSA RICHARD & VECCHIOLY LILLIAN B	Arrowhead Point HO Ass'n	R7	Residential	Ranch	15,035	1947	1947	72	1	1,850	450



**APPENDIX D CANDLEWOOD LAKE STUDY AREA MAPS – 11” X 17” PLATES –  
SEPARATE DOCUMENT**

