Thetford, Vermont
Community Water Systems
Assessment Report

Prepared for:
Town of Thetford, Vermont

Prepared by:
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Rev. #	Description	Author	Quality Check	Independent Review
1	Draft Report for Town and Water System Owner Comments and Feedback	BMR	RL	WFR
2	Final Report	BMR	RL	WFR

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Executive Summary

At the request of the Town of Thetford, Vermont, and based on the feedback received from the stakeholders during the June 30, 2022, engineering services request for proposals (RFP) interview for the project and subsequent meetings with the Town and associated water system stake holders, Stantec performed a Community Water System Assessment, performed analysis, and developed associated recommendations for the six privately owned and maintained community water systems in the Town of Thetford.

The primary goal of this study was to perform an assessment of the existing water system infrastructure and to provide a 50-year plan to identify operational and capital improvement needs to support community development in Thetford, VT. Additionally, as part of this study, Stantec has reviewed and provided recommendations for infrastructure improvements and sustainability of the Town's existing six (6) privately owned and operated independent community water systems to support community development.

The information in this report is based on the feedback that Stantec has received from the various Town Departments, Schools, and the water systems' operators/owners to identify the various goals, objectives, and associated recommended improvements for the existing systems, as well as recommendations for future sustainability of the water system(s) in the Town of Thetford. The report includes the following:

- Summary of existing water systems,
- Existing water system assessments,
- Recommended water system improvements,
- Current and projected users and associates' costs,
- Recommended improvements for the current water systems,
- Assessment of potential system expansions for community development,
- Water systems maps,
- Fire flow need and availability,
- Proposed conceptual level schedule for required and desired upgrades,
- Alternatives development and analysis
- Summary and final recommendations,

Abbreviations

AWWA	American Water Work Association
ADA	Americans with Disabilities Act
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ALLOW	Allowance
ANR	Vermont Agency of Natural Resources
ANSI	American National Standards Institute
ARPA	America Rescue Plan Act
ASR	Aquifer Storage and Recovery
ASTM	American Society of Testing Materials
BM	Benchmark
BMQL	Below Minimum Quantitation Level
CFS	Cubic Feet Per Second
CIPC	Cast In Place Concrete
CT	Copper Tubing
CTS	Copper Tubing Size
CY	Cubic Yard
DEC	Vermont Department of Environmental Conservation Drinking Water and Groundwater Protection Division
DF	Dilution Factor
DEQ	Vermont Department of Environmental Quality
DI	Ductile Iron

DIP	Ductile Iron Pipe
DPW	Department of Public Works
DWGPD	Drinking Water and Groundwater Protection Division
EA	Each
EL	Elevation
EPA	Environmental Protection Agency
EPSC	Erosion Prevention and Sedimentation Controls
ERC	Equivalent Residential Connection
ET	Evapotranspiration
EX	Existing
F	Degrees Fahrenheit
FEMA	Federal Emergency Management Agency
FT	Linear Feet
GAL	Gallons
GIS	Geographic Information System
GPM	Gallons Per Minute
GPS	Global Positioning System
GS	Ground Surface
GW	Ground Water
GWUDI	Ground Water Under Direct Influence of Surface Water
HDPE	High Density Polyethylene
HGL	Hydraulic Grade Line
HO	Harmonic Oscillator
HVAC	Heating, Ventilation and Air Conditioning

HYD	Hydrant
Hz	Hertz
I&C	Instrumentation and Controls
ISO	International Standard Organization
LB	Pound
LF	Linear Feet
LOQ	Limit of Quantitation
LRAA	Locational Running Annual Average
LS	Lump Sum
LT or (L)	Left
MW	Monitoring Well
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	Method Detection Limit
MF	Membrane Filtration
MG	Million Gallons
MGD	Million Gallons per Day
MRDL	Maximum Residual Disinfectant Level
NA	Not Applicable
ND	Not Detected (at the reporting limit)
ng/L	Nano-Grams per Liter (parts per trillion)
NIST	National Institute of Standards and Technology
NTU	Nephelometric Turbidity Units
O&M	Operation and Maintenance

OSHA	Occupational Safety and Health Administration
pH	Potential of Hydrogen
PCV	Pressure Control Valve
PE	Professional Engineer
PFAS	Polyfluoroalkyl Substances
PFAO	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonic Acid
PFHxS	Perfluorohexane Sulfonic Acid
PFHpA	Perfluoroheptanoic Acid
PFNA	Perfluorononanoic Acid
PL	Property Line
PLC	Programmable Logic Controller
POE	Point of Entry
PPB	Parts Per Billion
PPM	Points Per Million
PPT	Parts Per Trillion
PRV	Pressure Reducing Valve
PSI	Pounds Per Square Inch
PUC	Public Utilities Commission
PVC	Polyvinyl Chloride
PWS	Public Water Supply
QUAL	Qualifier
RD	Road
RL	Reporting Limit

ROW	Right of Way
RTD	Resistance Temperature Detector
SCADA	Supervisory Control and Data Acquisition
SF	Square Feet
ST	Street
SY	Square Yards
SVC	Service
THD	Total Harmonic Distortion
TNTC	Too Numerous to Count
TON	Threshold Odor Number
TT	Treatment Technique
TC	Top of Cover
TRORC	Two Rivers Ottauquechee Regional Commission
TYP	Typical
UPS	Uninterruptible Power Source
USACOE	United States Army Corp. of Engineers
USGS	United States Geological Survey
UV	Ultraviolet
VAOT	Vermont Agency of Transportation
VT	Vermont
WM	Water Main
WS	Water Service
WSO	Water Shut Off
WTP	Water Treatment Plant

Glossary

ACTION LEVEL	The specified concentration of a contaminant in drinking water. If this concentration is reached or exceeded, certain actions (such as further treatment and monitoring) must be taken to comply with drinking water regulations.
ACUTE HEALTH EFFECT	An immediate (within 24-hours) adverse health effect that may result from exposure to a contaminated drinking water.
ALLUVIAL ACQUIFER	An aquifer that is shallow and unconfined that is formed as a result of sediment deposited in river channels or on floodplains. Alluvial aquifers experience fluctuating water levels and are susceptible to contamination.
ACQUIFER	A geologic formation or part of a formation (such as gravel, sand, or porous stone) that supplies water to wells or springs.
BEST AVAILABLE TECHNOLOGY	The water treatment(s) that the US EPA certifies to be the most effective for removing a contaminant.
BACKFLOW	A hydraulic condition caused by a difference in water pressure that causes water from one piped system to enter another piped system.
BACKSIPHONAGE	A hydraulic condition caused by negative or sub-atmospheric pressure within a piped water system, resulting in backflow.
BACKWASH	Flow of water through filter element(s) or media in a reverse direction to dislodge and remove accumulated dirt, debris or filter aid from the filter tank.
BATHER LOAD	The number of bathers using a swimming pool or spa at any one time.
BIOFILM	A group of micro-organisms – often a mix of bacteria, fungi and amoebas that live together and release a slimy,

	glue-like substance which allows them to stick to surfaces. Biofilm is more likely to grow in places where water does not move, like inner surfaces of water pipes, water storage tanks, or water heaters.
BOIL WATER ADVISORY	A statement to the public advising that tap water should be boiled before drinking because of suspected or known microbial contamination.
BOTTLED WATER	Commercially produced water.
CAPACITY	A water system that has the technical, financial, and managerial capabilities to comply with the current performance standard.
CHLORAMINES	A group of disinfection byproducts or weak disinfectants used to treat drinking water, most commonly formed when ammonia is added to chlorine to treat drinking water in a process called secondary disinfection.
CHRONIC HEALTH EFFECT	The possible result of exposure over many years to a drinking water contaminate disease causing micro-organism.
CLASS	Pipe rating according to the maximum allowable pressure and thickness of the pipe.
COLIFORMS	A group of related bacteria whose presence in drinking water may indicate contamination by disease causing micro-organisms.
COMMUNITY WATER SYSTEM	A public water system which supplies drinking water for 25 or more residential users. (EPA Definition)
COMPLIANCE	The act of meeting all state and federal regulations.
CONTACT TIME	The length of that water and any pathogens in the water are exposed to a disinfectant, usually measured in minutes.
CONTAMINANT	Anything found in water (including but not limited to micro-organisms, minerals, chemicals, radionuclides, etc.) which may be harmful to human health.
CROSS-CONNECTION	Any actual or potential connection between drinking water supply and non-drinkable water.

CRYPTOSPORIDIUM	A micro-organism commonly found in lakes and rivers which is highly resistant to disinfection.
DEFICIENCY	An antecedent event or situation contributing to the occurrence of a waterborne disease or outbreak.
DISINFECTANT	A chemical (chlorine, chloramine, ozone) or physical (ultraviolet) process for treating drinking water.
DISINFECTANT BYPRODUCTS	Chemicals that may form when disinfectants react with plant matter and other naturally occurring materials in the water.
DISTRIBUTION SYSTEM	A network of pipes leading from a water source or water treatment plant to individual water service connections.
EASEMENT	A right acquired to use or control property outside of the established Right of Way limits for a designate purpose.
EXEMPTION	State or US EPA permission for a water system not to meet a specified drinking water standard. An exemption allows a system additional time to obtain financial assistance or make improvements in order to come into compliance with the applicable standards. The system must provide that (1) there are compelling reasons why it cannot meet US EPA health standards (2) was in operation on the effective date of the requirement(s) and (3) the exemption will not create an unreasonable risk to public health and safety. The state must set a schedule under which the water system will comply with the standard(s) for which it has received an exemption for.
ETIOLOGY	The pathogen, chemical or toxin causing a waterborne disease or outbreak or other health event. Infectious etiologic agents include bacteria, parasites, and viruses.
FILTRATION	In water treatment, the process of passing water through one or more permeable membranes or media of small diameter to remove suspended particles from the drinking water.
FINISH WATER	The delivery of drinking water to the distribution system after the treatment of the water.

FIRE POND	A water source that is created and maintained to provide a water supply for firefighters and firefighting activities to pump the water from the pond into a tanker to transport to an active fire to be used to contain and extinguish active fires.
FIRE FLOW	The water flow and pressure required to provide a water source for either sprinklers or firefighters based on the building type of materials used for construction, building use, building size and the associated hazard class of the buildings use, as determined by NFPA.
FIRE HYDRANT	A connection point which firefighters can access the water supply for firefighting operations.
FREE CHRLORINE	A common water quality test for the level of chlorine in the water.
GIARDIA IAMBLIA	A micro-organism frequently found in rivers and lakes, which, if not treated properly, may cause illness.
GROUND WATER	The water that is underground and contained in interconnected pours in an aquifer.
GROUND WATER SYSTEM	A drinking water system that uses water extracted from an aquifer (like a well or spring) as its source.
GROUND WATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER	Any water beneath the surface of the ground with 1) significant occurrence of insects of other microorganisms such as algae or large diameter pathogens such as Giardia duodenales or 2) significance and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatologic or surface water conditions. Direct influence must be determined for particular drinking water sources in accordance with criteria established by the State.
HEALTH ADVISORY	A US EPA document that provides guidance and information on contaminants that can affect human health and that may occur in drinking water.

INDIVIDUAL WATER SYSTEM	A drinking water system that does not meet the EPA definition for a public water system.
INORGANIC CONTAMINANTS	Mineral based compounds such as metals, nitrates and asbestos. The contaminants are naturally occurring in some water but can also get into water through farming, chemical manufacturing, and other human activities. US EPA has a current legal limit standard for 16 inorganic contaminants.
JURISDICTION	The pertinent governing agencies responsible for oversight, permitting and compliance confirmation for the type of subject and the associated location.
KARST AQUIFER	An aquifer characterized by water soluble limestone and similar rocks in which fractures or cracked have been widened by the dissolution of the carbonate rocks by ground water. The aquifer might contain sinkholes, tunnels or even caves.
MAXIMUM CONTAMINATION LEVEL (MCL)	The highest level of a contaminant that is allowed in the drinking water. MCL's are set as close to the MCLG as feasible using the best available treatment technology and taking cost into consideration. MCL's are enforceable standards.
MAXIMUM CONTAMINATION LEVEL GOAL (MCLG)	The level of contaminant in drinking water below which there is no known or expected risk to health. MCLG's allow for a margin of safety. MCLG's are non-enforceable health goals.
MICROBES	Tiny living organisms that can only be seen with the aid of a microscope.
MONITORING	Testing that water systems must perform to detect and measure contaminants.
NATIONAL PRIMARY DRINKING WATER REGULATIONS	Legally enforceable standards that apply to public water systems. These standards protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health and which are known or anticipated to occur in public water supplies.

NON-COMMUNITY WATER SYSTEMS	A public drinking water system that is not a community system; that does not serve year-round residents.
NON-TRANSCIENT WATER SYSTEMS	A public drinking water system that regularly supplies water to > 25 of the same people for > 6 months per year, but not year-round (schools, factories, office buildings, hospitals, seasonal businesses, etc.)
ORGANIC CONTAMINANTS	Carbon based chemicals like solvents and pesticides, which can get into water through runoff from cropland or discharge from manufacturing processes. US EPA currently has regulations on 56 organic contaminants. Disease causing organisms, such as bacteria, viruses, or protozoa.
PATHOGENS	Any agent or organism that can cause disease.
PRIMACY	Enforcement authority for drinking water program. Under the Safe Drinking Water Act, US Territories that meet certain requirements, including setting regulations that are as stringent as the US EPA's, may apply for, and receive, primary enforcement authority or primacy.
PLUMBING	Water pipes, storage reservoirs, tanks and other means used to deliver drinking water to consumers inside buildings or houses.
PUBLIC NOTIFICATION	An advisory that US EPA or the state requires a water system to distribute to affected consumers when the system has violated the MCL and or other regulations. The notice advises consumers what precautions, if any, they should take to protect their health.
PUBLIC WATER SYSTEM	Any water system which provides water to at least 15 services connections or 25 people at least 60 days annually.
RADIONUCLIDE	An unstable form of chemical element that radio-actively decays, resulting in the emission of nuclear radiation.
RAW WATER	Water in its natural state, prior to any treatment for drinking.

RESERVOIR IMPOUNDMENT	An artificially maintained lake or other body of water used to collect and store water.
SAMPLE	The water that is analyzed for the presence of US EPA regulated drinking water contaminants.
SANITARY SURVEY	An on-site review of the water sources, facilities, equipment, operations, and maintenance of a public water system for the purpose of evaluating the adequacy of the facilities for producing and distributing safe drinking water.
SECONDARY DRINKING WATER STANDARDS	Non-enforceable federal guidelines regarding cosmetic effects (such as tooth or skin discoloration) or aesthetic effects (such as taste, odor or color) of drinking water.
SERVICE	Small water pipe that extends off the main water supply pipe and provides water to individual homes or business.
SERVICE HYDRANT	Hydrant utilized for non-fire flow situations like maintenance or wash down.
SETTING	Location in which exposure to contaminated water occurred.
SOLE SOURCE ACQUIFER	An aquifer that supplies 50 percent or more of the drinking water of an area.
SOURCE WATER	Water in its natural state, prior to any treatment or process for drinking.
SURFACE WATER	The water that systems pump and treat from sources open to the atmosphere, such as rivers, lakes and reservoirs.
TRANSIENT, NON-COMMUNITY WATER SYSTEMS	A public water system which provides water in a place such as a gas station or campground where people do not remain for long periods of time.
TOTAL CHLORINE	A common water quality test for drinking water and treated recreational water that quantifies the level of chlorine in water that is free for disinfection.

TOTAL COLIFORMS	The total amount of fecal and nonfecal coliforms that are detected in water.
TREATED WATER	Water that has undergone a disinfection or treatment process to make it safer to drink.
TURBIDITY	The cloudy appearance of water caused by the presence of tiny particles. High levels of turbidity may interfere with proper water treatment and monitoring.
UNTREATED WATER	Water that has not been disinfected or treated to make it safe to drink.
USER	Any person utilizing water from the water system.
VARIANCE	State of US EPA permission to not meet a certain drinking water standard or criteria.
VIOLATION	A failure to meet a State and/or US EPA drinking water regulations.
VULNERABILITY ASSESSMENT	An evaluation of drinking water source quality and its vulnerability to contamination by pathogens and toxic chemicals.
WATER QUALITY INDICATOR	A microbial, chemical, or physical parameter that indicates the potential of contamination.
WATERSHED	A land area that combines and contributes to the stormwater going to a single location.
WELLHEAD PROTECTION AREA	The area surrounding a drinking water well or well field which is protected to prevent contamination of the wells.

1.0 Introduction

The purpose of this study is to perform a review of the six (6) separate existing privately owned and operated water systems that serve Thetford Village Communities; summarize the system information, observed and reported limitations or concerns with the existing systems infrastructure and provide recommended improvements, expansion, or replacement of the existing water systems based on the Vermont Water Supply Rule and to support development and growth within the Thetford Community, specifically the Thetford Villages.

The assessment and associated recommendations for the upgrades to the existing water systems are based on the reported data, planned improvements, previous system reports and analysis and existing infrastructure information as provided by the system owners and operators, as compared to the Water Supply Rule, EPA and NFPA standards.

The analysis of the existing systems recommended future upgrades or system replacement to support growth in the community Villages are primarily based on feedback received from Town Officials and the Water systems' owners and based on the recommendations and goals identified in the Town Plan regarding the planned and anticipated areas of residential and community growth and development.

In developing this report, Stantec relied on the existing information and associated input provided by the system owners/operators, Town Officials, and school staff familiar with the Academy's and Elementary school's water system infrastructure.

2.0 Existing Water Systems

This section provides a summary of the existing water system infrastructure, system history and overview for the six (6) independent, existing water systems and the two (2) school water systems in Thetford, that include the following water systems:

- Union Water Company
- East Thetford Water Company
- North Village Water Company
- South Village Water Company

- Thetford Water Co-Op
- Post Mills Water Association
- Thetford Academy
- Thetford Elementary School

Based on the number of active system users, three (3) of the existing water systems are classified as a (regulated) Public Community Water System, and three (3) of the existing water systems are classified as a Private Community Water System. Regulatory requirements based on Vermont's Water Supply Rule vary based on the systems current number of users. The two schools in Town are classified as Public Water Systems Not Associated with a Community System.

The number of users, and the location of each system are summarized in **Table** 2-1. Maps showing the locations of the existing water systems are provided as Appendix A.

System Name	Village Location	Supply Pipe Size	Typical Service Pipe Size	# of Users
Post Mills Water Association	Post Mills	1-1/2"	3/4"	9
Union Water Co.	North Thetford	1-1/2"	1/2"	23
East Thetford Water Co.	East Thetford	4"	3/4"	35
North Village Water Co.	North Village	1-1/2"	3/4"	9
South Village Water Co.	North Thetford	1-1/2"	3/4"	9
Thetford Water Co-Op.	Thetford Hill	4"	3/4"	41
School Name				
Thetford Academy	*Thetford Hill*	*2"*	*2"*	*400*Note#1*
Thetford Elementary	*Thetford Hill*	*2"*	*2"*	*300*Note#1*

Table 2-1 Summary of Thetford Water Systems

Note#1 – Number of users indicated for the two schools is based on approximately number of daily users while school is in session and does not represent the number of users or associated demand as defined for the community water systems.

The Post Mills Water Association, North Village Water Company and South Village Water Company water systems have less than 15 full-time system users and are classified as an (unregulated) Private Community Water Systems.

The Union Water Company, Thetford Co-Op, and the East Thetford Water Company have more than 15 full time users and are classified as (regulated) Public Community Water Systems.

Two of the systems, The Thetford Water Co-Op and the East Thetford Water Company, supply water for both domestic and commercial uses; all other water systems supply water just for domestic use.

The existing water system information that was made available has been summarized and reviewed with the overall goal to provide an assessment of the existing infrastructure, and to provide recommended infrastructure upgrades and expansion to support growth and development in the Village Districts and Thetford community. The criteria used for this process included:

- System water sources,
- Source water protection,
- Water sampling and testing,
- Water treatment,
- Water system infrastructure upgrades and replacement,
- Existing water system classifications and requirements,
- Planning for future water system regulation requirements,
- Combining and/or expanding existing water systems,
- Replacing existing water systems,
- Eliminating system redundancies,
- Water system pressure and flow rates,
- Active users,
- Connected Inactive Users,
- Properties within the limits of the water system that are not connected,
- Water system expansion and adding additional users,
- Fire protection capabilities,
- Improvements required for fire protection capabilities,

- Town of Thetford Village Districts Historic Growth,
- Projected Town of Thetford Village District Future Growth,
- Potential future system water sources,
- System limitations,
- Alternatives Analysis,
- Conceptual Level Opinions of Probable Costs for Alternatives,
- Recommendations,

2.1 South Village Water Company

The South Village Water Company is an unregulated, private community water system located in the North Thetford Village District in Thetford, Vermont. The system was Originally built in the 1920's. Much of the original systems infrastructure was upgraded in the early 1990's. Since then, repairs have been made on an as needed basis and no current upgrades to the system are planned.

The existing water system consists of the following:

- **Location:** Water source, finish water storage, and the associated water system infrastructure is located off Latham Road adjacent to Gunn Brook, with an associated water distribution main that provides water to system users running adjacent to Latham Road and VT Rte. 5. A map of the water system is provided in Appendix A, as part of plan sheet C-104.
- **WSID#** N/A
- **System Users:** Eight (8) existing water system users
- **Approximate Surface Elevations:**
    - **Water Source and Storage Tank:** 455
    - **Hydraulically Most Remote Location:** 400

Figure 2-1 South Village Water Company Water Source Location

- **Water System Demand:** The water system demands are unknown but are assumed to be 900 GPD average and 1,400 GPD peak based on other systems with similar size and associated user demands.

- **System Water Source:** Spring 1 is beneath the spring box approximately 150 ft east of the water storage tank shown in **Figure** 2-2. The production of this spring has reduced over time and there has been a significant reduction in capacity during dry weather periods. As a result, the water company installed infrastructure for a second spring fed water source show in **Figure** 2-1.

  The second water system acts as the primary water source. It is a spring fed, 2-foot diameter, by 8-feet deep gravel packed precast concrete infiltration basin with an approximate yield of 5.0 GPM. Typically, there is 4-feet of water visible in the infiltration basin. The infiltration basin is located in the wetlands, the surface water watershed area to the system is primarily agricultural lands.

- **Water Storage:** Water is gravity fed from the system water source and is stored in an 8,000-gallon tank, shown in **Figure** 2-2, prior to entering the water distribution main.

- **System Pumps:** None.

- **Water Distribution Supply Line:** The water distribution supply line is approximately 2,500 linear feet of 1-1/2” CTS water pipe that runs cross country

on private property, outside the road right of ways (ROW) adjacent to Latham Road and along VT Rte. 5.

- **Water Service Lines:** The individual water services that provide water to the system users are 3/4-inch copper pipes that connect to basement storage tanks (cisterns) for each user and supply the users from the basement water storage. Curb stops are housed in access manholes to provide shut offs to the individual users.
- **System Pressure:** Estimated to be between 22 and 25 PSI.
- **Water Metering:** The systems water usage is not metered, and the individual users water usage is not metered.
- **User Rates:** Flat rate of $300 per user per year.
- **Water Sampling and Testing:** Quarterly sampling and testing for e-coli and bacteria.
- **Water Treatment:** Chlorine 'floater', typical of what is used for swimming pools.
- **Fire Protection:** The existing water system does not have sufficient water storage capacity, water pressure, or water flows to provide fire protection.
- **Additional Water System Information:** The existing water supply main runs cross country through and behind existing user's properties, it is understood that no (formal) easements have been obtained for the existing water line.

  The existing water main is currently exposed in the stream bed where it crosses Gunn River. The water main reportedly used to be buried at this crossing with roughly 4-feet of cover but has been fully exposed since the July 2017 storm. There have been no noted occurrences of the pipe freezing since it was observed as exposed.

  The water line from the water source to the water distribution station was recently replaced with 1-1/2" plastic pipe. The high ground water in the vicinity of this water pipe made it very difficult to dewater and replace this water pipe.

  This water system was at one time part of the North Thetford Water Company. In 1995 the two (2) companies separated to create two separate companies, the North Village Water Company, and the South Village Water Company.

  The existing water system cannot accept additional users without significant upgrades to satisfy the requirements of becoming a regulated, public water system.

Figure 2-2 South Village Water Company Water Storage Tank

- **System Goals:**
    - The South Water Company, Union Water Company, and North Village Water Company have main line distribution water pipes that are all located relatively in the same corridor (location) to supply water users along the same route. Realistically, the three systems should be combined to create one community water system.
    - Identify funding sources for system upgrades.
    - Identify a new water source to replace the existing springs. Attempts have been made to install a well to replace or supplement the existing spring water source with no success to date.

2.2 North Village Water Company

The North Village Water Company is an unregulated private community water system located in the center of the North Thetford Village District in Thetford, Vermont. The existing water system infrastructure is located in the North Thetford Federal Church off VT Rte. 5, adjacent to the Connecticut River.

The existing water system consists of the following:

- **Location:** The water source, water storage and associated water infrastructure are housed in the North Thetford Federal Church Association Building off VT Rte. 5, with a water supply distribution main that runs along the South side of VT Rte.

5. A map of the existing water system location is provided in Appendix A, as part of plan sheet C-104.

- **WSID#** N/A
- **System Users:** Eight (8) existing water system users
- **Approximate Surface Elevations:**
    - **Water Source and Storage Tank:** 420
    - **Hydraulically Most Remote Location:** 410
- **Water System Demand:** The water system demands were reported to be 900 GPD average and estimated to be 1,400 GPD peak.
- **System Source Water:** A drilled 6-inch diameter, 440-feet deep well, installed in 1998, the well yield less than 5 GPM.
- **Water Storage:** There is no water storage available for the water in the system.
- **System Pumps:** 1-1/2 HP 5.0 GPM submersible pump
- **Water Distribution Supply Line:** The existing water distribution supply main is a 1-1/2” plastic pipe.
- **Water Service Lines:** The individual water services that provide water to the system users are 3/4-inch copper pipes that connect to basement storage tanks (cisterns) for each user and supply the users from the basement water storage.
- **System Pressure:** 15 to 20 PSI
- **User Rates:** Flat rate of $325 per user per year.
- **Water Metering:** The existing system water meter is considered unreliable, and the individual users water usage is not metered.
- **Water Sampling and Testing:** Quarterly for nitrates. The North Village Water Company stopped testing for all other contaminates in 2017 and has been just testing for Nitrates since, based on elevated nitrates that were identified during the 2017 test results.
- **Water Treatment:** Currently, the source water is not treated before it enters the distribution system. Water is treated at the individual user cisterns by reverse osmosis.

Figure 2-3 North Village Water Company Hydro-pneumatic Tank and Meter

- **Fire Protection:** The existing water system does not have sufficient water storage capacity, water pressure, or water flows to provide fire protection.
- **Additional Water System Information:** Unlike the other water systems in Thetford, the existing topography elevation over the limits of the water distribution pipe is relatively consistent, contributing to the lower than allowable operation pressures for the system.

  There have been occurrences where the North Village Water Company has required to borrow water from the other water systems during periods where their water system was offline for repairs or there was insufficient water supply to the system.

  This water system was at one time combined with the South Village Water Company. The two companies separated in 1995 to create the North Village Water Company and the South Village Water Company.

The existing water system cannot accept additional users without becoming a regulated, public water system.

2.3 Union Water Company

The Union Water Company is an existing, regulated, privately owned, and operated, public community water system that serves users on VT Rte.5 in the North Thetford Village District in Thetford, Vermont. The original system infrastructure was installed in the 1960's, when the pre-cast concrete infiltration basin was installed to provide a water source for the system.

The existing water system consists of the following:

- **Location:** The water source is located at the end of Turnpike Road South, water storage and infrastructure are located off Turnpike Road South, adjacent to the I-91 overpassing, with an associated water system distribution supply pipe to users primarily on VT Rte. 5. A map of the existing water system location is provided in Appendix A, as part of plan sheet C-104.
- **WSID#** VT0005182
- **System Users:** Twenty-three (23) existing active water system users
- **Approximate Surface Elevations:**
    - **Water Source and Storage Tank:** 607
    - **Hydraulically Most Remote Location:** 414
- **Water System Demand:** The water system demand was reported to be 2,560 GPD average with a peak demand of 4,000 GPD. The system is permitted for a peak system demand of 8,280 GPD.

o **System Water Source:** One (1) spring fed water source, that includes a 6-foot diameter, 16-feet deep infiltration basin, located immediately adjacent to Gunn Brook, with an approximate yield of 16.0 GPM.

Figure 2-4 Union Water Company Water Source Locations

- **Water Storage:** Finish water is stored in a 1,000 Gallon holding tank at the chlorination building before entering the water system's distribution pipe.
- **System Pumps:** There are no system pumps, the water is gravity fed by the water distribution main through the system to the users.
- **Water Distribution Supply Lines:** The existing water distribution main is roughly 9,600 LF, of roughly equal lengths of 1-1/2-inch, 1-1/4-inch, and 1-inch plastic water pipes that extend from the water source to the most remote limit of the water system. The 1-1/2-inch and 1-1/4-inch water distribution pipes serve as a transmission main, while a majority of the services to the system users are connected to the existing 1-inch water pipe in the North Thetford Village District.
- **Water Service Lines:** The individual water services that provide water to the system users are 1/2-inch plastic that connect to basement storage tanks (cisterns) for each user and supply the users from the basement water storage. The water system valves are stainless steel and are located in access manholes for each system users.
- **System Pressure:** System pressure is regulated by an existing pressure reducing valve (PRV). The system pressure is 100 PSI at the PRV. The system pressure for the domestic supply ranges between 50 PSI at the PRV and 20 PSI (or less) at the highest elevations within the distribution system.
- **User Rates:** Flat rate of $700 per user per year.

- **Water Metering:** The system's water usage is metered. The individual system users water usage is not metered.

- **Water Sampling and Testing:** There is a service hydrant located at the system control house that is used for sampling. The water system is classified as a regulated public community water system and a sampling and testing schedule is performed in compliance with the VT DWGWPD. A full list of sampling and testing frequencies are provided as part of Appendix B.

- **Water Treatment:** Continuous liquid chlorination feed.

- **Fire Protection:** The existing water system does not have sufficient water storage capacity, water pressure, or water flow necessary to provide fire protection.

- **Additional Water System Information:** The North Village Water Company and South Village Water Company also run in the same roadway corridor to supply users along the same route. It would be appropriate for the three systems to be combined.

  A simulated water system demand of 5.5 GPM for the Library, a water system user, caused the water system pressure to drop 25-psi, in a computer water model, as documented by the Dufresne Group in their hydraulic report summary.

  The access manholes for the water service shut offs are located along VT Rte. flood prone areas, and the access manholes occasionally fill with storm water.

  This water system cannot accept additional users without upgrades to the water system to comply with State of Vermont mandates.

- **Identified System Goals:**

  - The Union Water Company (UWC) and North Village Water Company run in the same roadway corridor to supply water to users along the same route. The UWC feels the three systems can be combined to establish a municipally owned and operated community system.

  - Identify funding sources for system upgrades or replacement.

  - Identify a new water source to replace the existing system water source.

Figure 2-5 Union Water Company Chlorination Building

2.4 Post Mills Water Association

The Post Mills Water Association is an existing non-regulated, private community water system that was created out of necessity when it was discovered that the adjacent landfill contaminated a number of private residential wells.

In 1980, levels of tetracholorethylene and trichloroethylene were discovered in the residential wells along VT Rte. 113, adjacent to the existing landfill. Hydrogeologic investigations determined that the groundwater gradient under the landfill was in the west/northwest direction, toward these VT Rte. 113 residential homes and had contaminated their private wells.

In 1988, a water system was constructed with a single community water supply well to replace the contaminated wells. With ongoing concerns that the replacement well would eventually also become contaminated by the landfill leachate, a replacement well location was identified and constructed in 2002, along with an associated booster pump station and additional infrastructure upgrades to serve as a community water system for the contaminated wells.

The current water system has operated for the past 20 years with minimum overhead costs and no noted significant issues or concerns. Additional connections to the water system are not anticipated or possible according to the systems operator.

Figure 2-6 Post Mills Water Association Pump House

The existing water system consists of the following:

- **Location:** Off VT Rte. 113 at the Southern edge of Post Mills Village District in Thetford, VT. A map of the existing water system location is provided in Appendix A, as part of plan sheet C-103.
- **WSID#** N/A
- **System Users:** Nine (9) existing water system users
- **Approximate Surface Elevations:**
    - **Water Source:** 690
    - **Pump House:** 725
    - **Hydraulically Most Remote System Location:** 700
- **Water System Demand:** The water system demands were reported to be 1,171 GPD average and estimated to be 1,600 GPD peak.
- **System Water Source:** One (1) drilled well and one (1) abandoned well.

  - The active well is a 6-inch diameter, 805-feet deep drilled well, with a yield of 6.0 GPM.
  - The system well is located in a 104-acre conservation easement that is owned and maintained by the Town.

- **Water Storage:** Finish water is stored in a 5,000-gallon holding tank beneath the pump house.
- **System Pumps:** A submersible well pump with a discharge capacity of 10 GPM pumps the well water to the Booster Pump Station building.

  Hydropneumatics tanks and a booster pump with a discharge capacity of 37-44 GPM are located in the Booster Pump Station building to maintain the system pressure above 20 PSI.
- **Water Distribution Supply Line:** The existing water distribution supply pipe is an approximately 2,400 LF 1-1/2-inch plastic line that runs cross country behind the existing users' homes.

  The water supply pipe from the existing well is 2,700 LF of 1-1/2" water pipe that runs from the well to the pump house.
- **Water Service Lines:** The water services are 3/4-inch.
- **System Pressure:** Between 20 and 30 PSI.
- **Water System Demand:** The water system demands were reported to be 1,171 GPD average and estimated to be 1,400 GPD peak.
- **Water Metering:** The system water usage and system users' water usage are metered.
- **User Rates:** Rates are based on usage and are $100 plus the percentage of the overall water system usage times $900. On average, user rates are $327 per user per year.
- **Water Sampling and Testing:** Sampling and testing is performed quarterly for bacteria and e-coli. Groundwater monitoring wells around the landfill are also required to be tested quarterly but are separate from the water system sampling and testing requirements and not affiliated with the water system.
- **Water Treatment:** UV disinfection. Continuous liquid chlorination injection is also available and in place but not currently used.

- **Fire Protection:** The existing water system does not have sufficient water storage capacity, water pressure, or water flow necessary to provide fire protection.
- **Additional Water System Information:** The existing water system, is in good working order, is self-sufficient and appears to be well operated and maintained.

  This existing system cannot be expanded to act as a community water system for the Neighborhood Residential Zoning area of the Post Mills Village District.

2.5 East Thetford Water Company

The East Thetford Water Company is an existing regulated public community water system that was originally incorporated in 1961 that serves the East Thetford Village District in Thetford, Vermont. The original water supply, Wheeler Spring, was contaminated with road salt in 1987. In 1988, the State of Vermont installed a new drilled well to replace the original source; the new source was located at Vaughn Farms. Along with the new well, the state also installed the underground supply pipe from the wellsite to the village of East Thetford where it was connected to the original network of distribution pipes.

By 2019, the output capacity of the 1988 well had diminished below the state requirements and based upon the Preliminary Engineering Report (PER) that was issued in 2017 by Otter Creek Engineering, the decision was made to drill a new source to replace the failed well at Vaughn Farms.

Much of the initial funding for the new source was provided by the State of Vermont through the Vermont Economic Development Authority (VEDA) with a Step I preliminary construction loan. Subsequent testing of the new well determined that there is too much manganese and iron in the source; therefore, a treatment system has been added to the design of the system and will be added during the upcoming Step III final construction and the associated loan from VEDA and the state. Additional infrastructure improvements are currently on-going to provide water treatment for pH, manganese, and iron.

The existing water system consists of the following:

- **Location:** The water source and associated infrastructure is located off VT Rte. 5 in East Thetford on the Vaughn Farms property. A map of the existing water system location is provided in Appendix A, as part of plan sheet C-101.
- **WSID#** VT0005184
- **System Users:** ETWC includes nineteen (19) members who collectively operate thirty-five (35) connections, within the village and alongside the main supply pipe as it travels down Rt 113 from the storage tank and source.

- **Approximate Surface Elevations:**
    - **Water Source and Pump House:** 710
    - **Hydraulically Most Remote Location:** 380
- **Water System Demand:** The water system demands are reported to be 2,260 GPD average and 6,624 GPD peak.
- **System Water Source:** One (1) drilled well.
    - The recently installed active well is a(n) 8-inch diameter, 505-feet deep drilled well with an estimated 25.5 GPM.
- **Water Storage:** Finish water is stored in two (2) existing tanks with a combined storage of 15,000 Gallons before being pumped into the system to the individual users.
- **System Pumps:** 1-1/2 HP Submersible well pump with a discharge capacity of 18 GPM to pump the well water to the Pumping / Chlorination building.
- **Water Distribution Supply Line:** The existing water distribution supply pipe is approximately 8,200 LF, 4-inch ductile iron water main that is located (mostly) cross country along VT Rte. 113 and along VT Rte. 5 in East Thetford Village District.
- **Water Service Lines:** The water services are primarily 3/4-inch; however, some services range between 3/4-inch and 2-inch, depending on the user.
- **System Pressure:** Regulated between 40 and 50 PSI. There is a pressure reducing valve at the bottom of VT Rte 113 that can adjust the system pressure.

Figure 2-7 East Thetford Pressure Reducing Vault

- **Water Metering:** The water system usage is metered; the individual system users water usage is not metered.
- **User Rates:** Current annual water rates are around $800/user per year.
- **Water Sampling and Testing:** The water system is classified as a regulated public community water system and a sampling and testing schedule is performed in compliance with the VT DWGWPD. A full list of sampling and testing frequencies are provided as part of Appendix B.
- **Water Treatment:**
    - Continuous liquid chlorination injection
    - pH adjustment (Scheduled but not installed at the time of this report)
    - Iron removal (Scheduled but not installed at the time of this report)
    - Manganese removal (not fully compliant as of the date of this report)

- **Fire Protection:** The existing water system does not have sufficient water storage capacity, water pressure, or water flows necessary to provide fire protection.

- **Additional Water System Information:** The recent and scheduled upgrades will (likely) establish this system as a self-sufficient system.

  It was reported that the system becomes air locked and has to be flushed to remove the air once every other week and most frequently in the fall. The cause for air entering the system is unknown.

  The original design and constructed water system was sized to serve the Village of East Thetford, roughly 100 water system users with the anticipated expansion for 115 system users.

  With the current infrastructure in place, the existing system has capacity for additional users to be served by the system.

2.6 Thetford Water Cooperative

The Thetford Water Cooperative (Co-Op) water system was originally created in 1940. The water system provides a water supply to the Thetford Hill Village District in Thetford, VT. At one time, the system provided water to Thetford Academy, but that service connection has since been disconnected. In 2007, the State of Vermont, during a project construction permitting review inspection, determined that the dual connection at the Academy is considered comingling of two separate water supplies; therefore, the service to the Academy was terminated. Since then, the Co-Op has reduced the size of their water supply tanks. Reportedly, there were plans for the water system to provide water to the Thetford Elementary School but a service to school has not be installed to date and there is no timetable for this installation.

The existing water system consists of the following:

- **Location:** Off Houghton Hill Road, roughly 3/4 removed from VT Rte. 113 and providing service to commercial and residential users from Houghton Hill Road to Thetford Academy. A map of the existing water system location is provided in Appendix A, as part of plan sheet C-102.

- **WSID#** VT0005181

- **System Users:** Forty-One (41) system users, including seven (7) commercial water system users.

- **Approximate Surface Elevations**

  - **Water Source:** 860

  - **Pump House:** 875
  - **Hydraulically Most Remote Location:** 960

- **Water System Demand:** The water system demands are reported to be 7,296 GPD average and 18,000 GPD peak (from 2008).
- **System Water Source:** Two Drilled Wells
  - Well#1 is a 6-inch diameter, 500-feet deep, with a yield of 8.0 GPM
  - Well#2 is a 6-inch diameter, 900-feet deep, with a yield of 15.0 GPM
- **Water Storage:** Water is stored in two (2) 10,000-gallon elevated tanks.

  The originally constructed water system tank was 90,000 gallons; this tank has been taken out of service and disconnected from the domestic water system.
- **System Pumps:** Two (2) 1-1/2 HP well pumps
- **Water Distribution Supply Line:** The existing system's water distribution pipe is roughly 6,400 LF of 4-inch ductile iron pipe that is located primary outside of the road ROW.
- **Water Service Lines:** In most cases, the existing water services are 3/4-inch plastic pipe with some larger services for commercial users.
- **System Pressure:** between 32 and 83 PSI.
- **Water Metering:** The water source use and individual water system users' water usage are both metered.
- **Water Sampling and Testing:** The water system is classified as a regulated public community water system and a sampling and testing schedule is performed in compliance with the VT DWGWPD. A full list of sampling frequencies and contaminant testing requirements are provided as part of Appendix B.
- **Water Treatment:** Continuous liquid chlorination feed. During the inspection it was unclear if the chlorination feed was functioning properly.
- **Fire Protection:** The existing water system does not have sufficient water storage capacity or water flows to provide fire protection.
- **Additional Water System Information:** Because of the location and hydraulic grade line this system is one of the better candidates for expansion to connect to and/or replace other existing water systems.

The Thetford Co-Op appears to be at roughly the same hydraulic grade line as the Union Water Company and it is possible a cross connection could be made between the two systems with a transmission, installed in the cross-country segment between the water supplies for the two systems.

The water system was originally designed for 115 residential user equivalents with expansion anticipated for 128 users.

In the past ten (10) years the following infrastructure upgrades have been made to improve the existing systems infrastructure, including the following:

- Reconstruction emergency water supply well
- Replace water boxes.
- Replace the water treatment equipment.

The existing 90,000-gallon storage is no longer used for the domestic system and is currently available to be used by the fire department for fire protection measures.

Unlike any of the other water systems, A generator and backup power is capable of providing uninterrupted services during a power outage.

Figure 2-8 Thetford Co-Op Chlorination Assembly

Figure 2-9 Thetford Co-Op Pump House

2.7 Thetford Schools

There are two existing schools that are located in proximity to the existing Thetford Water Co-Op water system in the Thetford Hill Village District in Thetford, VT: Thetford Elementary School and Thetford Academy.

Both schools have private water systems, classified by the State of Vermont as regulated Public Water System not associated with a Community Water System.

This section provides a summary of the existing water infrastructure at each school, and the potential future connection to the water systems.

2.7.1 Thetford Academy

Thetford Academy is a private school that hosts approximately 60 professional staff and 300 students in grades 7 through 12, located in the Thetford Hill Village District in Thetford, VT. Thetford Academy is serviced with domestic water from private water wells with existing, separate water storage for fire protection capabilities on site.

Figure 2-10 - Thetford Academy

The schools existing water system consists of the following:

- **Location:** Off Academy Road in the Thetford Hill Village District in Thetford, VT.
- **WSID#** VT0006764
- **Approximate Ground Elevation:** 955-feet to 990-feet over the campus
- **System Water Source:** Two Drilled Wells for domestic use and, a third well for water supply for fire protection.

  - Well#1 is an 8-inch diameter, 745-feet deep with a yield of 7.3 GPM for domestic water supply
  - Well#2 supply is reserved for fire protection and is not used for domestic use
  - Well,#3 is a 6-inch diameter, 660-feet deep with a yield of 5.0 GPM for domestic water supply

- **Water System Demand:** The water system demands are 1,500 GPD on average and 1,900 GPD peak.
- **Water Storage:** Finished water, after treatment is stored in a 4,500-gallon tank.
- **System Pumps:** Pressure in the distribution system is maintained by three (3) 800-gallon hydro-pneumatic tanks and associated booster pumps to maintain the system pressure between 50 and 55 PSI.
- **Water Supply Line:** The existing domestic water supply line to the school is a two-inch (2) plastic pipe.
- **Water Sampling and Testing:** The water system is classified as an (individual) public water system, separate from a community system, and a sampling and testing schedule is performed in compliance with the VT DWGWPD. A full list of sampling frequencies and contaminant testing requirements are provided as part of Appendix B.
- **Water Treatment:** The water sources are treated continuously with primary and secondary chlorination. In addition, the system water is treated for both arsenic and PFOA/PFAS contaminants.
- **Fire Protection:** Roughly 2/3 of the school is sprinklered including mechanical, storage and higher hazard areas. The water source for the sprinkler system is a separate water storage tank from the domestic water system/storage.

  The sprinkler water source is a dedicated 20,000 cistern for sprinkler supply with a dry hydrant connection for water supply for firefighting.
- **Other System Information:** Initially, Well#3 was the primary water source for the Academy, but the yield from this well could not meet the systems demand. As a result, a connection was provided from the Thetford Co-Op system to meet their demand for the system. In 2007 the State of Vermont ANR, during a project construction permitting review, specified that the dual connections were considered comingling of two separate water sources and was not allowed. Because of this determination, a well was drilled to provide water supply to the

Academy and the water service from the Thetford Co-Op was discontinued/disconnected.

Based on discussions, the Academy ideally would be connected in the future to the Thetford Co-Op water system. The time and costs associated with the treatment and maintain the private system are reported as being in excess of what the Academy has resources to maintain.

2.7.2 Thetford Elementary School

Thetford Elementary is located in the Thetford Hill Village District and is a public school with roughly 204 students in grades K through 6 with roughly 40 professional staff.

Figure 2-11 - Thetford Elementary School

The school's existing water system consists of the following:

- **Location:** Off VT Rte 113 in the Thetford Hill Village District
- **WSID#** VT0006675
- **Approximate Ground Elevation:** 930-feet
- **System Water Source:** Two Drilled Wells
    - Well#1 is a 6-inch diameter, 925-feet deep, with a yield of 5.5 GPM
    - Well#2 is a 6-inch diameter, 1000-feet deep, with a yield of 2.5 GPM

    Both wells are utilized in tandem to provide a water source to the school. Combined, the existing wells provide 8.0 GPM to the school.

- **Water Storage:** Water is stored in a 5,000-gallon tank prior to entering the school's water distribution.
- **System Pumps:** Pressure in the distribution system is maintained by a booster pump.
- **Water Supply Line:** The existing water supply line from the wells to the storage tank are 2-inch plastic lines and from the storage tank to the school is a 3-inch plastic water service line.
- **Water Sampling and Testing:** The water system is classified as an (individual) public water system that is not part of a community water system, and a sampling and testing schedule is performed in compliance with the VT DWGWPD. A full list of sampling frequencies and contaminant testing requirements are provided as part of Appendix B.
- **Water Treatment:** The school ceased chlorinating the water in September 2018. It is reported that there have not been any noted issues with the water quality since that time.
- **Fire Protection:** The school is not sprinklered and does not have a dedicated water supply for sprinklers or fire suppression. There are currently a small number of sprinkler heads that extend off the existing domestic water line that provide sprinkler coverage in the mechanical rooms and in storage closets.
- The existing water system does not have sufficient water storage capacity, water pressure, or water flow necessary to provide fire protection for the school. The fire department is located roughly 300 feet from the school with a dedicated fire pond and hydrant on an immediately adjacent property.

2.8 System Water Sources

When people think of a water source, most people think of lakes, rivers, and streams, these are all types of surface runoff water bodies. However, in comparison of the different sources of drinking water for private and public water systems, over 95-percent of the drinking water and system water sources are ground water.

Surface water can be utilized as a domestic water system source, provided that they are effectively treated. There are a number of variables involved with using surface water as a domestic water source because the contaminates that come into the system can be more variable than a ground water source, because of that, it can be more expensive to design, permit, and treat the source water and infrastructure like a water treatment plant would need to be in place to treat the water source due to the variability in source water composition and contaminates.

There are two types of water supplies for the existing water systems in Thetford, drilled wells supply four (4) of the existing water systems and spring fed infiltration basins supply the other two water systems. The two (2) schools domestic water sources are supplied by two (2) drilled wells each.

A summary of the system water sources for the existing water systems are provided in Table 2-2.

SYSTEM WATER SOURCES					
Post Mills Water Association	**Union Water Company**	**East Thetford Water Co.**	**North Village Water Co.**	**South Village Water Co.**	**Thetford Water Co-Op**
Drilled Well	Spring Fed Basin	Drilled Well	Drilled Well	Spring Fed Basin	Drilled Well

Table 2-2 System Water Sources

There are potential limitations with the use of springs; although not a surface water source, the two water systems that are spring fed can be influenced by surface waters and surface water contaminants. The Union Water Company infiltration basin is located adjacent to the Zebedee Brook River and is in an area subject to flooding; and the South Village Water Companies spring fed water source is adjacent to Gunn Brook and is also located in an area subject flooding and surface water contamination.

2.8.1 Private Cisterns

Currently, all of the existing water systems utilize existing water cisterns for individual users to compensate for the limit pressures in the water system. The Vermont Water Supply rule does not allow the use of individual user water storage systems because there are health risks associated with bacteria and contamination in the water tank. To eliminate these existing storage tanks the water main infrastructure would also need to be improved to provide the required water systems' pressures.

The private property costs associated with the removal of the existing basement cisterns could be anticipated to be on average $12,000 per user based an average 25-foot water service on private property, an assumed 25-foot service within the public way and associated plumbing costs.

2.9 Fire Protection

The Thetford Volunteer Fire Department, Inc. (TVFD) is a 501-c3 nonprofit organization that provides fire, rescue, and emergency medical services to the town. TVFD is also an active member of the regional mutual aid system.

The TVFD has two facilities; one is located on Thetford Hill adjacent to the Elementary School, and the second on VT Rte. 244 in Post Mills. The Thetford Hill Station has two E-One Rescue / Pumper trucks; Engine#1 is a 2018 E-One Pumper/Tanker that can hold 1,500 gallons of water and has a 30-gallon foam tank see Figure 2-10; Engine#2 is a 2014 E-One Rescue/Pumper that can hold 800 gallons of water and has a 24-gallon foam tank; Engine#3, located in the Post Mills station is a 2009 E-One Engine that can hold 1,500 gallons of water and has a 1,250 gallon/minute pump. The fire department also has a rescue truck, forestry truck and Polaris 6-wheeler for firefighting operations.

Water for firefighting operations is required to follow the Vermont Department of Public Safety Division of Fire Safety in conjunction with NFPA 1, as determined by the local authority having jurisdiction, which is the TVFD. Water supply for firefighting is required to be provided at between 500 and 12,000 GPM, depending on the building's materials of construction, combustibility class, number of stories and building size. A water supply must be capable of providing between 2 and 4 hours of continuous water supply, depending on the size of the building. Most of the existing fire ponds / cisterns in Thetford are limited to between 1,000 and 2,000 GPM flow rates. Because tanker trucks can only hold 1,500 gallons, which only provides three minutes (or less) of flows for firefighting, the tankers must be connected to a water source to provide continuous water flows for firefighting operations.

Figure 2-12 Thetford Hill Engine#1 - 1,500-Gal Pumper Truck

2.9.1 Fire Cisterns

None of the existing water systems provide water capable of public firefighting water supply so the fire department rely primarily on fire ponds and associate dry hydrants, and

in a few cases, cisterns for firefighting water supply. The Town, in 1992 began raising funds for the Fire Department to install dry hydrants in existing ponds that were identified as being potential sources of water for firefighting operations. The Town currently has roughly twenty-seven (27) dry hydrant locations/fire pond locations throughout the Town. An example of a fire pond with an associated dry hydrant typical of what is available in the Town of Thetford is provided as **Figure** 2-13.

A majority of the existing buildings in Thetford are within 3,000 feet of an existing water supply source; however, the existing water sources are inadequately sized, have been reported to be: unsuitable for fire apparatus use in the summer, inaccessible in winter, and do not have access for the fire department to utilize these water sources with a dry hydrant.

The TVFD inspects and provides yearly maintenance to the dry hydrants in Town, but because of multiple factors, it is reported that there is little or no maintenance performed for the ponds. In some cases, existing fire ponds have reduced in capacity due to silt accumulation from the more frequently occurring higher intensity storms, like July 2017, that have eroded slopes, caused erosion, and impacted the previously established fire pond and dry hydrant infrastructure. Other fire ponds in Town have been reported as being dry for some time, suggesting that some of the locations of the surface water collection areas that were identified and implemented as fire ponds may not be suitable to be relied upon to provide a water source for fire protection. An assessment of the available capacity of the existing fire ponds to confirm compliance with NFPA 1231 should be performed to confirm that the existing water sources being relied upon for fire protection are sufficient.

Figure 2-13 Dry Hydrant and Fire Pond

Proposed subdivisions that create three or more lots are required to have a fire pond and dry hydrant installed to NFPA standard to provide fire protection for the proposed development.

3.0 Community Growth and Development

Based on feedback received from the Town, Stantec assessed the existing, proposed, and projected future Zoning Ordinances (requirements) for both residential and commercial uses in Town.

Based on the feedback received and the review of the Zoning Amendments to promote residential and business growth in the Village Districts the following were reviewed and analyzed:

- Whether an existing water system can support the desired areas of population, housing and business growth that have been identified by the Development Review Board
- What (if any) improvements need to be made to the existing water systems to support future development
- In locations where the existing water system cannot support future development, what are the logistics of installing a new water system to support development in the village communities.

3.1 Village Districts

In the Town of Thetford, there are seven, non-interconnected villages that provide downtown areas, including:

- Thetford Center
- Thetford Hill
- East Thetford
- North Thetford
- Rices Mills
- Union Village
- Post Mills

Of these existing village districts Thetford Hill, East Thetford, and North Thetford have existing water systems, while Rice Mill's, Union Village and Thetford Center do not have either municipal or community water systems that provide service to the existing village.

Post Mills has a water system, but it is on the southern edge of the village boundary and is removed from the village overlay. A map of the existing water systems, and where they are located within the existing Village districts are provided as Appendix A.

East Thetford has only one water system, that which is owned and operated by ETWC. All other nearby villages with a water system in them are also limited to just one water system serving that village and, in most cases, the existing water system only provides water to just a portion of the village. Table 3-1 provides a summary of the village districts and the water system that currently serves them.

Village	Water System
Thetford Center	None
Thetford Hill	Thetford Water Co-Op.
East Thetford	East Thetford Water Co.
North Thetford	North Village Water Co. South Village Water Co. Union Water Co.
Rices Mills	None
Union Village	None
Post Mills	Post Mills Water Association

Table 3-1 Village District Water Coverage

The existing properties in the Village district were reviewed to estimate the potential growth as compared to the location of the existing water systems to establish a residential water system user equivalent for the Village District areas for the anticipated growth based on the direction of the Community Development Comity.

In addition, at the request of the Town, Stantec reviewed the feasibility and developed costs associated with establishing a new water system to serve the Neighborhood Residential and the Village District areas for anticipated future development in Post Mills.

3.2 Historic Population Growth

The Town of Thetford through the Town's history has experienced relatively consistent population and residential growth dating back to the 1960's with the most significant population increase occurring between 1970 and 1980 and noted decrease in population from 2000 to 2010. In general, the historic population increase of 0.5% per year in

Thetford, VT is slightly more than the population growth in Orange County but is less than the population growth in the State of Vermont as a whole.

Information regarding historic populations or growth is not available for the Village Districts, so the growth and potential future growth in the districts and the priorities regarding water system implementation for the districts is based on feedback reviewed from Town Officials.

Figure 3-1 shows the Town's population growth since the 1960's and **Table** 3-2 provides census recorded population data by year for Thetford, Orange County, and the State of Vermont for comparison.

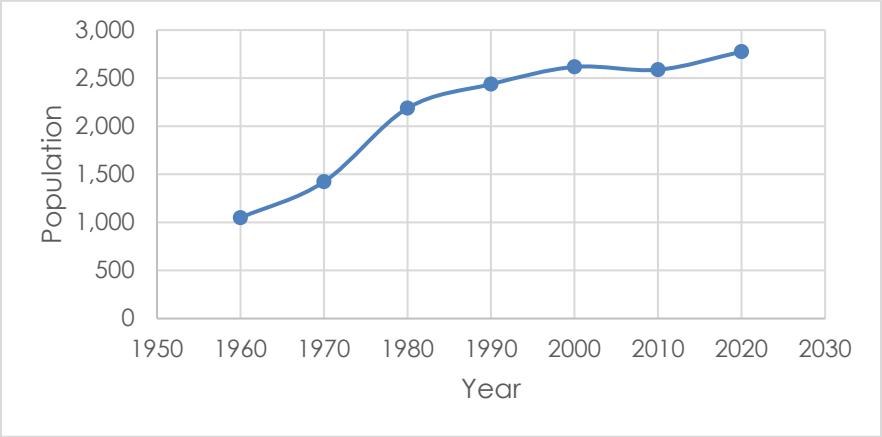


Figure 3-1 Town of Thetford Population Trend by Year

Census Year	Population (Thetford)	Population (County)	Population (Vermont)
1990	2,438	26,149	529,474
2000	2,617	28,226	608,827
2010	2,588	28,936	625,741
2020	2,775	29,277	643,077
Annual Percent Growth from 1990 to 2020	0.45%	0.39%	0.69%

Table 3-2 Population Growth Thetford, Orange County and State of Vermont

The Town's population growth is consistent with the growth in Orange County and the State of Vermont should provide some indication of the necessary demand but does not

necessarily translate to additional water system users. On average, every 2.3 to 2.5 people account for one residential building that could be a potential future water system user. **Figure** 3-2 summarizes the number of residential units per year as reported by the Town of Thetford in the Town Report.

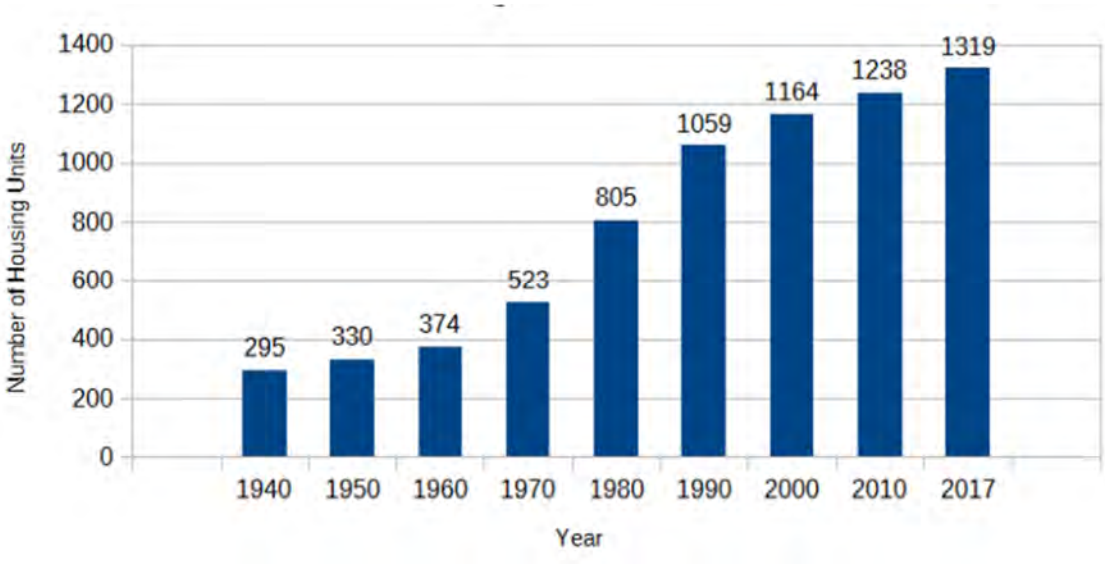


Figure 3-2 Thetford Houses Per Year

Based on the review of the historic population and residential growth in Town, two of the existing water systems can support the projected growth: the Thetford Co-Op and the East Thetford Water Company. These water systems are capable of providing water supply for future projected growth; all of the other existing water systems are at or exceed current capacity and are not likely to accept additional system users without facility upgrades.

3.3 Future Development

Based on feedback received from the Town Officials, community expansion and growth are not anticipated to be from new lot creation or new building construction but are anticipated to be from the change of use of existing single family residential homes to multi-unit rental units. The growth and development that is anticipated is the change in use from a one family house to two and three family rental units based on the steering from the Community Development Committee.

The areas, that were prioritized by the Town as having the highest potential for growth based on the planned changes to the Zoning Regulations and anticipated areas of growth were identified as:

1. Post Mills Village

2. East Thetford

3. North Thetford

Based on discussions with Town Officials, Thetford Center and Thetford Hill are not anticipated to be developed or require planning for future development, specifically as it relates to water system resource for additional infrastructure beyond what currently exists, except for some potential for modified building use groups.

Given the remote locations and the lower populations of Post Mills and Rices Mills, these villages were not reviewed for potential future development, or analyzed to determine the logistics of extending an existing water system or furnishing and installing a new water system to serve these Village Districts.

Based on the information regarding the natural resources and limitations for developable areas from the Town's existing resource maps, provided as Appendix C, the review of the existing properties, existing buildings, number of empty lots and feedback received from the Town, we approximated a projected future additional residential equivalent number of water system users for the village districts, provided as **Table** 3-3.

Village	Zoning	# Lots	# Houses	# Empty Lots	Projected Future Residential Equivalent Users
Post Mills	Neighborhood Residential	108	94	12	132
Post Mills	Village Residential	61	60	7	75
Thetford Center	Village Residential	42	38	7	54
Thetford Hill	Village Residential	56	58	8	71
East Thetford	Community Business	38	42	2	44
North Thetford	Village Residential	45	43	4	54

Table 3-3 Thetford Village Districts Anticipates Growth

The project future residential equivalent users are based on both the growth and properties within the water system that are not currently connected. For some of the existing water systems, there are water users that are connected to the water system and are not an active user and there are users that were connected to the water system and disconnected from the system and furnished their own private well. Reasons for water users leaving the system are assumed to be related to issues with a discontinuity in water supply due to either equipment failure or water source availability.

In East Thetford, several former members of ETWC left the company because of the annual cost, compared to what they expected to pay for private wells. Some reverted to using old wells, and others drilled new wells in the past few years.

The current Thetford Village Districts are split into three zoning Districts, which include:

- Village Residential
- Rural Residential
- Community Business

The guidelines for development and land use for each district are as follows:

Village Residential *– The purpose of the Village Residential District is to comprise relatively dense areas of settlement with the following characteristics:*

- *Networks of streets and utilities that make efficient use of land;*
- *Neighborhoods with resources such as schools, shops and libraries within walking distance of residences.*
- *Relatively dense housing, noting that villages' lots "grandfathered" before zoning were often smaller than the current minimum of 20,000 square feet.*
- *Mixed-use development, compatible in scale and lot coverage with existing development, supporting commercial and public services for residents.*

Community Business *– The purpose of the Community Business district is to share the characteristics of the Village Residential district, with an emphasis on commercial development, compatible in scale and lot coverage with existing development, ranging from small to medium in size.*

Rural Residential *– The purpose of the Rural Residential district is to maintain an area of low average density that is compatible with clusters of high-density, remaining primarily a district of open space, farms, residences, and woodlands, with scattered commercial uses that are either home-based or dependent on natural resources. This area is characterized by development that has:*

- *Particular sensitivity to agriculture and natural resources.*
- *Minimal sprawl, as the term is defined in Zoning Ordinance Section 8.02.*

Thetford Hill Historic Preservation Overlay *– The purpose of this district is to ensure the protection, enhancement, and renovation of significant architectural and historic resources in Thetford Hill. The district shall preserve such property, districts, buildings, and sites in the Town having special historical associations or significance or of special architectural merit or significance. While not all buildings are of equal historic significance, all buildings and lands support and contribute to any given district.*

Village Residential and Community Business allow a minimum of 20,000 square foot per dwelling, which is a much denser development than Rural Residential zones, which require 80,000 square foot lots.

A residential water user, in general, is the most common water system user, and because of the variation in water demand for different types of users for the purpose of analyzing and determining the future water system demands for future growth, a residential user equivalent water demand was used to determine future water demand specific uses.

Based on the available water use data provided by the water companies, most of the existing water system users could reasonably be assumed to be one and two person households, given that the reported average daily demand per user was between 100 GPD and 130 GPD. Using this available information, reducing the average daily demand need from 400-GPD per residency to 250-GPD is warranted and is appropriate even for the anticipated conversion of single-family residences to multi-family rental units.

4.0 Regulations and Requirements

Water systems in Vermont are required to be in compliance with Chapter 21 of the State of Vermont Water Supply Rule. This section includes excerpts of key aspects taken directly from the State regulations for the different type of water systems and the associated regulations that apply to those water systems.

4.1 Vermont Water Supply Rule

All water systems are initially classified as either a public water system or a non-public water system. Classification as a Public water system depends on the number of service connections (15 or more) or people served (25 or more) by the system.

Public water systems are further subdivided into Public Community water systems and Public Non-Community water systems. Generally, Public Community water systems are those which serve residents on a year-round basis, while Public Non-Community water systems serve non-residential groups of people (e.g., restaurants, schools).

Public Non-Community water systems are further subdivided into those systems who serve non-residential users who don't change over time (Public Non-Transient Non-Community water system), such as schools and offices, and those non-residential users who do change over time (Public Transient Non-Community water system), such as restaurants and motels.

There are four categories of water systems referred to throughout this rule and grouped for convenience:

- *Public Community water systems.*
- *Public Non-Transient Non-Community (NTNC) water systems.*
- *Public Transient Non-Community (TNC) water systems; and*
- *Bottled water systems.*

4.1.1 Public Community Water System Requirements

4.1.1.1 Operator Certification

All Public water systems shall be operated by a certified operator of the appropriate class as defined in this subchapter. A certified operator is one who has met the requirements of this subchapter and has a current, valid certification from the Secretary.

All Public Community, Domestic Bottled, and Public Non-Transient Non-Community water systems must have a designated certified operator in responsible charge available at all times. "Available" means based on system size, complexity, and source water quality, a certified operator must be on site or able to be contacted as needed to initiate the appropriate action in a timely manner.

For purposes of certifying public water system operators, each public water system shall be classified according to degree of treatment, and in the case of Class 4, according to size of population served.

The class of operator certification required is dependent upon the classification of such facility. There are five classes of water systems. Classes 1, 2, 3, and 4 apply to water systems with their own source(s) of supply, and Class D applies to systems which distribute water.

4.1.1.2 Capacity

All proposed new Public Community and Public Non-Transient Non-Community water systems, for which applications were submitted on or after October 1, 1999, shall demonstrate technical, managerial, and financial capacity prior to obtaining a Construction Permit or an Operating Permit.

A Construction Permit or an Operating Permit shall not be issued until a determination has been made by the Secretary that the water system has demonstrated that it has, and will continue to have over the long term, technical, financial, and managerial capacity. Subchapters 21-4 (Construction Permits) and 21-5 (Operating Permits) identify the necessary information required for submittal as part of permit applications.

4.1.1.3 Water Quality Testing Laboratories

All laboratories doing analyses which are to be submitted by public water systems under this rule, must be certified by the Vermont Department of Health and all shall be subject to the laboratory certification provisions of 40 CFR, Part 141, Subpart C, and §142.10(b)(3) and (b)(4).

4.1.1.4 Laboratory Testing

Each Public water system shall have minimum equipment and facilities for laboratory testing as approved by the Secretary and as necessary to assure proper operation. Laboratory equipment shall be based on the characteristics of the water sources and the complexity of the treatment process involved.

At a minimum, or as approved by the Secretary, the following laboratory equipment shall be provided:

- *Surface water systems shall have a nephelometric turbidimeter meeting the requirements of Standard Methods for the Examination of Water and Wastewater, latest edition.*

- *Each surface water treatment plant shall have a pH meter.*

- *Each iron and/or manganese removal plant shall have test equipment capable of accurately measuring iron to a minimum of 0.1 mg/l and/or test equipment capable of accurately measuring manganese to a minimum of 0.03 mg/l.*

- *Public water systems which chlorinate shall have test equipment for determining both free and total chlorine residual using the N, N-diethyl-p-phenylenediamine colorimetric method in Standard Methods for the Examination of Water and Wastewater, latest edition.*

- *Public water systems which fluoridate shall have test equipment for determining fluoride by methods in Standard Methods for the Examination of Water and Wastewater, latest edition.*

- *Public water systems which feed polyphosphates shall have test equipment capable of accurately measuring phosphates from 0.1 to 20 mg/l. 2.9.2 Physical facilities Sufficient bench space, ventilation, lighting, safety equipment, storage and a laboratory sink shall be provided.*

Monitoring Equipment Water treatment plants shall have monitoring equipment to monitor water being discharged to the distribution system as follows:

- *Plants treating surface water must have the capability of monitoring and recording turbidity to meet the requirements of Section 6.4. Free chlorine must be monitored daily per Subsection 7.2.3.*

- *Plants treating groundwater shall have the capability to monitor and record free chlorine residual.*

4.1.1.5 Reporting

Public Water Systems providing treatment and all Public Community water systems shall submit a signed report to the Secretary at least once a month (or as otherwise directed by the Secretary) no later than ten (10) days following the end of the month, with the following information, as applicable:

- *A summary of the water system operation, including the amount of water produced or purchased; (b) Results of water temperature measurements.*

- *Results of all turbidity analyses.*

- *Results of chlorine residual analyses.*

- *Results of fluoride residual analyses.*

- *Results of pH analyses.*

- *Calculated CT values for highest peak hourly flow during the month; and*

- *Any other information specified by the Secretary as a condition of a permit or temporary permit to operate.*

The summary shall be submitted either on a form or in digital format prescribed by or approved by the Secretary. All laboratory test results submitted shall include copies of the original test reports on the letterhead of the laboratory which performed the analyses unless other arrangements have been approved by the Secretary.

4.1.1.6 Water System Pressure and Infrastructure

Pressure All water mains, including those not designed to provide fire protection, shall be sized after a hydraulic analysis based on flow demands and pressure requirements. The system shall be designed to maintain a minimum pressure of 20 psi at ground level at all points in the distribution system under all conditions of flow. The normal working pressure in the distribution system should be approximately 60 psi and not less than 35 psi.

The minimum size of water main for providing fire protection and serving fire hydrants shall be eight-inch diameter. Larger size mains will be required if necessary to allow the withdrawal of the required fire flow while maintaining the minimum residual pressure.

Where dead end mains occur, they shall be provided with a fire hydrant if flow and pressure are sufficient, or with an approved flushing hydrant or blow off for flushing purposes. Flushing devices should be sized to provide flows which will give a velocity of at least 2.5 feet per second in the water main being flushed. No flushing device shall be directly connected to any sewer. The open end of a blow off must be capped and terminate at least 18 inches above grade.

Sufficient valves shall be provided on water mains so that inconvenience and sanitary hazards will be minimized during repairs. Valves should be located at not more than 500-foot intervals in commercial districts, at not more than one block or 800-foot intervals in other districts, and at not more than 5000-foot intervals on transmission lines.

4.1.1.7 Water Storage

The materials and designs used for finished water storage structures shall provide stability and durability as well as protect the quality of the stored water. Steel structures shall follow the current AWWA standards concerning steel tanks, standpipes, reservoirs, and elevated tanks wherever they are applicable. Other materials of construction are acceptable when properly designed to meet the requirements of Appendix A Part 7. Design for cast-in-place and pre-cast concrete structures must show the placement of structural steel and specify the material for sealing the joints.

Sizing Storage facilities shall have sufficient capacity, as determined from engineering studies, to meet average daily domestic demands, and where fire protection is provided, fire flow demands:

- *When fire protection is provided, the minimum flow requirement shall be 500 gpm at 20 p.s.i. system residual pressure for a 2-hour duration for residential structures. If the Insurance Services Office or an other responsible agency (e.g., local fire department) recommends a higher flow rate than this minimum, the higher flow rate should be considered.*

- *The minimum storage capacity (or equivalent capacity) for systems not providing fire protection shall be equal to the average daily demand. This requirement may be reduced when the source and treatment facilities have sufficient capacity with standby power to supplement peak demands of the system.*

- *Level control is recommended but low water level alarm is required for Public Community water systems. (See Appendix A Subpart 7.3.3)*

4.1.1.8 Source Protection

A Source Protection Plan shall consist of a map of the delineated Source Protection Area; an inventory of the potential and actual sources of contamination in the Source Protection Area located on the map; a management plan for the risks from the potential and actual sources of contamination; and a contingency plan. Some parts of the Source Protection Plan may also be required in the Operation and Maintenance Manual (see Appendix D of this rule).

Source Protection Area Maps: The Source Protection Plan shall include a topographic map showing:

- *the source(s) identified by name and the Drinking Water and Groundwater Protection Division's Source Number.*

- *the Source Protection Area, including any delineated zones.*

- *the lots and associated landowners, unless this information is included on a tax or orthophoto map showing the Source Protection Area; and*

- *the location of any potential and actual sources of contamination.*

Source Protection Area Delineation for Public Community Water Systems, the Source Protection Area shall be:

- *the area approved by the Secretary.*

- *the 3,000-foot fixed radius circle assigned by the Secretary prior to September 24, 1992; or*

- *the area approved by the Vermont Department of Health prior to July 1, 1991. These approvals do not include restrictions imposed by the Board of Health in Health Orders.*

Where multiple Source Protection Areas have been delineated for a particular source, only the most current, approved, Source Protection Area shall be in effect.

Non-Transient, Non-Community water systems with groundwater sources shall delineate a Source Protection Area in accordance with Vermont's Wellhead Protection Program Guidance Document. Non-Transient, Non-Community water systems with a surface water source or Groundwater Under the Direct Influence of Surface Water source shall use the delineation methodology in Appendix A Part 3 of this Rule.

Surface water systems with a 3000-foot radius circle Source Protection Area shall re-delineate their Source Protection Area(s) in accordance with Appendix A of this Rule, except for surface water systems using Lake Champlain as a source. Surface water systems using Lake Champlain as a source shall re-delineate their Source Protection Areas in accordance with Appendix A of this Rule or in accordance with the EPA approved Assessment Protocol for Great Lakes Sources, dated August 8, 1999. The public water system shall choose which method to use.

4.1.1.9 Design Criteria

The water treatment plant, water system sources, and pump stations shall be designed for maximum day demand at the design year, recommended 20 years hence. Water system treatment plants, for water systems planning on future growth, shall be designed for maximum day demands expected at least 10 years hence. Water mains and transmission lines shall be designed for 50 years projected growth. Public water systems serving fewer than 100 connections, such as condominiums or subdivisions, need only plan for known projected demand. Specific per capita per day demands as outlined in Subpart 2.2, Table A2-1, shall be used to establish initial average day demand.

When a water system, expecting future growth, reaches 90% of the capacity of treatment or pumping systems capacity, it shall commence planning for the required additional capacity. When pumping or treatment capacities reach 100%, the water system shall initiate construction of these facilities.

Water Demand: Source yields will be compared against the maximum demands of the water systems to determine the adequacy of the source(s) to meet the expected demand.

Average Day Demands: The source's ability to meet the average day demand is based on pumping 12 hours per day. When a water system's average day demand is being met by pumping in excess of 12 hours per day at the permitted rate, the water system shall immediately apply for additional source capacity.

For design of new systems or modification to systems without metered data records, the average day demands shall be based on the average day flow quantities.

Maximum Day Demand: When the peaking factor is two (2), meeting the maximum day demand is based on finished water production when pumping 24 hours per day at the same rate (GPM) as needed to meet the average day demand. Maximum day demands are determined as follows: Average day demands x peaking factor = maximum day demands. In the absence of site-specific data, the peaking factor shall be two (2). Please note that the basis of design, including the definitions for average day demand and maximum day demand differ in Part 11, Small Scale Systems.

The peaking factor on new projects and non-metered existing projects if based on metered data, must be based on the ratio of the metered maximum day demand to the metered average day demand. The maximum day demand is the greatest amount of water produced by the water system on a single day during a 12-month period, or other appropriate time period.

4.2 Drinking Water Contaminants

The EPA sets primary and secondary limits of drinking water standards. The following section summarizes these drinking water standards and pending additional drinking water standards that must be considered for the near-term future upgrades to the water systems to continue to provide a safe drinking water source.

4.2.1 EPA National Primary Drinking Water Standards

The EPA has established National Primary Drinking Water Regulations (NPDWRs) that set mandatory water quality standards for drinking water contaminants. These are enforceable standards called "maximum contaminant levels" (MCLs) which are established to protect the public against consumption of drinking water contaminants that present a risk to human health. An MCL is the maximum allowable amount of a contaminant in drinking water which is delivered to the consumer.

These contaminants can be classified into the following categories:

- *Micro-Organisms*
- *Disinfectants*
- *Disinfection Byproducts*
- *Inorganic Chemicals*
- *Organic Chemicals*
- *Radionuclides*

A summary of the regulated contaminant limit, the potential health risk based on long term potential health risks from long term exposure to these contaminants, the common sources for these contaminants in drinking water and the associated public health goal are provided as Appendix H.

4.2.2 EPA National Secondary Drinking Water Standards

In addition to Primary Drinking Water Standards, the EPA has established National Secondary Drinking Water Regulations (NSDWRs) that set non-mandatory water quality standards for 15 contaminants. EPA does not enforce these "secondary maximum contaminant levels" (SMCLs). They are established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the SMCL. While SMCLs are not federally enforceable, EPA requires a special notice for exceedance of the fluoride SMCL of 2.0 mg/L. Community water systems that exceed the fluoride SMCL of 2 mg/L, but do not exceed the MCL of 4.0 mg/L for fluoride, must provide public notice to persons served no later than 12 months from the day the water system learns of the exceedance in conformance with EPA Federal Code 40 CFR 141.208. Secondary Drinking Water Standards and associated noticeable effects above the specified MCL's are summarized in the table 4-1.

Contaminant	*Secondary MCL*	*Noticeable Effects above the Secondary MCL*
Aluminum	*0.05 to 0.2 mg/L**	*colored water*
Chloride	*250 mg/L*	*salty taste*
Color	*15 color units*	*visible tint*
Copper	*1.0 mg/L*	*metallic taste; blue-green staining*
Corrosivity	*Non-corrosive*	*metallic taste; corroded pipes/ fixtures*
Fluoride	*2.0 mg/L*	*tooth discoloration*
Foaming agents	*0.5 mg/L*	*frothy, cloudy; bitter taste; odor*
Iron	*0.3 mg/L*	*rusty color; sediment; metallic taste; staining*
Manganese	*0.05 mg/L*	*black to brown color; black staining; bitter*
Odor	*3 TON*	*"Rotten egg", musty or chemical smell*
pH	*6.5 - 8.5*	*low pH: bitter metallic taste; corrosion* *high pH: slippery feel; soda taste; deposits*
Silver	*0.1 mg/L*	*skin discoloration; graying of eye whites*
Sulfate	*250 mg/L*	*salty taste*
TDS	*500 mg/L*	*hardness; deposits; colored water; staining; salty*
Zinc	*5 mg/L*	*metallic taste*

Table 4-1 Secondary MCL Contaminants

4.2.3 Recently Identified Drinking Water Contaminants

The EPA under the Safe Water Drinking act identifies contaminants that are included on the Contaminant Candidate List in order to identify and set maximum allowable concentration limits for newly identified contaminants in the drinking water.

Section 1412(b)(1)(B)(i) of Safe Water Drinking Act requires EPA to publish the Contaminant Candidate List every five years after public notice and an opportunity to comment. The Contaminant Candidate List is a list of contaminants which are not subject to any proposed or promulgated National Primary Drinking Water Regulations (NPDWRs) but are known or anticipated to occur in public water systems (PWSs) and may require regulation under SDWA. SDWA section 1412(b)(1)(B)(ii) directs EPA to determine, after public notice and an opportunity to comment, whether to regulate at least five contaminants from the CCL every five years.

Under Section 1412(b)(1)(A) of SDWA, the EPA determines to regulate a contaminant in drinking water if the Administrator determines that:

- *(a) The contaminant may have an adverse effect on the health of persons.*

- *(b) The contaminant is known to occur or there is a substantial likelihood that the contaminant will occur in public water systems with a frequency and at levels of public health concern; and*

- *(c) In the sole judgment of the Administrator, regulation of such contaminant presents a meaningful opportunity for health risk reduction for persons served by public water systems.*

If after considering public comment on a preliminary determination, the Agency decides to regulate a contaminant, EPA will initiate the process to propose and promulgate an NPDWR. In that case, the statutory time frame provides for Agency proposal of a regulation within 24 months and action on a final regulation within 18 months of proposal. When proposing and promulgating drinking water regulations, the Agency must conduct a number of analyses.

Even though the identified allowable contamination levels have not been formally confirmed, and officially mandated as regulatory requirements by the EPA, all existing and proposed infrastructure should be designed to implement testing and if necessary, treatment based on the existing (or proposed) water sources and the recommended maximum contamination levels and provide treatment where required to meet these proposed EPA standards.

In the most recently released Contaminant Candidate List, 109 contaminants were identified; of these contaminants, seven (7) are identified as being the most common and potentially having the most impact to the necessary testing and water treatment for the existing Thetford water systems. They are:

- *PFAS*
- *PFOS*
- *PFHxS*
- *PFBS*
- *PFNA*
- *HFPO*
- *Manganese*

4.2.4 PFAS

Under the Safe Water Drinking Act, the EPA has the authority to set enforceable National Primary Drinking Water Regulations (NPDWRs) for drinking water contaminants and require monitoring of public water systems. In March 2021, EPA published the Regulatory Determinations for Contaminants on the Fourth Contaminant Candidate List, which included a final determination to regulate PFOA

and PFOS in drinking water. As a part of that final determination, the EPA indicated it would also evaluate additional PFAS and consider regulatory actions to address groups of PFAS.

PFAS tend to co-occur with each other. This regulation will also remove many other PFAS when they co-occur with these six regulated PFAS. The EPA is following recent peer-reviewed science that indicates that mixtures of PFAS can pose a health risk greater than each chemical on its own. Concurrent with the proposed PFAS NPDWR published on March 29, 2023, EPA also announced it is making preliminary regulatory determinations for PFNA, GenX Chemicals, PFHxS, and PFBS in accordance with the Safe Drinking Water Act regulatory development process. EPA proposes to regulate PFNA, GenX Chemicals, PFHxS, and PFBS using a Hazard Index formula.

On March 14, 2023, the EPA announced the proposed National Primary Drinking Water Regulation (NPDWR) for six PFAS including perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorononanoic acid (PFNA), hexafluoropropylene oxide dimer acid (HFPO-DA, commonly known as GenX Chemicals), perfluorohexane sulfonic acid (PFHxS), and perfluorobutane sulfonic acid (PFBS).

The proposed PFAS NPDWR does not require any actions until it is finalized. EPA anticipates finalizing the regulation by the end of 2023 and that the regulations will be fully implemented.

The EPA is proposing a National Primary Drinking Water Regulation (NPDWR) to establish legally enforceable levels, called Maximum Contaminant Levels (MCLs), for six PFAS in drinking water. PFOA and PFOS as individual contaminants, and PFHxS, PFNA, PFBS, and HFPO-DA (commonly referred to as GenX Chemicals) as a PFAS mixture. The EPA is also proposing health-based, non-enforceable Maximum Contaminant Level Goals (MCLGs) for these six PFAS. The proposed MCLGs are summarized in ***Table*** *4.2.*

Compound	***Proposed MCLG***	***Proposed MCL (enforceable levels)***
PFOA	*Zero*	*4.0 parts per trillion (also expressed as ng/L)*
PFOS	*Zero*	*4.0 ppt*
PFNA	*1.0 (unitless)*	*1.0 (unitless)*
PFHxS		
PFBS		
HFPO-DA (commonly referred to as GenX Chemicals)	*Hazard Index*	*Hazard Index*

***Table** 4.2 – EPA Proposed MCLG PFAS Levels in Drinking Water*

The proposed regulation would also require public water systems to:

- *Monitor for these PFAS,*
- *Notify the public of the levels of these PFAS,*
- *Treat the water to reduce the levels of these PFAS in drinking water if they exceed the proposed standards.*

4.2.5 Manganese

The ubiquitous element, manganese, is an essential nutrient, but toxic at exposure levels. The EPA has set guideline levels for manganese exposure through inhalation at concentrations of 0.05 g/m3 and ingestion at 0.14 mg/kg/day, equivalent to 10 mg/day for a 70 kg person with a modifying factor of 3 for water (0.047 mg/kg/day). The Mn drinking water equivalent level (DWEL) is 1.63 mg/L for adults (70 kg person consuming 2 L water/day).

The EPA has not set a regulatory maximum contaminant level goal (MCLG) for manganese, which would be based on the DWEL for the most susceptible population and modified by consideration of the relative source contribution (e.g., 20% of ingested manganese intake through water). However, the EPA has established an advisory secondary maximum contaminant level of 50 g/L based on aesthetic concerns.

Recent evidence from environmental exposure studies is relevant to assessing the adequacy of these levels for protecting human health and determining research needs. Derivation of the manganese drinking water contaminant threshold of 0.05 g/m3 was based on observations of neurobehavioral deficits in workers with sub-chronic exposure to mean airborne manganese at 150 g/m3 and adjustments for continuous exposure and uncertainty factors. A recent population-based study observed subtle Parkinson-like

alterations in adults with chronic exposure to airborne- manganese at levels near the preliminary established limit in an area with a low mean drinking-water level of 4.4 g/L

Residence in areas with higher airborne- manganese levels was associated with higher blood- manganese levels, which were associated with neurologic deficits, particularly in men over the age of 50 years of age.

A study where manganese drinking-water levels ranged from 4-15, 82-253, and 1,800-2,300 g/L across three areas, but air manganese levels were unreported, also observed Parkinson-like signs in men > 50 years of age.

A composite Parkinson's score increased with manganese drinking-water levels, as did hair Mn levels. Another study observed learning and neurobehavioral deficits and altered serum neurotransmitter levels in school children where Mn drinking-water levels ranged from 241-346 g/L, relative to the control children's range of 30-40 g/L.

The effects from excessive manganese exposure may be qualitatively different across the life span. Parkinson-like alterations may occur in older adults chronically exposed to airborne manganese levels near the RfC or drinking water levels about 5-times the SMCL. Similar environmental exposures may impact learning and behavior in children and younger adults.

5.0 Funding Sources

Based on the systems limited number of users the cost per user to pay directly for upgrades to maintain the system with current technology to provide a sustainable water system would not be feasible. Most of the upgrades discussed in this report will require funding sources to implement the required infrastructure upgrades and expansion of the existing water systems. This section provides a summary of potential funding sources that can be utilized to upgrade and/or replace the existing water systems. The following funding source information was taken directly from the referenced funding agencies' websites.

5.1 Rural Utilities Service Water and Environmental Programs (WEP)

Through Rural Utilities Service Water and Environmental Programs (WEP), rural communities obtain the technical assistance and financing necessary to develop drinking water and waste disposal systems. Rural Development is a leader in helping rural America improve the quality of life and increase the economic opportunities for rural people.

WEP provides funding for the construction of water and wastewater facilities in rural communities and is the only Federal program exclusively focused on rural water and wastewater infrastructure for rural communities with populations less than 10,000 people. WEP also provides funding to organizations that provide technical assistance and training to rural communities for operating and maintaining their water and wastewater systems. WEP is administered through National Office staff in Washington, DC, with associated networks of field staff in each State.

Funds may be used to finance the acquisition, construction, or improvement of:

- *Drinking water sourcing, treatment, storage, and distribution*
- *Sewer collection, transmission, treatment, and disposal*
- *Solid waste collection, disposal, and closure*
- *Storm water collection, transmission, and disposal*

Additional details for WEP funding include the following:

- *Legal and engineering fees*
- *Land acquisition, water and land rights, permits and equipment.*
- *Start-up operations and maintenance*
- *Interest incurred during construction.*
- *Purchase of facilities to improve service or prevent loss of service.*
- *Up to 40-year payback period, based on the useful life of the facilities financed.*
- *Fixed interest rates, based on the need for the project and the median household income of the area to be served.*
- *Additional costs determined to be necessary for completion of the project.*
- *Borrowers must have the legal authority to construct, operate and maintain the proposed services or facilities.*
- *All facilities receiving federal financing must be used for a public purpose.*
- *Partnerships with other federal, state, local, private and nonprofit entities that offer financial assistance are encouraged.*
- *Projects must be financially sustainable.*

This program helps very small, financially disadvantaged rural communities extend and improve water and wastewater treatment facilities that serve local households and businesses.

5.2 Drinking Water State Revolving Fund (SRF) *Program*

The Drinking Water State Revolving Fund (DWSRF) program provides low-cost financing for public water systems for planning and for capital improvements that improve public

health protection and facilitate compliance with the Safe Drinking Water Act. Loads can be provided to eligible regulated community water systems (municipal or private) and to eligible non-profit non-community water systems. Eligible borrowers, projects and costs defined in the EPA's DWSRF eligibility handbook and in VT DWSRF Guidance Document 8. For information that changes with the annual funding cycle including deadlines for construction projects, reference to the current Intended Use Plan.

The types of work that are eligible for loans under this program include the following:

5.2.1 SRF Planning Loans

Planning Loans can be utilized for preliminary engineering, feasibility studies, water system acquisitions, income surveys, environmental reporting, structural evaluations and similar scope of work.

5.2.2 SRF Source Protection Loans

Source Protection Loans can be utilized for municipal community water systems to purchase land or a conservation easement to protect an existing or future public water source and ensure compliance with state and federal drinking water standards. The water system must have a current approved Source Protection Plan for the source or have submitted the SPP update to the DWGPD prior to loan application. The water system must demonstrate how the project will directly promote public health protection or compliance with national drinking water regulations. Loan rates and terms are 20-years at 3% interest, but the current Intended Use Plan may have additional allowances for principal loan forgiveness.

5.2.3 SRF Construction Loans

Construction loans are competitive and are awarded through a two-step process based on the following:

A priority list application that results in a preliminary eligibility determination and score, with points awarded for addressing the most significant deficiencies to facilitate compliance with the State Drinking Water Act.

There are also requirements and points awarded for readiness to proceed within the near future. Typically loan rates and terms are up to 30 years at 0% interest, plus 2.00 to 2.75% administrative fee, but certain disadvantaged applicants can receive a term of up to 40 years and fees as low as 0%. Loan terms are limited by the weighted average expected useful life of funded assets.

5.3 State CDBG Program

The Town of Thetford would need to assume ownership of the existing (or proposed) water system(s)s to be eligible for this municipal aid grant program.

Under the State CDBG Program, the state of Vermont award grants to smaller units of general local government that develop and preserve decent affordable housing, to provide services to the most vulnerable in our communities, and to create and retain jobs.

Annually, each State develops funding priorities and criteria for selecting projects to receive this funding. Since States are in the best position to know, and to respond to, the needs of local governments, Congress amended the Housing and Community Development Act of 1974 (HCD Act) in 1981 to give each State the opportunity to administer CDBG funds for non-entitlement areas. Non-entitlement areas include those units of general local government which do not receive CDBG funds directly from HUD. Non-entitlement areas are cities with populations of less than 50,000 (except cities that are designated principal cities of Metropolitan Statistical Areas), and counties with populations of less than 200,000.

The State of Vermont participates in the CDBG Program. HUD distributes funds to each State based on a statutory formula which considers population, poverty, incidence of overcrowded housing, and age of housing.

States participating in the CDBG Program award grants only to non-entitlement Units of General Local Government (UGLG).

CDBG funds may be used for activities which include, but are not limited to:

- *Acquisition of real estate property*
- *Relocation and demolition*
- *Rehabilitation of residential and non-residential structures*
- *Construction of public facilities and improvements, such as water and sewer facilities, streets, neighborhood centers, and the conversion of school buildings for eligible purposes*
- *Public utility services*
- *Activities relating to energy conservation and renewable energy resources.*
- *Provision of assistance to nonprofit and profit-motivated businesses to carry out economic development and job creation/retention activities.*

Each activity must meet one of the following national objectives for the program: benefit low- and moderate-income persons, prevention or elimination of slums or blight, or address community development needs having a particular urgency because existing conditions pose a serious and immediate threat to the health or welfare of the community for which other funding is not available. A need is considered urgent if it poses a serious and immediate threat to the health or welfare of the community and has arisen in the past 18 months.

Generally, the following types of activities are ineligible:

- *Acquisition, construction, or reconstruction of buildings for the general conduct of government*
- *Political activities*
- *Income payments*
- *Construction of new housing (with some exceptions)*

States may use $100,000 plus up to 50% of costs it incurs for program administration, up to a maximum of three percent of its CDBG allocation. The amounts expended on administration in excess of $100,000 must be matched. States may expend up to three percent of their CDBG allocation on technical assistance activities. However, the total a state spends on both administrative and technical assistance expenses may not exceed three percent of the state's allocation.

Over a 1, 2, or 3-year period, as selected by the grantee, not less than 70 percent of CDBG funds must be used for activities that benefit low- and moderate-income persons.

HUD does not provide CDBG assistance directly to individuals, businesses, nonprofit organizations, or other non-governmental entities.

If a State CDBG grantee cannot answer your questions, or if you are a local official, contact the HUD field office that serves your area.

Under the State CDBG Program, states are responsible for:

- *Designing the CDBG Program within statutory and regulatory parameters*
- *Setting priorities and deciding what activities to fund*
- *Distributing funding according to the method of distribution*
- *Establishing financial management, recordkeeping, reporting, monitoring, audit and closeout systems for their programs*
- *Ensuring compliance by state grant recipients*
- *Developing the Consolidated Plan*

The Consolidated Plan is a jurisdiction's comprehensive planning document and application for funding under the following Community Planning and Development formula grant programs: CDBG, Emergency Solutions Grants (ESG), HOME Investment Partnerships (HOME), and Housing Opportunities for Persons with AIDS (HOPWA). The Consolidated Plan is carried out through Annual Action Plans which must contain the required certifications, description of CDBG eligible activities to be funded, and timetables for completing the projects.

Under the State CDBG Program, UGLG are responsible for:

- *Prioritizing the types of activities, they apply for*
- *Carrying out eligible activities*
- *Complying with federal and state requirements*
- *Handling local citizen participation*

As part of the Consolidated Planning process, units of local government receiving CDBG from their state must follow the requirements of 24 CFR 570.486 which provides for, and encourages, citizen participation and which emphasizes participation by persons of low- or moderate-income, particularly residents of predominantly low- and moderate-income neighborhoods, slum or blighted areas, and areas in which the local government proposes to use CDBG funds. The plan must:

- *Provide citizens with reasonable and timely access to local meetings, information, and records related to the grantee's proposed and actual use of funds.*
- *Provide for public hearings to obtain citizen views and to respond to proposals and questions at all stages of the community development program, including at least the development of needs, the review of proposed activities, and review of program performance.*
- *Provide for timely written answers to written complaints and grievances.*
- *Identify how the needs of non-English speaking residents will be met in the case of public hearings where a significant number of non-English speaking residents can be reasonably expected to participate.*

5.4 American Rescue Plan Act (ARPA)

Congress passed the American Rescue Plan Act (ARRA) to address economic impacts due to the COVID-19 pandemic. This national plan commits $1.9 trillion in ARPA funds to address the public health and economic crises caused by the COVID-19 pandemic. ARPA includes money to invest in broadband, water and sewer infrastructure, and assistance for economically disadvantaged communities to help protect them from future crises or to remediate impacts caused by the pandemic.

5.4.1 ARPA in Vermont

The State of Vermont will receive more than $2.7 billion in ARPA funds for projects related to the pandemic. More than half of these dollars are directly appropriated to federal agencies, individuals, local governments, education institutions, and others, leaving approximately $1 billion for the State to deploy between now and December 31, 2024.

Vermont's Legislature and Governor Phil Scott have agreed to invest the ARPA monies in broadband infrastructure, clean water, climate action, housing, and economic development related to pandemic impacts. The state budget for fiscal year 2022, which started on July 1, 2021 and ends June 30, 2022, allocates nearly $640 million of the ARPA funds to programs and initiatives in these six areas – including $100 million for clean water and $65 million for climate action.

5.4.2 ARPA and the Vermont Agency of Natural Resources

Infrastructure improvements that include the following scopes of work need to submit to the Vermont Agency of Natural Resources for funding consideration:

1. *Treating stormwater runoff from larger sites*
2. *Reducing sewer overflows*
3. *Improving water and sewer infrastructure in manufactured housing communities*
4. *Providing financial assistance to low-income homeowners with failed septic systems and/or wells*
5. *Developing community water systems in some of the villages that lack such systems.*
6. *Designing and installing pretreatment process to address high strength of toxic wastewater commonly seen in craft brewing, dairy and meat processing and other small industries.*

6.0 Alternatives Analysis

In this section, the alternatives that were either identified by Town Officials and by system owners as areas for potential improvements that could be implemented or should be assessed to confirm their feasibility to either improve the existing water systems or provide new infrastructure that can be designed, installed, and implemented for community development are discussed.

6.1 Water Supply Sources

It is recommended that the existing spring fed infiltration basins for the Union Water Co. and the North Village Water Company be removed and replaced in an alternate location with a drilled well system. To furnish and install a drilled well system similar to what exists for the water systems with a drilled well, costs can be anticipated to be between $20,000 and $35,000 for individual private wells but depending on the required system demand can be anticipated to be between $300,000 and $700,000 for a combined community system, depending on the following criteria:

- Location
- Required system yield.
- Infrastructure and improvements required for access and to maintain access.
- Depth of Well
- Additional infrastructure (piping, pumps, etc) required to convey the system source water to the water system for distribution.

Existing detailed aquifer maps for Thetford, VT are not readily available. The state of Vermont ANR in conjunction with the VT Geological Survey has developed an approximate map of well yields for the state of Vermont, provided as Appendix E. A majority of Thetford is shown with an anticipated well yield of between 10 and 15 GPM, with areas adjacent to the Connecticut River at 2 to 9 GPM yield. These maps should be considered approximate and since aquifer map is not readily available for the Town it suggests that aquifers do not exist in the Town of Thetford. If Aquifers are not available, then a fracture trace analysis study needs to be performed to determine the appropriate location to drill for water sources with the yields required for a community system.

Based on these anticipated lower well yield rates, it is anticipated to support an expanded system where multiple water sources (wells) will be required to provide the adequate system capacity.

6.1.1 Fairlee Water System Connection

Stantec, at the request of the Town, communicated with the Town of Fairlee to determine the feasibility and associated logistics with extending the Fairlee Water Department's water supply pipeline along VT Rte. 5 from Fairlee into the Town of Thetford to provide a municipal water source for North Thetford.

After some discussions, the Town indicated that, at this time, they would not have interest in extending their water main into Thetford to provide a municipal water source to the

Town of Thetford. Based on a preliminary conceptual level route to extend the water line along VT Rte. 5, we estimate that the approximate cost to construct and extend the water main from Fairlee into Thetford to provide municipal water to the Town of Thetford could be anticipated to cost roughly $4.0 million; with additional costs that could be anticipated for the replacement of the existing water services to the new main, additional operational costs associated with the operation and maintenance of the water and associated treatment of the water infrastructure in the Town of Thetford.

6.1.2 Connecticut River Water Source

Stantec, at the request of the Town, reviewed the logistics of the Connecticut River as a possible future system water source. The preliminary design process and associated permitting required to demonstrate the Connecticut River as a viable system water source could be anticipated to be extensive.

The Connecticut could potentially be a feasible water source. The watershed area, at the point where the Connecticut River reaches Thetford, is over 2-million acres (3,140 square miles). The USGS Stream Stats simplified results for the Connecticut River watershed area to Thetford, VT is provided as Appendix G. The water is sufficient to act as a water source for any of the town's existing water systems or potentially a combination of all of the systems.

The limiting factor for the use of the Connecticut River as a water source is performing the treatment required to maintain an acceptable water quality. Because of the large watershed area, the types and amounts of contaminants, associated treatment, and associated treatment costs are anticipated to be significantly greater than for a ground water source. In order to assure that this water source could be maintained as a safe drinking water source, a water treatment plant and associated water treatment infrastructure would need to be in place to treat the types of contaminants that could enter the encountered in the source water.

Figure 6-1 Connecticut River

The design, construction, and implementation of this infrastructure are anticipated to be roughly $10 million, and yearly operating costs are anticipated to be significantly greater than that of the costs associated with running and maintaining the system pump and chlorination houses for the water systems.

6.2 Combining and Expanding Water Systems

There are significant limitations with the expansion of the existing water systems. This section discusses the feasibility and logistics associated with combining different systems based on the systems current needs and anticipated future growth.

6.2.1 Thetford Town Wide Water System

The existing water systems are strategically located within village districts to provide domestic drinking water to the areas of Thetford with the highest existing density within Town and within the Village Districts. As discussed, the existing Village Districts are separated by miles, with very few potential additional system users.

Based on our review of the location of all the water systems, we developed a preliminary conceptual level estimate of the pipe length and distance between the system to provide context regarding connecting the existing Water System and provide a magnitude of scale for planning and discussion. The summary approximate lengths of water main required to provide a water pipe connection between districts are summarized in **Table** 6-1.

Start Location	End Location	Distance (Miles)
East Thetford Village (South Limit)	East Thetford Village (Northern Limit)	0.7
Thetford Hill Village VT Rte 113 (West Limit)	Thetford Hill Village VT Rte 113 (East Limit)	0.6
Thetford Hill Village (West Limit)	Thetford Hill Village (East Limit)	1.6
Thetford Center Village (South Limit)	Thetford Center Village (North Limit)	0.6
Post Mills Village (W Fairlee)	Post Mills Village (Thetford)	7.5
Post Mills Village	Thetford Center Village	2.5
Thetford Center Village	Thetford Hill Village	0.8
Thetford Hill Village	East Thetford Village	2.1
East Thetford Village	North Thetford Village	1.7
Thetford Hill Village	Union Village	1.4
Thetford Hill Village	North Thetford Village	1.2 Cross Country
Thetford Hill Village	North Thetford Village	3.8 Road

Table 6-1 Separation of Village Districts

Water main infrastructures to provide an 8-inch water supply pipe, valves and hydrants to provide a water system that is capable of fire suppression flows and pressures can be anticipated to cost roughly $1.3 million per mile.

6.2.2 North Thetford Water Systems

There are three existing water systems in North Thetford Village that all provide water to roughly the same service area along VT Rte. 5 in the North Thetford Village in Thetford, VT. The South Village Water Company and the North Village Water Company were once

part of the same company, and the Union Water Company is also located within the same corridor where the other two water systems are currently located.

Two of the existing water sources for the existing systems are spring fed, and the only water system that has an existing drilled well as a water source is the North Village Water Company, with an estimated yield of 5.0 GPM.

Based on our discussions with system owners/operators, the three water systems are interested in the possibility of combining into a single Public Community Water System.

For a water system to replace the three existing water systems and provide a combined water system to provide drinking water to the North Thetford Village District, some key drinking water regulation must be considered:

State Regulations

- The system must be capable of providing a minimum water supply equal to the Average Day Demand (ADD) and Maximum Day Demand (MDD).
- North Village Water Company does not currently have water storage tanks or provided water treatment and water storage would need to either be provided at the existing South Village Water Company's facility or would need to be installed as part of an expansion project.
- The system must be capable of providing a minimum water supply equal to the (ADD) with redundancy.
- The system must have a minimum available water storage equal to the ADD.

ADD Assessment:

- Combined Current ADD – 5,460 GPD
- Combined Future ADD – 7,960 GPD
    - North Village Water Company – 900
    - South Village Water Company – 2,000 GPD (based on 250 GPD design criteria for 8 system users due to no available demand information)
    - Union Water Company – 2,560 GPD
    - Future System Expansion 10 Users @ 250 GPD/Each = 2,500 GPD

Available Water Supply:

- North Village Water Company

- Well#1 - 5 GPM (Assumed) =7,200 GPD (24 hr) @12 hrs[1] 3,600 GPD
    - Required future source supply = ADD or 7,960 GPD (5,460 GPD initial)

ADD Review: The North Village Water Company Well yield was not provided and is assumed to be 5 GPM, or less. It is recommended that the North Village Community Water Company's well yield be confirmed, and an alternate water source be investigated to determine if the existing well has sufficient supply capacity, or a supplemental (or alternative) water source will be required. Based on the assumptions made, the well's existing yield is insufficient to provide a water supply to meet the demand and a supplemental water source would be required.

Note#1: State standard limits supply operation to 12 hrs/day

Water Storage Assessment:

- The existing available water storage of the South Village Water Company is 8,000 gallons and is sufficient for the calculated future demands but does not allow for any expansion. The water source would need to be pumped from the source location at the current North Village Water Companies well to the South Water Company's holding tank to utilize the existing infrastructure.

6.2.3 Thetford Hill

The Thetford Water Co-Op water system and associated infrastructure originally provided water to Thetford Academy as a redundant source to their private water supply. However, because this was considered a combined cross connection water source it was not allowed, and the school was disconnected from the water system.

It is reported that originally the Thetford Water Co-Op also intended to provide a water service to Thetford Elementary School, but the school has never been connected to the water system. From discussions, it is understood that both schools would like to be connected to the Community Water system. There are existing limitations with the Elementary School's well yield. There have been reported instances where the water supply has been insufficient for the Elementary School and bottled water has needed to be provided for water use at the school.

Based on recent discussions that Stantec has had with operations staff at both schools, there is interest in being served by the Thetford Water Co-Op water system.

For Thetford Water Co-Op to provide drinking water, some key state drinking water regulation must be considered:

State Regulations

- The system must be capable of providing a minimum water supply equal to the Average Day Demand (ADD) and Maximum Day Demand (MDD).
- The system must be capable of providing a minimum water supply equal to the (ADD) with redundancy.
- The system must have a minimum available water storage equal to the ADD.

ADD Assessment:

- Combined ADD - 10,296 GPD
    - Thetford Academy – 1,500 GPD
    - Thetford Middle School – 1,500 GPD (ADD not available; however, there are fewer students; therefore, for this purpose, we are using the Thetford Academy ADD)
    - Thetford Water Co-Op – 7,296 GPD

Available Water Supply:

- Thetford Water Co-Op
- Well#1 - 8 GPM =11,520 GPD (24 hr) @12 hrs[1] 5,760 GPD
- Well#2 – 15 GPM = 21,600 GPD (24 hr) @12 hrs[1] 10,800 GPD
    - Required source supply = ADD or 10,296

ADD Review: Thetford Water Co-Op Well#2 is adequate to supply the ADD; however, Well#1 is not adequate to meet ADD or the redundancy requirement. A third water source would be necessary to provide the sufficient system capacity to add the Academy and Elementary as system users.

Note 1: State standard limits supply operation to 12 hrs/day

Water Storage Assessment:

- The existing available water storage of the Thetford Water Co-Op is 20,000 gallons.
- Required minimum water storage capacity for the schools and Thetford Water Co-Op is as follows:

- Thetford Middle School ADD – 1,500 GPD (assumed)
- Thetford Academy ADD – 1,500 GPD
- Thetford Water Co-Op – 7,296 GPD

  TOTAL – 10,296 GPD = Required ADD = Minimum Required Water Storage

Minimum Water Storage Volume Review: As noted, the Thetford Water Co-Op currently has 20,000 gallons of water storage which is sufficient to add the Thetford Elementary and Thetford Academy as system users.

6.2.4 New Post Mills Water System

One of the more remote water systems, the Post Mills water system is limited on the number of additional users that can be served from this system. Additional added users on this system would change the classification to a regulated system, which would result in testing, treatment and reporting requirement requirements that would result in additional system costs. The existing drilled well and pump house cannot support the expansion of the water system with the current Post Mills water system.

This existing water system, although sufficient and potentially sustainable for existing users, could not be expanded or extended to provide service to the Village Residential and Neighborhood designated areas which account for roughly 90-percent of the properties in the Post Mills Village.

In review of the Post Mills Village, in order to provide domestic water to the Post Mill Village area it has been determined that key system requirements would be the following:

- Approximately future demand for 120 Equivalent Residential Units which is an ADD of 48,000 GPD with an associated MDD equal to twice the calculated ADD or 96,000 GPD.
- Minimum provided water storage is required to equal the calculated ADD, which is 48,000 Gallons.
- Water transmission and distribution Pipe to serve the Neighborhood Residential portion of the Post Mills Village District is estimated to be approximately 2 miles of the roughly 7.5 miles of roadway in Post Mills based on the more densely populated areas of Post Mills.
- 120 Potential service connections to provide a water source to the community.
- It is anticipated based on the generally low yields of the existing wells in Thetford that two (2) wells may be required to provide a sufficient water supply to for this

system. Additional investigation is required to make a formal determination regarding water source location(s).

The total costs to design, permit, furnish and install a new water system based on this information can be anticipated to cost between $5.5 and $6.5 million for a 4-inch water line system and $7.5 and $8.5 million for a 8-inch water system with fire flow capabilities and fire hydrants.

Tug Mountain is reported to have a significant water supply yield. Access is limited to the mountain and a transmission line would need to be run roughly ¾ of a mile to a mile to the more densely populated area of Post Mills. A water study would be required to determine the best location to maximize a well yield location for a public drinking water supply.

6.2.5 Transmission Water Main on VT Rte. 5

Since this alternative has already been reviewed and details were analyzed as part of Otter Creeks 2017 Preliminary Engineering Report this option was not analyzed or reviewed. It should be noted however, if there is an interest in pursuing this alternative that the costs listed in that report should be revisited prior to proceeding with funding or final design for construction due to the extreme inflation that has occurred over the past couple of years.

6.3 System Pressures

The Vermont Water Supply Rule requires that the water distribution system pipe pressure in the street to be a minimum of 35 psi for Public Community Water Systems under normal flow conditions and a minimum of 20 psi under maximum flow conditions.

Currently, the Thetford water systems provide a water service that supplies water to private water tanks (cisterns) that are located in the basement of each of system users. The cisterns are triggered by a solenoid valve that then pumps water to the house fixtures. **Table** 6-2 summarizes the existing maximum and minimum water system pressures in the water distribution pipe.

System Name	System Low Pressure (PSI)	High Pressure (PSI)
Post Mills Water Association	20	30
Union Water Co.	**20**	**50**
East Thetford Water Co.	**40**	**50**
North Village Water Co.	20	25
South Village Water Co.	15	22
Thetford Water Co-Op.	**43**	**90**

Table 6-2 Water System Pressures

The combination of the small diameter water pipes and ended dead end pipe segments contribute to lower system pressures.

If basement cisterns were eliminated from the existing water system infrastructure, which is recommended, then the water system pressure must be increased to 35-psi operating pressure. There are significant pressure losses with the existing smaller diameter water distribution mains.

It is recommended that improvements be made to increase the system pressures. It is recommended that the following be implemented:

- Maintain a minimum system pressure of 35 PSI for domestic water supply and 70 PSI (to be determined based on fire flows) if fire protection capabilities are desired. However, it should be noted that currently there is not sufficient water storage at any of the existing water systems to support fire flow operations.
- Increase water main sizes to account for system pressure losses and allow for expansion and interconnection of the systems.
    - Water distribution main sizes in most instances for the current demand can be provided as 4-inch pipes and in some cases even 2-inch pipes for the small systems but to provide for future expansion and phased interconnection 6-inch minimum water distribution mains should be utilized and an 8-inch water distribution pipes are required where fire protection is provided by the system.
- Provide elevated water tanks for additional system pressure where required.
- Combine/connect multiple water systems to provide the water supply in elevated locations and provide looped water system piping to eliminate dead ends and promote continuous flows.

6.4 System Costs

As previously noted, limitation to any alternative is the costs associated with the improvements, but more specifically the cost per user to provide upgrades or improvements to the existing water systems. The water systems are all privately owned and operated nonprofit organizations, and most of the maintenance and repairs to those systems are performed on either a volunteer or as needed basis, which is not sustainable.

This section reviews the user rates and associated cost per user for some upgrade options that are discussed in the report.

6.4.1 Existing System Rates

The existing water systems currently operate as non-profit systems. The existing rates are flat yearly rates that are determined based on yearly costs to run and maintain the existing water system based on a given calendar year. A summary of the water rates by system are provided in Table 6-3. It should be noted that these yearly budgetary costs are based on the available money from the system user rates and are not based on a planned yearly budget for infrastructure improvements.

System Name	# of Users	$ Per User Per Year	Yearly Budget
Post Mills Water Association	9	$325	$2,925
Union Water Co.	**23**	**$750**	**$17,250**
East Thetford Water Co.	**35**	**$800**	**$28,000**
North Village Water Co.	8	$325	$2,600
South Village Water Co.	8	$300	$2,400
Thetford Water Co-Op.	**41**	**$450**	**$18,450**

Table 6-3 Water System Rates and Associated Costs

The bolded water systems are the Public Community Water systems and the remaining water systems are the Private Community Water Systems. In general, the costs per user are fairly consistent for the existing Community water systems, depending on whether they are public or private systems.

Some of the existing water Systems don't have water meters that meter the flows to the individual users, and in some instances, the existing systems don't have water meters to determine the amount of water demand that is being supplied from the system.

6.4.2 Estimated Existing User Cost Increases Associated with Water Distribution Pipe Upgrades

There are a number of factors that have limited the potential upgrades and expansion of the existing water systems that are primarily due to the number of users and the per user costs associated with the potential system upgrades.

The costs to upgrade, replace, expand, and inter-connect the water systems beyond the current system's limits are cost prohibitive based on both the number of current users and the potential additional users that could be added to each water system. On average, the existing water system piping extends between 0.5 and 1.0 mile to serve between, nine (9) and twenty-two (22) properties. On average, the separation of services is roughly 250-feet within the limits of the existing water systems. Table 6-4 provides an average cost per user to increase the water main pipe size for the system based on an average 250-feet water service separation.

As shown on Table 6-4 and 6-5, the costs associated with upgrading/replacing and extending the water mains beyond the existing service area will have a significant effect on user fees. It should be noted that the costs in the referenced tables do not include engineering costs or contingencies, and do not consider potential funding grants. However, the intent is to demonstrate the significant effect of system upgrades, limited to water main replacements and extension, on user fees.

Replacement Water Main Size	Average System Cost Per LF	Existing User Separation (feet)	Estimated Cost Per User
2" HDPE	$75	250	$18,750
4" DI CL52	$145	250	$36,250
6" DI CL52	$175	250	$43,750
8" DI CL52	$225	250	$56,250

Table 6-4 Estimated Infrastructure Cost Per Added User

Table 6-4 provides an average cost per user to extend the existing water main for the water systems beyond their current Village districts to provide interconnections for the water systems.

Replacement Water Main	Average System Cost Per LF (Furnished and Installed)	Average User Separation Outside Village Districts (feet)	Estimated Cost Per User
2" HDPE	$75	700	$52,500
4" DI CL52	$145	700	$101,500
6" DI CL52	$175	700	$122,500
8" DI CL52	$225	700	$157,500

Table 6-5 Average User Cost to Extend Water System Mains Beyond Their Current Locations Within Their Associated Village District

By comparing the two tables, one could conclude that the direct user costs associated with replacing or extending the water main outside of the more densely populated village districts is roughly 3 times that of the anticipated costs to replace or extend the water main in the more densely populated Village District(s).

As a point of reference, the current rates are below the national average for water system user rates but are currently greater than the Vermont State average for water system user rates, which are roughly $18/month ($216/per year).

The estimated monthly user cost is based on a 30-year, zero interest loan. Other loans, like a sub-prime interest loan could also be obtained for the upgrade of the water system. Grants could also be obtained to upgrade the existing water system, but the average monthly user costs for a 30-year period for upgrades is not feasible to be borne by the current (or future) system users.

Both tables demonstrate the need for additional system users to the system to reduce the per user costs of the proposed upgrades. Regardless of the direction that is decided for the proposed system upgrades or expansion of the water systems, based on this cost per user analysis summarized in these two tables, that grant and/or municipal funding is necessary to upgrade the systems.

Another option for funding system upgrades is for the Town to borrow funds and pay for loans and/or bonds through taxation of the entire Town. The justification for this approach would be that a water main extension would be intended to expand the tax base through the addition of new residential home, multi-family housing, commercial development, professional businesses and light industrial, etc.

6.4.3 Potential Additional Users

We reviewed the existing properties within the existing water systems and identified additional properties that could be connected to the existing system without extending or

expanding the existing systems. Table 6-6 provides a summary of the existing water systems and the potential additional users.

System Name	# of Existing Users	#Potential Additional Users Within Area	Total #Potential System Users w/o Expansion	Notes
Post Mills Water Association	9	6	9	The system operator indicated that the existing system was at capacity.
Union Water Company	**23**	**10**	**33**	Additional users would only be approved by the State of Vermont with a replacement water source
East Thetford Water Company	**35**	**15**	**50**	Includes five (5) users that disconnected to the system and are now on private wells
North Village Water Company	8	0	8	The coverage area overlaps with Union Water and the existing system is not capable of adding additional users.
South Village Water Company	8	0	8	The coverage area overlaps with Union Water and the existing system is not capable of adding additional users.
Thetford Water Cooperative	**41**	**10**	**51**	Both schools are included in the future users.

Table 6-6 Potential Additional System Users

The additional users identified for the Union Water Company would need to be approved by the State, and it is unlikely that additional users would be approved to be added to the system without the installation of a new water source to replace the existing spring fed infiltration system and additional system infrastructure improvements like providing average daily demand storage, removing private basement cisterns and upsizing water piping to provide adequate system pressures.

Because both the Post Mills and the North Thetford Village water systems are both incapable of accepting additional system users, the only available water source option for future development in those villages is limited to private wells, which both limits residential growth and deters commercial growth/development.

6.5 Water Treatment

It is a moral responsibility of the water system owner / operators to provide the necessary treatment of the source water to ensure safe drinking water conditions are maintained. Table 6-7 summarizes the water treatment in the existing water systems.

System Name	Water Treatment Method	Chemical Feed
Post Mills Water Association	UV Purification	Yes
Union Water Co.	Chlorination	Yes
East Thetford Water Co.	Chlorination, pH Adjustment and Manganese Removal	Yes
North Village Water Co.	Sediment Filter	No
South Village Water Co.	Chlorination	No
Thetford Water Co-Op.	Chlorination	Yes

Table 6-7 Existing Water Treatment

Similar to the testing requirements, only the Public Community Water Systems provide water treatment to the source water. Without testing the water supply, determination cannot be made on what water treatment is necessary to provide safe drinking water.

6.6 Water Testing

Based on the information received from the water system owners, it is our understanding that not all of the water systems regularly test for contaminants in the drinking water. Specifically, the private community water systems, who are not required to test or report to the EPA and the State of Vermont Department of Environmental Conservation Drinking Water and Groundwater Protection Division.

Community water systems owners are obligated to ensure that the water being delivered to the users within the system satisfies the EPA's requirements for contaminant levels regardless of whether the system is a regulated or unregulated water system. By accepting payment for the delivery of water, this is an understanding by the user that the drinking water is being maintained and confirmed to be safe for consumption.

There is technology available that can provide continuous contaminant level readings and monitoring of the water. At a minimum, the following contaminants should be tested for

quarterly for all systems to ensure that the drinking water being supplied is within the acceptable levels for each:

- E-Coli
- Bacteria
- Manganese
- P-FAS Hydrocarbons
- Arsenic
- Radon

Specifically, but not limited to Post Mills, because of its proximity to the existing landfill, should be testing for contaminants in compliance with standards for the Public Community Water System, even though the system operates as a Private Community Water System.

It should be understood that the absence of contaminants does not confirm that there will be no future contaminants in the water supply, and routine testing for contaminants, even if a negative determination was made during the previous testing, should be performed.

Water quality is required to be tested in conformance with the Vermont Water Supply Rule, Chapter 21, Table 6-1 and 6-2 for Public Community Water Systems, but should be performed for all systems to confirm that the drinking water is a safe for human consumption. Without water quality sampling and testing, it is impossible to know what treatments are necessary to provide safe drinking water.

6.7 Fire Protection

Water systems are typically designed and sized to support the fire protection requirements of the community or proposed development. Currently, Thetford's water systems cannot support the NFPA required water supply, water pressure of supply for either individual fire suppression systems (sprinklers) or community fire systems (hydrants).

It is reported that the Fire Insurance Underwriter's Bureau recently revised Thetford's Public Protection Classification (PPC) upward, from 9 to 8b. The PPC uses a scale from 1 to 10, with 1 being the best and 10 being the worst rating. Thetford's rating is obviously very low, which can have an effect on homeowners' insurance and commercial business insurance rates.

A number of fire ponds have been installed in remote areas of Town to provide a water supply for firefighting activities, but there are reported limitations and maintenance

concerns with these water supplies. The majority of fire ponds only provide a water source for one or a small number of properties and do not provide infrastructure that supports fire protection for the community at large.

Water distribution main pipe sizes and system pressures are required to be provided or increased to 8-inches. Fire protection requires, on average, 1,000 GPM at 60,000 total gallons as specified by NFPA 1141, for fire flows for the protection of a residential building. This water supply is in excess of what the existing water systems store.

Minimum water system pressures and flow rates need to be determined for future developments dependent of:

- the proposed materials of construction,
- the hazard classification,
- occupancy,
- building use,
- building separation,
- building guide,

When planning new water main infrastructure or evaluating an existing water system upgrade, minimum water system pressures and flow rates need to be determined for future development depending on the proposed materials of construction, the hazard classification, and building separation. In general, based on the existing infrastructure in Town, 1,500 GPM available fire flow, at 65- 75 PSI residual pressure while maintaining a minimum 20 PSI system pressure throughout the entire water system. Water mains would need to be provided to be a minimum of 8-inch in diameter, with hydrants required every 500 feet on a lateral line of 6-inches in diameter.

Some rural communities, at the discretion of the Fire Chief, will require developers to provide a financial contribution, in an amount equal to the cost of a fire protection system to the Fire Department (or Water Department) to be utilized for the Town's Water Supply funds for Fire Protection.

Goals, policies, and recommendations were identified by the Town in the Town Plan for the Fire Department and associated fire protection. The following are directly related to the water supply system:

- *Require the Development Review Board to address water supply issues in all major developments that come before it.*
- *Encourage home and business owners to consider installing approved fire suppression systems.*

7.0 Recommendations

This section discusses the feasibility and provides an analysis and recommendations for infrastructure improvements and system expansion for items that were identified by the Town, Stantec, and the system owners/operators to improve the existing water systems and establish infrastructure to support future development.

7.1 System Upgrades

Based on the discussions, feedback, and input received from the Town we recommend the following:

1. Perform sampling and testing for contaminants and for the frequency required for compliance with Vermont Water Supply Rule standard for Public Community Systems, regardless of whether the system is a Public or Private System.
2. Perform water treatment in compliance with the Vermont Water Supply Rule. Confirm existing chemical feed systems are operating properly and replace inoperable systems.
3. Create a Thetford Water advisory committee that has representation from each water system in Thetford to develop mutual support and technical advice.
4. Perform a detailed water resource capacity study, including a fracture trace analysis for the Post Mills, Thetford Hill and North Thetford to identify a sufficient water source for a community water system for a future Post Mills Water system, supplemental (or replacement) water supply for Thetford Hill and water supply for a combined North Thetford water system.
5. Confirm the well yield of the North Village Water Company to verify if it is a viable water source for combining the three North Thetford Water Systems.
6. Test and treat (as required) for PFAS contaminates.
7. Replace the existing spring fed water sources with drilled wells.
8. Obtain and record formal easements for all infrastructure on private property.
9. Eliminate individual user water storage tanks (cisterns).

10. Upgrade the water distribution piping to provide a minimum of 35 PSI under normal system flow conditions and a minimum of 20 PSI under peak flow conditions.

11. Perform an assessment of the existing fire ponds and dry hydrants to confirm sufficient capacity of the existing infrastructure for fire protection.

12. Provide new and replacement water system infrastructure designed to support future expansion and fire protection.

7.2 Combining Systems

Based on review of the water systems and the feasibility of combining the systems we recommended the following:

1. Collaborate between water companies to determine the direction of water system combination and replacement.

2. Design, permit and install the necessary upgrades to the Thetford Co-Op Water System to provide a water source connection for the Thetford Elementary School and Thetford Academy.

3. Design, permit and install the necessary upgrades to combine the Union Water Company, South Village Water Company, and North Village Water Company into one Public Water System Company.

4. Submit to funding agencies to advance grant and loan applications for the above noted project(s).

7.3 Potential Future Expansion

1. Replace existing water system distribution pipes with 8-inch water mains to provide fire protection capabilities for the systems.

2. Design, permit and create a new water system owned and operated by the Town for the Post Mills Village District. This system could be separate or combined with the existing water system in Post Mills to support the future anticipated development in Post Mills.

3. Appropriate funds for a feasibility study to upgrade the water system to provide water system infrastructure capable of providing fire protection infrastructure for the Town.

4. Design, permit and construct a connection between the Thetford Co-Op Water System and the North Thetford Water Systems (3 existing systems)

via a cross country connection to provide increased water flows, system pressure, and water quality.

7.4 Next Steps

1. Perform a detailed water resource capacity study, including a fracture trace analysis for the Post Mills, Thetford Hill and North Thetford to identify a sufficient water source for a community water system for a future Post Mills Water system, supplemental (or replacement) water supply for Thetford Hill and water supply for a combined North Thetford water system.
2. Develop a preliminary engineering report, for the design of specific future (or expanded) water system(s) to develop the location specific costs for proposed improvements to submit for pre-approval to funding sources.
3. Submit applications to the funding source(s) to be included on the priority list(s).
4. Obtain funding to perform detailed system designs for bidding and construction.

It should be noted that some funding sources require a loan commitment and are limited to municipalities, which would require the Town to take ownership of the water system for funding, operating and maintenance.

8.0 References

- *Environmental Protection Rules – Chapter 21 – Water Supply Rule, by VT ANR, dated March 17, 2020*
- *Federal Code Regulations, Title 40, Volume 22, Chapter 1, by the US EPA, dated July 1, 2009*
- *Avoiding Filtration of Surface Water and GWUDI of Surface Water in Vermont, by VT ANR, dated March 30, 1998*
- *Act 193 – Avoidance of Use of Lead in Plumbing Supplies, VT ANR, dated November 24, 2009*
- *Environmental Protection Rule : Groundwater Protection Rule and Strategy, by VT ANR, dated July 11, 2018*

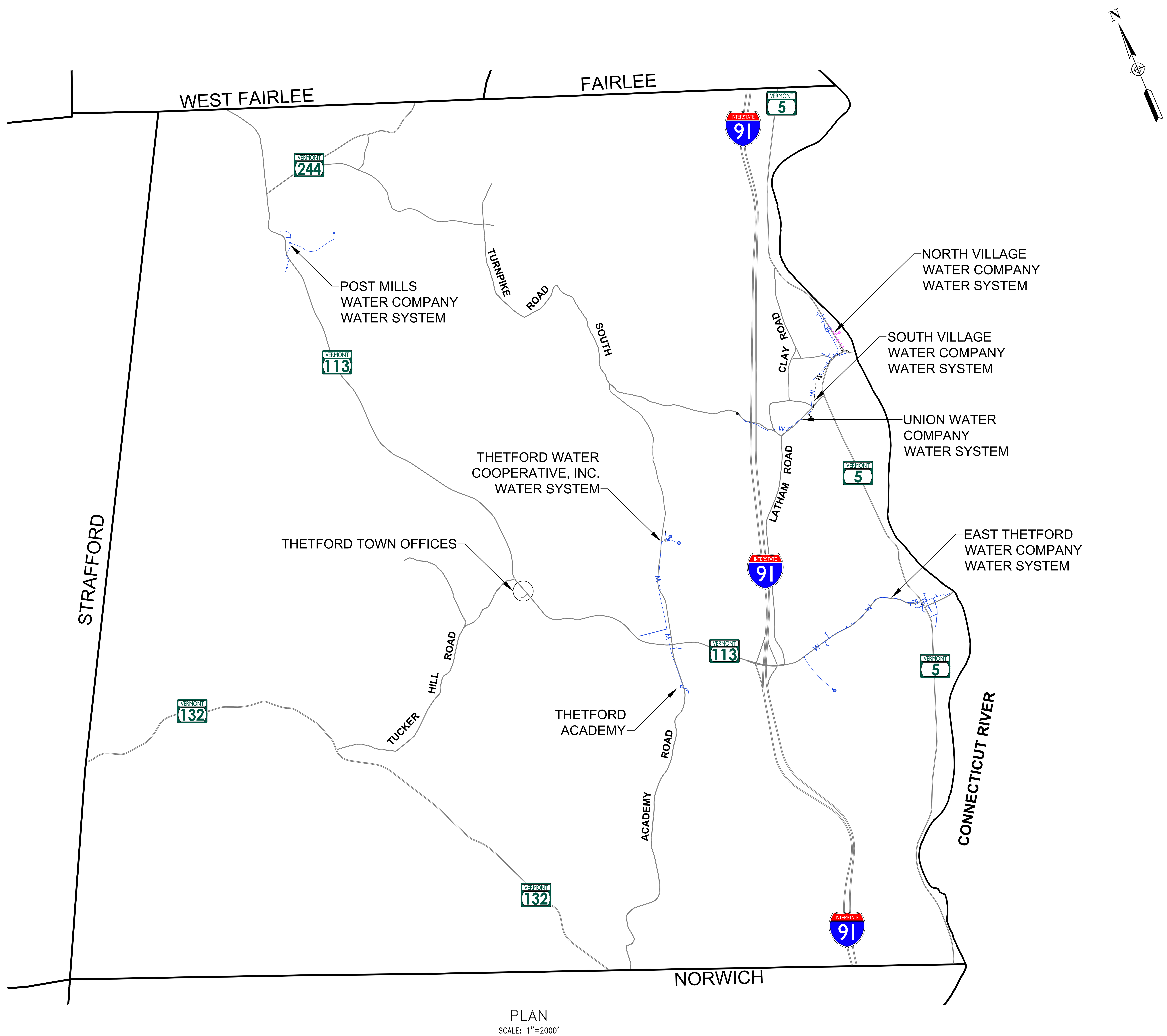
- *Thetford, Vermont 2020 Town Plan, adopted by the Thetford Selectboard, dated September 23, 2020*
- *Thetford, Vermont 2020 Town Plan Maps, by TRORC, dated September 11, 2020*
- *Town of Thetford, VT Zoning Bylaws, Adopted September 26, 2011*
- *Town of Thetford, VT Subdivision Regulations, effective June 28, 2021*
- *Preliminary Engineering Report – Post Mills Water System Improvements, by Wright Engineering, dated May 8, 2001*
- *Water System Improvements Plans for the Post Mills Water Association (6 plan sheets), by Wright Engineering, Ltd., dated December 5, 2021*
- *Upper Valley Regional Landfill Executive Order, dated July 28, 1998*
- *US Census data for Thetford, VT*
- *Vermont Well Yield Summary, by VT ANR, dated 2009*
- *Vermont Water Wells, by VT ANR, dated 2009*
- *East Thetford Water Company, Preliminary Engineering Report Plan, by Otter Creek Engineering, dated February 3, 2017*
- *FEMA Flood Insurance Maps, Town of Thetford, VT, Community Panel Numbers 500075 0010C, 5000750015C, 5000750020C, and 50002400020C, dated December 20, 1999*
- *Thetford Water Co-Op, Inc. Water Systems Upgrade (8 sheet plan set), By Harrington Engineering Inc., dated March 22, 2010*
- *System Base Map, Union Water Co., by Dufresne Group, dated May 2021*
- *Union Water Company Hydraulic Evaluation, by Dufresne Group Consulting Engineers, dated June 29, 2021*
- *Thetford Co-Op Source Protection Plan, by The Thetford Co-Op, dated June 2007*
- *Thetford Academy Water System WSID 6764 Operations and Maintenance Manual, by Otter Creek Engineering, Dated October 1, 2021*

- *Proposed Future Land Use Map – Thetford, Vermont Town Plan 2020 by TRORC, dated September 9, 2020*
- *Thickness of Overburden Map (of Vermont), by VT ANR, dated 2010*
- *Surficial Geological Map of Vermont, by Charles Doll, State of Vermont Geologist, dated 1970.*
- *Thetford Co-Op Sanitary Survey Letter, by VT DEC, dated October 21, 2021*
- *Survey of Highway Construction Materials in the Town of Thetford, by State of Vermont Engineering Geology Section, dated May 1965*
- *State of Vermont Agency of Natural Resources Department of Environmental Conservation Vermont Pollutant Discharge Elimination (VPDES) General Permit 3-9040 for Stormwater Discharges from Municipal Roads, dated January 26, 2018*
- *Ductile Iron Pipe Research Association, by Ductile Iron Pipe Association, dated 2015*
- *VTRANS 2-Year and 5-year Unit Weighted Prices, dated April 12, 2021*

APPENDICES

Appendix A

WATER SYSTEM MAPS



PLAN
SCALE: 1"=2000'

Stantec

Stantec Consulting Services Inc.
5 Dartmouth Drive Suite 200
Auburn NH 03032-3984
Tel: (603) 669-8672
www.stantec.com

LEGEND

- APPROX. PROPERTY LINE
- W — MAIN WATER DISTRIBUTION LINE
- WATER SERVICE LINE
- 970 — EXISTING CONTOUR
- W — WELL / WATER SOURCE
- PUMP / CONTROLS BUILDING (AS SPECIFIED)

NOTES

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TOWN OF THETFORD, VERMONT

THETFORD WATER SYSTEMS STUDY

Thetford, Vermont

Title
THETFORD WATER SYSTEMS MAP

Project No. 195113491
Scale AS SHOWN
Revision 0
Sheet 1 of 6
Drawing No. C-100

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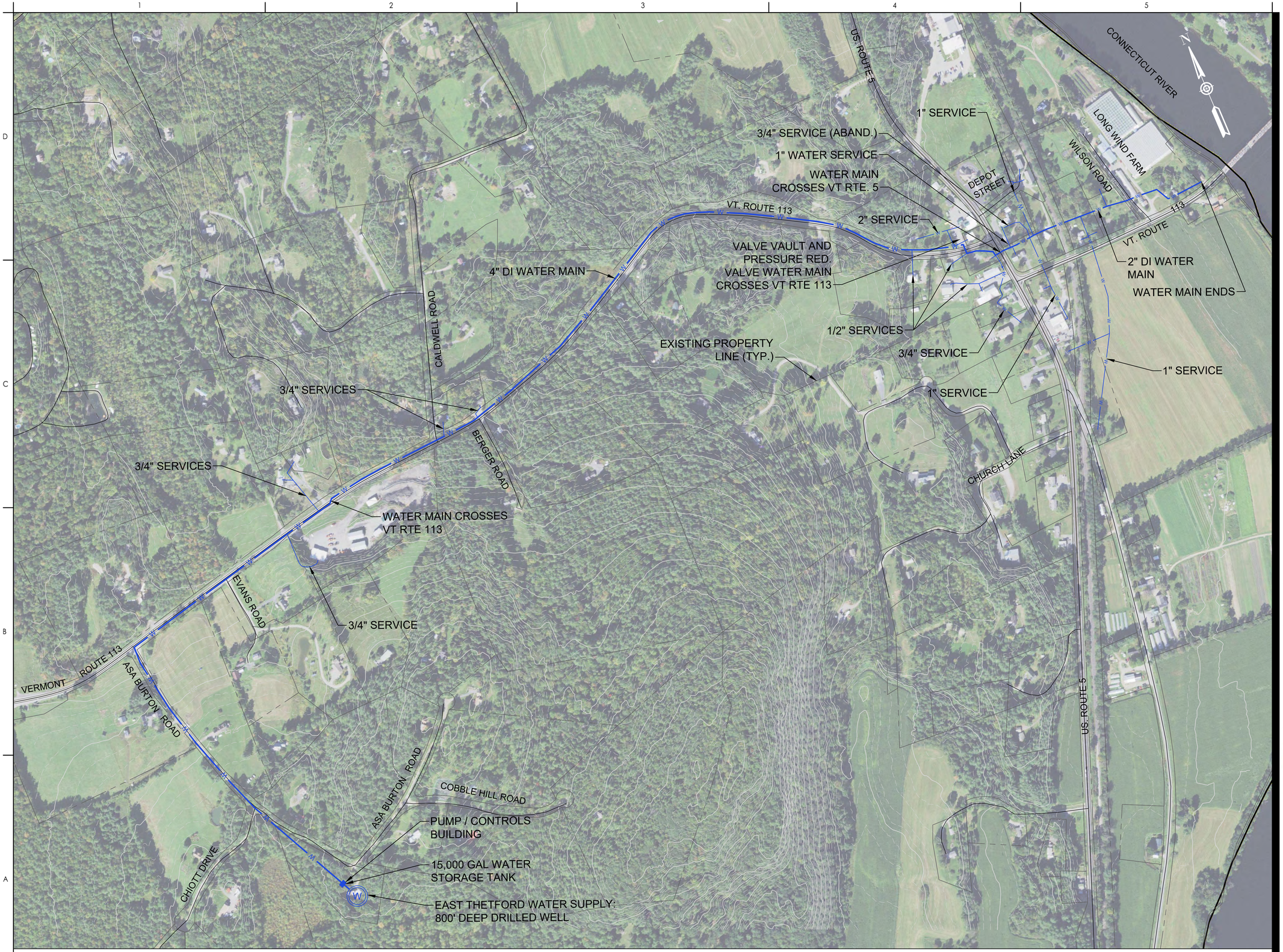

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THETFORD WATER SYSTEMS STUDY

Thetford, Vermont

Title
EAST THETFORD SYSTEM MAP

Project No.	Scale
195113491	AS SHOWN

Revision	Sheet	Drawing No.
0	2 of 6	C-101

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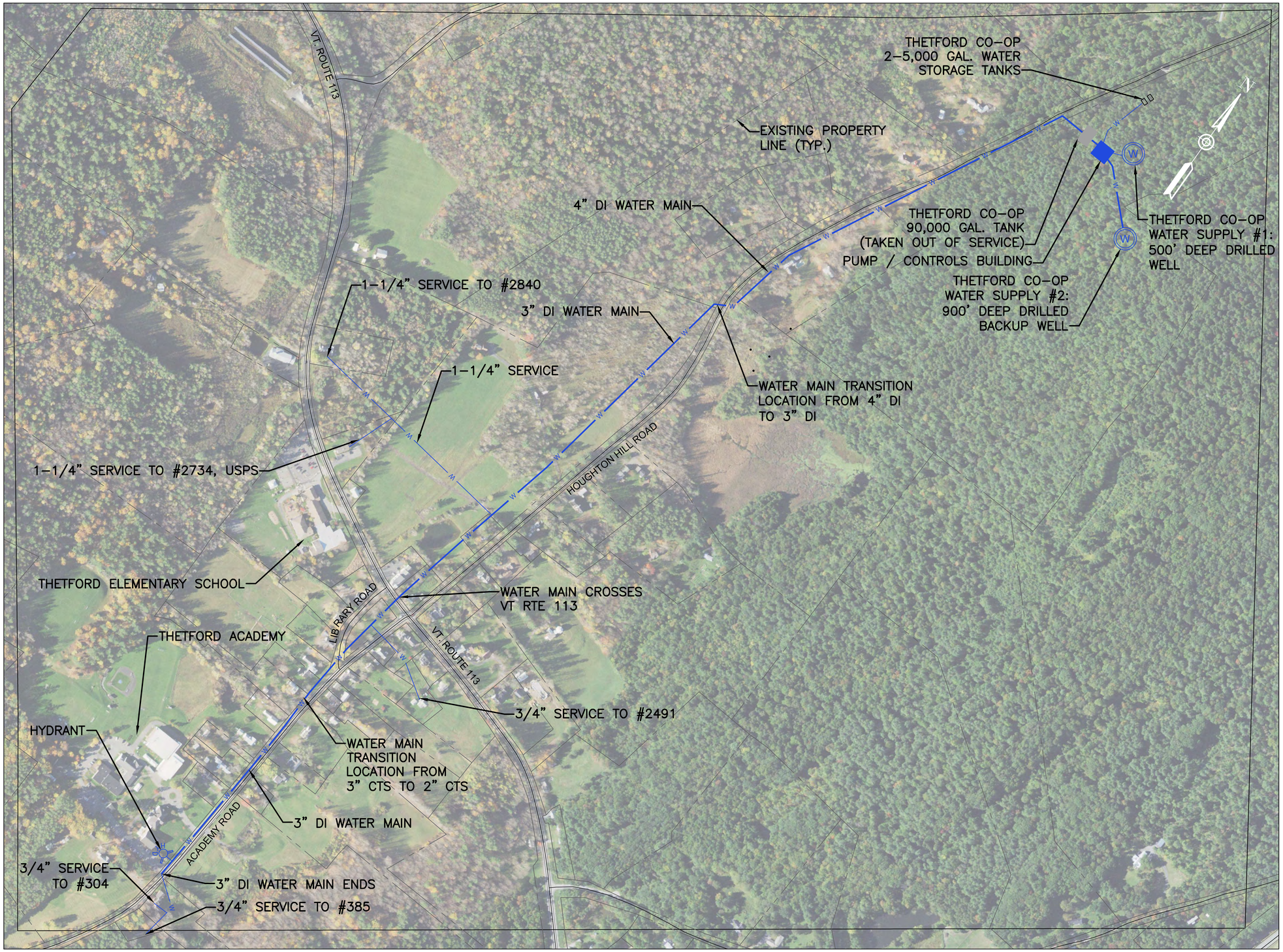

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THETFORD WATER SYSTEMS STUDY

Thetford, Vermont

Title
THETFORD CO-OP INC.
WATER SYSTEM MAP

Project No.	Scale
195113491	AS SHOWN
Revision: 0	Sheet: 3 of 6
Drawing No.	C-102

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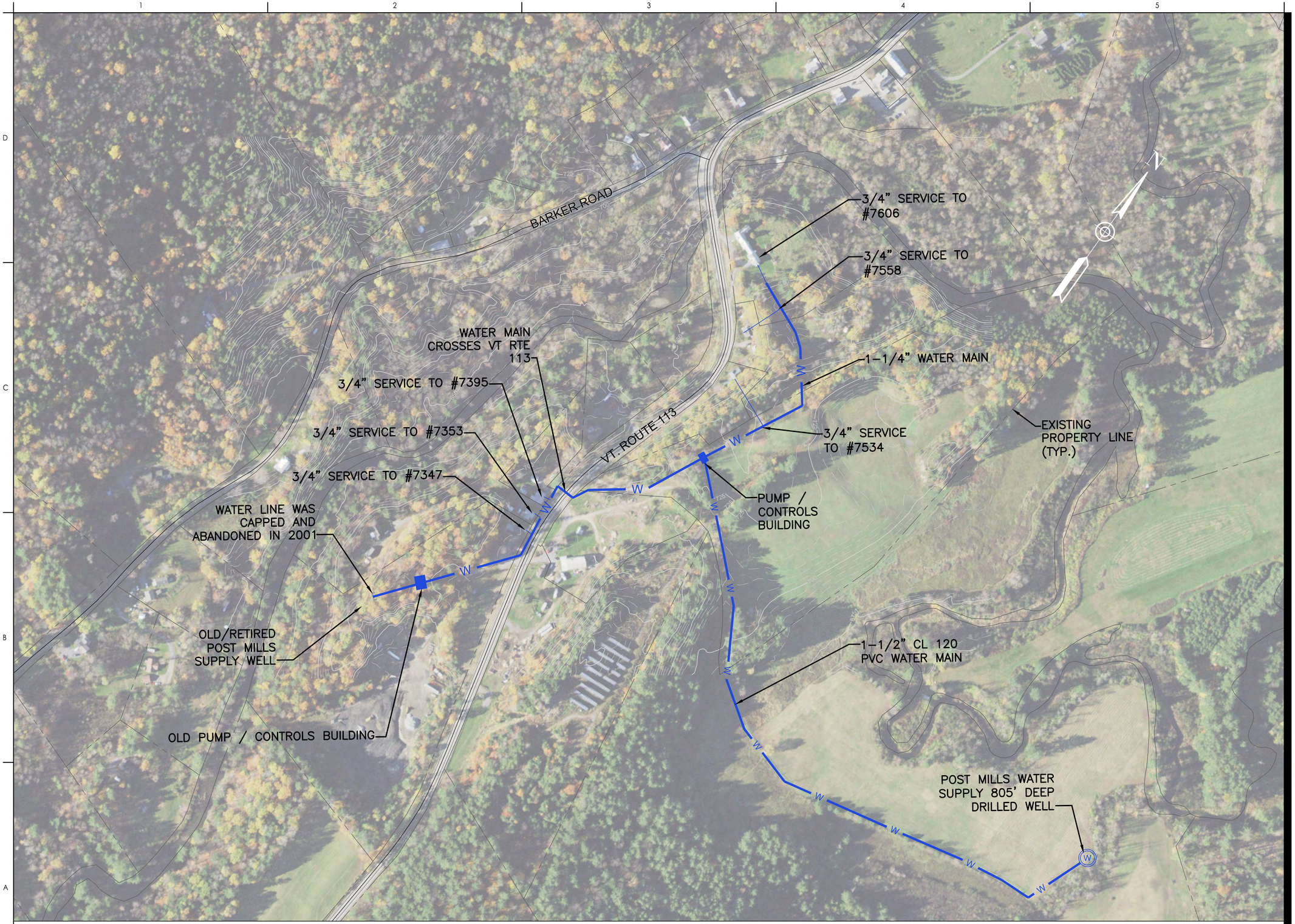

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Thetford, Vermont

Title
POST MILLS WATER COMPANY
WATER SYSTEM MAP

Project No.	Scale
195113491	AS SHOWN
Revision: 0	Sheet: 4 of 6
Drawing No.	C-103

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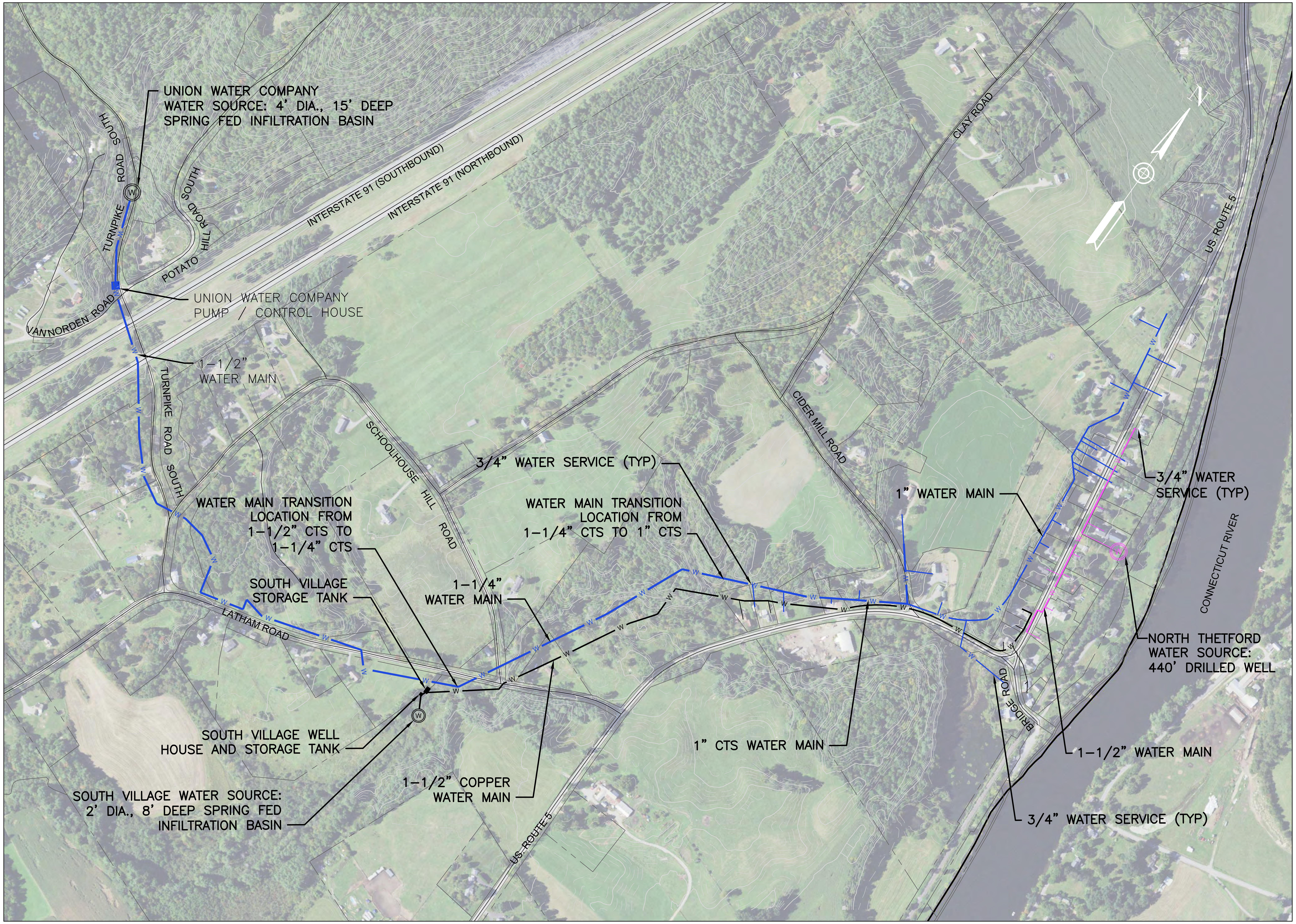

PLAN
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- WATER SERVICE LINE
- 970 EXISTING CONTOUR
- W WELL / WATER SOURCE
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THETFORD WATER SYSTEMS STUDY

Thetford, Vermont

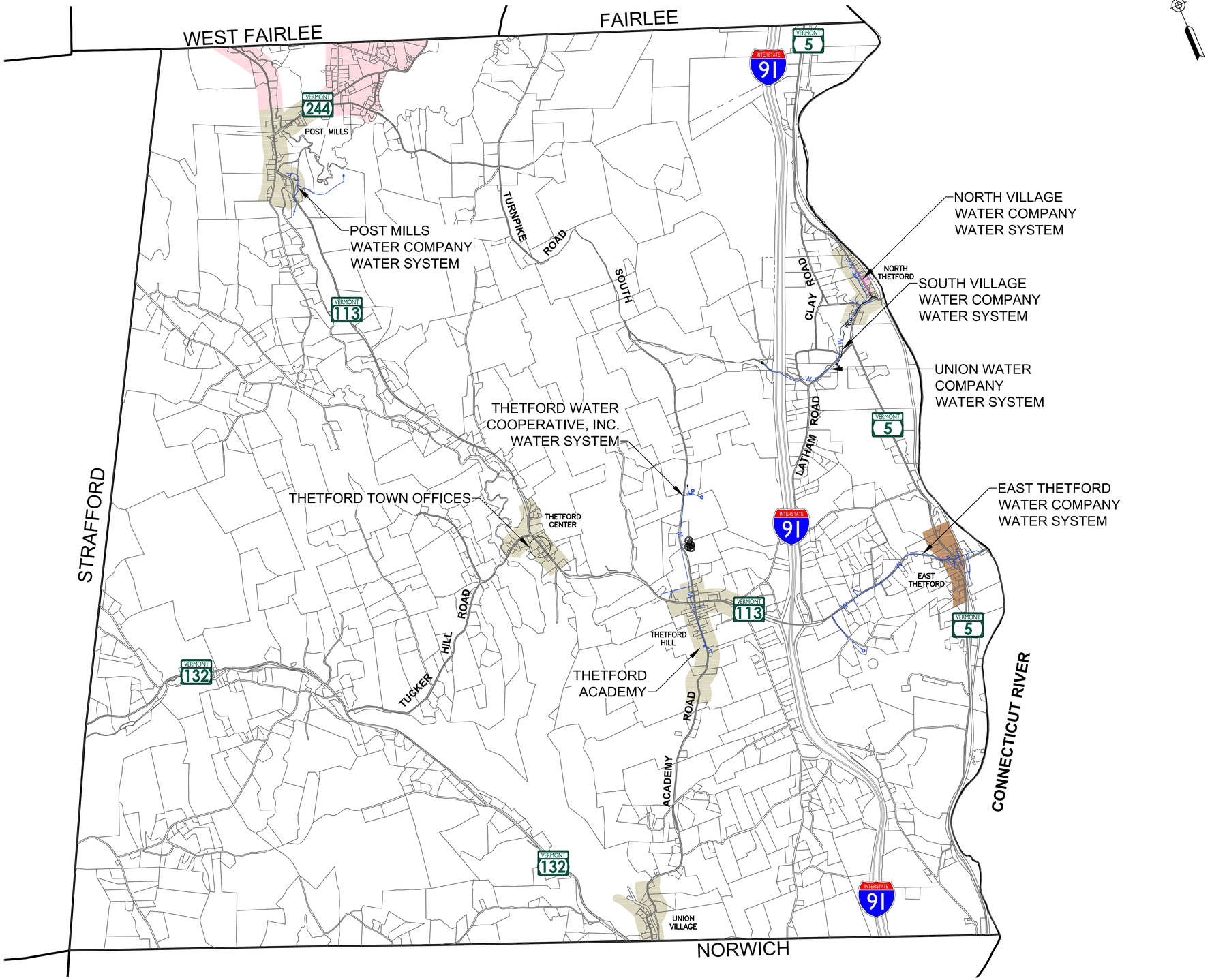
Title
UNION WATER COMPANY WATER SYSTEM MAP

Project No.	Scale
195113491	AS SHOWN

Revision	Sheet	Drawing No.
0	5 of 6	C-104

ORIGINAL SHEET - ARCH D

LAND USE AREAS



PLAN
SCALE: 1"=2000'

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- WATER SERVICE LINE
- EXISTING CONTOUR
- WELL / WATER SOURCE
- PUMP / CONTROLS BUILDING (AS SPECIFIED)
- NEIGHBORHOOD RESIDENTIAL
- VILLAGE RESIDENTIAL
- COMMUNITY BUSINESS

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THETFORD WATER SYSTEMS STUDY

Thetford, Vermont

Title
VILLAGES - FUTURE DEVELOPMENT AREAS

Project No.	Scale
195113491	AS SHOWN

Revision	Sheet	Drawing No.
0	6 of 6	C-105

Appendix B

SAMPLING, TESTING AND MONITORING SCHEDULE

VERMONT
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Drinking Water & Groundwater Protection Division
One National Life Drive - Davis 4
Montpelier, VT 05620-3521
http://dec.vermont.gov/water
Phone: 802-828-1535
Fax: 802-828-1541
Contact Us

2023 Monitoring Schedule Details

VT0005182 - UNION WATER CO

System Type: C Population: 61 Primary Source: GW

Generated on 4/19/2023 from https://anrweb.vt.gov/DEC/dwgwp

Notes: For additional monitoring requirement details, view instructions here. Click on chemical groups below for a list of all included analytes within the group. Water Systems that do not follow their required monitoring schedule will receive a monitoring violation.

Entry Point to Distribution System Samples (Finished Water)

If using treatment, take these samples from finished water after treatment

Facility ID: TP001 - TREATMENT PLANT
Sample Point: EP002

Analyte/Group	Monitoring Period	Sample Frequency	Sample Site
PFAS - VT 5 SUM	4/1 - 6/30	1 per 3 years	
NITRATE	10/1 - 12/31	1 per year	

Distribution System Samples - always follow approved sampling plans

Routine Total Coliform Bacteria

Sample location(s):

Facility ID	Facility Name	Sample Point
DS001	DISTRIBUTION SYSTEM	TC001

Sample schedule(s):

Monitoring Period	Sample Frequency
1/1 - 12/31	1 per month

Lead and Copper

Facility ID: DS001 - DISTRIBUTION SYSTEM
Sample Point: LC001

Analyte/Group	Monitoring Period	Sample Frequency	Sample Sites
LEAD AND COPPER	6/1 - 9/30	5 per 3 years	

VERMONT
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Drinking Water & Groundwater Protection Division
One National Life Drive - Davis 4
Montpelier, VT 05620-3521
http://dec.vermont.gov/water
Phone: 802-828-1535
Fax: 802-828-1541
Contact Us

2023 Monitoring Schedule Details

VT0005181 - THETFORD WATER COOP INC

System Type: C Population: 115 Primary Source: GW

Generated on 4/19/2023 from https://anrweb.vt.gov/DEC/dwgwp

Notes: For additional monitoring requirement details, view instructions here. Click on chemical groups below for a list of all included analytes within the group. Water Systems that do not follow their required monitoring schedule will receive a monitoring violation.

Entry Point to Distribution System Samples (Finished Water)

If using treatment, take these samples from finished water after treatment

Facility ID: TP001 - TREATMENT PLANT 1
Sample Point: EP001

Analyte/Group	Monitoring Period	Sample Frequency	Sample Site
NITRATE	4/1 - 6/30	1 per year	
PFAS - VT 5 SUM	10/1 - 12/31	1 per 3 years	

Distribution System Samples - always follow approved sampling plans

Routine Total Coliform Bacteria

Sample location(s):

Facility ID	Facility Name	Sample Point
DS001	DISTRIBUTION SYSTEM	TC001

Sample schedule(s):

Monitoring Period	Sample Frequency
1/1 - 12/31	1 per month

Lead and Copper

Facility ID: DS001 - DISTRIBUTION SYSTEM
Sample Point: LC001

Analyte/Group	Monitoring Period	Sample Frequency	Sample Sites
LEAD AND COPPER	6/1 - 9/30	5 per 3 years	

VERMONT
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Drinking Water & Groundwater Protection Division
One National Life Drive - Davis 4
Montpelier, VT 05620-3521
http://dec.vermont.gov/water
Phone: 802-828-1535
Fax: 802-828-1541
Contact Us

2023 Monitoring Schedule Details

VT0005184 - EAST THETFORD WATER CO

System Type: C Population: 250 Primary Source: GW

Generated on 4/19/2023 from https://anrweb.vt.gov/DEC/dwgwp

Notes: For additional monitoring requirement details, view instructions here. Click on chemical groups below for a list of all included analytes within the group. Water Systems that do not follow their required monitoring schedule will receive a monitoring violation.

Entry Point to Distribution System Samples (Finished Water)

If using treatment, take these samples from finished water after treatment

Facility ID: TP001 - TREATMENT PLANT 1
Sample Point: EP001

Analyte/Group	Monitoring Period	Sample Frequency	Sample Site
IRON AND MANGANESE	1/1 - 3/31	1 per quarter	DISTRIBUTION ENTRY POINT
IRON AND MANGANESE	4/1 - 6/30	1 per quarter	DISTRIBUTION ENTRY POINT
IRON AND MANGANESE	7/1 - 9/30	1 per quarter	DISTRIBUTION ENTRY POINT
NITRATE	7/1 - 9/30	1 per year	DISTRIBUTION ENTRY POINT
IRON AND MANGANESE	10/1 - 12/31	1 per quarter	DISTRIBUTION ENTRY POINT
PFAS - VT 5 SUM	10/1 - 12/31	1 per 3 years	DISTRIBUTION ENTRY POINT
VOLATILE ORGANIC CHEMICALS	10/1 - 12/31	1 per year	DISTRIBUTION ENTRY POINT

Distribution System Samples - always follow approved sampling plans

Routine Total Coliform Bacteria

Sample location(s):

Facility ID	Facility Name	Sample Point
DS001	DISTRIBUTION SYSTEM	TC001

Sample schedule(s):

Monitoring Period	Sample Frequency
1/1 - 12/31	1 per month

Lead and Copper

Facility ID: DS001 - DISTRIBUTION SYSTEM
Sample Point: LC001

Analyte/Group	Monitoring Period	Sample Frequency	Sample Sites
LEAD AND COPPER	1/1 - 6/30	10 per 6 months	
LEAD AND COPPER	7/1 - 12/31	10 per 6 months	

Distribution System Samples - always follow approved sampling plans

Routine Total Coliform Bacteria

Sample location(s):

Facility ID	Facility Name	Sample Point
DS001	DISTRIBUTION SYSTEM	TC001

Sample schedule(s):

Monitoring Period	Sample Frequency
1/1 - 12/31	1 per quarter

Disinfection Byproducts (DBPs)

Facility: DS001 - DISTRIBUTION SYSTEM

Analyte	Monitoring Period	Sample Point	Sample Site
Haloacetic Acids	9/1 - 9/30	HA001	GARAGE
Trihalomethanes	9/1 - 9/30	TH001	GARAGE

Appendix C

THETFORD RESOURCE MAPS

THETFORD, VERMONT, 2020 TOWN PLAN — MAP APPENDIX

Adopted September 11, 2020.

CONTENTS

Current
Land Use Map
Thetford, Vermont
Town Plan 2020

Adopted 9/11/2020

1:43,969

1 inch = 3,664 feet

0 0.5 1

Miles

N

- Interstate Highway
- US Highway
- State Highway
- Town Highway Class 2
- Town Highway Class 3
- Town Highway Class 4
- Private Road
- State Forest Highway
- 911 structure

- Federal Lands
- State Lands
- Town Lands
- Private Conserved Lands
- Current Use

TRORC
Two Rivers-Ottauquechee
REGIONAL COMMISSION

For Planning purposes only.
Not for regulatory interpretation.

Current and Proposed Transportation Map
Thetford, Vermont
Town Plan 2020

Adopted 9/11/2020

1:43,969
1 inch = 3,664 feet
0 0.5 1
Miles

- VT route/TH cls 1
- TH cls 2
- TH cls 2 gravel
- TH cls 3
- TH cls 3 gravel
- TH cls 4
- trail
- private
- US route
- US interstate
- VT forest hwy
- RR
- Stagecoach 91 Service

Public Lands

N

Two Rivers-Ottauquechee Regional Commission

For Planning purposes only.
Not for regulatory interpretation.

Current and Proposed Utilities, Facilities & Education Map

Thetford, Vermont

Town Plan 2020

Adopted 9/11/2020

VERSHIRE
WEST FAIRLEE
FAIRLEE
ORFORD
LYME
STRAFFORD
SHARON
NORWICH
HANOVER

Thetford Vol. FD- Post Mills Station
Peabody Library
Post Mills Airport
POST MILLS NATURE AREA
TOWN OF THETFORD
THETFORD TOWN FOREST
HUGHES FOREST
Barker Brook
Abbott Brook
Jackson Brook
Fulton Brook
Police Station
Town Office
Town Garage
Thetford Vol. FD Communications Bldg.
Thetford Elementary School
Latham Library
Open Fields School
Thetford Academy
Thetford Hill State Park
THETFORD HILL STATE FOREST
Thetford Amerigas Water Coop Inc
PARK & RIDE
East Thetford Water Co
Communication Tower
Connecticut River
Ledoge Brook
West Branch Ompompanoosuc River
Lord Brook
Coppers Brook
USACE UNION VILLAGE DAM
Ompompanoosuc River
Avery Brook

VERMONT 113
VERMONT 244
VERMONT 132
91
5

- VT route/TH cls 1
- TH cls 2
- TH cls 2 gravel
- TH cls 3
- TH cls 3 gravel
- TH cls 4
- trail
- private
- US route
- US interstate
- VT forest hwy
- 911 structure
- Facilities
- 3 Phase Line
- Transmission Line

- Federal Lands
- State Lands
- Town Lands

1:43,994

1 inch = 3,666 feet

0 0.5 1

Miles

N

For Planning purposes only.
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REGIONAL COMMISSION

Water & Slope
Thetford, Vermont
Town Plan 2020

Adopted 9/11/2020

- VT route/TH cls 1
- TH cls 2
- TH cls 2 gravel
- TH cls 3
- TH cls 3 gravel
- TH cls 4
- trail
- private
- US route
- US interstate
- VT forest hwy

- Wetlands
- WellHead Protection Areas
- SPECIAL FLOOD HAZARD AREA
- VT RIVER CORRIDORS

SLOPE

- 0 - 15 %
- 15 - 25 % Steep
- > 25 % Very Steep

River Corridor and FEMA NFIP maps are available for Vermont here:

http://tinyurl.com/floodreadyatlas

N

1:42,290
1 inch = 3,524 feet

0 0.5 1
Miles

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Two Rivers-Ottauquechee
REGIONAL COMMISSION

For Planning purposes only. Not for regulatory interpretation.

Proposed Future Land Use Map
Thetford, Vermont
Town Plan 2020

Adopted 9/11/2020

1:43,969

1 inch = 3,664 feet

0 0.5 1

Miles

- VT route/TH cls 1
- TH cls 2
- TH cls 2 gravel
- TH cls 3
- TH cls 3 gravel
- TH cls 4
- trail
- private
- US route
- US interstate
- VT forest hwy
- 911 structure

LAND USE AREAS

- Neighborhood Residential NR
- Village Residential VR
- Community Business CB
- Rural
- Thetford Hill Historic Overlay
- Forest Block Overlay

OTHER AREAS

- Federal Lands
- State Lands
- Town Lands

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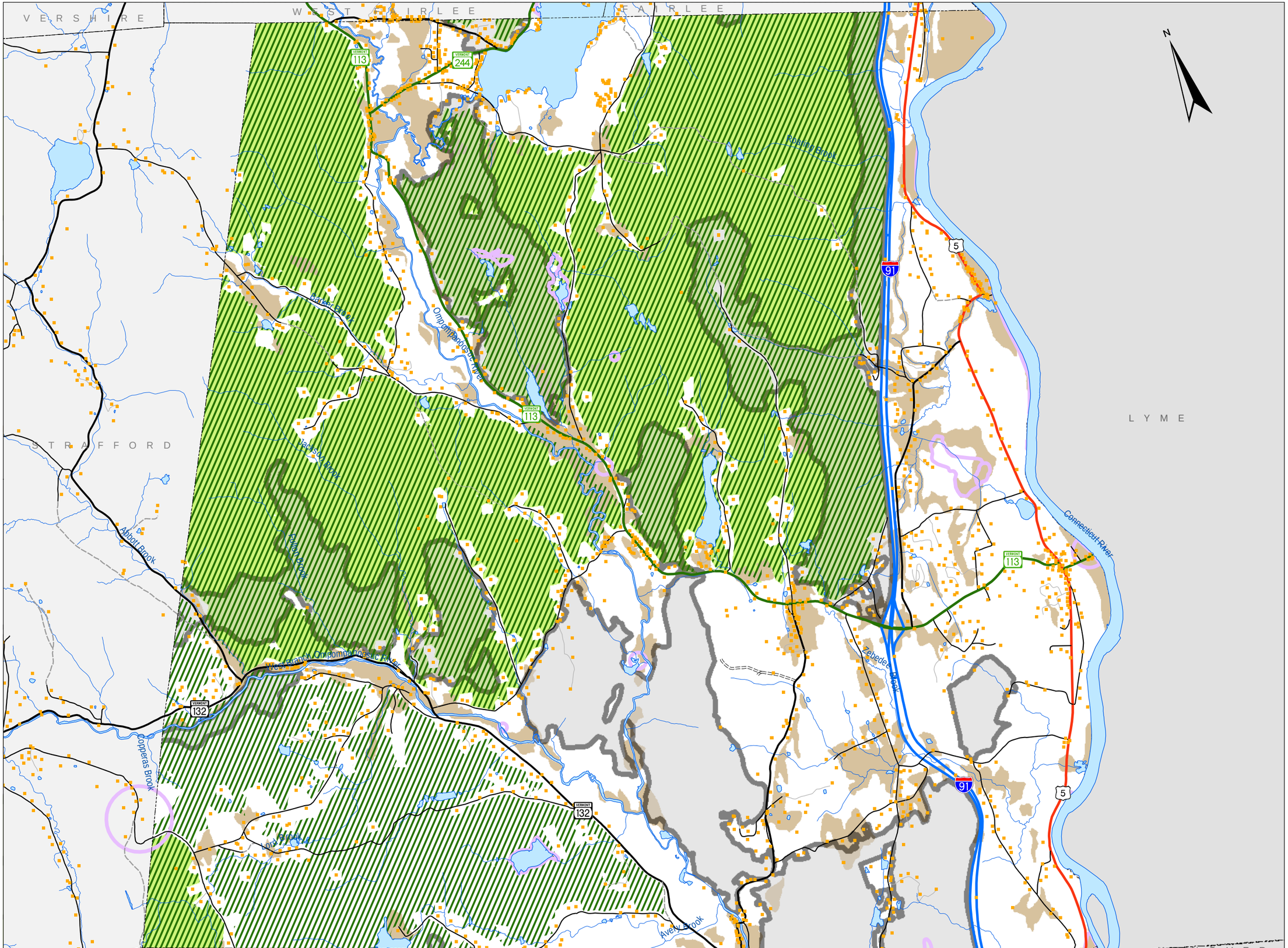
Two Rivers-Ottauquechee
REGIONAL COMMISSION

Natural Resources
Thetford, Vermont
Town Plan 2020

Adopted 9/11/2020



- Interstate Highway
- US Highway
- State Highway

- Town Highway Class 2
- Town Highway Class 3
- Town Highway Class 4
- Private Road
- State Forest Highway

- Natural Communities
- Deer Wintering Areas
- NRCS Prime Ag.

VT Conservation Design

- Highest Priority Interior Forest Blocks
- Highest Priority Connector Forest Blocks

1:42,290

1 inch = 3,524 feet

0 0.5 1

Miles

TRORC
Two Rivers-Ottauquechee
REGIONAL COMMISSION

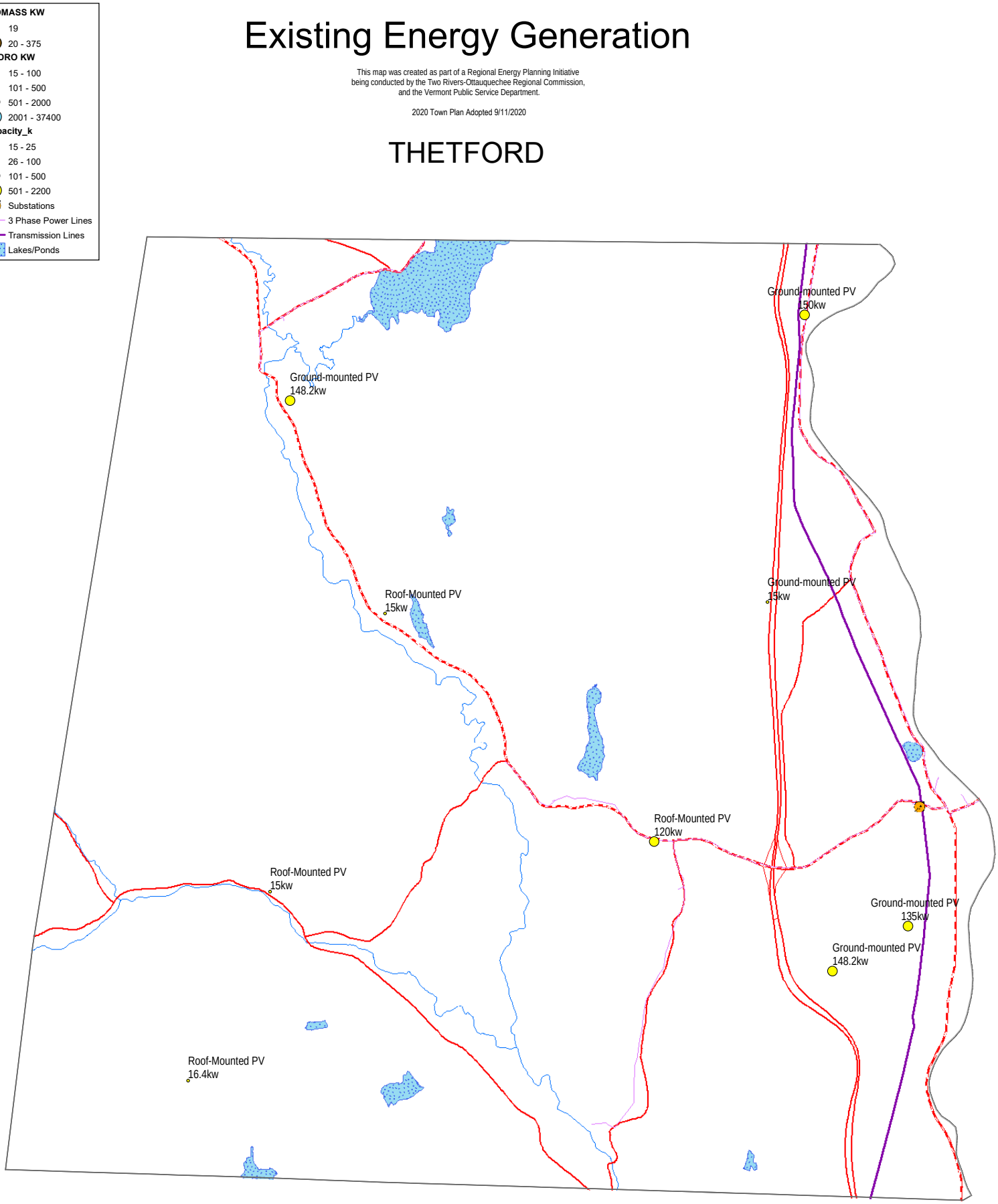
For Planning purposes only. Not for regulatory interpretation.

Existing Energy Generation

This map was created as part of a Regional Energy Planning Initiative
being conducted by the Two Rivers-Ottauquechee Regional Commission,
and the Vermont Public Service Department.

2020 Town Plan Adopted 9/11/2020

THETFORD



Two Rivers-Ottauquechee
REGIONAL COMMISSION
trorc.org

Solar Energy Potential

This map was created as part of a Regional Energy Planning Initiative being conducted by the Two Rivers-Ottauquechee Regional Commission, and the Vermont Public Service Department.

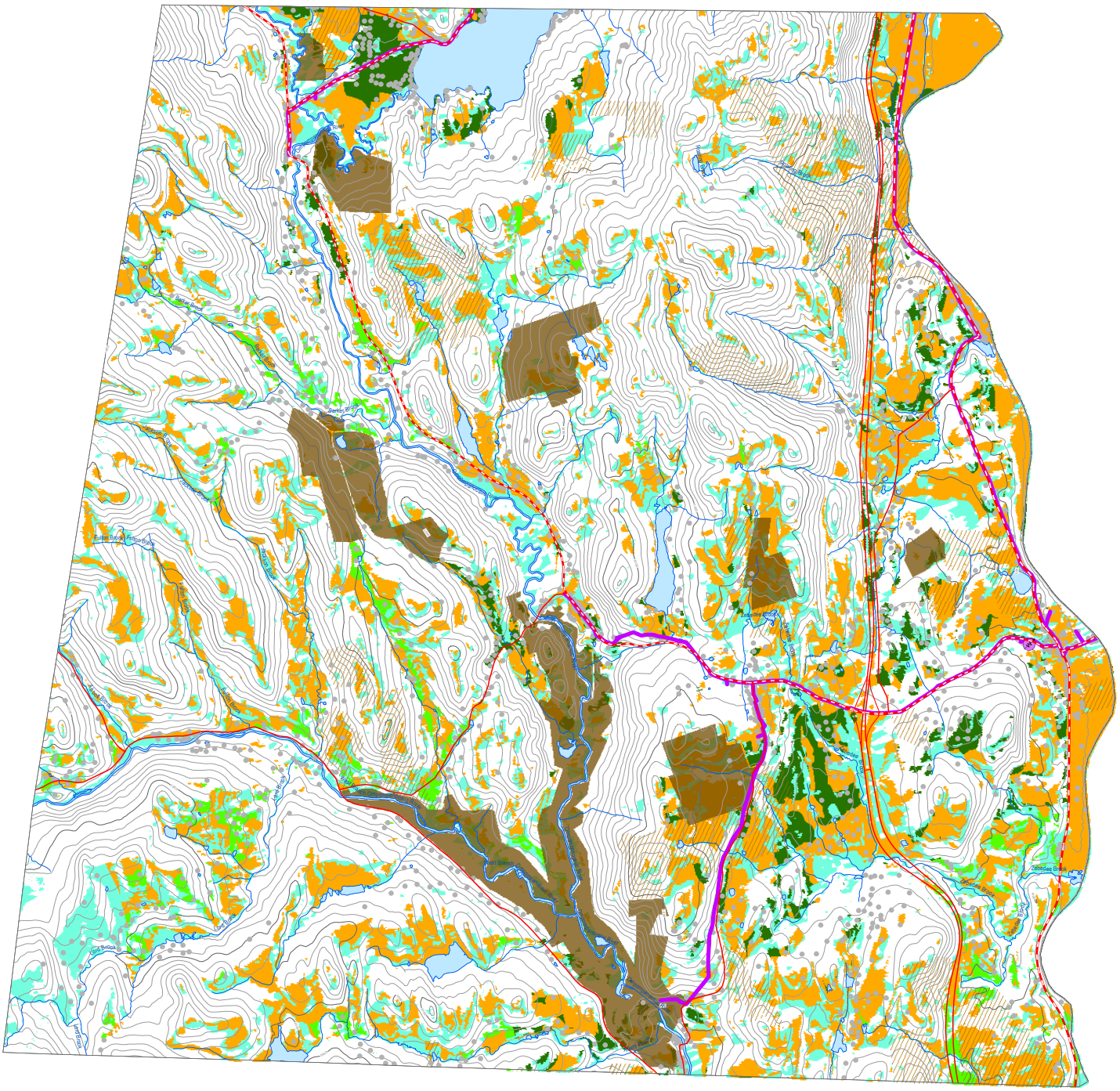
2020 Town Plan Adopted 9/11/2020

THETFORD

Substations
3 Phase Power Lines
Structures w/1ac buffer

Conserved
Public Cons
Private Cons

SOLAR POTENTIAL
Suitability
Prime
Constraints
Prime 1m 3phase
RAW solar



Solar
This map shows areas of potential electricity generation from solar energy. It includes areas with good access to solar radiation and also considers other conditions that may limit the feasibility of solar energy development. These limiting factors are referred to as constraints. Areas of prime solar potential exist where the natural conditions make development feasible and no constraints are present.

These maps are designed to initially identify areas and follow-up on-site work is required to verify the areas are feasible for projects. They are subject to revision and are NOT intended to green-light or fast-track projects.

DARK GREEN Prime: No Constraints within 1 mile 3 phase power
GREEN Prime: No Constraints no known or possible constraints present
ORANGE Constraints no known but at least one or more possible constraints
BLUE GREEN Raw potential with constraints

Known Constraints
Vernal Pools (confirmed and unconfirmed layers)
DEC River Corridors
FEMA Floodways
State-significant Natural Communities and Rare, Threatened, and Endangered Species
Wilderness Areas, including National Wilderness Areas
Class 1 and Class 2 Wetlands (VSWI and advisory layers)

Possible Constraints
Agricultural Soils (VT Agriculturally Important Soil Units)
FEMA Special Flood Hazard Areas
Protected Lands (Updated 07/26/2016.)
Act 250 Agricultural Soil Mitigation areas
Deer Wintering Areas
ANR's Vermont Conservation Design Highest Priority Forest Block Datasets
Forest Blocks - Connectivity
Forest Blocks - Interior
Forest Blocks - Physical Land Division
Hydric Soils

TRORC Unsuitable areas (included in known constraints)
FEMA Floodways
Wilderness Areas, including National Wilderness Areas
Class 1 Wetland

N

Two Rivers-Ottauquechee REGIONAL COMMISSION
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0 0.475 0.95 1.9 Miles

Wind Energy Potential

This map was created as part of a Regional Energy Planning Initiative being conducted by the Two Rivers-Ottauquechee Regional Commission, and the Vermont Public Service Department.

2020 Town Plan Adopted 9/11/2020

THETFORD

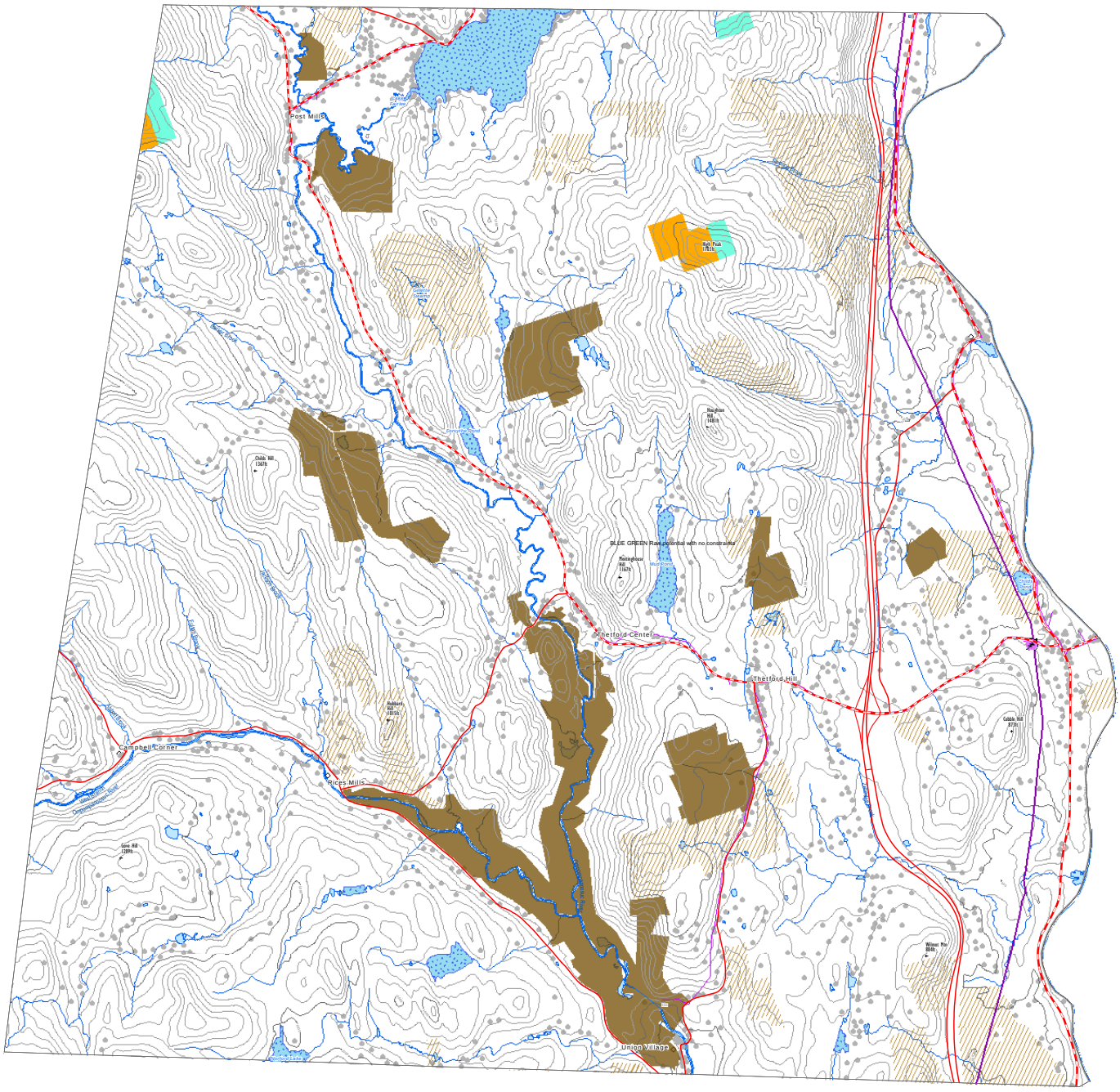
- Substations
- 3 Phase Power Lines
- Transmission Lines
- Lakes/Ponds
- Rivers/Streams

Conserved

- Public Cons
- Private Cons
- Structures w/1ac buffer

Wind Potential Suitability, HubHeight

- Prime, 50
- Prime, 70
- Constraints, 50
- Constraints, 70
- Prime 1m 3phase
- RAW wind



Wind
This map shows areas of potential wind energy development. It includes areas with good access to wind resources and also considers other conditions that may limit the feasibility of wind energy development. These limiting factors are referred to as constraints. Areas of prime wind potential exist where the natural conditions make development feasible and no constraints are present.

These maps are designed to initially identify areas and follow-up on-site work is required to verify the areas are feasible for projects. They are subject to revision and are NOT intended to green-light or fast-track projects.

DARK GREEN Prime: No Constraints within 1 mile 3 phase power
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ORANGE Constraints no known but at least one or more possible constraints
BLUE GREEN Raw potential with constraints

Known Constraints
Vernal Pools (confirmed and unconfirmed layers)
DEC River Corridors
FEMA Floodways
State-significant Natural Communities and Rare, Threatened, and Endangered Species
Wilderness Areas, including National Wilderness Areas
Class 1 and Class 2 Wetlands (VSWI and advisory layers)

Possible Constraints
Agricultural Soils (VT Agriculturally Important Soil Units)
FEMA Special Flood Hazard Areas
Protected Lands (Updated 07/26/2016.)
Act 250 Agricultural Soil Mitigation areas
Deer Wintering Areas
ANR's Vermont Conservation Design Highest Priority Forest Block Datasets
Forest Blocks - Connectivity
Forest Blocks - Interior
Forest Blocks - Physical Land Division
Hydric Soils

TRORC Unsuitable areas (included in known constraints)
FEMA Floodways
Wilderness Areas, including National Wilderness Areas
Class 1 Wetland

N

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Two Rivers-Ottauquechee
REGIONAL COMMISSION
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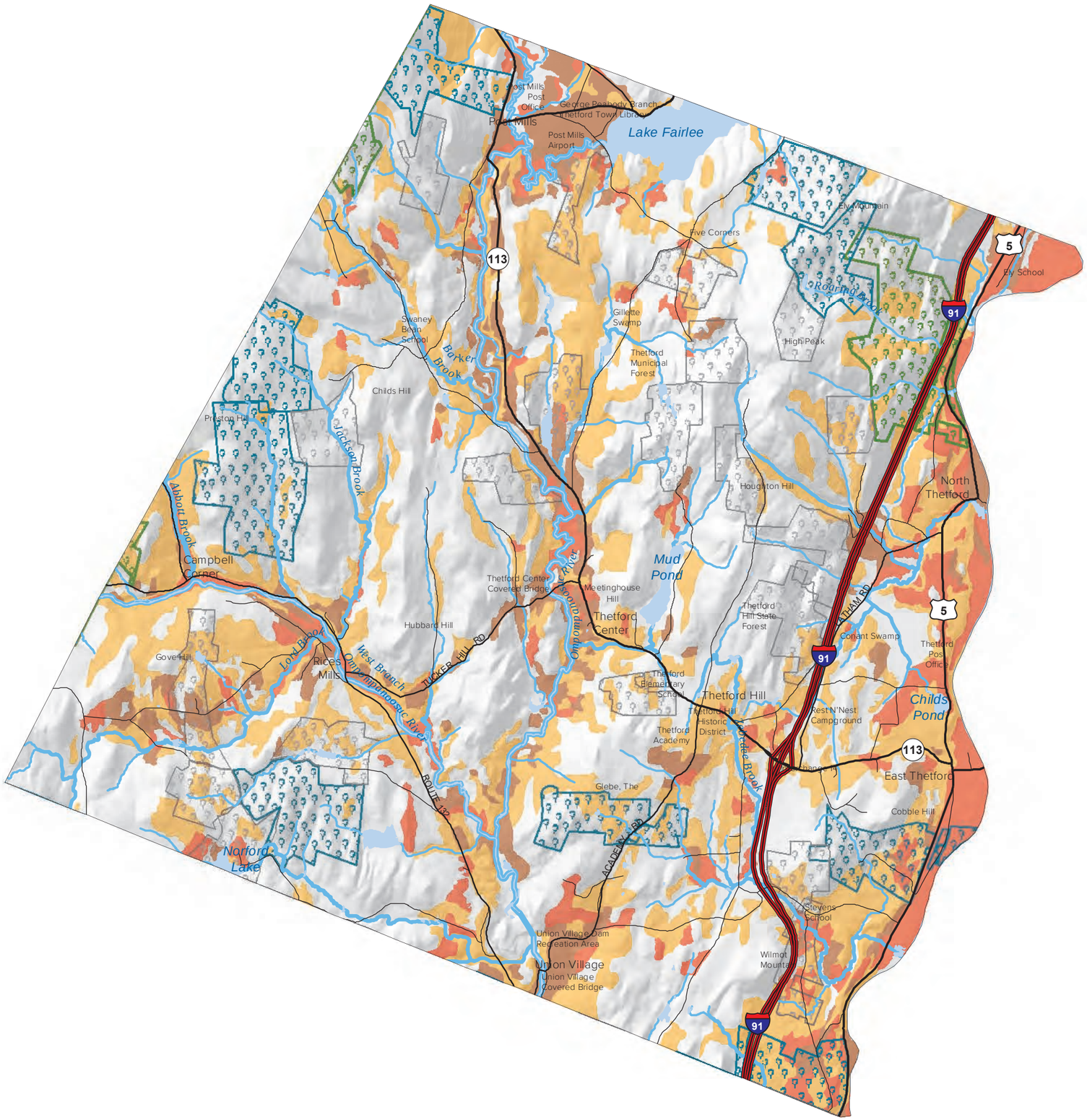
0 0.5 1 2 Miles

Town of Thetford Vermont

Phase-I Natural Resources Inventory

Thetford Working Forest Resources

1:55,000



This map is not a survey. Map contains data of varying accuracy and age.

Map produced: 11/11/2019
Map Coordinate System: VT State Plane (NAD 83)

Analysis by:

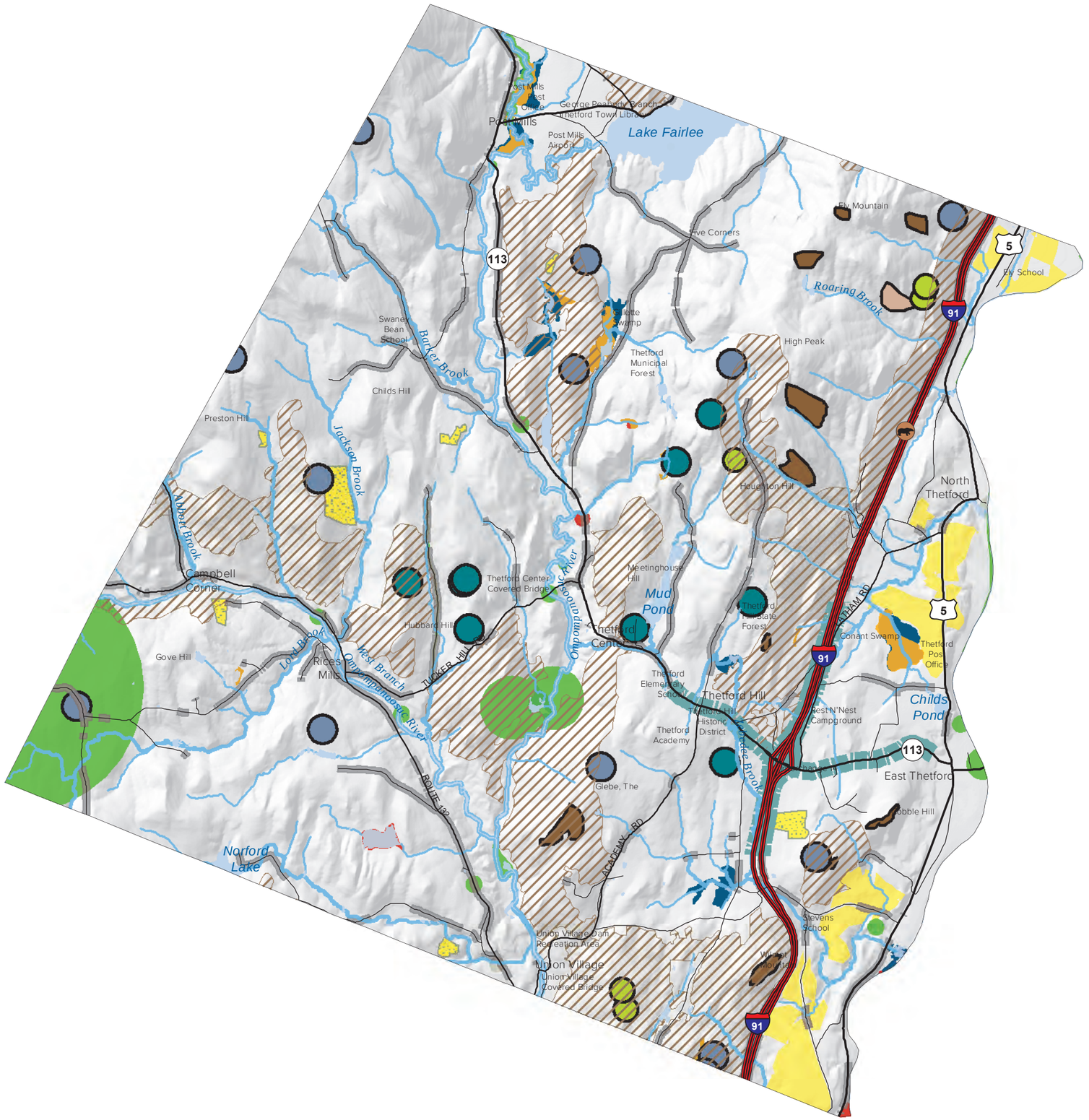
Native Geographic, LLC

Town of Thetford Vermont

Phase-I Natural Resources Inventory

Thetford Wildlife Plant, and Natural Community Resources

1:55,000



- Bear Crossing
- Moose Crossings (Medium)
- Potential High Priority Wildlife Crossings
- Deer Wintering Area
- Confirmed Vernal Pools (VVMP)
- Confirmed Vernal Pools (NG)
- Unconfirmed Vernal Pools
- Rare, Threated, and/or Endangered Animal
- Rare, Threated, and/or Endangered Plant
- State Sig. Natural Community
- Uncommon Animal
- Uncommon Plant
- Locally Sig. Wetland (AE)
- Shrublands
- Grassland Bird Core Habitat
- Mast Area (NG)
- Potential Mast Area (NG)

This map is not a survey. Map contains data of varying accuracy and age.

Map produced: 11/11/2019
Map Coordinate System: VT State Plane (NAD 83)

Analysis by:

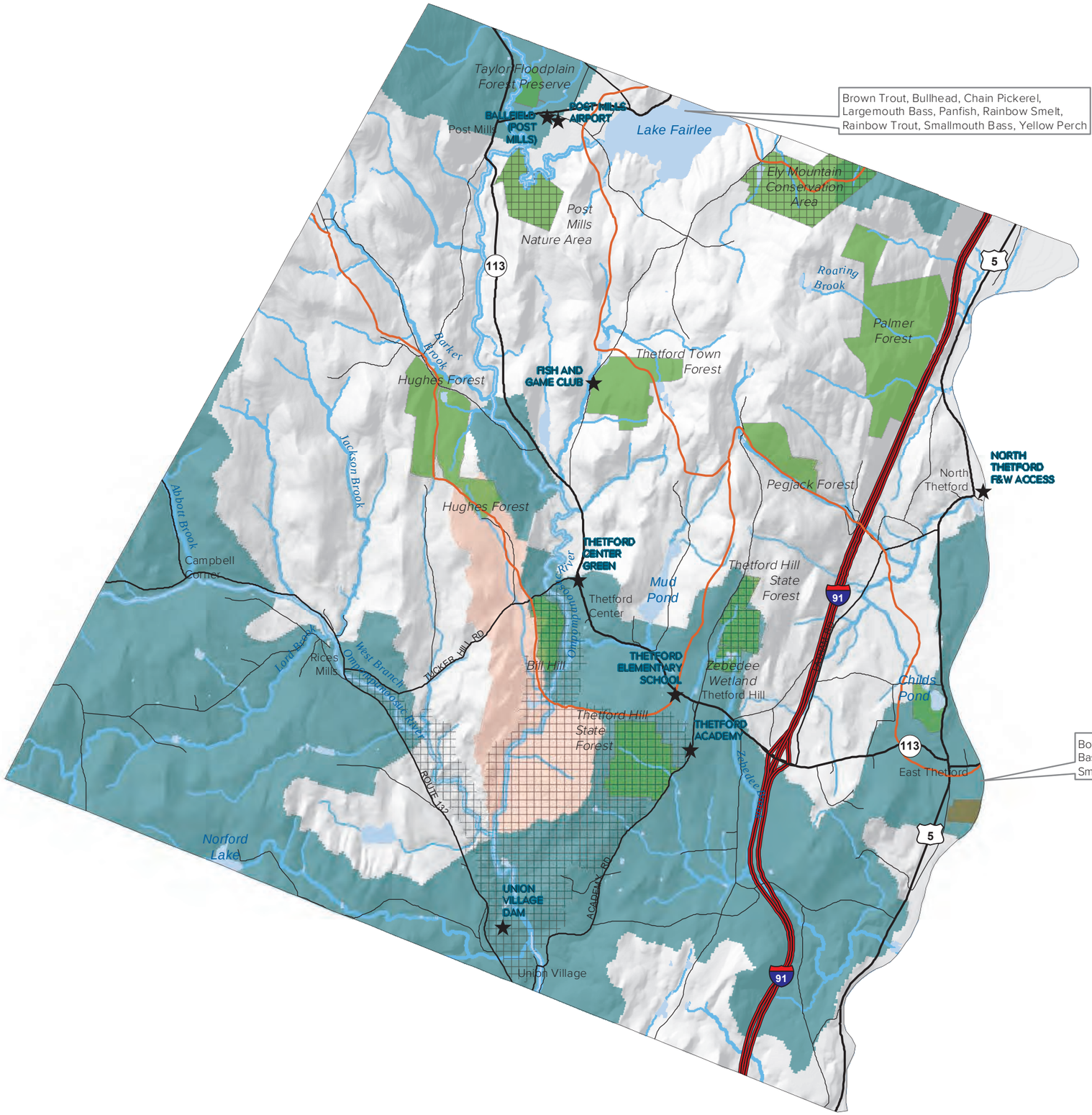
Native Geographic, LLC

Town of Thetford Vermont

Phase-I Natural Resources Inventory

Thetford Recreation Resources

1:55,000



- Outdoor Recreation Sites
- Snowmobile Trail
- Property with Public Trails

Protected Lands with Public Access

- Public Access
- Limited Public Access

Trout Streams and Rivers

- Mixed Wild Trout
- Wild Brook Trout

This map is not a survey. Map contains data of varying accuracy and age.

Map produced: 11/11/2019
Map Coordinate System: VT State Plane (NAD 83)

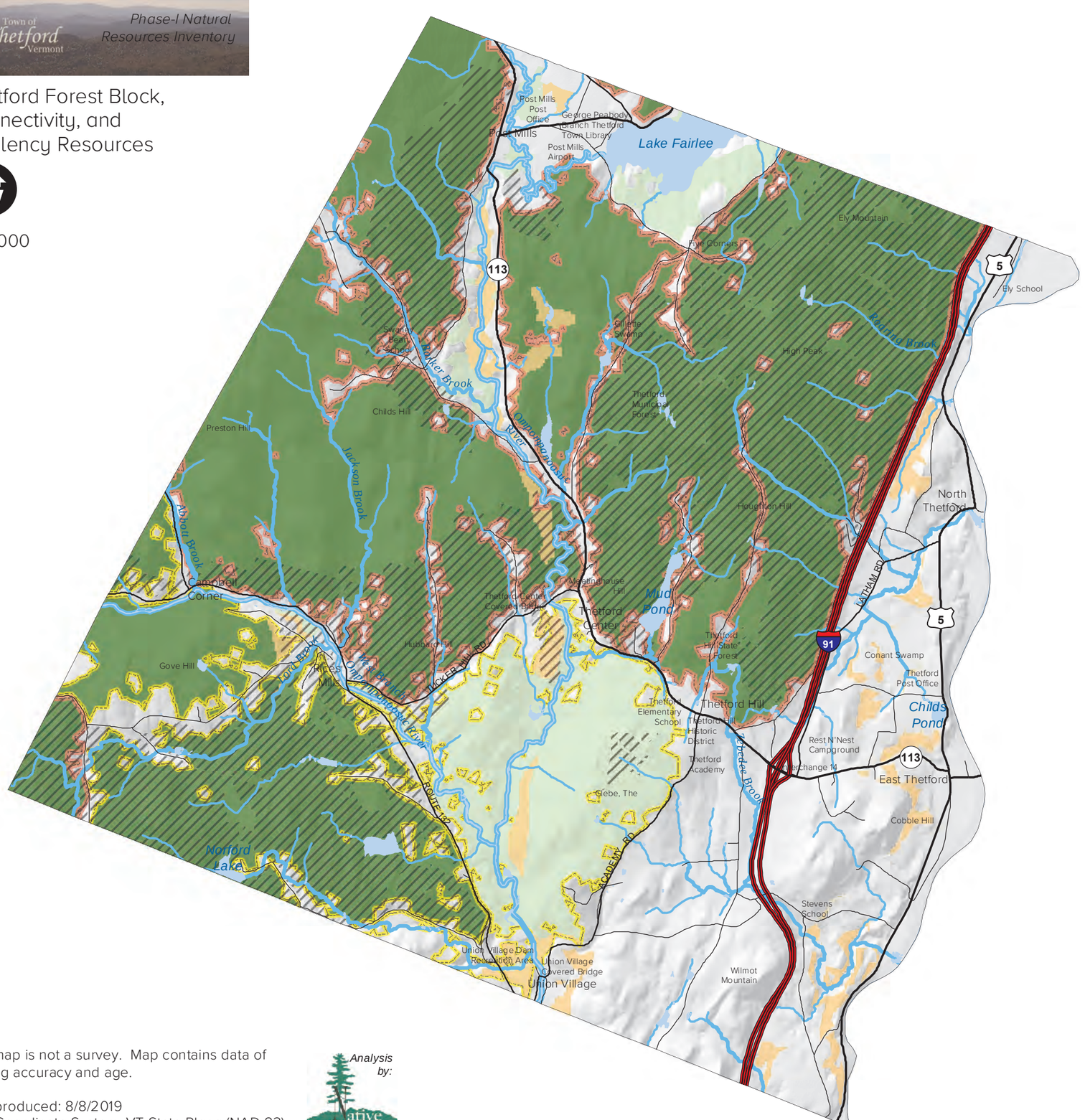
Analysis by: Native Geographic, LLC

Town of Thetford Vermont

Phase-I Natural Resources Inventory

Thetford Forest Block, Connectivity, and Resilency Resources

1:55,000



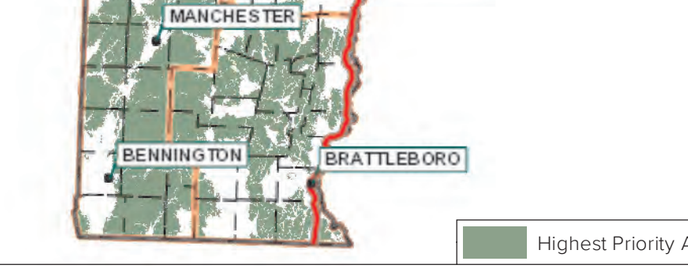
- Highest Priority Interior Forest Blocks
- Priority Interior Forest Blocks
- Highest Priority Connectivity Blocks
- Priority Connectivity Forest Blocks
- Physical Landscape Diversity Blocks
- Priority Resilient Lands

This map is not a survey. Map contains data of varying accuracy and age.

Map produced: 8/8/2019
Map Coordinate System: VT State Plane (NAD 83)

Analysis by: Native Geographic, LLC

Vermont Highest Priority Interior Forest Blocks, Connector Blocks, and Physical Landscape Diversity Blocks



Highest Priority Area

Town of Thetford Vermont

Phase-I Natural Resources Inventory

Thetford Farmland Resources

1:55,000

- Active Farms
- Fields

Important Agricultural Soils

- Prime
- Prime with limitations
- Statewide
- Statewide with limitations

This map is not a survey. Map contains data of varying accuracy and age.

Map produced: 8/8/2019
Map Coordinate System: VT State Plane (NAD 83)

Analysis by:

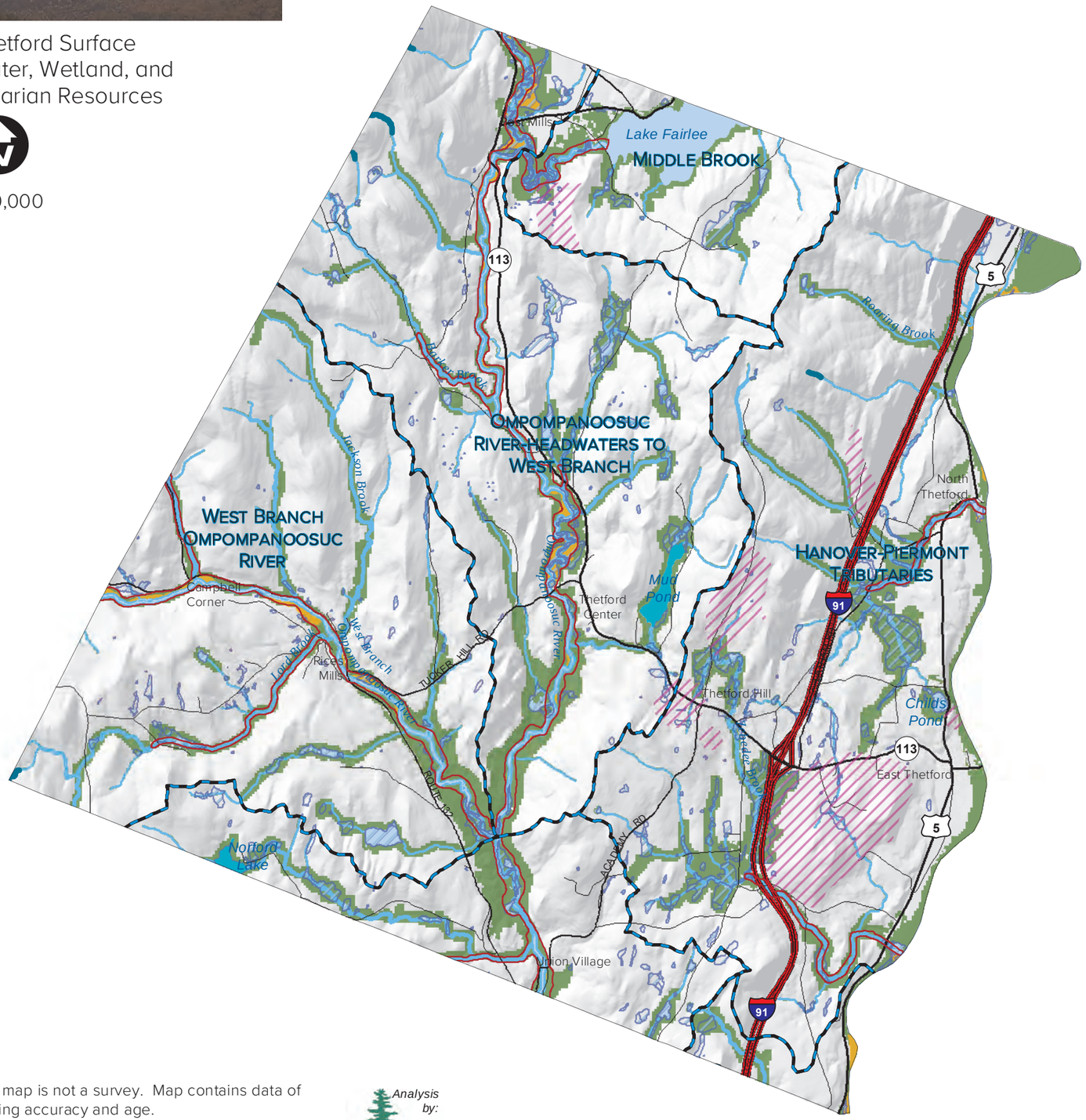
Native Geographic, LLC

Town of Thetford Vermont

Phase-I Natural Resources Inventory

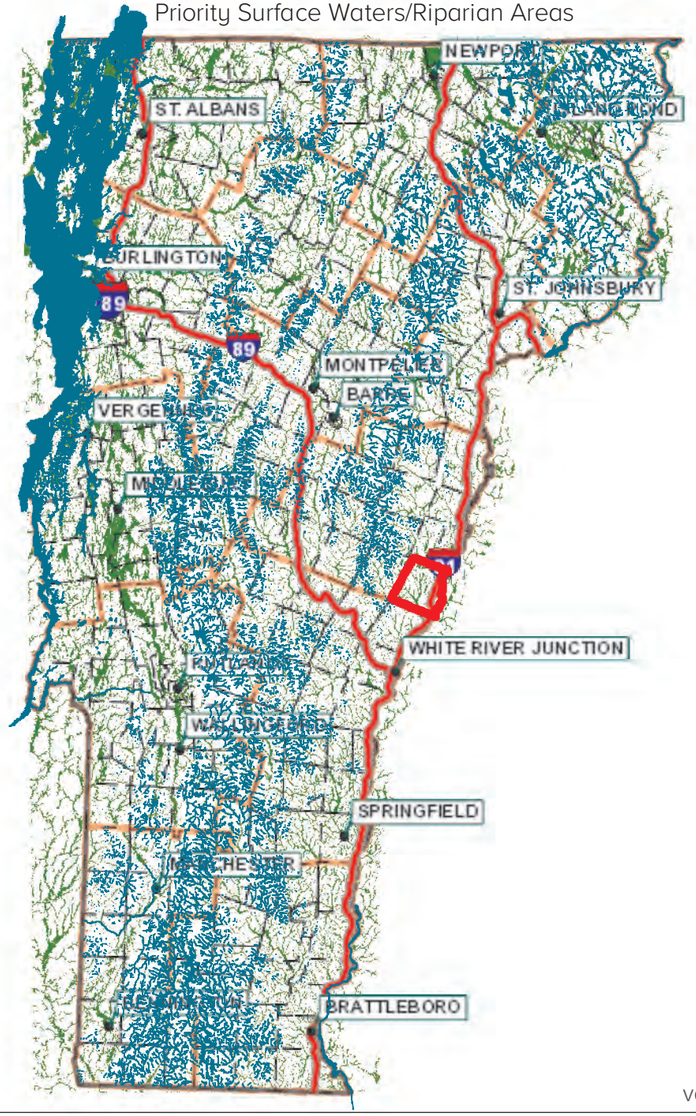
Thetford Surface Water, Wetland, and Riparian Resources

1:60,000



- Watershed (HUC 12)
- Representative Lakes/Ponds
- Exemplary Surface Waters
- River Corridors
- Ground Water Source Protection Areas
- Wetlands (Advisory)
- Potential Floodplain Forest
- Priority Surface Waters/Riparian Areas

Vermont Exemplary Surface Waters and Priority Surface Waters/Riparian Areas



VCGI

This map is not a survey. Map contains data of varying accuracy and age.

Map produced: 8/8/2019
Map Coordinate System: VT State Plane (NAD 83)

Analysis by: Native Geographic, LLC

Appendix D

THETFORD ZONING MAPS

Proposed Future Land Use Map
Thetford, Vermont
Town Plan 2020

Adopted 9/11/2020

1:43,969

1 inch = 3,664 feet

0 0.5 1

Miles

- VT route/TH cls 1
- TH cls 2
- TH cls 2 gravel
- TH cls 3
- TH cls 3 gravel
- TH cls 4
- trail
- private
- US route
- US interstate
- VT forest hwy
- 911 structure

LAND USE AREAS

- Neighborhood Residential NR
- Village Residential VR
- Community Business CB
- Rural
- Thetford Hill Historic Overlay
- Forest Block Overlay

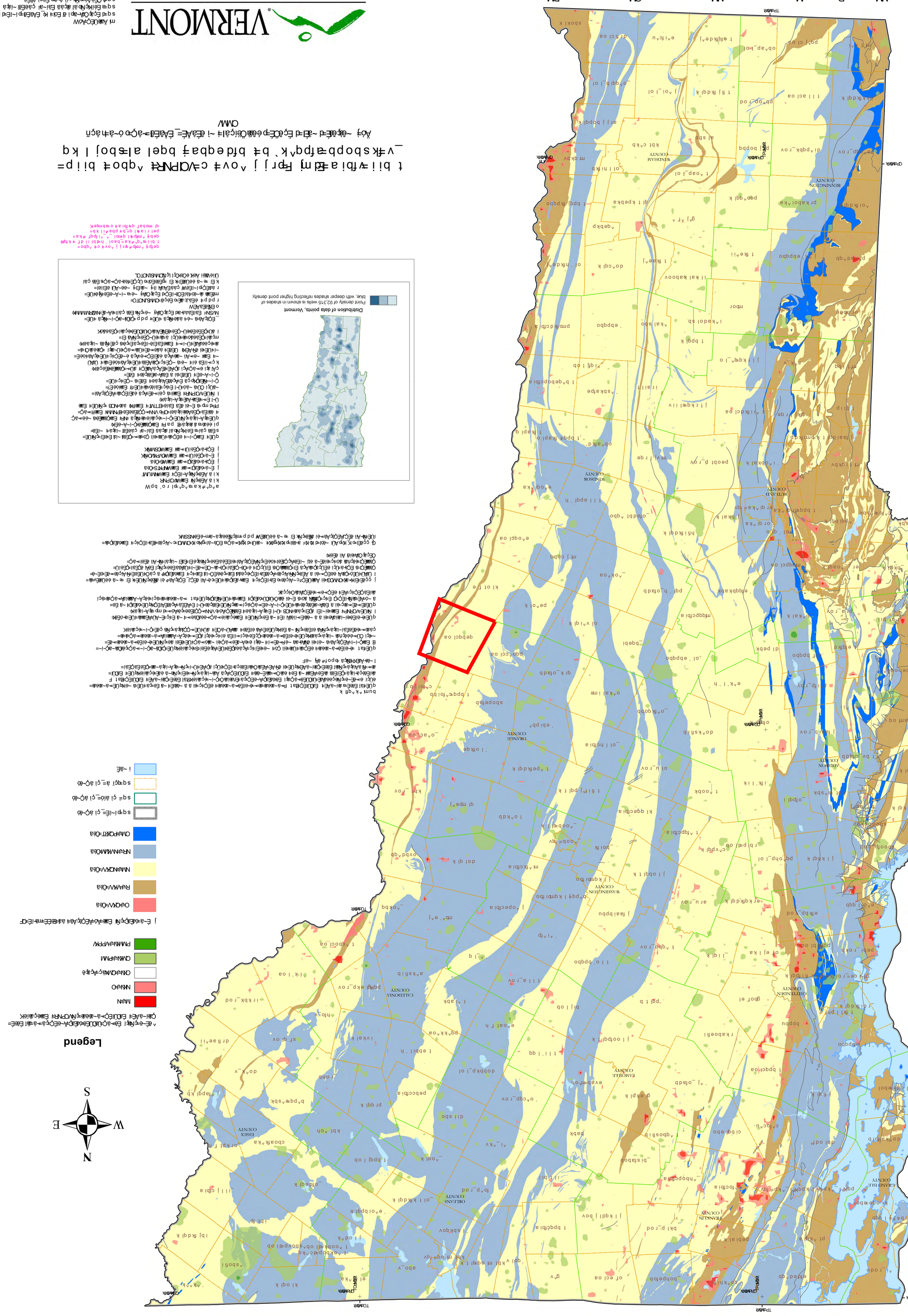
OTHER AREAS

- Federal Lands
- State Lands
- Town Lands

TRORC
Two Rivers-Ottauquechee
REGIONAL COMMISSION

Appendix E

WELL YIELD MAPS



AGENCY OF NATURAL RESOURCES
Vermont Geological Survey

Published by:
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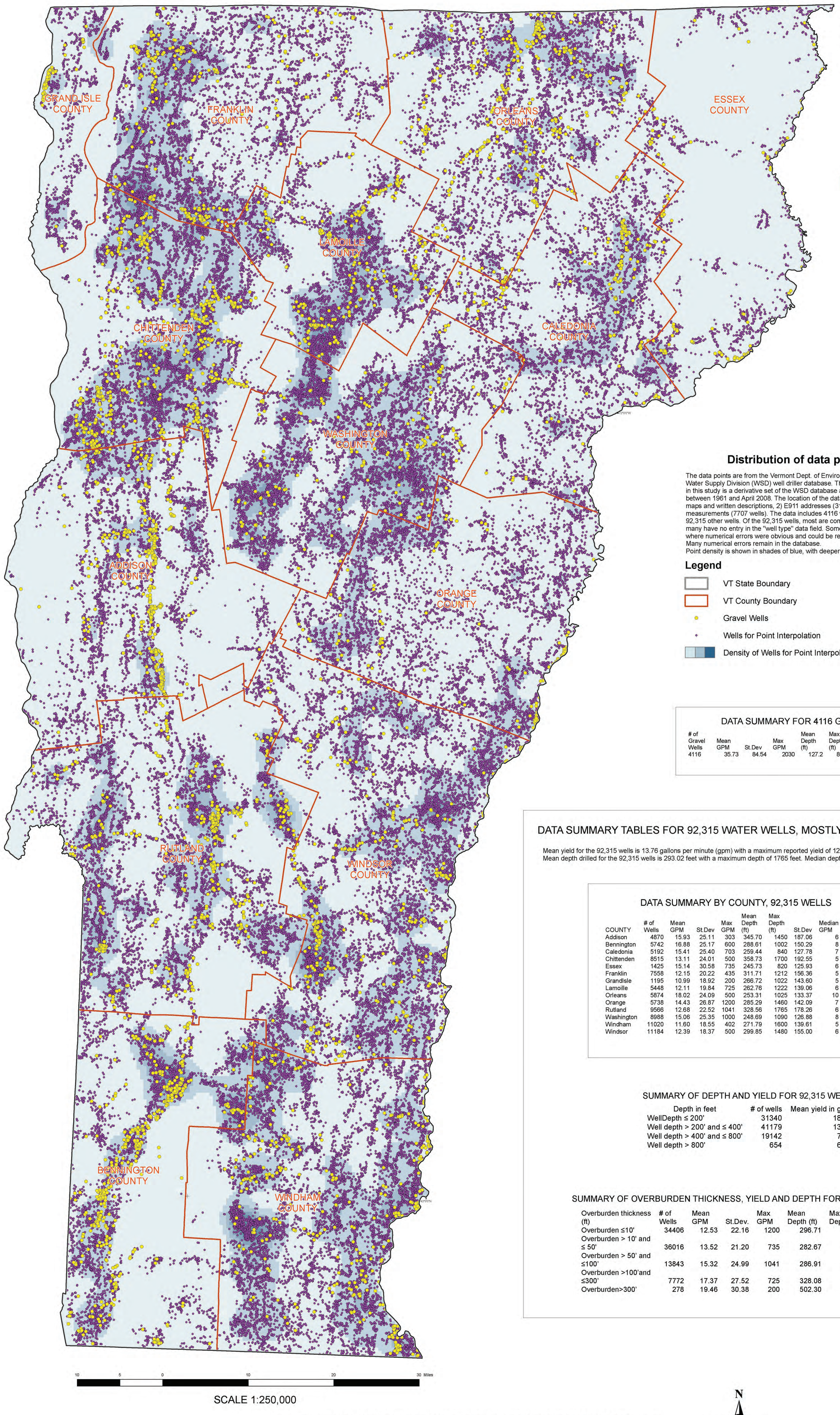
VT Dept. of Environmental Conservation
Vermont Agency of Natural Resources
103 South Main ST., Logue Cottage
Waterbury, VT 05671-2420
http://www.anr.state.vt.us/dec/geo.vgs.htm

PRELIMINARY MAP



SCALE 1:250,000

Distribution of data points, Vermont

The data points are from the Vermont Dept. of Environmental Conservation Water Supply Division (WSD) well driller database. The well data used in this study is a derivative set of the WSD database and includes wells completed between 1961 and April 2008. The location of the data points is from 1) well driller maps and written descriptions, 2) E911 addresses (3100 wells), and 3) GPS measurements (7707 wells). The data includes 4116 wells identified as "gravel" wells and 92,315 other wells. Of the 92,315 wells, most are completed in bedrock, although many have no entry in the "well type" data field. Some corrections were made to the database where numerical errors were obvious and could be reconciled with a driller report. Many numerical errors remain in the database.
Point density is shown in shades of blue, with deeper shades reflecting higher point density.

Legend

- VT State Boundary
- VT County Boundary
- Gravel Wells
- Wells for Point Interpolation
- Density of Wells for Point Interpolation

DATA SUMMARY FOR 4116 GRAVEL WELLS

# of Gravel Wells	Mean GPM	St.Dev	Max GPM	Mean Depth (ft)	Max Depth (ft)	St.Dev	Median GPM	Median Depth (ft)
4116	35.73	84.54	2030	127.2	87.78	810	20	104

DATA SUMMARY TABLES FOR 92,315 WATER WELLS, MOSTLY BEDROCK WELLS

Mean yield for the 92,315 wells is 13.76 gallons per minute (gpm) with a maximum reported yield of 1200 gpm. Median yield is 6 gpm.
Mean depth drilled for the 92,315 wells is 293.02 feet with a maximum depth of 1765 feet. Median depth is 260 feet.

DATA SUMMARY BY COUNTY, 92,315 WELLS

COUNTY	# of Wells	Mean GPM	St.Dev	Max GPM	Mean Depth (ft)	Max Depth (ft)	St.Dev	Median GPM	Median Depth (ft)
Addison	4870	15.93	25.11	303	345.70	1450	187.06	6	301
Bennington	5742	16.88	25.17	600	288.61	1002	150.29	8	260
Caledonia	5192	15.41	25.40	703	259.44	840	127.78	7	235
Chittenden	8515	13.11	24.01	500	358.73	1700	192.55	5	321
Essex	1425	15.14	30.58	735	245.73	820	125.93	6	220
Franklin	7558	12.15	20.22	435	311.71	1212	156.36	5	300
Grandlsle	1195	10.99	18.92	200	266.72	1022	143.60	5	242
Lamoille	5448	12.11	19.84	725	262.76	1222	139.06	6	224
Orleans	5874	18.02	24.09	500	253.31	1025	133.37	10	225
Orange	5738	14.43	26.87	1200	285.29	1460	142.09	7	250
Rutland	9566	12.68	22.52	1041	328.56	1765	178.26	6	285
Washington	8988	15.06	25.35	1000	248.69	1090	126.88	8	220
Windham	11020	11.60	18.55	402	271.79	1600	139.61	5	250
Windsor	11184	12.39	18.37	500	299.85	1480	155.00	6	271

SUMMARY OF DEPTH AND YIELD FOR 92,315 WELLS

Depth in feet	# of wells	Mean yield in gpm
WellDepth ≤ 200'	31340	18.43
Well depth > 200' and ≤ 400'	41179	13.15
Well depth > 400' and ≤ 800'	19142	7.64
Well depth > 800'	654	6.90

SUMMARY OF OVERBURDEN THICKNESS, YIELD AND DEPTH FOR 92,315 WELLS

Overburden thickness (ft)	# of Wells	Mean GPM	St.Dev.	Max GPM	Mean Depth (ft)	Max Depth (ft)	St.Dev.
Overburden ≤10'	34406	12.53	22.16	1200	296.71	1765	165.03
Overburden > 10' and ≤ 50'	36016	13.52	21.20	735	282.67	1485	154.37
Overburden > 50' and ≤100'	13843	15.32	24.99	1041	286.91	1465	148.86
Overburden >100'and ≤300'	7772	17.37	27.52	725	328.08	1205	147.96
Overburden>300'	278	19.46	30.38	200	502.30	1000	139.66

DATA SUMMARY, VERMONT WATER WELLS

by
Marjorie Gale, Ryan Knox, George Springston, and Laurence Becker
2009

N W E S

Appendix F

PRELIMINARY OPINIONS OF PROBABLE COSTS

Stantec

City /Town of Thetford, VT Contract # 195113491

Project Name: Thetford Town Wide Water System Assessment

Project Road & Length Private Water Service Replacements and Basement Cistern Removals (Per Property)

ITEM #	Approx. Quantity	UNIT	DESCRIPTION OF ITEM	UNIT PRICE $	AMOUNT $
1	1	EACH	Internal Plumbing	$ 1,600	$ 1,600
2	1	EACH	Water Service Tap	$ 900	$ 900
3	25	LF	1" Water Service In ROW	$ 125	$ 3,125
4	50	LF	1" Water Service On Private Property	$ 55	$ 2,750
4	1	EACH	Water Meter	$ 950	$ 950
TOTAL 2023 CONSTRUCTION COSTS					**$ 9,325**
2023 CONSTRUCTION CONTINGENCY (25%)					**$ 2,331**
2023 PROJECT SUBTOTAL					**$ 11,656**

HED-614 (R)

Bryan Ruoff - Project Manager/Associate

7/20/2023
Date

Stantec

City /Town of Thetford, VT Contract # 195113491

Project Name: Thetford Town Wide Water System Assessment

Project Road & Length Post Mills 4" Water Main (3 Miles)

ITEM #	Approx. Quantity	UNIT	DESCRIPTION OF ITEM	UNIT PRICE $	AMOUNT $
1	16,000	LF	4" DI Water Main	$ 145	$ 2,320,000
2	38	EACH	4" DI GV	$ 700	$ 26,880
3	120	EACH	1" Water Services	$ 4,800	$ 576,000
4	1	LS	Erosion and Sedminentation Controls	$ 70,000	$ 70,000
5	1	LS	Maintenance and Protection of Traffic	$ 100,000	$ 100,000
6	1	LS	General Restoration	$ 150,000	$ 150,000
7	1	LS	Drilled Well	$ 500,000	$ 500,000
8	1	LS	Water Storage Tank	$ 400,000	$ 400,000
9	1	LS	Pump and Treatment Facility	$ 650,000	$ 650,000
TOTAL 2023 CONSTRUCTION COSTS					**$ 4,792,880**
2023 ENGINEERING DESIGN AND PERMITTING					**$ 383,430**
2023 ENGINEERING DURING CONSTRUCTION					**$ 575,146**
2023 CONSTRUCTION CONTINGENCY (25%)					**$ 1,198,220**
2023 PROJECT SUBTOTAL					**$ 6,374,530**

HED-614 (R)

Bryan Ruoff - Project Manager/Associate

7/20/2023

Date

Stantec

City /Town of Thetford, VT Contract # 195113491

Project Name: Thetford Town Wide Water System Assessment

Project Road & Length Post Mills 8" Water Main (3 Miles)

ITEM #	Approx. Quantity	UNIT	DESCRIPTION OF ITEM	UNIT PRICE $	AMOUNT $
1	500	LF	6" DI Water Main	$ 175	$ 87,500
2	16,000	LF	8" DI Water Main	$ 225	$ 3,600,000
3	16	EACH	6" DI GV	$ 750	$ 12,000
4	55	EACH	8" DI GV	$ 1,200	$ 66,000
5	22	EACH	Fire Hydrant	$ 4,800	$ 105,600
6	120	EACH	1" Water Services	$ 4,800	$ 576,000
7	1	LS	Erosion and Sedminentation Controls	$ 70,000	$ 70,000
8	1	LS	Maintenance and Protection of Traffic	$ 100,000	$ 100,000
9	1	LS	General Restoration	$ 150,000	$ 150,000
10	1	LS	Drilled Well	$ 500,000	$ 500,000
11	1	LS	Water Storage Tank	$ 750,000	$ 750,000
12	1	LS	Pump and Treatment Facility	$ 650,000	$ 650,000
TOTAL 2023 CONSTRUCTION COSTS					**$ 6,667,100**
2023 ENGINEERING DESIGN AND PERMITTING					**$ 533,368**
2023 ENGINEERING DURING CONSTRUCTION					**$ 800,052**
2023 CONSTRUCTION CONTINGENCY (25%)					**$ 1,666,775**
2023 PROJECT SUBTOTAL					**$ 8,867,243**

HED-614 (R)

Bryan Ruoff - Project Manager/Associate

7/20/2023
Date

Stantec

City /Town of Thetford, VT Contract # 195113491

Project Name: Thetford Town Wide Water System Assessment

Project Road & Length North Thetford 4" Water Main (2 Miles)

ITEM #	Approx. Quantity	UNIT	DESCRIPTION OF ITEM	UNIT PRICE $	AMOUNT $
1	11,600	LF	4" DI Water Main	$ 145	$ 1,682,000
2	28	EACH	4" DI GV	$ 700	$ 19,488
3	60	EACH	1" Water Services	$ 4,800	$ 288,000
4	1	LS	Erosion and Sedminentation Controls	$ 35,000	$ 35,000
5	1	LS	Maintenance and Protection of Traffic	$ 85,000	$ 85,000
6	1	LS	General Restoration	$ 100,000	$ 100,000
7	1	LS	Drilled Well	$ 350,000	$ 350,000
8	1	LS	Water Storage Tank	$ 300,000	$ 300,000
9	1	LS	Pump and Treatment Facility	$ 500,000	$ 500,000
TOTAL 2023 CONSTRUCTION COSTS					**$ 3,359,488**
2023 ENGINEERING DESIGN AND PERMITTING					**$ 268,759**
2023 ENGINEERING DURING CONSTRUCTION					**$ 403,139**
2023 CONSTRUCTION CONTINGENCY (25%)					**$ 839,872**
2023 PROJECT SUBTOTAL					**$ 4,468,119**

HED-614 (R)

Bryan Ruoff - Project Manager/Associate

7/20/2023

Date

Stantec

City /Town of Thetford, VT Contract # 195113491

Project Name: Thetford Town Wide Water System Assessment

Project Road & Length North Thetford 8" Water Main (2 Miles)

ITEM #	Approx. Quantity	UNIT	DESCRIPTION OF ITEM	UNIT PRICE $	AMOUNT $
1	500	LF	6" DI Water Main	$ 175	$ 87,500
2	11,600	LF	8" DI Water Main	$ 225	$ 2,610,000
3	14	EACH	6" DI GV	$ 750	$ 10,500
4	28	EACH	8" DI GV	$ 1,200	$ 33,600
5	14	EACH	Fire Hydrant	$ 4,800	$ 66,816
6	60	EACH	1" Water Services	$ 4,800	$ 288,000
7	1	LS	Erosion and Sedminentation Controls	$ 70,000	$ 70,000
8	1	LS	Maintenance and Protection of Traffic	$ 100,000	$ 100,000
9	1	LS	General Restoration	$ 150,000	$ 150,000
10	1	LS	Drilled Well	$ 350,000	$ 350,000
11	1	LS	Water Storage Tank	$ 550,000	$ 550,000
12	1	LS	Pump and Treatment Facility	$ 500,000	$ 500,000
TOTAL 2023 CONSTRUCTION COSTS					**$ 4,816,416**
2023 ENGINEERING DESIGN AND PERMITTING					**$ 385,313**
2023 ENGINEERING DURING CONSTRUCTION					**$ 577,970**
2023 CONSTRUCTION CONTINGENCY (25%)					**$ 1,204,104**
2023 PROJECT SUBTOTAL					**$ 6,405,833**

HED-614 (R)

Bryan Ruoff - Project Manager/Associate

7/20/2023
Date

Stantec

City /Town of Thetford, VT Contract # 195113491

Project Name: Thetford Town Wide Water System Assessment

Project Road & Length Thetford Hill (Connect Schools)

ITEM #	Approx. Quantity	UNIT	DESCRIPTION OF ITEM	UNIT PRICE $	AMOUNT $
1	900	LF	4" DI Water Main	$ 145	$ 130,500
2	8	EACH	4" DI GV	$ 700	$ 5,600
3	2	EACH	2" Water Services	$ 6,800	$ 13,600
4	2	EACH	Water Meter and Back Flow Preventor	$ 8,500	$ 17,000
5	1	LS	Erosion and Sedminentation Controls	$ 18,000	$ 18,000
6	1	LS	Maintenance and Protection of Traffic	$ 35,000	$ 35,000
7	1	LS	General Restoration Inc. Paving	$ 65,000	$ 65,000
8	1	LS	Drilled Well and Water Supply Line	$ 65,000	$ 65,000
9	1	LS	Water Storage Tank	$ 400,000	$ 400,000
TOTAL 2023 CONSTRUCTION COSTS					**$ 749,700**
2023 ENGINEERING DESIGN AND PERMITTING					**$ 59,976**
2023 ENGINEERING DURING CONSTRUCTION					**$ 89,964**
2023 CONSTRUCTION CONTINGENCY (25%)					**$ 187,425**
2023 PROJECT SUBTOTAL					**$ 997,101**

HED-614 (R)

Bryan Ruoff - Project Manager/Associate

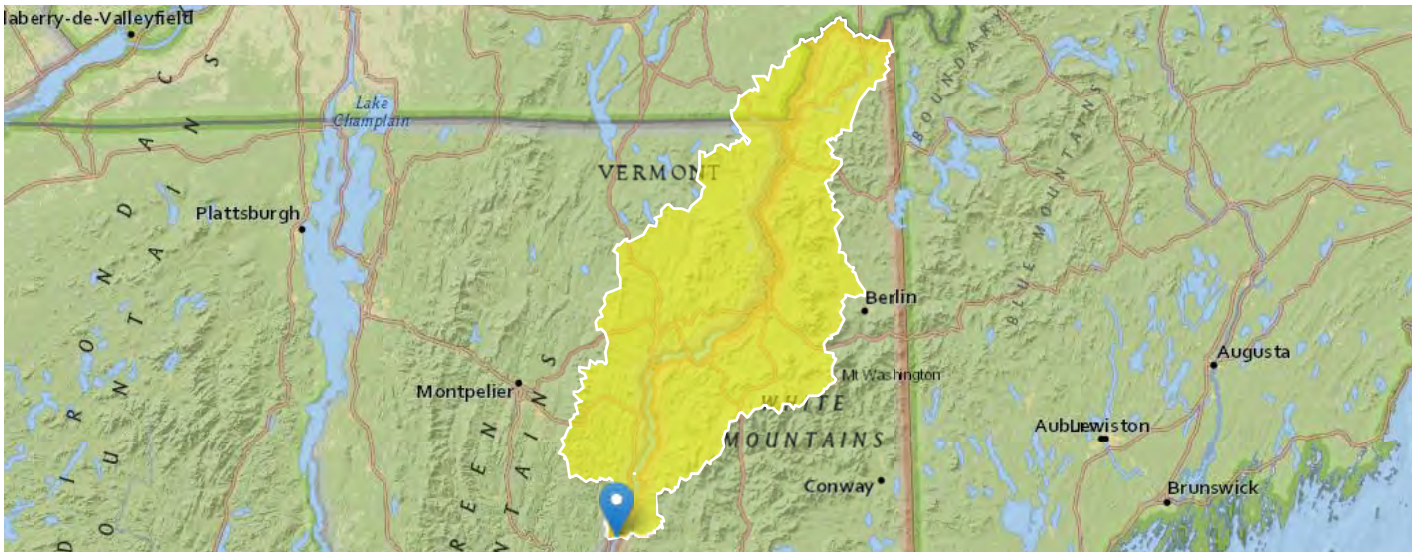
7/20/2023
Date

Appendix G

CONNECTICUT RIVER WATERSHED AREA

StreamStats Report

Region ID: VT
Workspace ID: VT20230417125010950000
Clicked Point (Latitude, Longitude): 43.81239, -72.18333
Time: 2023-04-17 08:50:36 -0400



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	3140	square miles
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	1.21	percent
PRECPRIS10	Basin average mean annual precipitation for 1981 to 2010 from PRISM	44.2	inches

General Disclaimers

The delineation point is in an exclusion area. WARNING! The Connecticut River is regulated. The regression equations are not applicable to this location.

Peak-Flow Statistics

Peak-Flow Statistics Parameters [99.9 Percent (3140 square miles) Statewide Peak Flow]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3140	square miles	0.18	689
LC06STOR	Percent Storage from NLCD2006	1.21	percent	0	18.5
PRECPRIS10	Mean Annual Precip PRISM 1981 2010	44.2	inches	33.5	70.4

Peak-Flow Statistics Disclaimers [99.9 Percent (3140 square miles) Statewide Peak Flow]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Peak-Flow Statistics Flow Report [99.9 Percent (3140 square miles) Statewide Peak Flow]

Statistic	Value	Unit
50-percent AEP flood	62500	ft^3/s
20-percent AEP flood	89200	ft^3/s
10-percent AEP flood	108000	ft^3/s
4-percent AEP flood	136000	ft^3/s
2-percent AEP flood	159000	ft^3/s
1-percent AEP flood	182000	ft^3/s
0.5-percent AEP flood	208000	ft^3/s
0.2-percent AEP flood	247000	ft^3/s

Peak-Flow Statistics Citations

Olson, S.A.,2014, Estimation of flood discharges at selected annual exceedance probabilities for unregulated, rural streams in Vermont, with a section on Vermont regional skew regression, by Veilleux, A.G.: U.S. Geological Survey Scientific Investigations Report 2014–5078, 27 p. plus appendixes. (http://pubs.usgs.gov/sir/2014/5078/)

Application Version: 4.14.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

Appendix H

EPA NATIONAL PRIMARY DRINKING WATER REGULATIONS

National Primary Drinking Water Regulations

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Acrylamide	TT[4]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/ wastewater treatment	zero
Alachlor	0.002	Eye, liver, kidney, or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	zero
Alpha/photon emitters	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	zero
Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	0.006
Arsenic	0.010	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes	0
Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	7 MFL
Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	0.003
Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	2
Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	zero
Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	zero
Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	0.004
Beta photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	zero
Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	zero
Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	0.005
Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	0.04

LEGEND

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Carbon tetrachloride	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities	**zero**
Chloramines (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort; anemia	Water additive used to control microbes	**MRDLG=4[1]**
Chlordane	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide	**zero**
Chlorine (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes	**MRDLG=4[1]**
Chlorine dioxide (as ClO_2)	MRDL=0.8[1]	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Water additive used to control microbes	**MRDLG=0.8[1]**
Chlorite	1.0	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Byproduct of drinking water disinfection	**0.8**
Chlorobenzene	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories	**0.1**
Chromium (total)	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits	**0.1**
Copper	TT[5]; Action Level=1.3	Short-term exposure: Gastrointestinal distress. Long-term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits	**1.3**
Cryptosporidium	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	**0.2**
2,4-D	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops	**0.07**
Dalapon	0.2	Minor kidney changes	Runoff from herbicide used on rights of way	**0.2**
1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards	**zero**
o-Dichlorobenzene	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories	**0.6**
p-Dichlorobenzene	0.075	Anemia; liver, kidney, or spleen damage; changes in blood	Discharge from industrial chemical factories	**0.075**
1,2-Dichloroethane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	**zero**

LEGEND DISINFECTANT | DISINFECTION BYPRODUCT | INORGANIC CHEMICAL | MICROORGANISM | ORGANIC CHEMICAL | RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
1,1-Dichloroethylene	0.007	Liver problems	Discharge from industrial chemical factories	**0.007**
cis-1,2-Dichloroethylene	0.07	Liver problems	Discharge from industrial chemical factories	**0.07**
trans-1,2, Dichloroethylene	0.1	Liver problems	Discharge from industrial chemical factories	**0.1**
Dichloromethane	0.005	Liver problems; increased risk of cancer	Discharge from industrial chemical factories	**zero**
1,2-Dichloropropane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	**zero**
Di(2-ethylhexyl) adipate	0.4	Weight loss, liver problems, or possible reproductive difficulties	Discharge from chemical factories	**0.4**
Di(2-ethylhexyl) phthalate	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories	**zero**
Dinoseb	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables	**0.007**
Dioxin (2,3,7,8-TCDD)	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories	**zero**
Diquat	0.02	Cataracts	Runoff from herbicide use	**0.02**
Endothall	0.1	Stomach and intestinal problems	Runoff from herbicide use	**0.1**
Endrin	0.002	Liver problems	Residue of banned insecticide	**0.002**
Epichlorohydrin	TT[4]	Increased cancer risk; stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals	**zero**
Ethylbenzene	0.7	Liver or kidney problems	Discharge from petroleum refineries	**0.7**
Ethylene dibromide	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries	**zero**
Fecal coliform and *E. coli*	MCL[6]	Fecal coliforms and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes may cause short term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, and people with severely compromised immune systems.	Human and animal fecal waste	**zero[6]**

LEGEND

DISINFECTANT | DISINFECTION BYPRODUCT | INORGANIC CHEMICAL | MICROORGANISM | ORGANIC CHEMICAL | RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Fluoride	4.0	Bone disease (pain and tenderness of the bones); children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	**4.0**
Giardia lamblia	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	**0.7**
Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	**n/a[9]**
Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	**zero**
Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	**zero**
Heterotrophic plate count (HPC)	TT[7]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	**n/a**
Hexachlorobenzene	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories	**zero**
Hexachloro-cyclopentadiene	0.05	Kidney or stomach problems	Discharge from chemical factories	**0.05**
Lead	TT[5]; Action Level=0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities; Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits	**zero**
Legionella	TT[7]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems	**zero**
Lindane	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, and gardens	**0.0002**
Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands	**0.002**
Methoxychlor	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, and livestock	**0.04**
Nitrate (measured as Nitrogen)	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	**10**

LEGEND DISINFECTANT | DISINFECTION BYPRODUCT | INORGANIC CHEMICAL | MICROORGANISM | ORGANIC CHEMICAL | RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Nitrite (measured as Nitrogen)	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	1
Oxamyl (Vydate)	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes	0.2
Pentachlorophenol	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood-preserving factories	zero
Picloram	0.5	Liver problems	Herbicide runoff	0.5
Polychlorinated biphenyls (PCBs)	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals	zero
Radium 226 and Radium 228 (combined)	5 pCi/L	Increased risk of cancer	Erosion of natural deposits	zero
Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum and metal refineries; erosion of natural deposits; discharge from mines	0.05
Simazine	0.004	Problems with blood	Herbicide runoff	0.004
Styrene	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills	0.1
Tetrachloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners	zero
Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	0.0005
Toluene	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories	1
Total Coliforms	5.0 percent[8]	Coliforms are bacteria that indicate that other, potentially harmful bacteria may be present. See fecal coliforms and *E. coli*	Naturally present in the environment	zero
Total Trihalomethanes (TTHMs)	0.080	Liver, kidney, or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection	n/a[9]
Toxaphene	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle	zero
2,4,5-TP (Silvex)	0.05	Liver problems	Residue of banned herbicide	0.05
1,2,4-Trichlorobenzene	0.07	Changes in adrenal glands	Discharge from textile finishing factories	0.07

LEGEND

DISINFECTANT | DISINFECTION BYPRODUCT | INORGANIC CHEMICAL | MICROORGANISM | ORGANIC CHEMICAL | RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
1,1,1-Trichloroethane	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories	**0.2**
1,1,2-Trichloroethane	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories	**0.003**
Trichloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories	**zero**
Turbidity	TT[7]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites, and some bacteria. These organisms can cause short term symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff	**n/a**
Uranium	30µg/L	Increased risk of cancer, kidney toxicity	Erosion of natural deposits	**zero**
Vinyl chloride	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories	**zero**
Viruses (enteric)	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
Xylenes (total)	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories	**10**

LEGEND DISINFECTANT | DISINFECTION BYPRODUCT | INORGANIC CHEMICAL | MICROORGANISM | ORGANIC CHEMICAL | RADIONUCLIDES

NOTES

1 Definitions
- **Maximum Contaminant Level Goal (MCLG):** The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- **Maximum Contaminant Level (MCL):** The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- **Maximum Residual Disinfectant Level Goal (MRDLG):** The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- **Maximum Residual Disinfectant Level (MRDL):** The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- **Treatment Technique (TT):** A required process intended to reduce the level of a contaminant in drinking water.

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 Health effects are from long-term exposure unless specified as short-term exposure.

4 Each water system must certify annually, in writing, to the state (using third-party or manufacturers certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05 percent dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01 percent dosed at 20 mg/L (or equivalent).

5 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

6 A routine sample that is fecal coliform-positive or E. coli-positive triggers repeat samples--if any repeat sample is total coliform-positive, the system has an acute MCL violation. A routine sample that is total coliform-positive and fecal coliform-negative or E. coli-negative triggers repeat samples--if any repeat sample is fecal coliform-positive or E. coli-positive, the system has an acute MCL violation. See also Total Coliforms.

7 EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:
- ***Cryptosporidium*:** 99 percent removal for systems that filter. Unfiltered systems are required to include Cryptosporidium in their existing watershed control provisions.
- **Giardia lamblia:** 99.9 percent removal/inactivation
- **Viruses:** 99.9 percent removal/inactivation
- ***Legionella*:** No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, according to the treatment techniques in the surface water treatment rule, *Legionella* will also be controlled.
- **Turbidity:** For systems that use conventional or direct filtration, at no time can turbidity (cloudiness of water) go higher than 1 nephelometric turbidity unit (NTU), and samples for turbidity must be less than or equal to 0.3 NTU in at least 95 percent of the samples in any month. Systems that use filtration other than the conventional or direct filtration must follow state limits, which must include turbidity at no time exceeding 5 NTU.
- **HPC:** No more than 500 bacterial colonies per milliliter
- **Long Term 1 Enhanced Surface Water Treatment:** Surface water systems or ground water systems under the direct influence of surface water serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, *Cryptosporidium* removal requirements, updated watershed control requirements for unfiltered systems).
- **Long Term 2 Enhanced Surface Water Treatment:** This rule applies to all surface water systems or ground water systems under the direct influence of surface water. The rule targets additional *Cryptosporidium* treatment requirements for higher risk systems and includes provisions to reduce risks from uncovered finished water storages facilities and to ensure that the systems maintain microbial protection as they take steps to reduce the formation of disinfection byproducts. (Monitoring start dates are staggered by system size. The largest systems (serving at least 100,000 people) will begin monitoring in October 2006 and the smallest systems (serving fewer than 10,000 people) will not begin monitoring until October 2008. After completing monitoring and determining their treatment bin, systems generally have three years to comply with any additional treatment requirements.)
- **Filter Backwash Recycling:** The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

8 No more than 5.0 percent samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or E. coli. If two consecutive TC-positive samples, and one is also positive for E. coli or fecal coliforms, system has an acute MCL violation.

9 Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:
- **Haloacetic acids:** dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- **Trihalomethanes:** bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

NATIONAL SECONDARY DRINKING WATER REGULATION

National Secondary Drinking Water Regulations are non-enforceable guidelines regarding contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, some states may choose to adopt them as enforceable standards.

Contaminant	Secondary Maximum Contaminant Level
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	Noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

FOR MORE INFORMATION ON EPA'S SAFE DRINKING WATER:

visit: **epa.gov/safewater**

call: **(800) 426-4791**

ADDITIONAL INFORMATION:

To order additional posters or other ground water and drinking water publications, please contact the National Service Center for Environmental Publications at: **(800) 490-9198**, or email: **nscep@bps-lmit.com**.