Moosup River

Watershed Summary

WATERSHED DESCRIPTION AND MAPS

The Moosup River watershed covers an area of approximately 12,323 acres in eastern Connecticut (Figure 1). The largest portion of the watershed, is located in Foster and Coventry, Rhode Island, upstream of the impaired segment. The lower watershed, containing the impaired segment, is located in Sterling and Plainfield, Connecticut.

The Moosup River watershed includes one segment impaired for recreation due to elevated bacteria levels. This segment was assessed by the Connecticut Department of Energy and Environmental Protection (CT DEEP) and was included in the CT 2010 303(d) list of impaired waterbodies. Some segments in the watershed may be unassessed as of the writing of this document. This does not suggest that there are no issues on these segments, but indicates a lack of current data to evaluate the segments as part of the assessment process. An excerpt of the Integrated Water Quality Report is included in Table 1.

The Moosup River begins at Clark Pond in Foster, RI. From there, the river flows south through Foster and Coventry, RI, and west through the Nicholas Farm Management Area into Sterling, CT. The impaired segment (CT3500-00_03) begins at the Connecticut-Rhode Island state-line and flows west for 7.36 miles through a mix of forestland intermixed with agricultural land and developed land. The river flows through Oneco and Sterling ponds in downtown Sterling and into the more urbanized Town of Plainfield, CT (which includes the villages of Moosup and Central Village, Plainfield Village, and Wauregan). The end of the impaired segment is located at the Brunswick Mill Dam in Plainfield, south of Route 14. The river continues west through the villages of Moosup and Central Village and into the Quinebaug River near the Plainfield-Canterbury town line (Figure 2).

Impaired Segment Facts

Impaired Segment Name: Moosup River (CT3500-00_03)

Municipalities: Sterling, Plainfield

Impaired Segment Length (miles): 7.36

Water Quality Classification: Class B

Designated Use Impairment: Recreation

Sub-regional Basin Name and Code: Moosup River, 3500

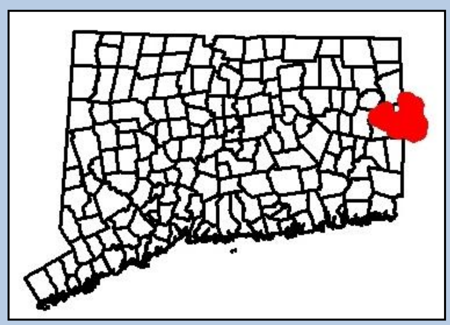
Regional Basin: Moosup

Major Basin: Thames

Watershed Area (acres): 12,323

MS4 Applicable? No

Figure 1: Watershed location in Connecticut

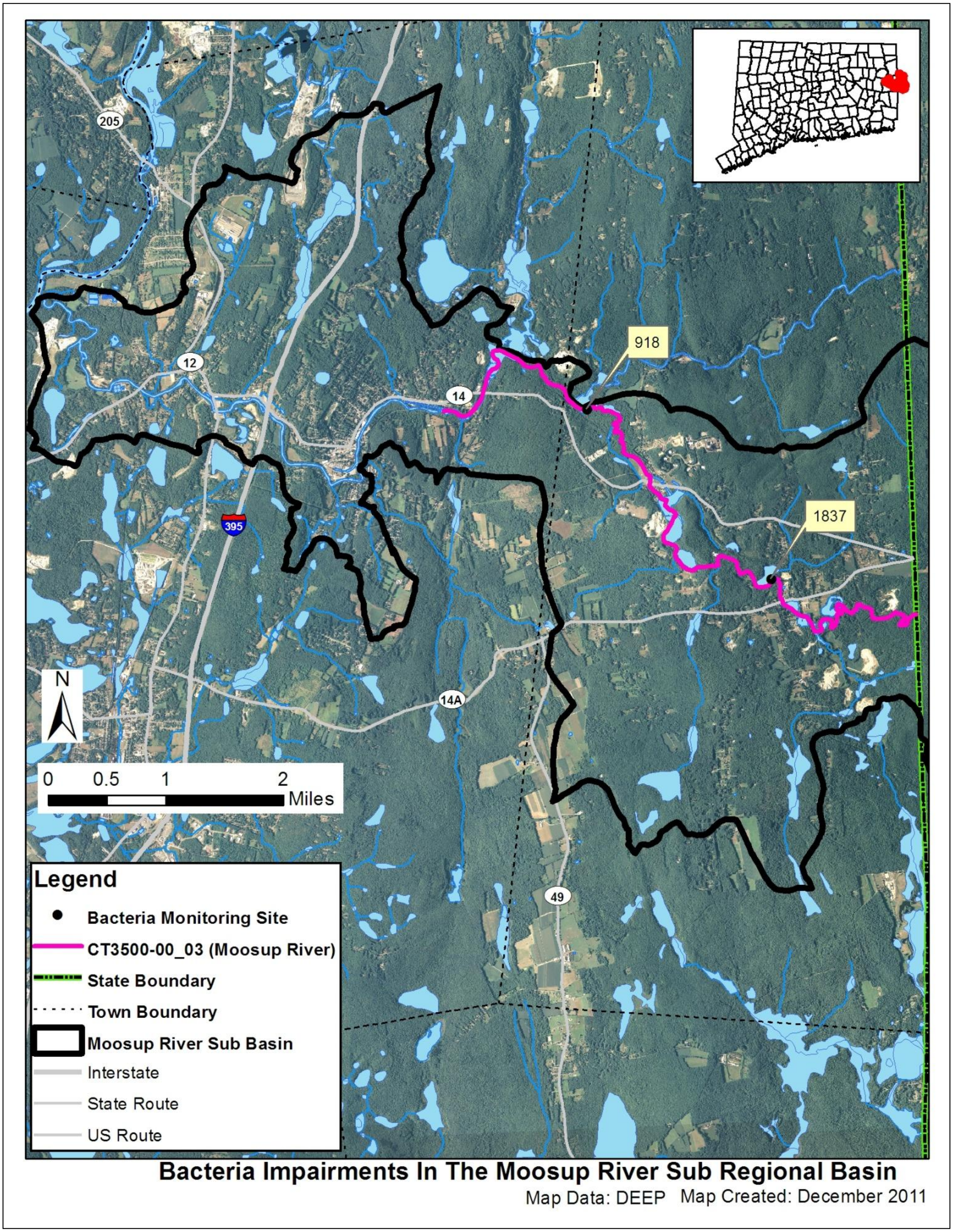


The impaired segment of the Moosup River has a water quality classification of B. Designated uses include habitat for fish and other aquatic life and wildlife, recreation, and industrial and agricultural water supply. As there are no designated beaches in this segment of the Moosup River, the specific recreation impairment is for non-designated swimming and other water contact related activities.

Table 1: Impaired segment from the Connecticut 2010 Integrated Water Quality Report

Waterbody ID	Waterbody Name	Location	Miles	Aquatic Life	Recreation	Fish Consumption
CT3500-00_01	Moosup River-01	From mouth at confluence with Quinebaug River, Plainfield, US to and including Plainfield North POTW outfall, Central Village.	1.77	U	U	FULL
CT3500-00_02	Moosup River-02	From POTW outfall (just DS from Black Hill Road crossing), Central Village, US to Brunswick Mill Dam #1(first impoundment in Almyville, parallel to Route 14), Plainfield.	4.01	FULL	U	FULL
CT3500-00_03	Moosup River-03	From Brunswick Mill Dam #1 (first impoundment in Almyville, parallel to Route 14), Plainfield, US to Rhode Island border.	7.36	U	NOT	FULL
Shaded cells indicate impaired segment addressed in this TMDL **FULL = Designated Use Fully Supported** **NOT = Designated Use Not Supported** **U = Unassessed**						

Figure 2: GIS map featuring general information of the Moosup River watershed at the sub-regional level



Land Use

Existing land use can affect the water quality of waterbodies within a watershed (USEPA, 2011c). Natural processes, such as soil infiltration of stormwater and plant uptake of water and nutrients, can occur in undeveloped portions of the watershed. As impervious surfaces (such as rooftops, roads, and sidewalks) increase within the watershed landscape from commercial, residential, and industrial development, the amount of stormwater runoff to waterbodies also increases. These waterbodies are negatively affected as increased pollutants from nutrients and bacteria from failing and insufficient septic systems, oil and grease from automobiles, and sediment from construction activities become entrained in this runoff. Agricultural land use activities, such as fertilizer application and manure from livestock, can also increase pollutants in nearby waterbodies (USEPA, 2011c).

As shown in Figures 3 and 4, the Moosup River watershed consists of 57% forest, 25% urban, 12% agriculture, and 6% water/wetlands. Urban land in the eastern portion of the watershed is concentrated along roadways and in the Town of Sterling. The western, lower watershed area contains considerably more urban and suburban development in the villages of Moosup, Plainfield Village, Central Village and Wauregan, which is interspersed with patches of agriculture and forestland. Large areas of conservation land in the watershed include the Nicholas Farm Management Area on the CT-RI state line, and the northern extent of the Pachaug State Forest. Land use adjacent to the impaired segment of the Moosup River is dominated by forested wetlands, forestland and urban development, with small pockets of agricultural land (Figure 4).

Figure 3: Land use within the Moosup River watershed

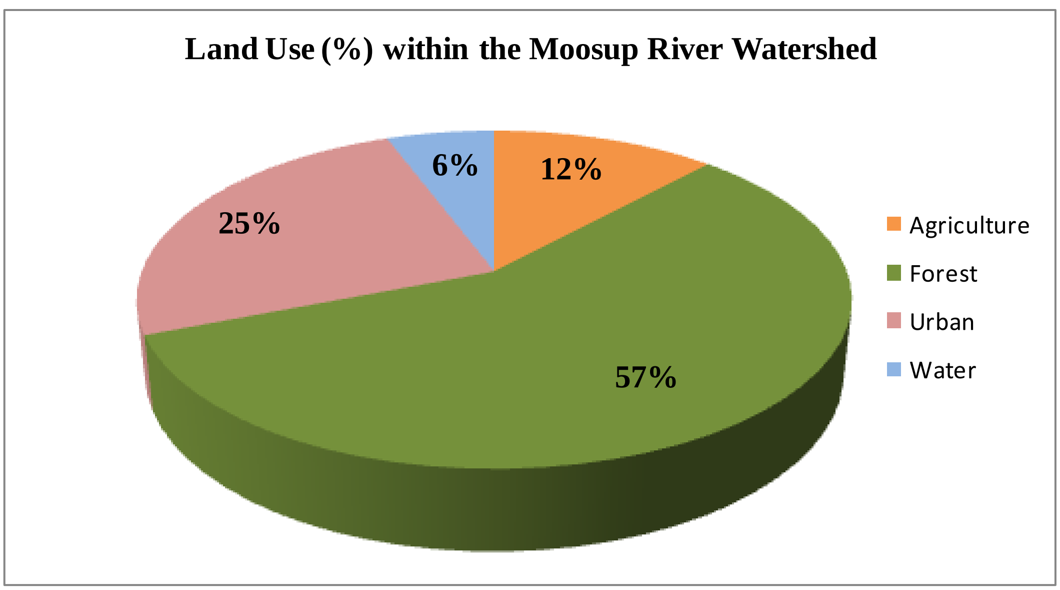
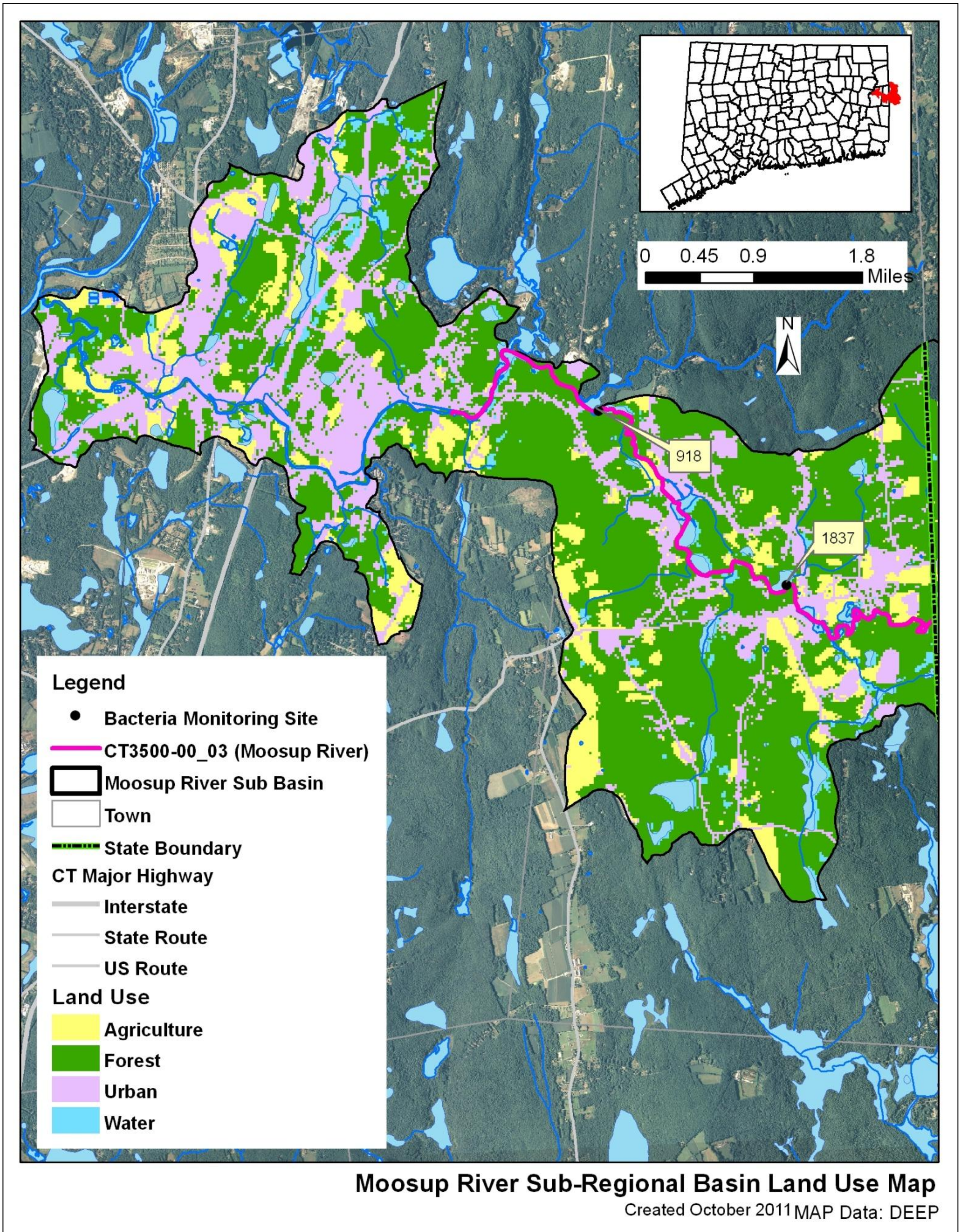


Figure 4: GIS map featuring land use for the Moosup River watershed at the sub-regional level



WHY IS A TMDL NEEDED?

E. coli is the indicator bacteria used for comparison with the CT State criteria in the CT Water Quality Standards (WQS) (CTDEEP, 2011). All data results are from CT DEEP, USGS, Bureau of Aquaculture, or volunteer monitoring efforts at stations located on the impaired segments.

Table 2: Sampling station location description for the impaired Segment in the Moosup River watershed

Waterbody ID	Waterbody Name	Station	Station Description	Municipality	Latitude	Longitude
CT3500-00_03	Moosup River	918	500 meters downstream of RR bridge crossing	Sterling	No data	No data
CT3500-00_03	Moosup River	1837	Route 14a	Sterling	41.696000	-71.812200

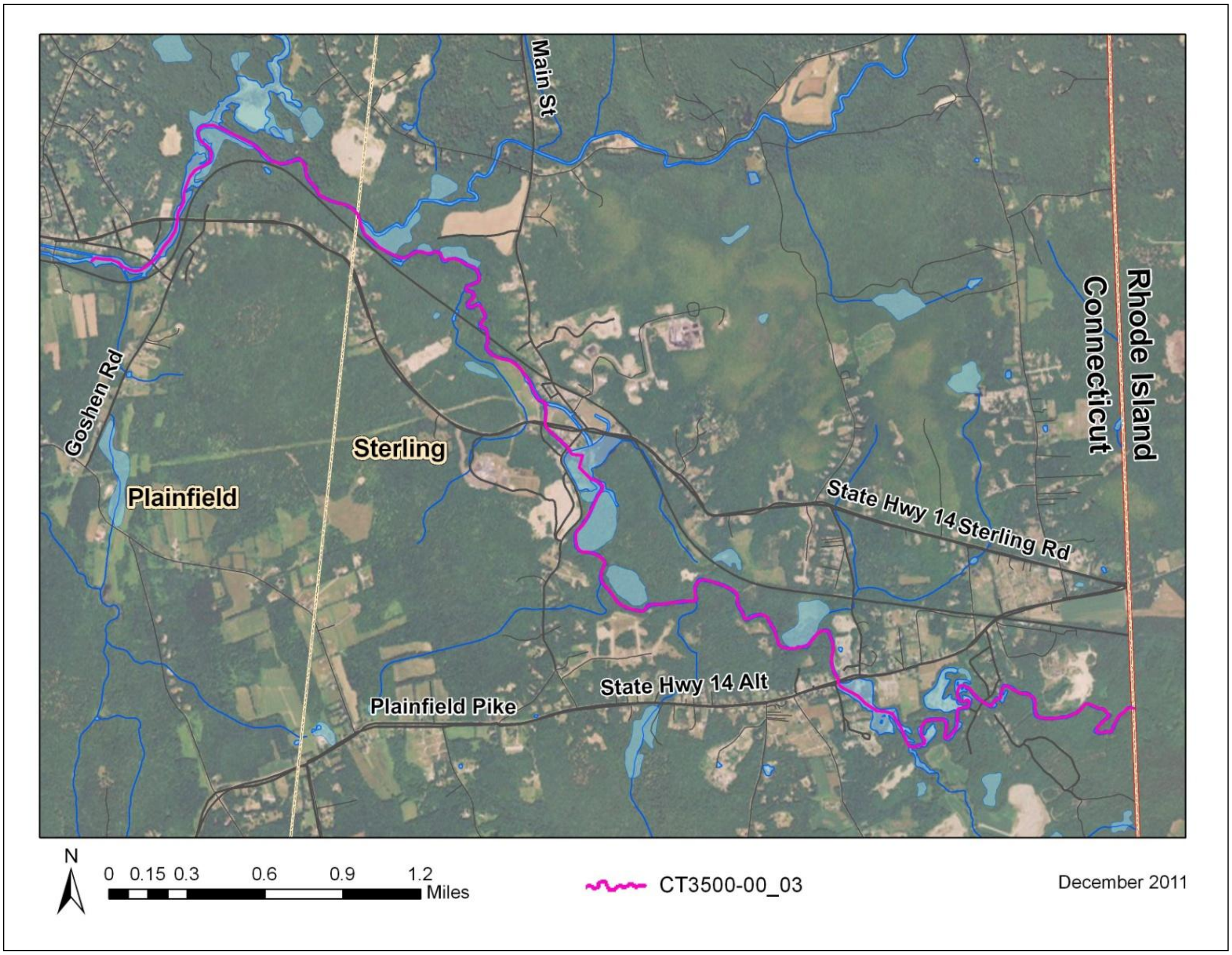
The Moosup River (CT3500-00_03) is a Class B freshwater river (Figure 5). Its applicable designated uses are habitat for fish and other aquatic life and wildlife, recreation, and industrial and agricultural water supply. Water quality analyses were conducted using data from two sampling locations from 2003-2009 (Stations 918 and 1837) (Table 2).

The water quality criteria for *E. coli*, along with bacteria sampling results for Station 1837 from 2006-2010, are presented in Table 9. The annual geometric mean was calculated for Station 1837 and exceeded the WQS for *E. coli* in two of the five years. Single sample values at this station also exceeded the WQS for *E. coli* at least once in each of the five years that samples were collected. Station 918 did not exceed single sample or geometric mean values on any sampling date.

To aid in identifying possible bacteria sources, the geometric mean was also calculated for wet-weather and dry-weather sampling days at both stations (Table 9). The geometric mean during wet-weather exceeded the WQS for *E. coli* at Station 1837, while dry weather samples did not exceed. Based on these geometric means, bacteria levels in wet weather samples were over twice dry weather levels.

Due to the elevated bacteria measurements presented in Table 9, this segment of the Moosup River did not meet CT's bacteria WQS, was identified as impaired, and was placed on the CT List of Waterbodies Not Meeting Water Quality Standards, also known as the CT 303(d) Impaired Waters List. The Clean Water Act requires that all 303(d) listed waters undergo a TMDL assessment that describes the impairments and identifies the measures needed to restore water quality. The goal is for all waterbodies to comply with State WQS.

Figure 5: Aerial map of the Moosup River



POTENTIAL BACTERIA SOURCES

Potential sources of indicator bacteria in a watershed include point and non-point sources, such as stormwater runoff, agriculture, sanitary sewer overflows (collection system failures), illicit discharges, and inappropriate discharges to the waterbody. Potential sources that have been tentatively identified in the Moosup River watershed based on land use (Figures 3 and 4) and a collection of local information for the impaired waterbody is presented in Table 3 and Figure 6. The list of potential sources is general in nature and should not be considered comprehensive. There may be other sources not listed here that contribute to the observed water quality impairment in the study segment. Further monitoring and investigation will confirm listed sources and discover additional sources. More detailed evaluation of potential sources is expected to become available as activities are conducted to implement these TMDLs.

Table 3: Potential bacteria sources in the Moosup River watershed

Impaired Segment	Permit Source	Illicit Discharge	CSO/SSO Issue	Failing Septic System	Agricultural Activity	Stormwater Runoff	Nuisance Wildlife/ Pets	Other
Moosup River CT3500-00_03	x	x		x	x	x	x	x

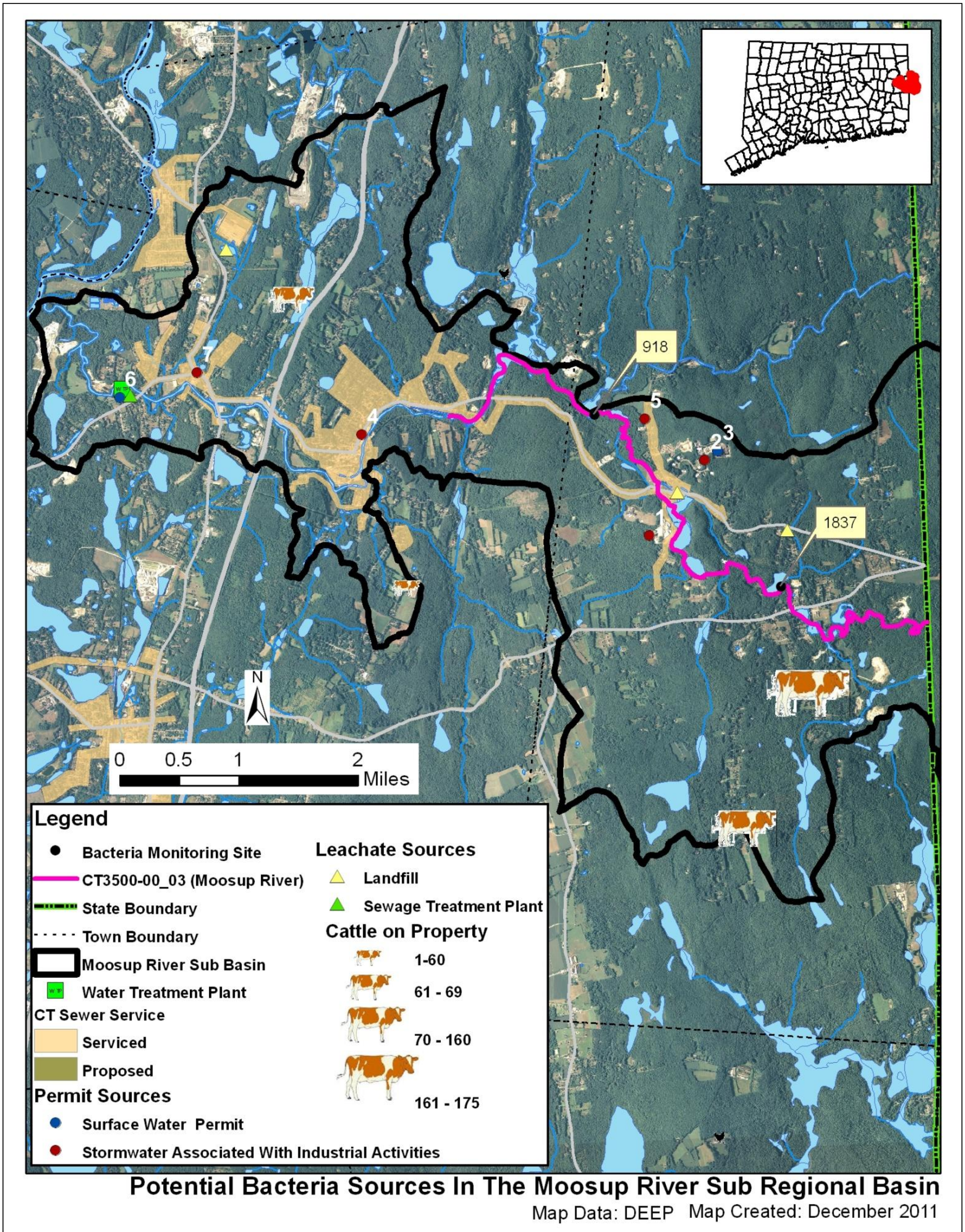
Point Sources

Permitted sources within the watershed that could potentially contribute to the bacteria loading are identified in Table 4. This table includes permit types that may or may not be present in the impaired watershed. A list of active permits in the watershed is included in Table 5. Additional investigation and monitoring could reveal the presence of additional discharges in the watershed. Available effluent data from each of these permitted categories found within the watershed are compared to the CT State WQS for the appropriate receiving waterbody use and type.

Table 4: General categories list of other permitted discharges

Permit Code	Permit Description Type	Number in watershed
CT	Surface Water Discharges	2
GPL	Discharge of Swimming Pool Wastewater	0
GSC	Stormwater Discharge Associated with Commercial Activity	0
GSI	Stormwater Associated with Industrial Activity	5
GSM	Part B Municipal Stormwater MS4	0
GSN	Stormwater Registration – Construction	0
LF	Groundwater Permit (Landfill)	0
UI	Underground Injection	0

Figure 6: Potential sources in the Moosup River watershed at the sub-regional level



The potential sources map for the impaired basin was developed after thorough analysis of available data sets. If information is not displayed in the map, then no sources were discovered during the analysis. The following is the list of potential sources that were evaluated: problems with migratory waterfowl, golf course locations, reservoirs, proposed and existing sewer service, cattle farms, poultry farms, permitted sources of bacteria loading (surface water discharge, MS4 permit, industrial stormwater, commercial stormwater, groundwater permits, and construction related stormwater), and leachate and discharge sources (agricultural waste, CSOs, failing septic systems, landfills, large septic tank leach fields, septage lagoons, sewage treatment plants, and water treatment or filter backwash).

Permitted Sources

As shown in Table 5, there are several permitted discharges in the Moosup River watershed both within the impaired river segment, and downstream of the segment. Bacteria data from 2001 – 2002 from at least one of these industrial permitted facilities are included in Table 6. Though this data cannot be compared to a water quality standard as there is no recreation standard for fecal coliform bacteria, multiple samples from Kaman Aerospace (GSI469), and one at Griswold Rubber (GSI832) were above the maximum number the analytical method could detect.

Since the MS4 permits are not targeted to a specific location, but the geographic area of the regulated municipality, there is no one accurate location on the map to display the location of these permits. One dot will be displayed at the geographic center of the municipality as a reference point (Figure 6). Sometimes this location falls outside of the targeted watershed and therefore the MS4 permit will not be displayed in the Potential Sources Map. Using the municipal border as a guideline will show which areas of an affected watershed area covered by an MS4 permit.

Table 5: Permitted facilities within the Moosup River watershed

Town	Client	Permit ID	Permit Type	Site Name/Address	Map #
Moosup	Griswold Corporation	GSI000832	Stormwater Associated With Industrial Activities	Griswold Rubber Company, Inc.	4
Plainfield	Strategic Commercial Realty, Inc	GSI001876	Stormwater Associated With Industrial Activities	Tillinghast South Quarry	7
Plainfield	Town Of Plainfield	CT0100447	Surface Water Permit	Plainfield North Wpcf	6
Sterling	Riverview Enterprises	GSI001994	Stormwater Associated With Industrial Activities	Riverview Enterprises	1
Sterling	Atma Investments Llc	GSI002220	Stormwater Associated With Industrial Activities	Atma Investments Llc Scrap Tire Facility	2
Sterling	Town Of Sterling	GSI000156	Stormwater Associated With Industrial Activities	Sterling Town Garage	5
Sterling	Exeter Energy Ltd. Partnership, Reenergy Sterling Ct Ltd. Partnership	CT0026972	Surface Water Permit	Sterling Energy Facility	3

Table 6: Industrial permits on the Moosup River and available fecal coliform data (colonies/100mL). The results cannot be compared to the water quality standard as there is no recreation standard for fecal coliform.

Town	Location	Permit Number	Receiving Water	Sample Location	Sample Date	Result
Plainfield	Kaman Aerospace	GSI469	Moosup River	outfall #2	09/21/01	TNTC*
Plainfield	Kaman Aerospace	GSI469	Moosup River	Outfall #2	07/23/02	3,900
Plainfield	Kaman Aerospace	GSI469	Moosup River	outfall #5	07/11/01	70
Plainfield	Kaman Aerospace	GSI469	Moosup River	outfall #5	05/28/02	TNTC*
Plainfield	Kaman Aerospace	GSI469	Moosup River	outfall #5	06/12/03	1,800
Plainfield	Kaman Aerospace	GSI469	Moosup River	outfall #6	07/11/01	10
Plainfield	Kaman Aerospace	GSI469	Moosup River	outfall #6	05/28/02	40
Plainfield	Kaman Aerospace	GSI469	Moosup River	outfall #6	06/12/03	200
Plainfield	Griswold Rubber Company	GSI832	Moosup River	WSN-northern outfall	09/21/01	800
Plainfield	Griswold Rubber Company	GSI832	Moosup River	WSN-northern outfall	08/20/02	460
Plainfield	Griswold Rubber Company	GSI832	Moosup River	WSS-southern outfall	09/21/01	TNTC*
Plainfield	Griswold Rubber Company	GSI832	Moosup River	WSS-southern outfall	08/20/02	20

***** TNTC = too numerous to count

Municipal Stormwater Permitted Sources

US Census Bureau Urbanized Areas (UAs) must be covered under MS4 permits regulated by the appropriate State agency. There is an EPA waiver process that municipalities can apply for to not participate in the MS4 program. In Connecticut, EPA has granted such waivers to 19 municipalities. All participating municipalities within UAs in Connecticut are currently regulated under MS4 permits by CT DEEP staff in the MS4 program.

The US Census Bureau defines a UA as a densely settled area that has a census population of at least 50,000. A UA generally consists of a geographic core of block groups or blocks that exceeds the 50,000 people threshold and has a population density of at least 1,000 people per square mile. The UA will also include adjacent block groups and blocks with at least 500 people per square mile. A UA consists of all or part of one or more incorporated places and/or census designated places, and may include additional territory outside of any place. (67 FR 11663)

For the 2000 Census a new geographic entity was created to supplement the UA blocks of land. This created a block known as an Urban Cluster (UC) and is slightly different than the UA. The definition of a UC is a densely settled area that has a census population of 2,500 to 49,999. A UC generally consists of a geographic core of block groups or blocks that have a population density of at least 1,000 people per square mile, and adjacent block groups and blocks with at least 500 people per square mile. A UC consists of all or part of one or more incorporated places and/or census designated places; such a place(s) together with adjacent territory; or territory outside of any place. The major difference is the total population cap of 49,999 people for a UC compared to >50,000 people for a UA. (67 FR 11663)

While it is possible that CT DEEP will be expanding the reach of the MS4 program to include UC municipalities in the near future they are not currently under the permit. However, the GIS layers used to create the MS4 maps in this Statewide TMDL did include both UA and UC blocks. This factor creates some municipalities that appear to be within an MS4 program that are not currently regulated through an MS4 permit. This oversight can explain a municipality that is at least partially shaded grey in the maps and there are no active MS4 reporting materials or information included in the appropriate appendix. While these areas are not technically in the MS4 permit program, they are still considered urban by the cluster definition above and are likely to contribute similar stormwater discharges to affected waterbodies covered in this TMDL.

As previously noted, EPA can grant a waiver to a municipality to preclude their inclusion in the MS4 permit program. One reason a waiver could be granted is a municipality with a total population less than 1,000 people, even if the municipality was located in a UA. There are 19 municipalities in Connecticut that have received waivers, this list is: Andover, Bozrah, Canterbury, Coventry, East Hampton, Franklin, Haddam, Killingworth, Litchfield, Lyme, New Hartford, Plainfield, Preston, Salem, Sherman, Sprague, Stafford, Washington, and Woodstock. There will be no MS4 reporting documents from these towns even if they are displayed in an MS4 area in the maps of this document.

The list of US Census UCs is defined by geographic regions and is named for those regions, not necessarily by following municipal borders. In Connecticut the list of UCs includes blocks in the following Census Bureau regions: Colchester, Danielson, Lake Pocotopaug, Plainfield, Stafford, Storrs, Torrington, Willimantic, Winsted, and the border area with Westerly, RI (67 FR 11663). Any MS4 maps showing these municipalities may show grey areas that are not currently regulated by the CT DEEP MS4 permit program.

The impaired segment of the Moosup River watershed is located within the towns of Plainfield and Sterling, CT. As described above, the Town of Plainfield received a waiver to preclude their inclusion in the MS4 permit program for the Discharge of Stormwater from Small Municipal Storm Sewer Systems. This general permit is only applicable to municipalities that are identified in Appendix A of the MS4 permit that contain designated urban areas and discharge stormwater via a separate storm sewer system to surface waters of the State. The permit requires municipalities to develop a Stormwater Management Plan (SMP) to reduce the discharge of pollutants and protect water quality. The MS4 permit is discussed further in the "TMDL Implementation Guidance" section of the core TMDL document. Additional information regarding stormwater management and the MS4 permit can be obtained on CTDEEP's website (http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325702&depNav_GID=1654). As shown in Figure 7, the Town of Plainfield is part of an Urban Cluster, which may be regulated in the future.

Publicly Owned Treatment Works

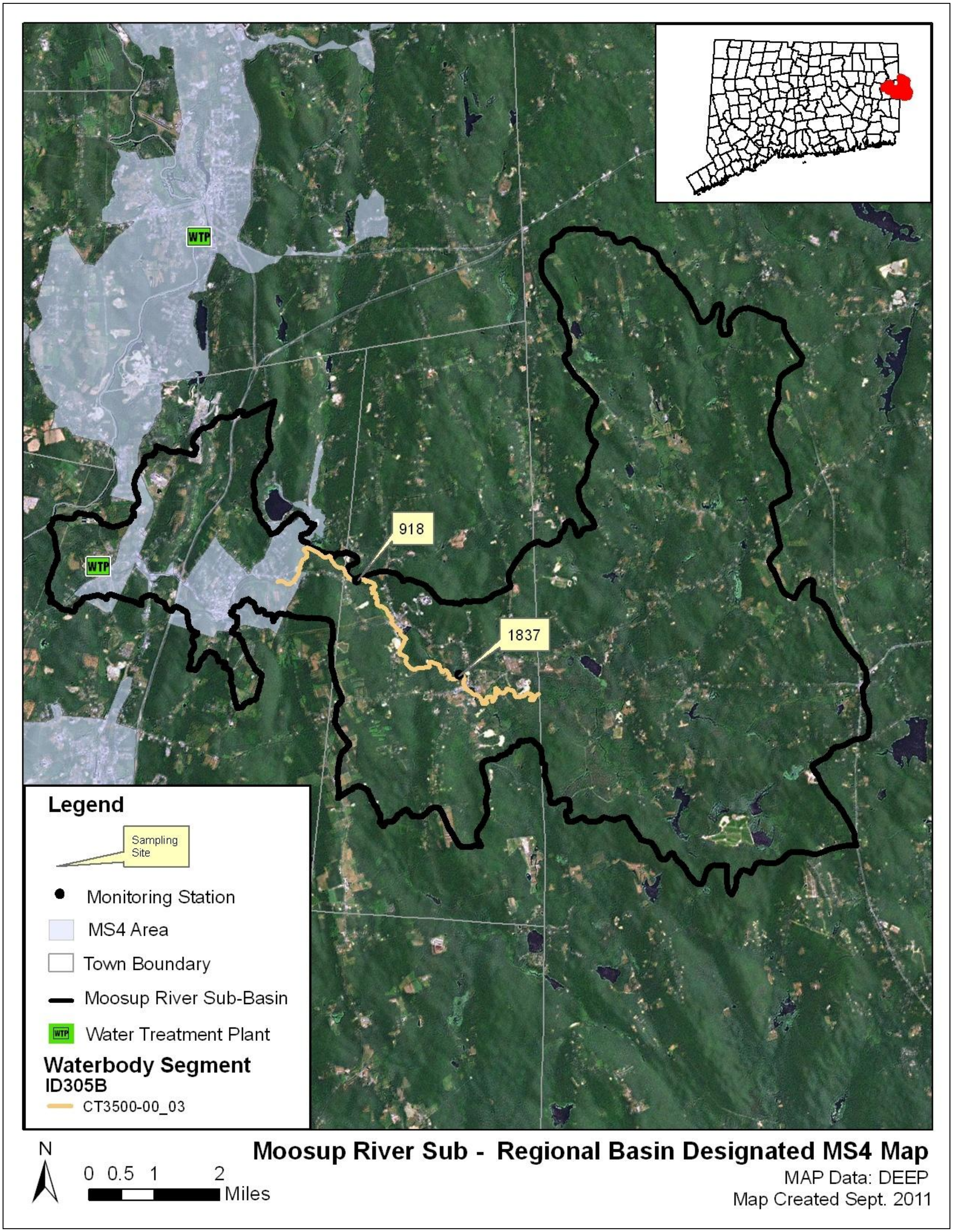
As shown in Table 7, there is one publicly owned wastewater treatment plant in the Moosup River watershed. The Plainfield North Water Pollution Control Facility (WPCF) is located downstream of the impaired river segment, approximately one mile from the confluence with the Quinebaug River on Black Hill Road (Figure 6). This WPCF discharges directly to the Moosup River. A second treatment plant, the Plainfield Village WPCF, is located behind Sunny Brook Park off Birch Street in Plainfield, just outside of the northern watershed boundary. This plant discharges to Mill Brook. Planned improvements to the North plant are expected to result in the closing of the Plainfield Village Plant, and more efficient treatment of sewage at the North plant (Norwich Bulletin, 2010).

Table 7: Water Treatment Facilities in the Moosup River watershed

Town	Client	Permit ID	Permit Type	Site Name/Address	Map #
Plainfield	Town of Plainfield	CT0100447	Surface Water Permit	Plainfield North WPCF	NA

A 2006 study of the Moosup River identified the Lower Moosup River as an area with the greatest threat from point-source pollution (Lerner, 2006). At the time of the study, eleven of the 23 regulated leachate wastewater discharge sources in the Moosup Watershed were located in Plainfield with two more located in Sterling. It was estimated that 48% of all leachate wastewater discharges to the river were located in this portion of the watershed (Lerner, 2006). In addition to the WPCF, there are three landfills located in the watershed, one of which is located within close proximity to a tributary of the Moosup River north of Station 1837, and the other downstream, near Sterling Pond (Figure 6).

Figure 7: MS4 areas of the Moosup River watershed



Non-point Sources

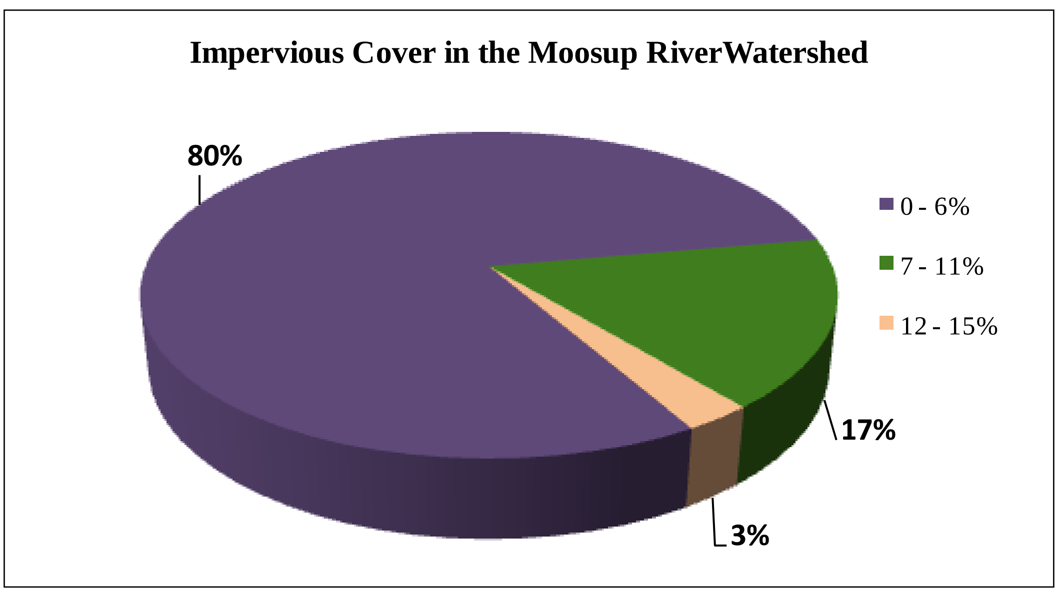
Non-point source pollution (NPS) comes from many diffuse sources and is more difficult to identify and control. NPS pollution is often associated with land-use practices. Examples of NPS that can contribute bacteria to surface waters include insufficient septic systems, pet and wildlife waste, agriculture, and contact recreation (swimming or wading). Potential sources of NPS within the Moosup River watershed are described below.

Stormwater Runoff from Developed Areas

Approximately one-third of the Moosup River watershed is developed (Figure 8). This development is dispersed along major roadways throughout the watershed and within towns and villages. Approximately 25% of the land use in the watershed is considered urban, with a majority of that urban development in the lower watershed, downstream of the impaired segment in Moosup, Plainfield Village and Central Village (Figures 4 and 9). The most heavily developed area in the eastern watershed is near Oneco Pond in Sterling, which is adjacent to the upstream water quality sampling station (Station 1837). Urban areas are often characterized by impervious cover, or surface areas such as roofs and roads that force water to run off land surfaces rather than infiltrate into the soil. Studies have shown a link between increasing impervious cover and degrading water quality conditions in a watershed (CWP, 2003). In one study, researchers correlated the amount of fecal coliform to the percent of impervious cover in a watershed (Mallin *et al.*, 2000).

A study of the Moosup River watershed showed that from 1999-2004, the Town of Sterling exhibited an increase of more than 100% in the number of building permits compared to the previous years. In addition, between 1980 and 2000, the Town of Sterling's population increased by 73%, far exceeding the percent change of the four other towns in the Moosup River watershed. This growth has been attributed to many factors, which include Rhode Island residents moving across the border to benefit from the lower cost of living and taxes in Connecticut (Lerner, 2006).

Figure 8: Range of impervious cover (%) in the Moosup River watershed



As shown in Figure 9, the portion of the Moosup River watershed containing the impaired segment contains between 0-6% impervious cover, with the exception of the small area near Oneco Pond containing between 7-11% impervious cover. The area with the highest percentage of impervious cover in the watershed is located downstream of the impaired segment. High geometric means during wet-weather may indicate that stormwater runoff is contributing to the bacterial impairment in a stream segment. As shown in Table 9, the geometric mean for wet weather exceeded the WQS at Station 1837 on the impaired segment of the Moosup River, indicating that the Moosup River is likely receiving bacteria from stormwater runoff.

Insufficient Septic Systems

As shown in Figure 6, many residents in the Moosup River watershed rely on onsite wastewater treatment systems such as septic systems. Properly managed septic systems and leach fields have the ability to effectively remove bacteria from waste. If systems are not maintained, waste will not be adequately treated and may result in bacteria reaching nearby surface and ground water. In Connecticut, local health directors or health districts are responsible for keeping track of any reported insufficient or failing septic systems in a specific municipality. The towns of Plainfield and Sterling are part of the Northeast District Department of Health (NDDH) which has a full-time health director (http://www.nddh.org/contact/contact.html).

Agricultural Activities

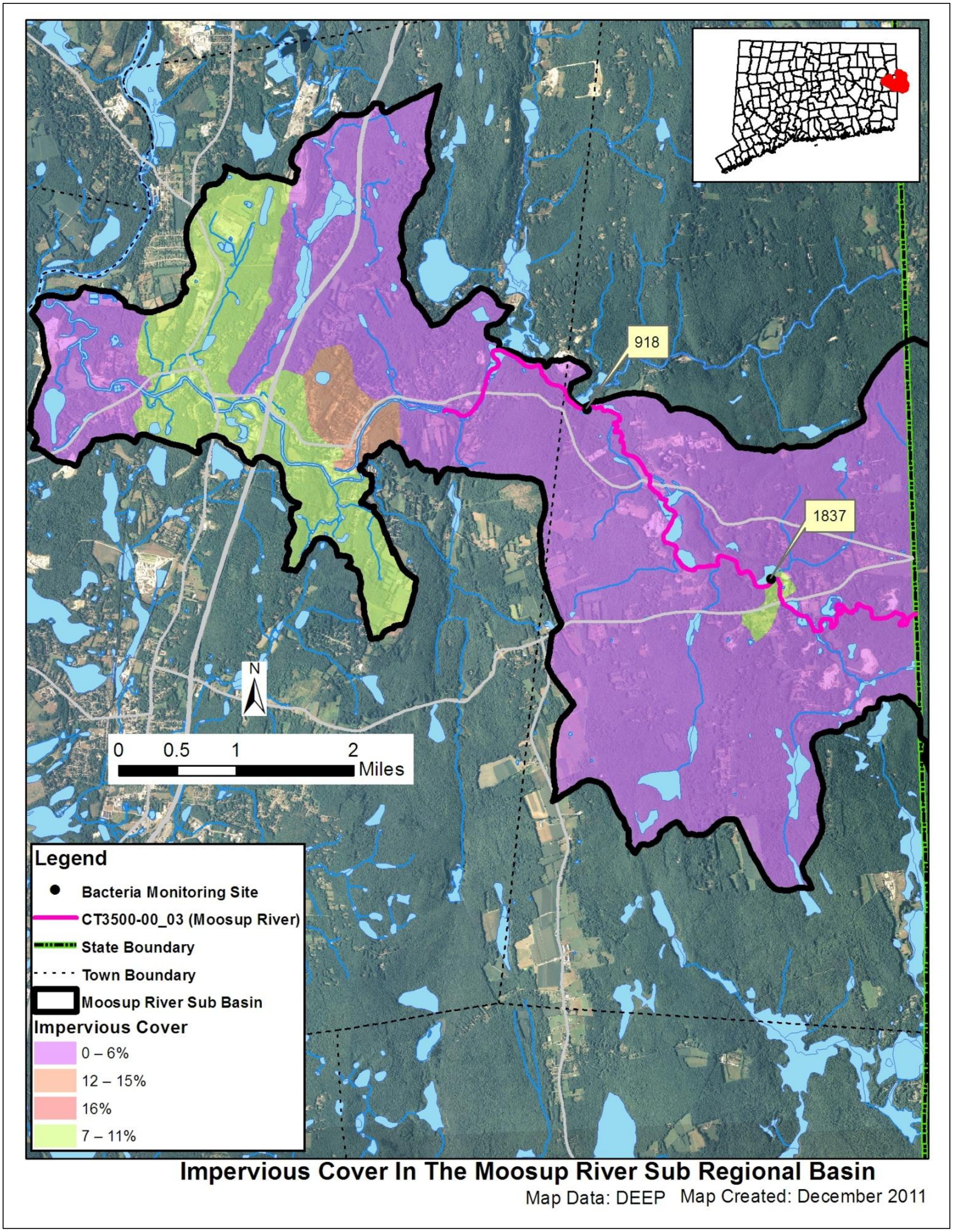
Agricultural operations are an important economic activity and landscape feature in many areas of the State. Runoff from agricultural fields may contain pollutants such as bacteria and nutrients (USEPA, 2011a). This runoff can include pollutants from farm practices such as storing manure, allowing livestock to wade in nearby waterbodies, applying fertilizer, and reducing the width of vegetated buffers along the shoreline. Agricultural land use makes up 12% of the Moosup River watershed, with patches of agricultural land interspersed across the landscape. In addition to the agricultural fields, there are several dairy farms in the watershed, two of which are located in the eastern portion of the watershed to the south of the impaired segment (Figure 6). These farms are located near tributaries that flow to the Moosup River, and therefore have the potential to contribute bacteria to the river.

Wildlife and Domestic Animal Waste

Wildlife and domestic animals within the Moosup River watershed represent another potential source of bacteria to the impaired waterbodies. Any elevated bacteria levels that are due solely to a natural population of wildlife are not subject to the WQS. Any exacerbation of wildlife population sizes or residency times influenced by human activities are subject to the CT WQS and TMDL provisions.

Fecal material from nuisance waterfowl such as Canada geese are a source of nonpoint source pollution, particularly pathogens and nutrients. Geese and other waterfowl are known to congregate in open areas including recreational fields and agricultural crop fields. In addition to creating a nuisance, large numbers of geese can also create unsanitary conditions on the grassed areas and cause water quality problems due to bacterial contamination associated with their droppings. Large populations of geese can also lead to habitat destruction as a result of overgrazing on wetland and riparian plants.

Figure 9: Impervious cover (%) for the Moosup River sub-regional watershed



With the construction of roads and drainage systems, these wildlife wastes may no longer be retained on the landscape, but instead may be conveyed via stormwater to the nearest surface waterbody. As such these physical land alterations can exacerbate the impact of natural sources on water quality (USEPA, 2001). As the majority of the watershed is undeveloped, wildlife waste is a potential source of bacteria in the Moosup River watershed.

Residential and commercial development in the watershed can result in stormwater runoff containing waste from domestic animals, such as dogs, which may also be contributing to high bacteria concentrations in the impaired segment of the Moosup River.

Additional Sources

There may be other sources not listed here that contribute to the observed water quality impairment in the Moosup River. Bacterial inputs from the 30.3 miles of river upstream of the impaired segment in Foster and Coventry, RI, to the east should be considered a potential source. The State of Rhode Island identified the upstream portion of the Moosup River as impaired due to elevated bacteria measurements collected between 2006-2008 (http://www.dem.ri.gov/programs/benviron/water/quality/swbpdf/moosup.pdf). Further monitoring and investigation will confirm the listed sources and discover additional ones. More detailed evaluation of potential sources is expected to become available as activities are conducted to implement this TMDL.

Land Use/Landscape

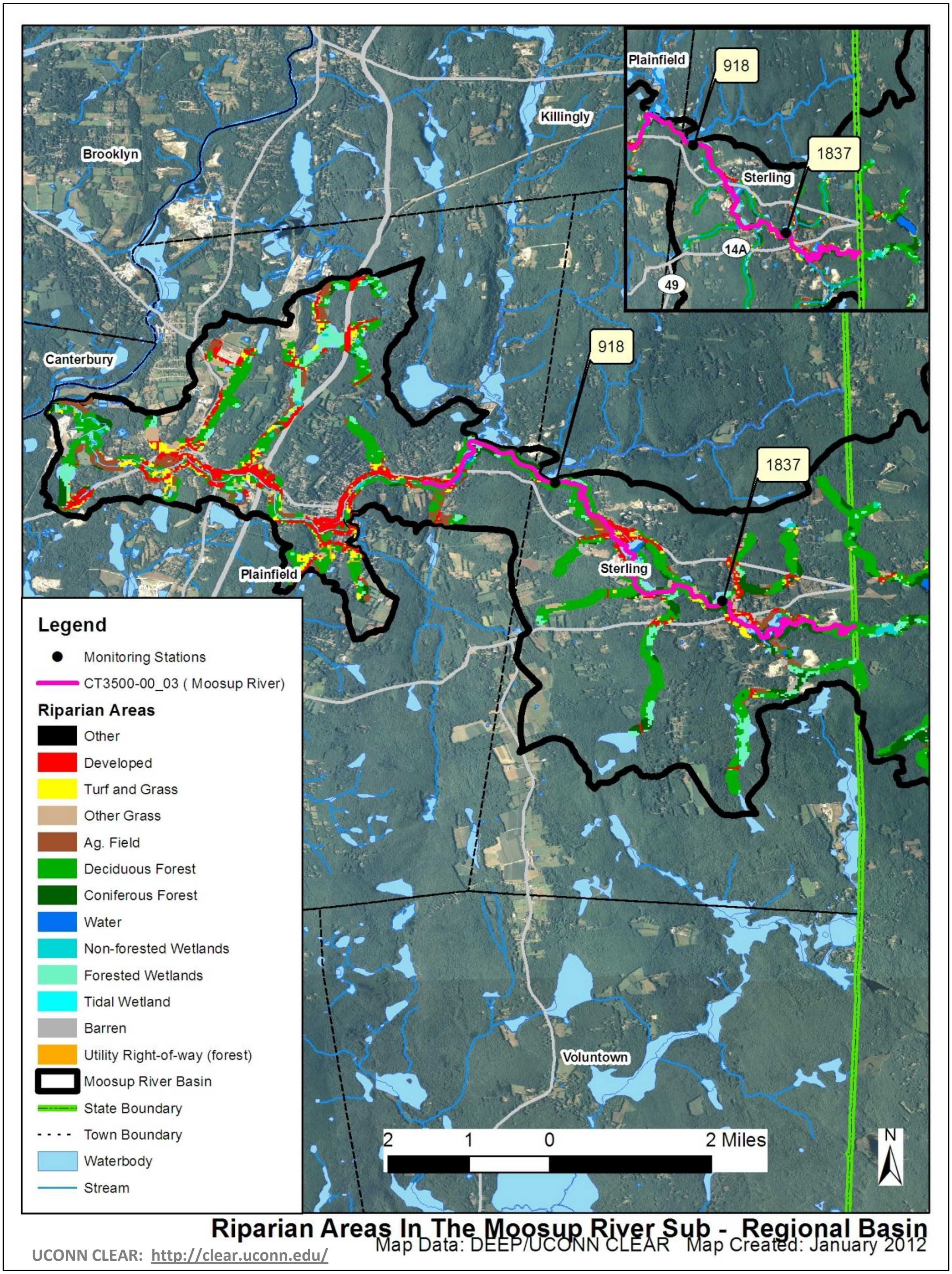
Riparian Buffer Zones

The riparian buffer zone is the area of land located immediately adjacent to streams, lakes, or other surface waters. The boundary of the riparian zone and the adjoining uplands is gradual and not always well-defined. However, riparian zones differ from uplands because of high levels of soil moisture, frequent flooding, and the unique assemblage of plant and animal communities found there. Through the interaction of their unique soils, hydrology, and vegetation, natural riparian areas influence water quality as contaminants are taken up into plant tissues, adsorbed onto soil particles, or modified by soil organisms. Any change to the natural riparian buffer zone can reduce the effectiveness of the natural buffer and has the potential to contribute to water quality impairment (USEPA, 2011b).

The CLEAR program at UCONN has created streamside buffer layers for the entire State of Connecticut (http://clear.uconn.edu/), which have been used in this TMDL. Analyzing this information can reveal potential sources and implementation opportunities at a localized level. The land use directly adjacent to a waterbody can have direct impacts on water quality from surface runoff sources.

The riparian zone for the impaired segment of the Moosup River is characterized by deciduous and coniferous forest, agriculture, and wetlands, as well as patches of developed land near roadways (Figure 10). Riparian areas downstream of the impaired segment are more heavily influenced by developed land and agriculture. A study of the larger Moosup River watershed (CT and RI) indicates that only 10% of all stream and river corridors within a 250 foot buffer of the Moosup River and its tributaries are protected from development (Lerner, 2006). If not properly treated, runoff from developed areas and agricultural fields may contain pollutants such as bacteria and nutrients because the natural riparian buffer is not available to treat this runoff.

Figure 10: Riparian buffer zone information for the Moosup River watershed



CURRENT MANAGEMENT ACTIVITIES

The Moosup River watershed is part of what is known as "the Borderlands", characterized by a relatively unfragmented forest corridor straddling 20 towns on the Rhode Island-Connecticut border. In 2011, the State of Rhode Island developed a Total Maximum Daily Load (TMDL) to address bacteria impairments upstream of the impaired segment (http://www.dem.ri.gov/programs/benviron/water/quality/swbpdf/moosup.pdf). Downstream of the impaired segment, plans are underway to improve the efficiency of Plainfield's Waste Water Treatment Plant which also discharges to the Moosup River.

RECOMMENDED NEXT STEPS

Future mitigative activities are necessary to ensure the long-term protection of the impaired segment of the Moosup River and have been prioritized below. In addition to addressing potential sources of bacteria within the watershed of the impaired segment of the Moosup River, the towns of Sterling and Plainfield would benefit from working with watershed towns upstream (Rhode Island) to address sources of bacteria on a watershed basis. By working together, the potential for success may be greater.

1) Identify areas along the the Moosup River to implement Low Impact Development (LID) and Best Management Practices (BMPs) to control stormwater runoff.

As noted previously, approximately 25% of the Moosup River watershed. The lower portion of the watershed, downstream of the impaired stream segment contains a higher percentage of developed land, while the upper portion of the watershed near the impaired segment has a higher percentage of agricultural land. Stormwater runoff from the developed areas is likely a source of bacteria and nutrients in the Moosup River. Low Impact Development (LID) is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treats stormwater as a resource rather than a waste product. Given the large areas of developed land in Plainfield, and the rapid growth trends in Sterling, both towns should consider adopting LID development principles into local land use plan regulations.

Since a large portion of the Moosup River watershed is located upstream of the impaired segment across the state line, it is possible that the bacteria impairment in the river could originate from land uses upstream of the impaired segment. Therefore, it is critical that watershed towns in Connecticut communicate with the watershed municipalities upstream in Rhode Island to begin discussions about how to address the problem.

2) Restore riparian vegetation in areas where it has been removed; address stream bank erosion.

Management of riparian vegetation protects streams from the impacts of developed land by trapping sediments, bacteria, nutrients, and other pollutants before they enter the stream. Therefore, restoring riparian vegetation in areas where it has been removed (developed areas) will help improve water quality in the stream. Identifying and prioritizing sites for establishment of buffers, obtain interest and permission from landowners and acquiring funding to plant the buffers are some of the key steps to success.

3) Reduce the amount of contaminated runoff from agricultural areas.

This can be accomplished a number of ways including: working with the agricultural community to enhance understanding of land stewardship and use of BMPs to protect water quality, encouraging the use of management practices such as no-till conservation farming, and conducting sampling and chemical analysis of manure prior to application will reduce the possibility of over application and minimize of bacteria in runoff. Exclusionary fences should be installed to direct livestock movement away from streams and riparian areas and maintenance of streamside buffers will reduce the amount of bacteria and other contaminants entering the stream. Manure storage areas should be located away from wetlands and waterbodies and drainage areas, and manure solids should be stored in covered areas.

4) Ensure there are sufficient buffers on agricultural lands along the Moosup River.

If not already in place, agricultural producers should work with the CT Department of Agriculture and the U.S. Department of Agriculture Natural Resources Conservation Service to develop conservation plans for their farming activities within the watershed. These plans should focus on ensuring that there are sufficient stream buffers, that fencing exists to restrict livestock and horse access to streams and wetlands, and that animal waste handling, disposal, and other appropriate Best Management Practices (BMPs) are in place. Particular attention should be paid to those agricultural operations located within the riparian buffer zone along the impaired segment, directly upstream from the impaired segment, or along tributaries of the Moosup River (Figure 10).

5) Continue monitoring of permitted sources.

Regular monitoring of discharge from permitted sources in the watershed should continue to ensure compliance with permit requirements and to determine if current requirements are adequate or if additional measures are necessary for water quality protection. The following table details the appropriate bacteria criteria for use as permit limits for permittees as permits are renewed and updated, within the Moosup River watershed.

Table 8 details the appropriate bacteria criteria for use as waste load allocations established by this TMDL for use as water quality targets by permittees as permits are renewed and updated, within the Moosup River watershed.

For any municipality subject to an MS4 permit and affected by a TMDL, the permit requires a modification of the SMP to include BMPs that address the included impairment. In the case of bacteria related impairments municipal BMPs could include: implementation or improvement to existing nuisance wildlife programs, septic system monitoring programs, any additional measures that can be added to the required illicit discharge detection and elimination (IDDE) programs, and increased street sweeping above basic permit requirements. Any non-MS4 municipalities can implement these same types of initiatives in effort to reduce bacteria source loading to impaired waterways.

Any facilities that discharge non-MS4 regulated stormwater should update their Pollution Prevention Plan to reflect BMPs that can reduce bacteria loading to the receiving waterway. These BMPs could include nuisance wildlife control programs and any installations that increase surface infiltration to reduce overall stormwater volumes. Facilities that are regulated under the Commercial Activities Stormwater Permit should report any updates to their SMP in their summary documentation submitted to DEEP.

Table 8. Water Quality Criteria for Receiving Waters Affected by this TMDL

		Instantaneous *E. coli* (#/100mL)						Geometric Mean *E. coli* (#/100mL)	
Class	**Bacteria Source**	**WLA[6]**			**LA[6]**			**WLA[6]**	**LA[6]**
B[4]	Non-Stormwater NPDES	235	410	576				126	
	CSOs	235	410	576				126	
	SSOs	0	0	0				0	
	Illicit sewer connection	0	0	0				0	
	Leaking sewer lines	0	0	0				0	
	Stormwater (MS4s)	235[7]	410[7]	576[7]				126[7]	
	Stormwater (non-MS4)				235[7]	410[7]	576[7]		126[7]
	Wildlife direct discharge				235[7]	410[7]	576[7]		126[7]
	Human or domestic animal direct discharge[5]				235	410	576		126

(1) **Designated Swimming.** Procedures for monitoring and closure of bathing areas by State and Local Health Authorities are specified in: Guidelines for Monitoring Bathing Waters and Closure Protocol, adopted jointly by the Department of Environmental Protections and the Department of Public Health. May 1989. Revised April 2003 and updated December 2008.

(2) **Non-Designated Swimming.** Includes areas otherwise suitable for swimming but which have not been designated by State or Local authorities as bathing areas, waters which support tubing, water skiing, or other recreational activities where full body contact is likely.

(3) **All Other Recreational Uses.**

(4) Criteria for the protection of recreational uses in Class B waters do not apply when disinfection of sewage treatment plant effluents is not required consistent with Standard 23. (Class B surface waters located north of Interstate Highway I-95 and downstream of a sewage treatment plant providing seasonal disinfection May 1 through October 1, as authorized by the Commissioner.)

(5) Human direct discharge = swimmers

(6) Unless otherwise required by statute or regulation, compliance with this TMDL will be based on ambient concentrations and not end-of-pipe bacteria concentrations

(7) Replace numeric value with "natural levels" if only source is naturally occurring wildlife. Natural is defined as the biological, chemical and physical conditions and communities that occur within the environment which are unaffected or minimally affected by human influences (CT DEEP 2011a). Sections 2.2.2 and 6.2.7 of this Core Document deal with BMPs and delineating type of wildlife inputs.

6) Implement a program to evaluate the sanitary sewer system.

A portion of the Moosup River watershed relies on a municipal sewer system (Figure 6), including those residents near the river. It is important for the Town of Plainfield to develop a program to evaluate its sanitary sewer system and reduce leaks and overflows. This program should include periodic inspections of the sewer line.

7) Develop a system to monitor septic systems.

Many areas of the Moosup River watershed rely on septic systems for human waste disposal. If not already in place, the towns of Sterling and Plainfield should establish a program to ensure that existing septic systems in the watershed are properly operated and maintained, and create an inventory of existing septic systems through mandatory inspections. Inspections help encourage proper maintenance and identify failed and sub-standard systems. Policies that govern the eventual replacement of sub-standard systems within a reasonable timeframe can be adopted. Sterling can also develop a program to assist citizens with the replacement and repair of older and failing systems.

8) Evaluate municipal education and outreach programs regarding animal waste.

Residents within the developed areas of the Moosup River watershed would benefit from an education and outreach program that highlights the importance of managing waste from horses, dogs, and other pets, and not feeding waterfowl and wildlife. Waterfowl, especially grazers like geese, prefer easy access to water. Maintaining an uncut vegetated buffer will make the habitat less desirable to geese and encourage migration. In addition, any educational program should emphasize that feeding waterfowl, such as ducks, geese, and swans, may contribute to water quality impairments in the Moosup River and can harm human health and the environment. Animal wastes should be disposed of away from any waterbody or storm drain system. BMPs effective at reducing the impact of animal waste on water quality include installing signage, providing pet waste receptacles in high-use areas, enacting ordinances requiring the clean-up of pet waste, and targeting educational and outreach programs in problem areas.

9) Conduct Bacteria Source Surveys in tributary watersheds that flow to the Moosup River to determine sources of bacteria.

Conduct bacterial analysis and visual surveys for some of the key tributaries that flow to the impaired segment of the Moosup River to determine sources of bacteria that may be contributing to the impairment.

BACTERIA DATA AND PERCENT REDUCTIONS TO MEET THE TMDL

Table 9: Moosup River Bacteria Data

Waterbody ID: CT3500-00_03

Characteristics: Freshwater, Class B, Habitat for Fish and other Aquatic Life and Wildlife, Recreation, and Industrial and Agricultural Water Supply

Impairment: Recreation (*E. coli bacteria)*

Water Quality Criteria for E. coli:

Geometric Mean: 126 colonies/100 mL

Single Sample: 410 colonies/100 mL

Percent Reduction to meet TMDL:

Geometric Mean: **11%**

Single Sample: **63%**

Data: 2003-2009 from CT DEEP targeted sampling efforts, 2012 TMDL Cycle

Single sample *E. coli* (colonies/100 mL) data from Station 918 on the Moosup River with annual geometric means calculated

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
918	500 meters downstream of RR bridge crossing	5/1/2003	10	dry	17
918	500 meters downstream of RR bridge crossing	8/21/2003	52	dry	
918	500 meters downstream of RR bridge crossing	10/6/2003	10	dry	
918	500 meters downstream of RR bridge crossing	2/10/2004	10	dry	NA

Single sample *E. coli* (colonies/100 mL) data from Station 1837 on the Moosup River with annual geometric means calculated

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
1837	Downstream of Route 14a crossing	6/21/2006	340	dry	**141* (11%)**
1837	Downstream of Route 14a crossing	6/28/2006	320	wet	
1837	Downstream of Route 14a crossing	7/3/2006	63	dry**	
1837	Downstream of Route 14a crossing	7/11/2006	98	wet**	
1837	Downstream of Route 14a crossing	7/18/2006	85	wet**	
1837	Downstream of Route 14a crossing	7/27/2006	300†	wet**	
1837	Downstream of Route 14a crossing	8/2/2006	170	dry**	
1837	Downstream of Route 14a crossing	8/9/2006	63	dry	
1837	Downstream of Route 14a crossing	8/16/2006	200	wet	
1837	Downstream of Route 14a crossing	8/23/2006	380†	dry	
1837	Downstream of Route 14a crossing	9/11/2006	31	dry	
1837	Downstream of Route 14a crossing	6/6/2007	460	wet	112
1837	Downstream of Route 14a crossing	6/13/2007	130†	dry	
1837	Downstream of Route 14a crossing	6/20/2007	74	dry	
1837	Downstream of Route 14a crossing	7/11/2007	110	dry	
1837	Downstream of Route 14a crossing	7/19/2007	85	wet	
1837	Downstream of Route 14a crossing	7/26/2007	41	dry	
1837	Downstream of Route 14a crossing	8/9/2007	20	dry	
1837	Downstream of Route 14a crossing	8/23/2007	240	dry	
1837	Downstream of Route 14a crossing	9/4/2007	52	dry	
1837	Downstream of Route 14a crossing	9/12/2007	710†	wet	

Single sample *E. coli* (colonies/100 mL) data from Station 1837 on the Moosup River with annual geometric means calculated

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
1837	Downstream of Route 14a crossing	6/4/2008	190	dry	131
1837	Downstream of Route 14a crossing	6/11/2008	95	dry	
1837	Downstream of Route 14a crossing	6/19/2008	200	dry	
1837	Downstream of Route 14a crossing	6/25/2008	41	wet	
1837	Downstream of Route 14a crossing	7/2/2008	74	dry	
1837	Downstream of Route 14a crossing	7/9/2008	41†	dry	
1837	Downstream of Route 14a crossing	7/16/2008	10	dry	
1837	Downstream of Route 14a crossing	7/23/2008	**1100* (63%)**	wet	
1837	Downstream of Route 14a crossing	7/30/2008	110	dry	
1837	Downstream of Route 14a crossing	8/6/2008	98	dry	
1837	Downstream of Route 14a crossing	8/13/2008	**1100* (63%)**	wet	
1837	Downstream of Route 14a crossing	8/21/2008	430	dry	
1837	Downstream of Route 14a crossing	6/3/2009	63	dry	85
1837	Downstream of Route 14a crossing	6/11/2009	130	wet	
1837	Downstream of Route 14a crossing	6/25/2009	52	dry	
1837	Downstream of Route 14a crossing	7/1/2009	97	wet	
1837	Downstream of Route 14a crossing	7/9/2009	230	wet	
1837	Downstream of Route 14a crossing	7/16/2009	63	dry	
1837	Downstream of Route 14a crossing	7/23/2009	120	wet	
1837	Downstream of Route 14a crossing	7/29/2009	63	dry	
1837	Downstream of Route 14a crossing	8/6/2009	140	dry	
1837	Downstream of Route 14a crossing	8/13/2009	52	dry	
1837	Downstream of Route 14a crossing	8/20/2009	52	dry	

Shaded cells indicate an exceedance of water quality criteria

†Average of two duplicate samples

**** Weather conditions for selected data taken from Hartford because local station had missing data**

***Indicates single sample and geometric mean values used to calculate the percent reduction**

Wet and dry weather geometric mean values for Station 1837 on the Moosup River

Station Name	Station Location	Years Sampled	Number of Samples		Geometric Mean		
			Wet	Dry	All	Wet	Dry
918	500 meters downstream of RR bridge crossing	2003-2004	0	4	15	NA	15
1837	Downstream of Route 14a crossing	2006-2009	15	29	115	212	84

Shaded cells indicate an exceedance of water quality criteria

Weather condition determined from rain gages at West Thompson Lake, Grosvenor Dale in Thompson, CT and at Hartford Bradley International Airport

REFERENCES

Costa, Joe (2011). Calculating Geometric Means. Buzzards Bay National Estuary Program. **Online**: http://www.buzzardsbay.org/geomean.htm

CTDEEP (2010). State of Connecticut Integrated Water Quality Report. **Online:** http://www.ct.gov/dep/lib/dep/water/water_quality_management/305b/ctiwqr10final.pdf

CTDEEP (2011). State of Connecticut Water Quality Standards. **Online:** http://www.ct.gov/dep/lib/dep/water/water_quality_standards/wqs_final_adopted_2_25_11.pdf

CWP (2003). Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection. **Online**: http://clear.uconn.edu/projects/tmdl/library/papers/Schueler_2003.pdf

Federal Register 67 (March 15, 2002) 11663-11670. Urban Area Criteria for Census 2000.

Lerner, Amy M. (2006). Transboundary Conservation Planning for Ecological and Human Values: A Case Study for the Moosup River. M.A. Thesis, Brown University, Providence, RI. May, 2006. **Online:** http://www.borderlandsproject.org/content/Publications/THESIS_MOOSUP.pdf

Mallin, M.A., K.E. Williams, E.C. Escham, R.P. Lowe (2000). Effect of Human Development on Bacteriological Water Quality in Coastal Wetlands. Ecological Applications 10: 1047-1056.

Norwich Bulletin (2010). "Plainfield spending $33 million to improve sewage treatment". Norwich Bulletin, March 8, 2010. **Online:** http://www.norwichbulletin.com/news/x1918408514/Plainfield-spending-33-million-to-improve-sewage-treatment#ixzz1n87Q5ydY

PVPC (2011). Existing Conditions Assessment and Site Development Concepts, Brown Farm-Watchaug Meadows, East Longmeadow, MA. Pioneer Valley Planning Commission, October 2011.

RIDEM (2011). Moosup River Watershed Summary. In: Rhode Island Statewide Total Maximum Daily Load (TMDL) for Bacteria Impaired Waters. Rhode Island Department of Environmental Management, September, 2011. **Online:** http://www.dem.ri.gov/programs/benviron/water/quality/swbpdf/moosup.pdf

USEPA (2001). Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water. **Online**: http://www.epa.gov/safewater/sourcewater/pubs/fs_swpp_petwaste.pdf.

USEPA (2011a). Managing Nonpoint Source Pollution from Agriculture. **Online:** http://water.epa.gov/polwaste/nps/outreach/point6.cfm

USEPA (2011b). Riparian Zone and Stream Restoration. **Online:** http://epa.gov/ada/eco/riparian.html

USEPA (2011c). Land Use Impacts on Water. **Online**: http://epa.gov/greenkit/toolwq.htm