

MEDOMAK RIVER WATER QUALITY PROJECT

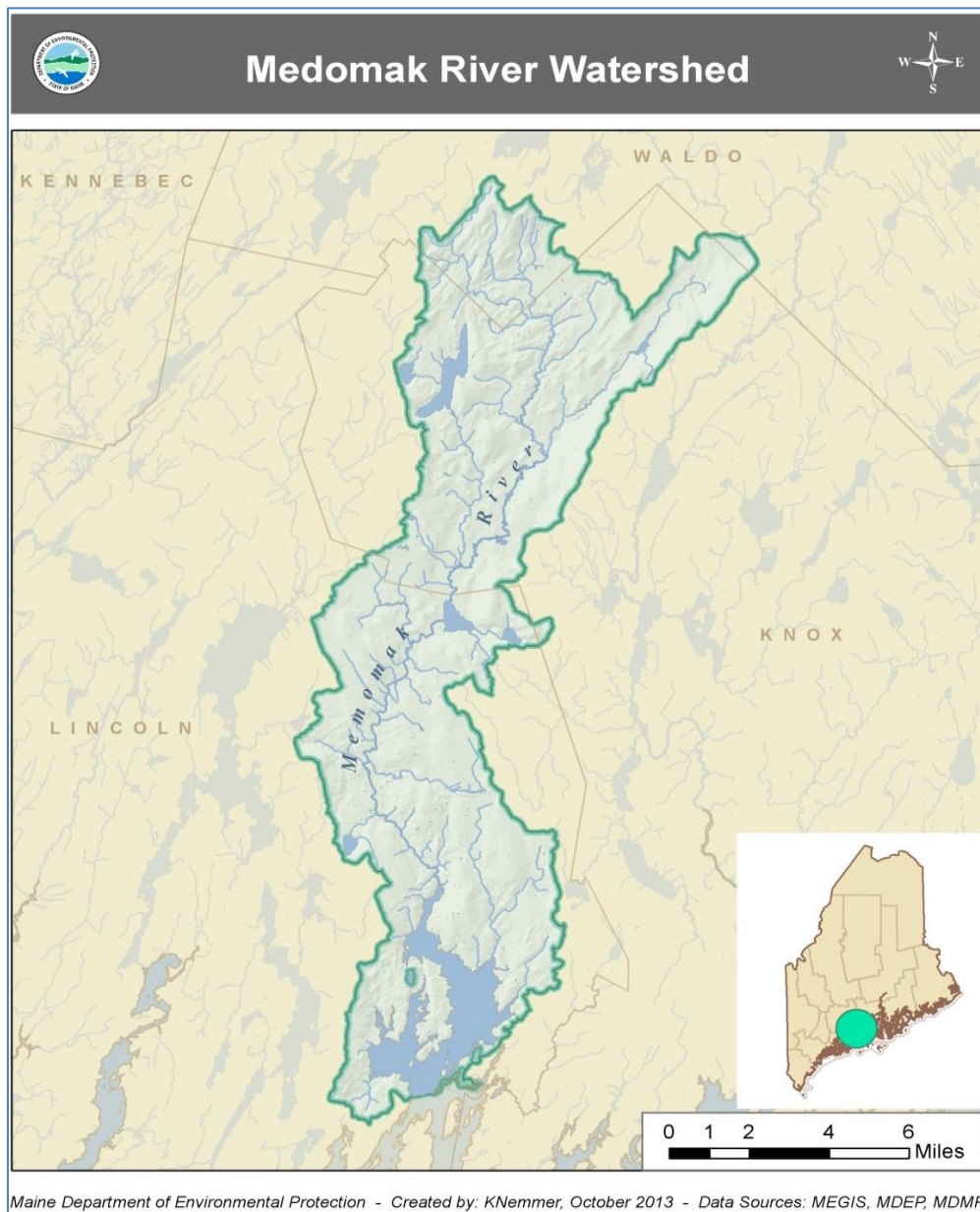


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Acknowledgements:

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Maine Sea Grant

INTRODUCTION

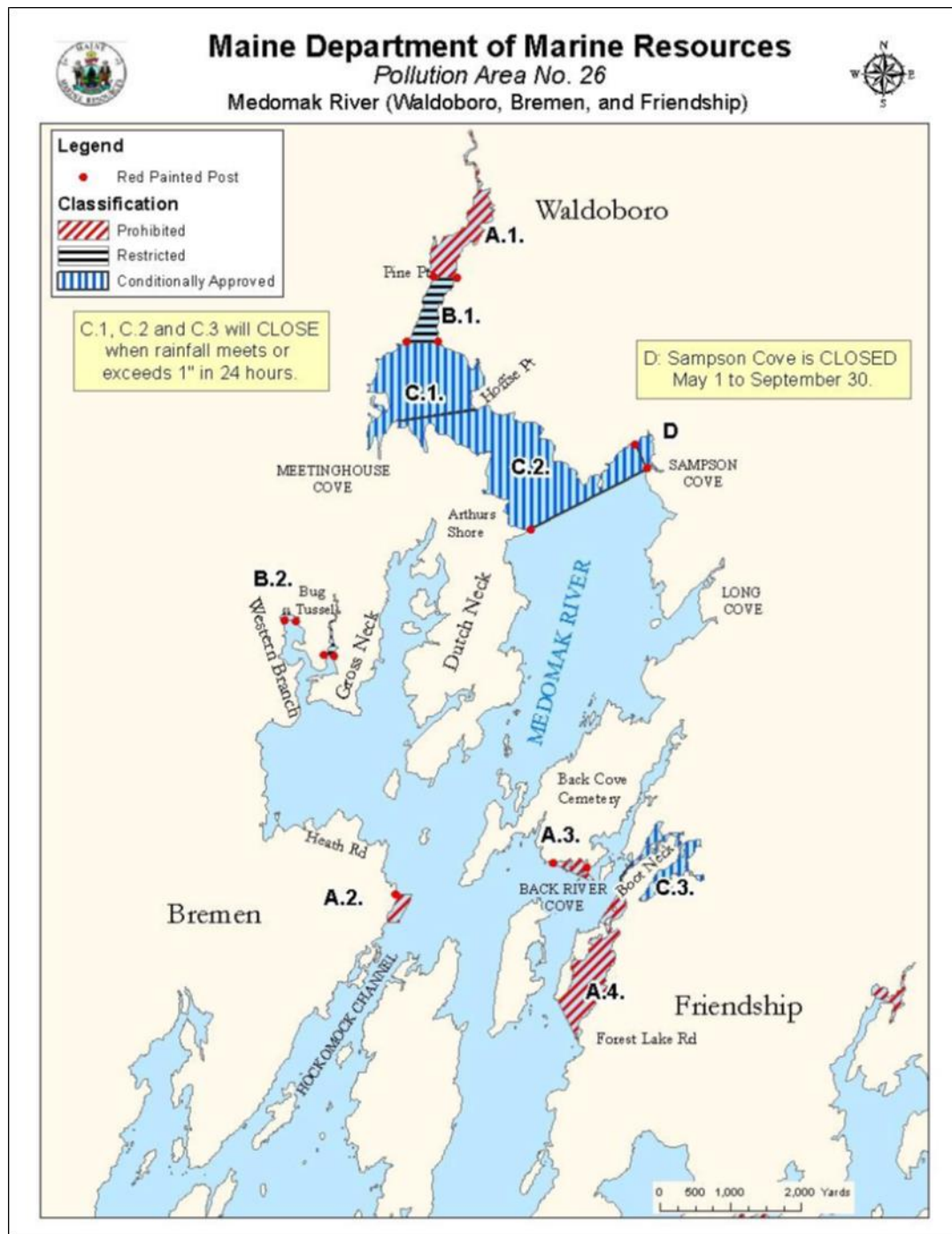
Background:

The Medomak River estuary is Maine's most productive shellfish harvesting area, located in Waldoboro, Maine. The headwaters of the Medomak are located in the towns of Liberty and Washington and the watershed includes small areas in Appleton and Jefferson (see Report Cover). The head of tide is in Waldoboro and the estuarine portion of the Medomak is bordered by Waldoboro, Friendship and Bremen. The most productive portions of the Medomak River shellfish growing area are located within Waldoboro. The Medomak has the potential to yield shellfish worth up to two million dollars per year in income for 150 shellfish harvesters. See Appendix A, Landings Report 2001-2010 for more detail. The total economic value is much more than 2 million dollars when the economic multiplier effects of shellfish dealers, seafood markets and restaurants are considered.

As with all shellfish growing areas, the Medomak River is managed by the Department of Marine Resources (DMR) under the National Shellfish Sanitation Program (NSSP). To ensure safe shellfish, the growing areas must meet fecal coliform bacteria standards to remain in open status for harvest. The fecal coliform bacteria test is used because the feces of all warm-blooded animals contain bacteria that are detectable with this test. Fecal coliform bacteria are mostly not pathogenic, but the fecal coliform test is used as a quick and relatively inexpensive indicator of the presence of fecal material in the water. For the most part, other bacteria and viruses carried in the feces of warm-blooded animals are the real danger. To test for fecal coliform bacteria, water samples are taken from various stations in shellfish growing areas, and tested in the laboratory. For more information on classification of shellfish growing areas, please see Appendix B.

The Medomak River growing area includes substantial conditional areas as shown in Figure 1 (NOTE: this map represents the 2013 status of the growing area, and changes have occurred during the course of this project). When the local rainfall accumulates to one inch or more in a 24-hour period ($\geq 1''/24$ hr), the large conditional areas labeled C.1. and C.2. (totaling 836 acres), as well as the smaller conditional area C.3., close due to pollution. Rainfall is monitored by an automated rain gauge located next to the Waldoboro Town Office and a manual gauge with reporting by the local Shellfish Warden. The conditional areas remain closed for a minimum of nine days, automatically reopening after the required length of time has passed. However, if additional rainfall events occur that result in daily totals of $\geq 0.75''$ during days 7 to 9, C.1 and C.2 will remain closed an additional 3 days from the day the rain exceeded $0.75''$ to ensure adequate depuration of bacteria.

Figure 1. Map of the Medomak River shellfish growing area in 2013. Status changes have occurred since that time.



History:

During the mid-1990's, portions of the Medomak River were not meeting water quality class standards for bacteria. At that time, the Waldoboro Utility District (WUD) wastewater treatment facility discharged its effluent directly to the Medomak River estuary in the vicinity of the town landing. In addition to its potential contribution of bacteria that could adversely affect shellfish harvest, the facility was the subject of frequent odor complaints due to its location in the village area and was difficult to operate due to its design and age. To remedy all of these issues, a new lagoon and land application treatment facility was constructed well away from the river (2.8 miles by direct line), and the discharge to the Medomak was terminated on August 20, 2001. The spray area is half in the Medomak watershed (via Benner Brook), and the other half is in the St. George River watershed (via Levensaler Brook). The treated wastewater percolates into the ground in the spray area, which is designed and managed to prevent any runoff. In the unlikely event that runoff occurred, any discharge would have to travel 8 stream miles via Benner Brook to reach tidewater in Waldoboro.

Because of program changes and ongoing rainfall closures, during 2002 the DMR imposed on the Medomak conditional areas the NSSP default rain closure period of 2 weeks. This sometimes resulted in the river being closed for over half of the harvest year. The DMR asked the Department of Environmental Protection (DEP) for assistance in 2003 to help identify and correct bacteria pollution sources affecting the conditional areas. Also involved in the identification project was the University of Maine Cooperative Extension program (UMCE), doing water sample analysis and outreach. DEP survey work began in late 2003 and continued through 2004, with a final survey report provided to the DMR and the Town of Waldoboro's Local Plumbing Inspector (LPI). This survey focused on the conditional area, covering the properties from the conditional area boundary at Waltz Point to the edge of the WUD sewer system on the west side of the river, and from Sampson Cove to the edge of WUD sewer system on the eastern shore. Another survey of the conditional areas was conducted by DMR in 2008-9, with assistance by DEP. The 2008-9 survey also found a number of properties with pollution sources, and all of the direct discharges were corrected.

Even with the 2003-4 and 2008-9 survey and follow-up work, the conditional areas still showed elevated bacteria scores in response to rain. The Waldoboro Shellfish Committee, under the new direction of Abden Simmons, then took on a more ambitious role. Teaming up with the Medomak Valley Land Trust (MVLT) and the UMCE, the Waldoboro Shellfish Committee attempted to clean up the river. Stations in the Medomak above U. S. Route 1, as well as tributaries, were sampled for fecal coliform bacteria. Some problems were found and solved, but the cause(s) of the wet weather problems remained unidentified.

In 2010, the new DMR Director of Public Health, Kohl Kanwit, contacted the Waldoboro Shellfish Committee, and asked how she could help Waldoboro's shellfish industry. Hearing the problem described, she committed to apply what resources she could to help. However, the DMR only has the ability to investigate within 500 feet from the shore, and no enforcement authority of its

own regarding pollution sources. The enforcement work to eliminate pollution would need to be done by a governmental agency such as the DEP, or Town Codes Enforcement. The involvement of the Department of Agriculture, Food and Rural Resources (DAFRR) would also be necessary to address any animal husbandry or manure handling issues. The DAFRR has since been merged with two other agencies into the Department of Agriculture, Conservation and Forestry (DACF)

The Waldoboro Shellfish Committee conducted a campaign to enlist support from the town, other local organizations and elected officials. The Town Manager, Town Selectmen, WUD, MVLT, State Senator Chris Johnson, and State Representative Ellen Winchenbach, all supported the initiative. The Waldoboro Shellfish Committee and Town Manager wrote letters to the Commissioners of the DMR, the DEP, and the DACF, requesting that they undertake a collaborative effort to address the sources of bacteria pollution affecting the Medomak River. In response, all three Commissioners committed to provide staff and other resources to the effort, and in January 2013 a kick-off meeting was held to initiate what is now referred to as the “Medomak Project” or “Medomak Task Force”.

SUMMARY OF WORK DONE BEFORE FORMATION OF THE MEDOMAK PROJECT

DMR routine bacteria sampling:

The DMR has an ongoing program requirement to sample every shellfish growing area at least 6 times per year based on a stratified random sampling design. In addition to the routine sampling of the Medomak, the DMR has conducted adverse sampling, stream sampling and experimental sampling at various times over the years. Under these various sampling efforts, the DMR has a very large data set of historical growing area bacteria results.

Volunteer water quality sampling:

With the goal of trying to determine the origin, or origins, of high bacteria numbers in the Medomak River, the Waldoboro Shellfish Committee, the MVLT and the UMCE office in Warren collaborated on water quality sampling. There were samples taken during 2010 by a volunteer effort, but the location IDs and geo-location information has been lost (see Appendix C). The only conclusions that can be drawn from the 2010 data is that the highest bacteria levels at the stations sampled were obtained on days with rain, consistent with the DMR conditional area determination. During 2011 and 2012, samples were taken by volunteers and DMR staff at 12 stations on 18 dates. Table 1 combines DMR and volunteer data sets for the freshwater portion of the Medomak and the prohibited and restricted growing areas. Not all stations were

Table 1. Fecal coliform data (cfu/100 mL) for the upper Medomak River, 2011-2012.

No shading in the station ID cells represents sampling done by the DMR. The stations that have IDs beginning with S were sampled by volunteers. Bacteria scores 200 cfu/100 mL and above are in cells with shading.

	Rain0 Hrs	Rain 24Hrs	Rain 48Hrs	Rain 72Hrs	WQ station South end restricted Area	WQ station North end restricted area	WQ station Launch Ramp	Button Factory culvert	Old WQ station Alewife Stairs	Elm St Culvert	WQ station at Park South of Rte 1 bridge	N of rte 1 bridge	Seaweed Plant (below Reed Farm)	Reed Farm	Wagner Bridge Rd (Above Reed Farm)	Old Augusta Rd
Date					WS41	WS41.5	WS43.9	S1WS43.9	WS45	S1WS45	WS46	WS46.5	WS46.9	S.5WS46.9	S1WS46.9	S2WS46.9
3/30/2011	0	0	0	0	42	1.9	1.9				25					
4/12/2011								8	1360	<2		1700	760			
4/20/2011	0.19	0	0.3	1	128	26	920				340					
4/25/2011	0	0.47	0	0			6		11		2	6	1700			
4/26/2011	0.81	0	0.47	0	36											
5/9/2011	0	0	0	0.15			92		46	7.3	58	27	1700	520		10
5/11/2011	0	0	0	0					40		36	32	27		11	8
5/16/2011	1.56	0	0	0.22			820		960	132	1160	980	520		400	80
5/17/2011	0.4	1.56	0	0			1240		1380	92	1300	1120	200		94	48
6/7/2011	0	0	0	0	2	2	32		54		52	38		340	18	2
6/13/2011	0	0.24	0	0.75					58		54	42	42	1700	33	15
7/25/2011	0.24	0	0.04	0	4		35				25					
8/1/2011	0	0	0.31	0										126	12	
9/7/2011	0	0.41	0	0	42	62	34				88					
10/19/2011	0	0	0.06	0	7.3	16	200				25					
10/20/2012	0.78	0	0	0								220	880	>1600	660	
10/24/2012	0	0	0	0.18								15	540	104	11	
10/26/2012	0	0	0	0								102	>1600	620	10	

sampled each date. Fecal coliform bacteria levels appear elevated in response to rain, although there were several sample dates without preceding rain on which the bacterial levels were elevated.

DMR rainfall closure study (2011 – 2012):

In early 2011 the Waldoboro Shellfish Committee requested that the DMR look at the data from the rainfall conditional area in the upper Medomak River and determine if a change in classification could occur. After the 2011 season, the DMR Public Health Growing Area Task Force reviewed the data and concluded that the dataset was insufficient to make a determination. The DMR would need to collect adverse sample data after rainfall in order to better assess the area. The goals of the study were to: 1) eliminate completely or reduce the closure period for the rainfall conditional area; and 2) establish automatic reopening for the existing rainfall conditional area.

Four shellfish and water collection stations in the rainfall conditional areas were chosen for the study and sample collection was scheduled after each $\geq 1''/24$ hr rainfall event from October 2011 through October 2012. Water sampling began at all pre-determined sample sites the day after the $\geq 1''/24$ hr trigger was reached and continued on days 3, 5, 7 and 9. Clam sample collection began two days after the $\geq 1''/24$ hr trigger and also continued on days 4, 6, 8 and 10, until two consecutive sets of clean scores were achieved for both water and shellfish. Data collected during this period verified that the $\geq 1''/24$ hr rainfall trigger was an appropriate management strategy for the upper Medomak River, but also supported the reduction from a 14-day closure to a 9-day closure. These data further showed that an additional rain event at or above 0.75'' during days 7 to 9 of a closure should extend the closure by three days after that rainfall amount occurred. Along with changes to the duration of the closure period, these data also justified automatic re-openings after the pre-set closure period.

Sanitary surveys:

- A. [Routine shoreline surveys by the DMR:](#) The DMR is required to survey all properties within 500 feet of the shore of every growing area at least once every 12 years, with reviews every 3 years, annual updates and spot checks as changes become known. Properties are classified as actual or potential pollution sources based on the findings of the survey. Any property that has a known malfunction or uncontained pollution source is categorized as an actual pollution source. Any property that has a pollution source that is considered at risk of malfunctioning or discharging is categorized as a potential pollution source. All pollution sources are also assessed as being either direct or indirect. Any pollution source that is categorized as actual, direct (A/D) is illegal, and is considered capable of impacting the waters of the growing area. When A/D discharges are discovered, appropriate closures must be imposed until the problem(s) is (are) reported to the relevant authorities (usually the Town and the Maine Department of Health and Human Services), remediated and sampling results show that standards are being met. Additionally, where the water sampling results indicate that there may be a problem not readily

identified by DMR staff, the DMR will notify the DEP, the DACF or the local authorities of the scores, and request assistance in identification and remediation of the source(s).

1. A shoreline survey of the upper Medomak Growing Area was conducted during 2008 and 2009 by the DMR with assistance from the DEP. Properties within the village area of Waldoboro were not inspected because they were presumed to be connected to the WUD sewer system. This survey identified 25 potential/indirect problems and 6 A/D pollution problems. By 2011 all but one of the A/D problems (5 of 6) were remediated by the LPI, and by the start of the Medomak Project in 2013, none remained.
2. During 2012, 26 properties were inspected by DMR staff accompanied by the LPI for the towns of Waldoboro and Bremen. Additional documentation of remediation to new and existing problems was completed. After the field inspections, all of the recent (2008 - 2012) town plumbing permits were reviewed and cross-checked with actual and potential problems noted in the DMR database. No problems from this review remain uncorrected.

- B. Surveys by the DEP: Traditionally, when DMR staff documented water quality “hot spots” that they were unable to resolve, or were attempting to bring a previously restricted or prohibited area to open status, a request for assistance would be made to the DEP. In cases where there were only a small number of properties involved, the DMR would retain the lead and the DEP would do investigative work with DMR staff. However, for larger-scale projects, the DEP would take the lead and report problems to the DMR and to town officials, monitoring the progress of corrective actions. Since 2010, the notification process has included the State Plumbing Inspector at the Department of Health and Human Services (DHHS), which has authority over municipalities to ensure they enforce the subsurface rules that require properly functioning septic systems.

As mentioned in the HISTORY section, above, the DMR requested assistance from the DEP in 2003 to address pollution sources affecting the conditional areas of the Medomak River. Beginning in October 2003, John Glowa of the DEP conducted sanitary survey work in the watershed of the Medomak River downstream of the extent of the WUD sewer system (the Waldoboro sewer system extent map is in Appendix D). The area surveyed extended to the seaward boundary of the conditional area on both shores of the Medomak River. John collaborated with Jan Barter of the DMR and Sarah Gladu of the UMCE for focused water sampling, outreach to property owners and public education. In all, 168 properties were surveyed, with 20 documented wastewater problems. Seven of the problems were addressed by the end of 2004, and the remaining problems were addressed over the ensuing years, with the last four corrected during 2009.

Agricultural runoff:

As part of the collaborative survey work by the DEP, the DMR and the UMCE during 2003-4, Sara Gladu worked with a number of livestock owners to encourage implementation of best

management practices (bmps). During 2011 and 2012, DMR staff along with an intern at the MVLTL conducted a survey that focused on farming activities along the shores of the upper Medomak River. A new farm-based interview form was created and a total of 30 properties were inspected. The resulting Farm Parcel Map can be found in Appendix E. Streams adjacent to significant farming operations were sampled and the compiled information was sent to the DAFRR for their review. During 2012, a problem form was submitted to the DAFRR regarding a farm where cows were allowed to graze in a wetland and streambed which flows directly into the fresh water segment of the Medomak River above Winslows Mills. DAFRR staff worked extensively with this farm owner with the goal of implementing bmps for control of contaminated runoff.

THE MEDOMAK PROJECT

TASK FORCE ACTIONS:

A. Meetings:

1. Kickoff meeting: The first, or Kickoff, meeting was convened on January 15, 2013, by the commissioners of the DEP (Patricia Aho), the DMR (Patrick Keliher) and the DAFRR (Walter Whitcomb). All parties stated their commitment to the project, with the membership being announced and the appointment of Phil Garwood of the DEP as the Medomak Project leader.
2. Periodic meetings to review results or status:
 - a. Initial Meeting: The first Task Force meeting was held on January 25, 2013 to assess what we knew, what we didn't know and what we thought we needed to know (see strategy document in Appendix F). We reviewed the existing bacteria data from both DMR and volunteer water quality monitoring, as well as the areas of Waldoboro that are served by municipal sewer service, and areas where properties have been surveyed or not surveyed. The water sampling program was established (see Section B, below) and we discussed the roles of the DEP, the DMR and the Town in survey work, the DACF in addressing agricultural and animal husbandry issues, the role of the Waldoboro Code Enforcement office in addressing pollution sources, and the roles that would be filled by the MVLT.
 - b. Routine Meetings: Routine progress review and planning meetings were held on February 15, March 22, May 17, July 25, October 11 and November 22, 2013 and April 18, May 16, July 17, October 29 and November 13, 2014, May 15, July 15 and November 20, 2015, May 6 and December 12, 2016 and March 6, 2017.
3. Special meetings:
 - a. Task Force Subgroup: Because the results of the canine detection study (discussed in RESULTS AND DISCUSSION Section G, below), were counter-intuitive in the context of the other water sampling results, a subgroup of four members of the Medomak Task Force met several times in the late summer and autumn of 2014 to brainstorm the reasons for the unexpected results, and to develop an alternative plan of study. The subgroup met on September 11, 2014 and designed paired three-day studies of bacteria numbers in the village section of the Medomak River: one during dry weather and one after a rain event large enough to trigger closure of the conditional areas. The group met again on October 7, 2014 to review the dry weather data, and to finalize plans for the

wet weather sampling effort. The data from those studies will be discussed in RESULTS AND DISCUSSION Section H below.

- b. Expanded subgroup: The original subgroup met a third time on November 19, 2014 with representatives from the DMR to review the data from the paired studies and to discuss the subgroup's recommendation that an intensive study of the streams directly discharging to the tidal portion of the Medomak be undertaken. The subgroup met again on March 30, 2015 at which the sampling design for 2015 was established, including determination of the contributions of all of the small streams discharging directly to tidewater in the upper Medomak prohibited and rainfall conditional areas, and the response of the conditional area during rain closures, comparing routine stations to new mid-channel stations. See Section E(6) below for detail.

The 2015 data were informative and led to focused survey work. However, the general nature of the bacteria testing did not easily lead to discovery of the sources of elevated bacterial pollution. The subgroup met and collaborated by email in early 2016 to create a successful grant application and design a study for 2016 incorporating microbial source tracking (MST) along with bacteria testing to look for further species-specific identification.

The subgroup met after the 2016 season to authorize development of a grant application for creating a non-point source (NPS) plan. The subgroup also applied to SeaGrant for support to conduct an additional year of MST work.

B. Medomak watershed sampling for bacteria – initial and spot checking:

1. DMR routine sampling and evaluations: Annually, the NSSP requires a review of an area's conditional management plan to ensure that management is appropriate and the area is meeting compliance standards. This review process cannot begin until all systematic random sampling for the year is complete and the required count of samples per station is reached as outlined by the NSSP. There are 7 water quality stations used for monitoring the rainfall conditionally-approved areas in the Medomak River. These stations must be sampled 6 times per year while the area is in open/approved status. If the area is closed as a result of a rain event, sampling may occur in order to study pollution sources and impacts, however, these samples would be considered "adverse" and not included in the compliance calculation.

To test for fecal coliform bacteria, water samples are taken from various stations in or flowing to shellfish growing areas, kept chilled (0°C – 4°C) and returned to the lab. In the lab, the water samples are passed through filters that capture the bacteria present and the filters are then placed on selective nutrient agar. The nutrient medium inhibits the growth of other bacteria and contains compounds that only fecal coliform bacteria can break down, generating colored products, thereby allowing selective identification.

After incubation for 24 hours, the number of colonies of fecal coliforms on each filter is counted. The data are recorded as colony-forming units per 100 milliliters (cfu/100 mL).

The DMR assesses compliance with water quality standards with two metrics: the geometric mean (geomean) and the P90 statistic. The geomean is used rather than an arithmetic mean because the exponential growth rate exhibited by bacteria can result in a very large range in values, and one large value could dominate an arithmetic mean. The primary compliance calculation metric is referred to as the P90 statistic. The P90 statistic is an estimate of the variability in the data, and indicates the fecal score at the 90th percentile in the data set. For shellfish growing area determinations, this probability statistic is calculated using a minimum of 30 samples of water quality data for an individual station. If a station is collected 6 times per year, it generally takes 5 years to acquire a 30-count dataset. Table 2 lists the standards of water quality classification for evaluation of shellfish growing areas.

Table 2. NSSP classification standards for fecal coliform data (cfu/100 mL).

Classification	Geomean	P90
Approved	14 or less	31 or less
Restricted	88 or less	163 or less
Prohibited	more than 88	more than 163

2. DMR increased routine sampling: As part of the Medomak Project, the DMR increased its routine sampling effort during 2013. The goal was to sample once per month, but a number of rain events interfered with the sampling plan, so water samples were obtained for routine testing 9 times during 2013. The DMR routine sampling effort returned to the typical 6 times per year frequency for 2014, and then back to 12 per year for 2015, 2016 and 2017. Figure 2 is a map of the locations for the routine DMR sampling stations within the upper Medomak. The upper river conditional, restricted and prohibited areas include DMR Stations WS037 through WS049.
3. Volunteer routine date sampling: In concert with the DMR sampling effort, the Medomak Project had volunteers collect water samples on the routine DMR sampling dates during 2013. The volunteer effort was split into two areas: the village area and downstream tributaries sample set (initially labelled VILxx) and the upstream sample set (initially labeled UPxx). The VILxx set initially comprised 13 stations from tidewater near DMR Station WS040 to the rest area just below U. S. Route 1, and the UPxx set comprised 11 stations from the upstream side of the U. S. Route 1 bridge to the outlet of Medomak Pond. The Medomak Project only sampled to Medomak Pond because the residence time of water in the pond would make it very unlikely that bacteria sources entering the pond would carry through to downstream waters. Figure 3 is a map of the locations for the VILxx series stations and Figure 4 shows the locations of the UPxx series stations. As the season progressed, three sample stations were added to the VILxx

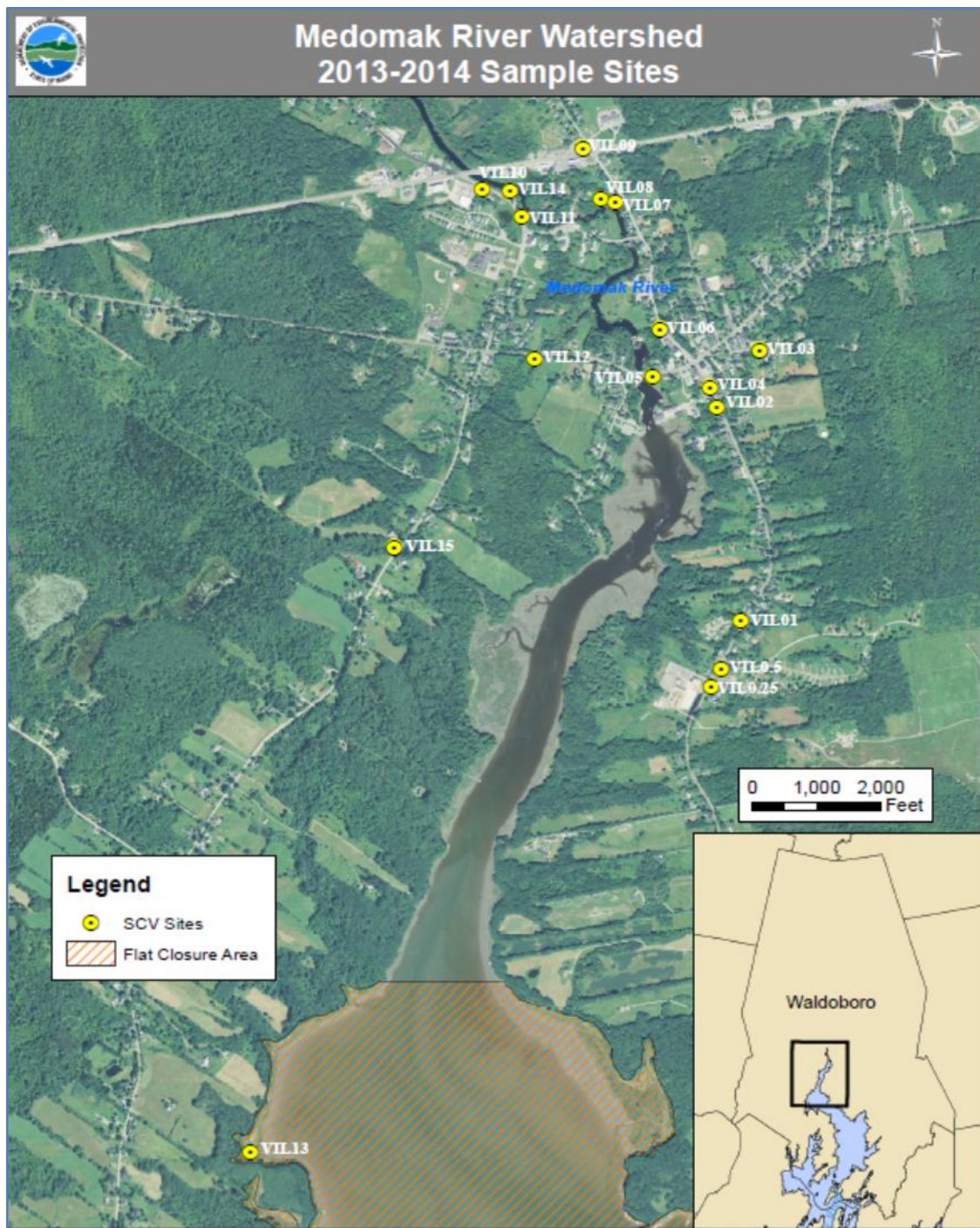
series to capture data from additional possible sources: VIL0.5, VIL0.25 and VIL15. Due to a miscommunication at the start of the project, VIL samples were taken at or near the same location as DMR Station WS046 (at the picnic area). That site was renamed as Station VIL14 and discontinued. The intended location (stream by the Hannaford Market) was assigned VIL10 for the remainder of the sampling dates.

Figure 2. DMR routine sample stations on the upper Medomak River.



4. *Rain event sampling:* During 2013, both the DMR and the volunteers conducted water sampling in response to rain events of $\geq 1''/24$ hr, large enough to trigger closure of the rainfall conditional areas. The volunteers sampled on days 1 and 3 after the rain, while the DMR sampled on days 5 and 7. The rainfall data sample sets included all of the same stations as the dry weather samples, unless there was not flow to sample from a given station on the sampling date.

Figure 3. Village and downstream tributary sample stations (VILxx set).



**Medomak River Watershed
2013-2014 Sample Sites**

Jefferson
Goose Hill Rd
Hodgkins Hill Rd
Waldoboro Rd
E Pond Rd
Cooks Pond
106 m
Eugley Hill
Old Augusta Rd
Washington Rd
Rear Rd
Winnons Mills Rd
N Waldoboro Rd
Katers Pond
200 ft
104 m
Cordwood Hill
Benner Hill
US-1
Medomak River
Medomak Lake
UP11
UP10
UP09
UP08
UP07
UP06
UP05
UP04
UP03
UP02
UP01
Old Augusta Rd
Washington Rd
Rear Rd
Winnons Mills Rd
N Waldoboro Rd
Katers Pond
200 ft
104 m
Cordwood Hill
Benner Hill
US-1
Medomak River
Medomak Lake
UP11
UP10
UP09
UP08
UP07
UP06
UP05
UP04
UP03
UP02
UP01

Legend

- MVLTS
- Flat Closure Area

0 0.5 1 1.5 2 Miles

Waldoboro

Sources: Esri, HERE, DeLorme, TomTom, Intermap, Increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), Swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

5. Freshwater sampling for water quality assessment: This part of the project focused on the segment of the river that flows downstream from Medomak Pond to the U. S. Route 1 bridge, and bacteria sampling was conducted for two purposes:

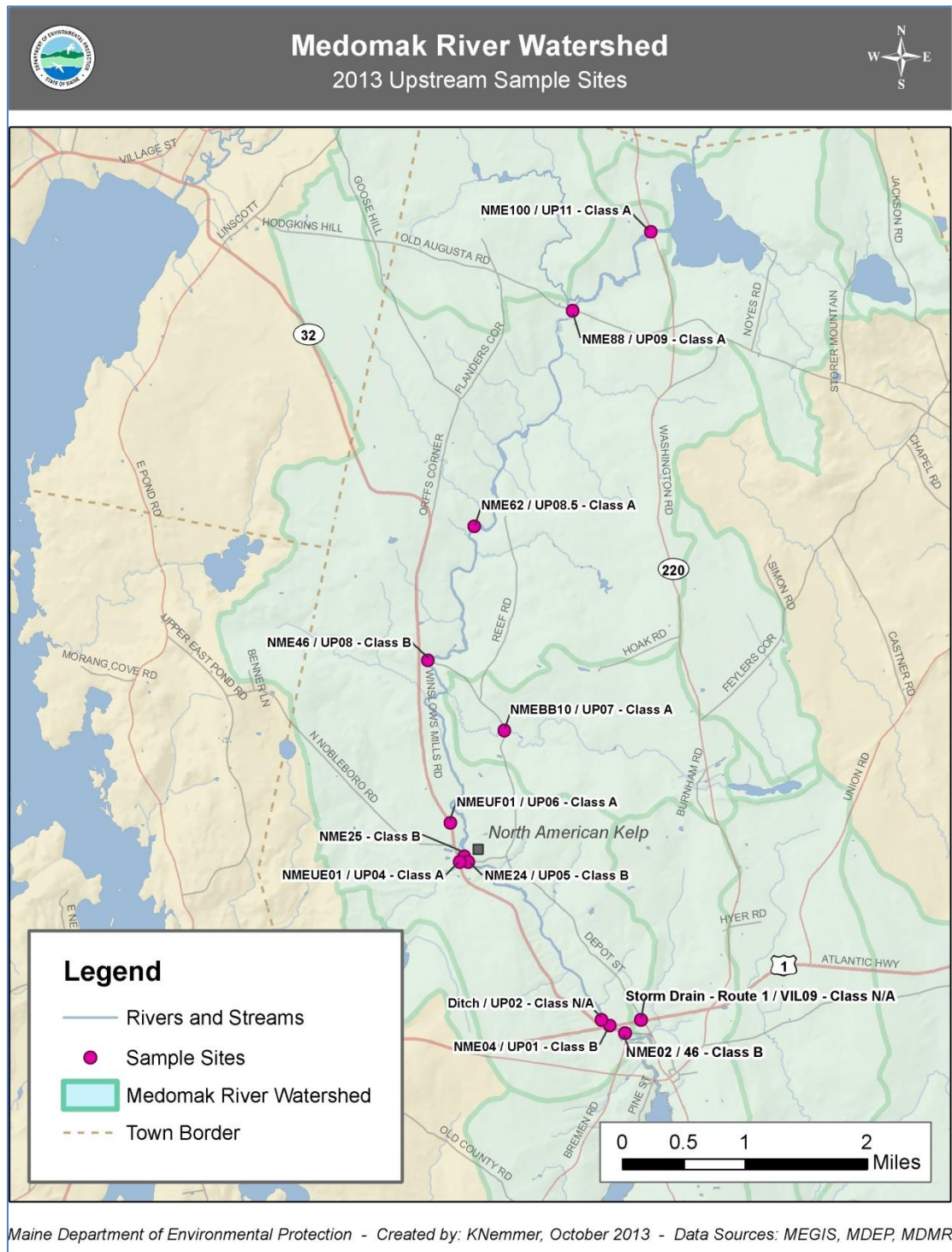
- Determine if the Medomak River above the urbanized area attains Maine Water Quality Criteria for freshwater bacteria (*Escherichia coli*);
- Locate sections of the river or its tributary streams that may have high bacteria levels and the potential to contribute to bacterial pollution observed in the estuary.

Bacteria sampling was conducted from 2013 to 2015 to meet the sampling objectives and encompass the natural variability that occurs between seasons. Samples were collected from May through September with the goal of collecting six samples at routine stations (Figure 5), and sampling included both base flow (dry weather) and storm flow conditions. In addition to routine samples, occasional exploratory samples were collected to aid tracking potential pollutant sources or to bracket stations with observed high bacteria counts.

The freshwater Medomak is divided between Class A upstream of Wagner Bridge Road, and Class B from Wagner Bridge Road to the old Route 1 crossing (Main Street), with all tributaries above Main Street being designated as Class A. These waters must meet water quality goals for designated uses, habitat characterization, dissolved oxygen content, and numbers of *Escherichia coli* (*E. coli*) bacteria. Class B waters must meet a geometric mean of no more than 64/100 mL of *E. coli* bacteria from human and domestic animal origin, and an instantaneous level of no more than 236/100 mL, from May 15 to September 30. Class A waters must contain levels of bacteria that are “as naturally occurs” and Maine uses the numeric criteria for bacteria in Great Ponds (GPA) as an estimate of attainment in Class A waters. The Class GPA criteria are: a geometric mean of no more than 29/100 mL of *E. coli* of human and domestic animal origin, and an instantaneous level of no more than 194/100 mL.

6. Spot sampling: In conjunction with sanitary survey work, or in response to elevated fecal coliform results from DMR or volunteer sampling, DEP staff took samples to test for *E. coli* bacteria at a number of locations in 2013, 2014 and 2015. Water samples for bacteria analysis by the DEP were taken in sterile whirl-pak bags or sterile Colilert sample bottles, kept on ice (0-4°C), returned to the DEP laboratory in Augusta and sampled within 6 hours by the Colilert method. These included single samples at 13 locations (one location sampled twice) and multiple samples at three sites. Some of the results of this spot sampling are referred to in the text of this report or are included in the GIS project, where relevant. The full data table may be found in Appendix G.

Figure 5. Medomak sample sites for freshwater assessment.



C. Sanitary survey work:

1. DMR routine/follow-up: With extensive surveys of the properties bordering the conditional areas in 2003-4 and 2008-9, DMR surveys during the Medomak Project have consisted only of spot checks of stream watersheds with elevated bacteria scores.
2. DEP/Town surveying: Based on various sources of information, including bacteria sample results and review of property maps or personal information, sanitary survey work was completed. In some cases, the survey work involved isolated properties or small clusters, while the larger surveys covered substantial areas and/or numbers of properties.
 - a. Winslow's Mills Road: High bacteria numbers in the Medomak River main stem at the rest area across from Hannaford, and above U. S. Route 1, especially at Station UP05, led to a large survey. The area surveyed extended from the end of the WUD sewer system in town on Winslow's Mills Road (Route 32) to approximately 0.5 mile north of the junction with Cross Street, for a total road distance of 2.25 miles. North of Cross Street, only the properties on the River side of the road were surveyed. From U. S. Route 1 to Cross Street all properties on both sides of the road were surveyed.
 - b. Scattered village area surveying: From review of a comprehensive property and sewer system map provided by WUD, it was determined that there were properties scattered through the village area among other properties connected to the sewers, or near the end of the sewered area that were not connected to the WUD sewer system. This survey covered 23 properties, all with structures. This effort included the drainage areas of sample stations UP02 and VIL01, which had shown occasional high scores.
 - c. Depot Street: Based on the canine detection study conducted by FB Environmental (FBE) and Environmental Canine Services (ECS) in June 2014 (see Section E: Special Studies, subsection 4), follow-up sanitary survey work was conducted along Depot Street. The area surveyed extended from the railroad track crossing to the intersection of Cross Street, for a total road distance of approximately 1.5 miles. The WUD sewer system ends approximately at the railroad track crossing.
 - d. Drainage behind Deb's Diner: During July 2014, Glen Melvin discovered a stream flowing into the Medomak from the wetland area behind Deb's Diner and the convenience stores on the south side of U. S. Route 1. This wetland and associated drainage does not appear on any maps of the area and is within the portion of the village served by the sewer collection system, so it was unknown to the Medomak Project until Glen's observation. The watershed of this drainage/wetland is very small, containing only 5 properties.

- e. Orff Brook: In the autumn of 2013, samples attributed to Station VIL07 in the DMR working spreadsheet were occasionally elevated. The stream at Station VIL07 is known as Orff Brook. The elevated results led to a survey (including sampling) of Orff Brook on April 30, 2014 by DEP staff, focused canine detection work on June 9, 2014, and additional sampling on December 11, 2014.
- f. Benner Brook: Benner Brook is a tributary of the Medomak River that enters the main stem about 1.5 miles above Cross Street, just below the Wagner Road Bridge, which is also just below where the Medomak changes from Class A to Class B. Both the volunteer sampling effort during 2013 and the Freshwater Water Quality study included a sample station (UP07 and NMEBB10, respectively) on this tributary at Wagner Bridge Road, a little more than a half mile above its confluence with the Medomak. During the freshwater sampling effort, that station periodically gave high results for bacteria. In response to the bacteria results, the properties close to this stretch of Benner Brook were surveyed during 2015.
- g. Skyview Ridge Mobile Home Park (MHP) area: Because of intermittent high scores at Station VIL0.5, which is located on Friendship Road where an unnamed stream comes out of the Skyview Ridge MHP, the watershed of the stream above Friendship Road was surveyed in 2015.

D. Agriculture/animal husbandry:

- 1. BMP assistance with farmer(s): As indicated on the Farm Parcel Map in Appendix E, agricultural compliance staff continued to work with farm operations in the Medomak watershed into 2013 on implementation of bmps. At the beginning of 2013, there was only one property that still appeared to be generating pollution loading with enough potential to impact the Medomak River shellfish growing area. Agriculture compliance staff have been available as needed to work with farmers and back yard animal “hobby” farmers to reduce impacts and implement bmps.

E. Focused studies:

- 1. GIS mapping projects: Staff at the DEP (Doug Sutor and Phil Garwood) worked to create a Geographic Information System (GIS) project that included a number of layers and color-coded attributes within layers. The goal of this project was to provide all of the relevant data from water quality sampling, property surveys, special projects and background information in a geographic presentation format. Map visualizations can highlight relationships within the data that may not be apparent from reviewing data in tabular or chart format. The GIS project is now managed by Becky Schaffner, who has also performed other mapping work for the Medomak Project (see subsection E(6). Tidewater Intensive Study, below).

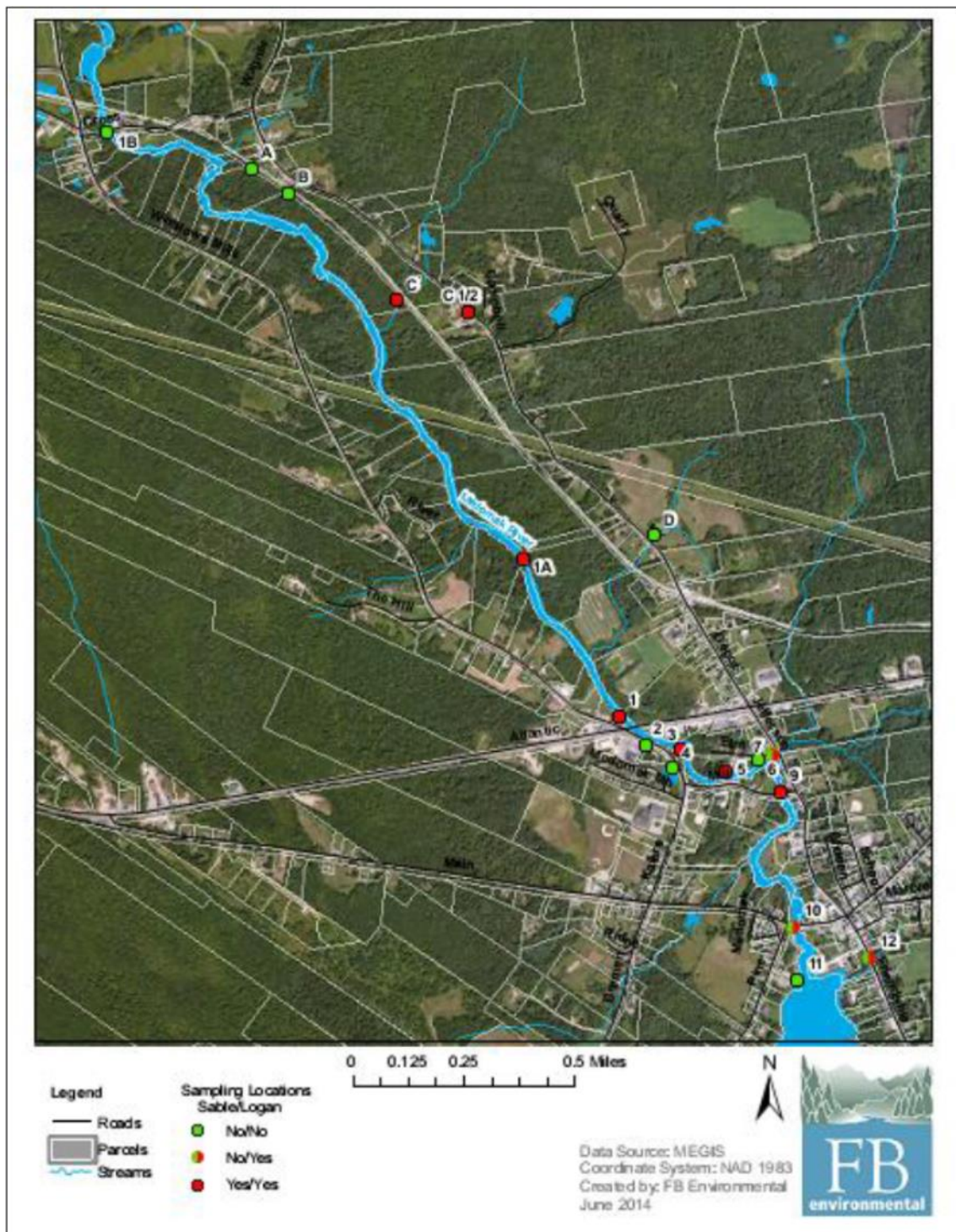
2. *NAK investigation:* The most consistent “hot spot” for bacteria during 2013 was Station UP05, which is located adjacent to the North American Kelp (NAK) facility next to the Cross Street bridge. This sampling site frequently tested above the limits of the DMR fecal coliform bacteria test (>1600 col/100mL), even without a rainfall event. The DEP began sanitary survey work around this station and observed two pipes discharging from NAK to the Medomak River. These discharges had been licensed by the DEP prior to 1986 as uncontaminated except for heat. Upon analysis showing that the thermal discharge from the cooling and condenser water was so small that it would have no effect on the Medomak, the DEP removed the license and monitoring requirement.

NAK processes rockweed into two types of products: a dried product consisting of pulverized seaweed fragments; and a concentrate made from hot alkaline digestion of the seaweed. The digested product is processed in an evaporator to create a concentrate, and the evaporated water is run through a condenser for cooling prior to discharge to the river. The cooling water for the condenser is drawn from the Medomak River and is discharged back to the river after a single pass, with the cooling water and condenser water discharged separately. At the beginning of this project, the condensed water from the evaporator was stored in an equalization tank for additional cooling and subsequently discharged to the river.

The DEP and NAK collaborated in an effort to determine the source of the high bacteria levels at Station UP05. Initial sampling by the DEP showed high numbers in the condenser effluent and repeated sampling was done at various internal locations and on several dates to track NAK’s progress in isolating the cause.

3. *Medomak Mobile Home Park:* Station VIL11 is the outlet of the “Skating Pond” which is adjacent to the Medomak Mobile Home Park (MMHP). The fecal coliform results at Station VIL11 were often very high, which led to the suspicion that the MMHP might be the source of human bacteria pollution. MMHP is connected to the WUD sewer system, so any MMHP problem that might be creating a high bacteria level in the Skating Pond would be from broken sewer pipes, overflowing or leaking manholes or pump station failures, or from such non-human sources as pet waste due to the density of development within MMHP. Several different investigations were conducted to determine whether MMHP was the source of the high bacteria results at the Skating Pond outlet.
4. *Canine detection project with FB Environmental and Environmental Canine Services:* In response to the DMR annual review of the Medomak for 2013, which concluded that there were serious pollution inputs to the Medomak River in the village area of Waldoboro, the Medomak Task Force recommended that the environmental consulting company, FB Environmental (FBE), be contracted to conduct a source tracking study including bacteria testing and dogs trained to differentiate human source pollution. The Waldoboro Shellfish Committee also voted to recommend funding the study, and the

Figure 6. FB Environmental and Environmental Canine Services sample locations in Waldoboro.
(taken from FBE report.)



Town Selectmen concurred. The canine detection study involved use of two trained dogs from Environmental Canine Services (ECS) that give an alert signal when they detect presence of human sewage in water samples or from locations in streams, near pipe outlets, at sewer manholes or storm drains, or on the ground. These dogs are trained much as bomb- or drug-sniffing dogs, including alerting on mixtures of sewage, manure and animal fecal matter only when human sources are included.

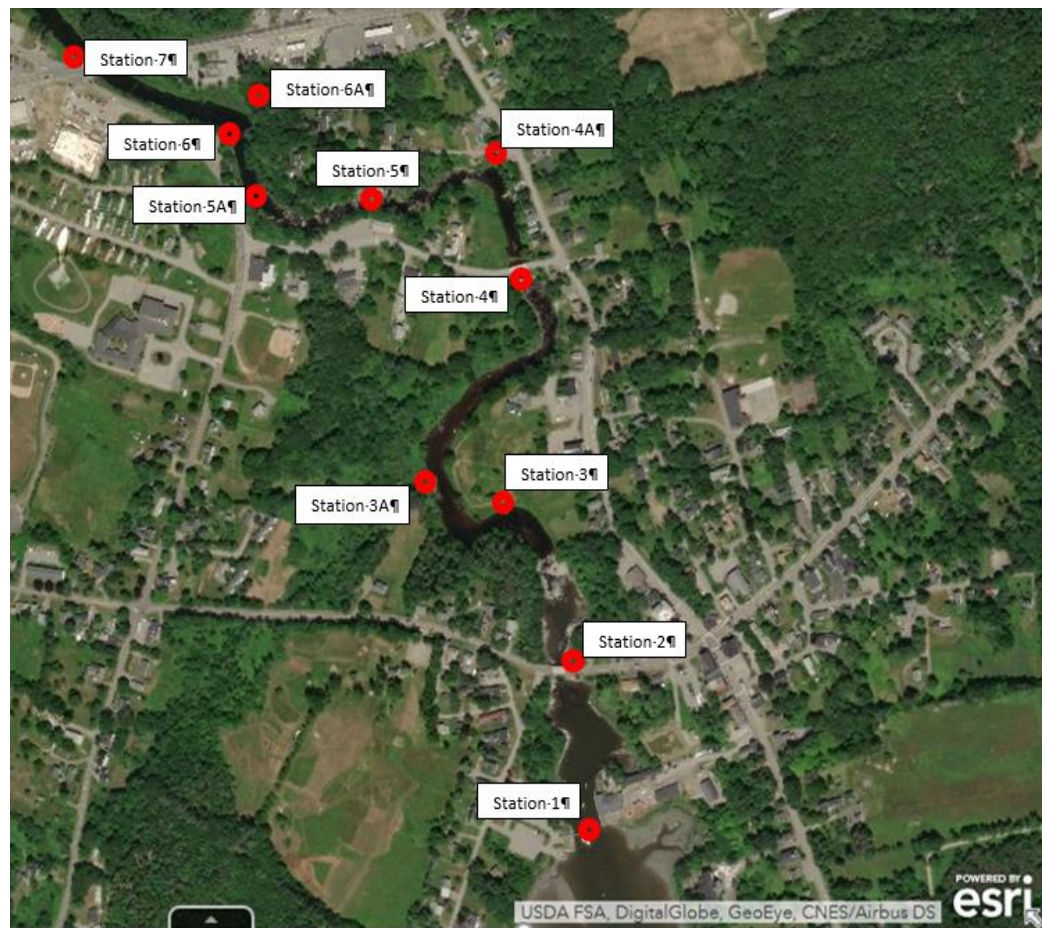
For this study, water samples for canine testing from selected locations within the village area and up to Winslows Mills were taken with care to eliminate human contact with the sample or its container, and concurrent samples were obtained for fecal coliform bacteria analysis by the DEP. Samples for canine testing are transported to a neutral location and individually presented to the dogs for their alert responses. One dog has a much more sensitive nose than the other, so testing each sample by both dogs provides interesting information regarding relative intensity of the human source. Figure 6 shows the study area and sampling locations for the FBE/ECS study. Two drainages (Skating Pond/MMHP, and Orff Brook) were selected for full exploration by the dogs to directly locate any sources on the ground.

5. *Village area intensive sampling study in 2014:* Because of the high variability of results at many sampling stations, the DMR concern about possible illicit discharges or sewer system leakage in the village area, and the canine detection study showing human alerts primarily on the samples with lower bacteria numbers, an unofficial subgroup was formed, consisting of John Fancy (WUD), Liz Petruska (MVL), Glen Melvin (Waldoboro Shellfish Committee) and Phil Garwood (DEP). The group designed an “intensive sampling study” of the village area, which consisted of a dry weather sample series and a wet weather series.

The dry weather series consisted of eight stations located in the main stem of the Medomak from the Cross Street bridge at Winslow’s Mills to the town landing. All stations were sampled on three consecutive days at about half-way through the ebb (outgoing) tide. The subgroup chose to sample midway through the ebb tide to minimize the possibility of the water samples being affected by bacteria carried in from “downstream” sources in the estuary. For this study, we also chose to sample from the float at the Town landing, which is always within the outgoing flow of water from the upstream Medomak on an ebb tide. Sampling from the float during the ebb tide focused the results on the effect of river flow, avoiding the upstream eddy currents along the western shore sometimes seen at the boat ramp. Figure 7 shows the intensive study sample stations for both dry weather and wet weather series.

The wet weather series also consisted of eight stations sampled three consecutive days after a rainfall of 1.5 inches in 24 hours. Four of the wet weather stations were at the same main stem stations used in the dry weather study (1, 4, 6, 7), along with 3 wet weather stations on tributaries (3A, 4A, 6A) and a new main stem site (5A) just below

Figure 7. Medomak Village Area Intensive study stations.



Station VIL11 (outlet of the skating pond). The tributary stations were chosen to determine whether their watersheds might be significant sources of bacteria pollution to the main stem within the village area.

6. *Tidewater Tributaries study in 2015:* Based on results of the Village Area Intensive Study that raised the possibility that main stem flow and the village area could be less important in the rainfall closure than the smaller tributary streams that flow directly into tidewater, the Village Area subgroup, joined by DMR staff, designed a study to document the bacteria inputs from small streams to tidewater and the response of the conditional area to rainfall. Sampling would focus on Days 1, 3 and 5 after rains above the 1"/24 hr closure trigger, with the goal to study one storm response each season (spring, summer and autumn).

Before starting the sampling effort, it was necessary to locate streams suitable for sampling. Becky Schaffner and Melissa Evers, of the DEP, established a GIS-based digital elevation model, and conducted an initial ground-truth survey on April 16, 2015. Based on that work, 18 freshwater streams that discharge into the prohibited area and 1 that discharges into the conditional area were identified and DEP stream-based Stations

The freshwater stream samples were transported to the DEP laboratory in Augusta and analyzed for *E. coli* using the Colilert 2000 method. The Day 3 and 5 samples obtained by the DMR were transported to the DMR Boothbay lab and analyzed for fecal coliform bacteria by the membrane filtration method.

7. *Watershed study using microbial source tracking (2016)*: By the end of 2015, a considerable amount of bacteria sampling and watershed surveying had been completed by the MTF. A number of pollution sources have been documented and remediated, but bacteria scores in the conditional area still warrant closure on rainfall. The lack of specificity of the fecal coliform and *E. coli* bacteria tests have not enabled corrective work to be focused easily on any particular source. Without knowing the species or species group that is the source of the bacteria, considerably more work is required to determine what source to remediate. This led to a strong interest in adding microbial source tracking (MST) to our effort. MST can be done by several different techniques that use either DNA or RNA of bacteria that only grow in the guts of warm-blooded animals. The available tests can differentiate between bacteria strains from various host organisms. To minimize testing costs, water samples were first tested to determine whether *E. coli* bacteria were present, and then MST analysis was performed on the positive samples to identify the host organism(s).

MST techniques are more expensive than bacteria testing, so grant support was essential to incorporate MST into the Medomak Project. Toward that end, MTF members worked with researchers at the University of Maine (UMaine) and University of New Hampshire (UNH) to develop and submit a grant proposal to Maine SeaGrant for just under \$5,000 to support a project incorporating MST. Our proposal was funded in July 2016, with a project duration of July 10 to December 31, 2016.

The goal of this project was to collect paired samples for bacteria and MST after rain events of $\geq 1''/24$ hr in summer and autumn conditions, with a dry weather sample event to start the project in July. On each sample date, two water samples were taken, one of 100 mL for *E. coli* testing and the other of at least 500 mL for filtration and temporary storage in a -80°C freezer at UNH for later MST analysis using the DNA polymerase chain reaction (PCR) technique. The analyses by UNH use a different group of gut bacteria, *Bacteroides*, that does not grow in the natural environment and only persist for approximately one week after the feces are released. The stored, filtered samples would only be tested for MST if the *E. coli* result came out above 100 MPN/100 mL. The first round of MST analyses produced a simple presence or absence result. To gain even more specificity regarding potential sources, a subset of the samples tested for MST was further analyzed to provide an estimate of the number of DNA copies in the initial water samples for either the human marker or a new, general bird marker. This analytical technique is termed quantitative PCR, or qPCR.

Table 3. Medomak main stem and tributary streams selected for potential paired study of *E. coli* scores and MST.

Station ID	priority	access	
Primary group			
UP01 (Main stem upstream of Rte. 1)	1	car	
Main Street falls	1	car or boat	
NMEUJ00	1	boat	
NMEUQ00	1	boat	
Vi11 (Skating Pond outlet)	2	car	
Vi10 (stream by Hannaford store)	2	car	
NMEUK00	2	car or boat	
Village area 6A (stream by Deb's Diner)	2	car	
Vi107 (Orff Brook)	3	car	
NMEUM00	3	boat	
NMEUP00	3	boat	
NMEUU00	4	boat	
Slaigo Brook (discharges to Sampson Cove)	4	car or boat	
DMR9	4	boat	
DMR5	4	boat	
Stations with fall season issues			
NMEUX00	S	boat	
NMEUY00	S	boat	
DMR3	S	car	
Other streams that may have pollution sources			
NMEUL00	5	boat or car	
DMR6	5	boat	
Village area 3A	5	car	
Brook by Tonken (upstream tributary)	5	car	

For the 2016 sampling effort, the streams were rated based on their history of bacteria scores, or being of a size to have flow during dry weather. Table 3 shows the selected streams and their accessibility. All stations except the brook by Tonken are located on earlier Figures in this report. Some of the streams were more easily accessed by car and others by boat. During initial discussions, we were contemplating sampling only a subset of these streams. However, with the SeaGrant support and the affordable cost per sample figure from UNH, we decided to sample all of these streams. We also recognized that, particularly in the dry weather sample run, many of the stream sites might have insufficient flow or no water to obtain a sample on a given sampling date.

F. Public education and outreach:

Public education and outreach efforts were primarily undertaken by MVL, although the Town Office and members of the Waldoboro Shellfish Committee also contributed. Multiple

opportunities to educate the public and provide information transfer or notifications to the public and interested parties will include postings or flyers at the Town Office, flyers included in various mailings to sectors of Waldoboro residents, posting items to the Town website, advertising Task Force meetings, presentations at farmers markets and other local events, and press relations, including press releases. Significant educational needs include awareness of sources and effects of pollution on clam harvesting, especially concerning the cumulative effects of seemingly small actions that accumulate to significant impacts (positive or negative) when practiced by many people in the watershed.

At important points in the progress of the Medomak Project, presentations of results were made to the Town Select Board or at Town Meetings. Presentations were also made to trade associations such as the Fisherman's Forum, or to environmental or scientific organizations or conferences.

RESULTS AND DISCUSSION:

A. Water sampling for bacteria:

Throughout the study by the Medomak Task Force, bacteria results have been comparable whether analyzed for *E. coli* or fecal coliform, which is consistent with published results indicating that fecal coliform numbers are usually 90 % due to *E. coli*.

1. Detailed review of the 2013 fecal coliform results: The raw fecal coliform data set can be viewed in Appendix H. In the village area, Stations VIL04, VIL05, VIL06 and UP02 are stormwater outfalls or intermittent streams. As a result, there were some sample dates when those sample stations did not have adequate flow to obtain samples. Station UP02 rarely had water during sampling runs, so this station was dropped from the effort by the end of June 2013. Station UP03 is very close to Station UP05 and seems to reflect closely the UP05 result, so this station was dropped after mid-July 2013. On two dates (7/10/13 and 10/22/13), there were communication errors which resulted in the VILxx sample set not being obtained.

As discussed elsewhere, elevated results at Stations UP01, WS046 and UP05 led to sanitary survey work by the DEP along Winslow's Mills Road and the Station UP05 results led to the NAK Special Project. The high values at Station VIL11 led to a focus on the MMHP, initially by Medomak Project members and subsequently by the FBE/ECS study. Elevated results at Station VIL01 led to the successful horse paddock effort by DACF (see RESULTS AND DISCUSSION section C), and the Station UP06 results were lower than in previous years, showing that the agricultural bmps were having a positive impact at that location.

Except for Stations UP05 and UP03, the early springtime scores in the Medomak freshwater stations seemed generally lower than later in the year. This may reflect better growing conditions for the bacteria in warmer waters, or the lack of fresh input from landscape uses such as land-spreading or pet waste accumulations over the winter and early spring. The rainfall results showed that the conditional area was often mostly or entirely back down to open approved numbers by day 3 or day 5 after the start of the rain closure.

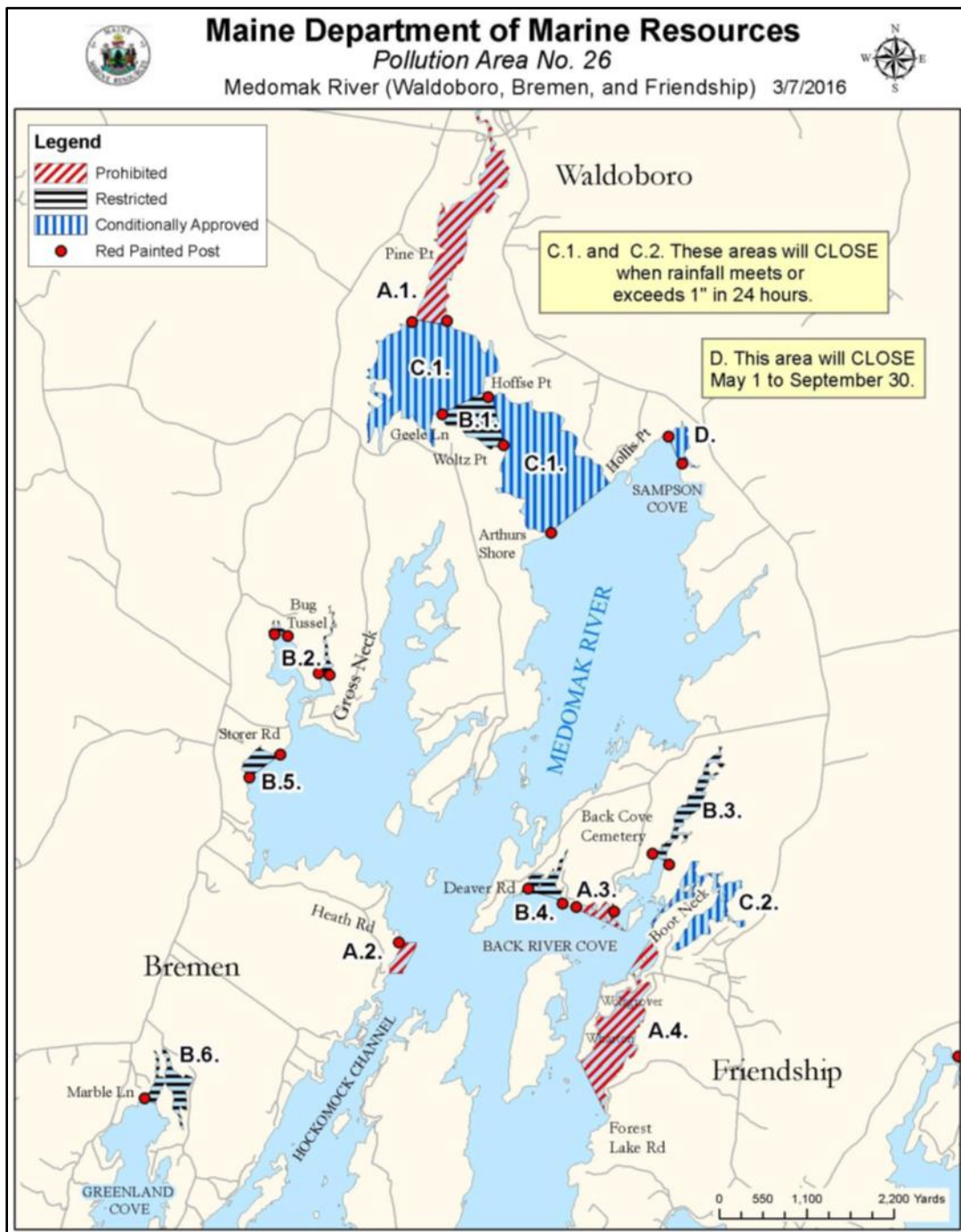
2. *DMR 2013 Annual Growing Area Evaluation:* The summary report presented to the Medomak Task Force by the DMR regarding the 2013 annual growing area evaluation can be found in Appendix I. The first of two major conclusions was that the conditional area is significantly impacted by higher bacteria levels during wet weather as compared to dry weather, which warrants continued management on rainfall. The evaluation also concluded that there were no significant differences between the two uppermost stations (WS046 and WS043.9) in any weather conditions and that salinity data showed a freshwater effect on fecal coliform scores. On that basis, the DMR concluded that there were chronic as well as rain-related sources in the village area above Station WS043.9.

The DMR strongly recommended that the Medomak Project focus on detection of illicit discharges in the village area including private sources and determination whether there may be chronic discharges from the WUD sewer system. The DMR also recommended that a consultant be brought in to use canine detection services to aid in the search for sources of human sewage in the village area.

Based on the 2013 annual evaluation (see Appendix J for the full report), the DMR made no changes to the current management strategy for the Medomak. However, the DMR also stated that if the 2014 evaluation continued to show chronic pollution impacts not related to wet weather, downward changes to classification could become necessary.

3. *DMR 2014 Annual Growing Area Evaluation:* During 2014, there were substantially fewer days with fecal coliform scores elevated into the hundreds and no days with results above the limits of detection within the conditional area. Conditions in 2014 were drier overall than in 2013, which could be a major factor in the better results. There was a rainfall closure in mid-July 2014 captured in the DMR sample results that showed elevated scores at several stations in the conditional area. In contrast to the generally better scores during 2014, there was an isolated high score at Station WS038 in late August 2014 that appears to be unrelated to wet weather. This may indicate a seasonal or fugitive discharge. Even though the 2014 data set overall had lower values than in 2013, the P90s for Stations WS041, WS041.8, WS043.9 and WS046 were above the restricted area threshold. Based on the Station WS041 P90 score, the DMR reclassified the restricted area to prohibited status on April 29, 2015. The DMR annual report for 2014 can be seen in Appendix K.

Figure 9. DMR Growing Area map for the Medomak River as of March 7, 2016.



4. DMR Triennial report (2015), and 2016 comments: Based on fecal coliform scores from 2015 in the upper Medomak Conditional Area labeled C.2 at that time, the DMR made two changes. The area around Station WS038, locally known as “Tom’s Shore”, was downgraded from Conditional to Restricted, amounting to 66 acres. An area amounting to 74 acres along the southern edge of the Conditional Area was upgraded from Conditional to Open. Figure 9 shows the Growing Area boundaries as determined in March 2016. These boundaries can be compared to those in Figure 1, which shows the DMR Growing Area map as it was at the beginning of the Medomak Project in 2013. The fecal coliform scores during 2016 from the Medomak did not warrant any status changes.
5. Freshwater sampling results (E. coli): Table 4 shows a summary of the freshwater results, and the full report of the freshwater sampling study can be found in Appendix L.

Table 4. Summary of annual *E. coli* results for the Medomak River.

<i>E. coli</i> MPN/100mL		Downstream Site GeoMean			Overall GeoMean		
Water Quality Class	# of Sites	2015	2014	2013	2015	2014	2013
B	3	58	69	93	55	66	83
A	5	35	52	71	39	56	56

The farthest upstream site sampled, at the Old Augusta Rd bridge (NME88), consistently attained Class A standards during the study period, which corroborates the assumption that the water coming out of Medomak Pond has low levels of bacteria. The bacteria levels observed in the main stem Medomak River above U. S. Route 1 during 2014 and 2015 are consistent with natural conditions observed elsewhere in Maine. High values that exceeded the instantaneous GPA criterion used as an indicator for Class A were discovered in two tributaries (Benner Brook to the east and an unnamed farm stream just north of North Nobleboro Road on the west side). These high values may result from human activities in those sub-watersheds. The unnamed tributary is a stream that runs from a wetland pond on a farm parcel, and even though the results from that stream are still above the Class GPA standard, the stream has shown continual improvement during the Medomak Project. Properties bordering Benner Brook were surveyed during the spring of 2015, as described in RESULTS AND DISCUSSION Section B(6).

As can be seen in Table 4, the trend over the three-year period is for progressively lower geometric means, both over the whole data set and for the downstream site near U. S. Route 1. This pattern may be the result of bacteria cleanup efforts by stakeholders, but because the differences in the values are relatively small, it could be the result of

natural variation in weather conditions. The downstream site is below the NAK discharge and the 2013 data may have been influenced by that discharge.

This type of Water Quality Standards attainment analysis looks at the overall levels of bacteria in the Medomak and answers questions on relative freshwater health, but does not specifically address the rainfall closure concerns for shell fishing. Generally, the higher bacteria values are associated with rain events, but out of 52 samples collected over three years in the Class B segment of the river, only one sample exceeded the instantaneous freshwater standard. This is an indication that the nonpoint source runoff in the watershed above Waldoboro village does not contribute significant levels of contamination to the estuary.

B. Sanitary survey work:

1. *DMR follow-up:* On August 19, 2013 a shoreline survey of the area around Sampson Cove was conducted by DMR staff with assistance from the DEP to try to find the reason for declining water quality in that area. There were 26 properties inspected and no outstanding issues remain.
2. *Winslows Mills Road:* This survey effort covered 85 properties, of which 16 were vacant, 6 had problems and one had a questionable situation. Five of the problems and the questionable situation were reported to the Town of Waldoboro Codes Enforcement office. The sixth problem led to the NAK special project which is described in the Special Studies section E(2), above, and in RESULTS AND DISCUSSION Section E, below. All but one of the problems have been remediated, and the one remaining is very unlikely to contribute significant amounts of bacteria to the river.
3. *Scattered village survey:* Of the 23 properties surveyed in the village area effort, only one domestic sewage problem was detected, and that property was connected to the WUD sewer system in August 2014. One problem and one questionable situation involved animal husbandry, so those were reported to the DACF. The property with the animal husbandry issue has been abated, and the questionable property has been determined not a problem.
4. *Depot Street survey:* This survey effort took two days (June 23 and June 27, 2014) and covered 36 properties, 3 of which were undeveloped. There were 5 problems found and one questionable situation, all of which were referred to the Town of Waldoboro Codes Enforcement office. Two of the five problems had been remediated as of June 2016.
5. *Drainage behind Deb's Diner:* During initial reconnaissance on July 30, 2014, the stream tested moderately high, at 300 colonies per 100 milliliters (col/100 mL) for fecal coliform bacteria. The watershed of this drainage has now been surveyed twice and the owners/managers of the businesses contacted regarding their connection to the WUD

sewer system. All properties appear to be properly connected to the WUD sewer system, with no problems observed. This stream was also included in the Village Area Intensive Study as Station 6A as described below in RESULTS AND DISCUSSION Section I, and tested above the limit of the *E. coli* test (2419.6 MPN/100 mL) during the first day after rain. This area is a good candidate for microbial source tracking (MST) to identify the species that is(are) the source of the high bacteria results, since there is no evidence of human input.

6. Orff Brook: All of the properties bordering Orff Brook from the Medomak to Atlantic Highway (U. S. Route 1) were investigated on April 30, 2014, and water samples were taken at 5 locations, including 3 small tributaries as well as the flow from upstream under U. S. Route 1. The property survey work showed no pollution sources entering Orff Brook below U. S. Route 1, and all of the water samples were very low for *E. coli* bacteria (see Appendix G). Fecal coliform results for Orff Brook in the autumn samples were elevated, and the canine detection unit alerted on Orff Brook as a human pollution source. *E. coli* samples in December 2014 were higher in the northern branch, which originates above U.S. Route 1, so that area should be surveyed, although the pattern of alerts by the canine unit also would make this another good candidate watershed for MST.
7. Benner Brook: This area was surveyed on May 8, 2015. Even though this area included only 6 properties with residences near Benner Brook, two properties with problems were documented and referred to the Town Codes Enforcement office for action.
8. Skyview Mobile Home Park area: This area was surveyed on May 8, 2015 and included only five properties. The two properties to the north of the stream contained three possible sources, while the mobile home park contains 22 mobile homes near the stream channel branches. The stream branches extend into two vacant properties. No problems were identified during this survey effort.

C. **Agricultural actions:**

After bmps for protection of wetland/stream areas from active grazing were implemented at the one farm of concern at the beginning of 2013, the bacteria levels in the stream exiting this property improved (see also the Freshwater Sampling Results section) and have continued to improve during the course of the Medomak Project. As the wetland area recovers, it should become less attractive to geese, which should reduce the bacteria levels even further.

DEP staff discovered an apparent impact from a horse paddock at a property on Friendship Road that was in the drainage leading to Station VIL01 and reported it to the DACF. DACF staff met with the owners, and ultimately aided the elderly owners by installing a new fence line to exclude the horses from the brook area. *E. coli* results from the stream in December 2014 demonstrated that the new fence has allowed the stream area to recover and bring the bacteria levels down to natural background. Good work by Raymond Bryant of the DACF.

D. GIS projects:

The Medomak River Water Quality Survey GIS project was initially constructed in Google Maps, but was subsequently migrated to ArcOnline and is now available from the DEP website. Accessing the GIS project does not require any GIS software to be loaded onto the user's computer – one only needs an internet browser capable of accessing the DEP website. The DEP website has undergone periodic revisions over the past 4 years, so the description below may become dated and somewhat inaccurate over time. The Medomak GIS project will be accessible from a page of other maps and data layers. Currently there are two ways to find the project. Select Water Quality and then Monitoring and Reporting. When you click on Monitoring and Reporting, a page opens with a number of options – click on Data maps and Downloads, which opens a page titled “GIS Maps and Other Data Files” - then scroll down to the Medomak River Water Quality Survey. To open the Medomak project, click on the green globe next to its title. The other way is to click on Subject Index in the black “Search DEP” box. In the page that opens, click on Maps and Data within the list on the left side. That page has a box on the right side titled GIS MAPS AND OTHER DATA, with a hotlink to “Interactive maps and other DEP data files”. That link goes to the GIS Maps and Other Data Files page as described above.

It may take some time to connect and initialize, but you will have full access to the project. At first, you will see only the map, but if you click the zoom in button at the upper left (the white plus sign), the sample stations will show as colored hexagons. Data layers specific to the Medomak Project include: historic fecal coliform monitoring (dry dates), historic fecal coliform monitoring (rain dates), bacteria monitoring sites, project fecal coliform data, *E. coli* data, Waldoboro Parcel Survey and a layer showing all of the structures in the village area (color-coded to indicate whether they are connected to the sewer system). The map includes a time slider that allows the user to select a specific time interval or the entire data set for display, and the slider can be run as a time interval “movie” to show changes over time. The bacteria data are color and size coded, with green meeting standards grading to red being the highest values (above 1200 col/100mL). The parcel data is color coded by wastewater status, with the most common status types being: green = connected to the sewer system, blue = OK during survey, yellow = problem fixed and red = a wastewater problem with no reported correction. A sample map from the Medomak GIS Project can be seen in Appendix M.

E. NAK Source remediation:

In May 2013, the DEP contacted NAK regarding the elevated bacteria levels in the Medomak, and the intent to sample their discharges as part of a comprehensive investigation of possible sources. The owner and staff of NAK were very concerned about the possibility that they might be the source of high bacteria levels in the Medomak, and were very proactive and aggressive in investigating and addressing potential sources of bacteria on their property or within their system. A minor problem with their subsurface system was immediately repaired, along with upgrades to keep storm flows out of their septic tank, even though their subsurface system is located on the side of the plant away from the river.

Testing of NAK effluent showed that the condenser waste stream was likely the source of the high scores in the river at Station UP05 because the results were above the limit of the *E. coli* bacteria test (>2419.6 MPN/100mL). By contrast, the cooling water effluent was very close to the levels in the river. See Table 5 for the *E. coli* results obtained as part of the NAK special project. Although the Task Force attributes the high results in the Medomak at Station UP05 to NAK effluent, the results for Station UP05 shown in Table 5 appear to conflict with that assessment. Sampling by DEP staff at UP05 was always conducted early in the day, which is near the beginning of the NAK evaporation runs. This would not have allowed sufficient time for NAK effluent to mix into the receiving water and be transported to the Station UP05 sample site.

Table 5. North American Kelp project bacteria results.

<i>Escherichia coli</i> (MPN/100mL):								
	4/24/2013	5/7/2013	5/9/2013	5/15/2013	6/4/2013	6/26/2013	7/15/2013	5/14/2014
Station								
UP05	9.7	12.2	40.8	26.2	30.9	83	45	8.4
UP05 1/10								<1
NAK(pool)	65							
NAK effluent		>2419.6	>2419.6	920.8	34.1	<1		410.6
NAK effluent 1/10				648.8		1		44.1
NAK eff 1/100				85.7				
NAK condensate				>2419.6				
NAK cond 1/10				2419.6				
NAK cooling				28.2		93.4	54.5	5.2
NAK well					<1			

There were no cross-connections or other obvious sources of *E. coli* bacteria within the digestion/evaporator system, so the DEP became concerned that there might be a false positive error with the Colilert *E. coli* test when used on NAK effluent. After contacting IDEXX, which produces the Colilert test, DEP staff collaborated with IDEXX to determine whether the Colilert *E. coli* results were truly representing the bacteria content of NAK condensate effluent. Effluent samples taken on May 15, 2013 were diluted 1:10 and 1:100, and internal samples of condensate were diluted to 1:10. After obtaining high results, the test trays with high results, along with trays for the 1:10 and 1:100 dilutions, were delivered to IDEXX. IDEXX determined by identification of the bacteria within the trays that there was no false positive issue and that the test was correctly measuring the target *E. coli*, with an estimated 6,500 to 8500 MPN/100mL of *E. coli* and >240,000 MPN/100mL of total coliforms (primarily *Klebsiella*) in the effluent samples. total coliform results are not presented in this report.

NAK's condenser is designed to keep cooling water and condensate completely separate, but during their investigative work, NAK found that the condenser was cracked and cooling water from the river was leaking into the condenser. That allowed bacteria from the river to colonize the warm condensate from the evaporator and grow exponentially within the system, resulting in bacteria numbers in the effluent discharge two or three orders of magnitude higher than in the water coming from the Medomak. At the same time, the cooling water was not being cross-

contaminated by the condensate, as indicated by no obvious elevation of the cooling water results as compared to the river water sample results.

NAK repaired the leak and scrupulously cleaned the whole evaporator/condenser system. The last tests of 2013 showed that bacteria had been reduced to undetectable levels in the condenser discharge, thereby eliminating this large source. Unfortunately, in late December 2013, the repairs to the condenser failed, at least partially, raising the concern that the condenser effluent would again exhibit high *E. coli* numbers. Effluent sampling was conducted during 2014, and the results showed moderate levels of *E. coli* in the effluent. Probably due to the elimination of the equalization tank, the bacteria levels never returned to the extremely high levels seen before this project. NAK had a new condenser fabricated during 2014 and replaced the old condenser during mid-January 2015.

F. Evaluation of the effect of condenser repairs at North American Kelp:

The Medomak Task Force was interested in determining whether the bacteria loading from NAK discovered during 2013 could have been a significant factor in the elevated fecal coliform bacteria scores within the Medomak River. Because the NAK condenser discharge was contributing large concentrations of *E. coli* bacteria to the Medomak River, at flow rates equivalent to at least ten and possibly dozens of septic system malfunctions or straight pipes, it was possible that rehabilitation of the condenser in early July 2013 could result in a demonstrable reduction in bacteria concentrations well downstream of the NAK site.

Based on a request by the Medomak Task Force, the DMR conducted an evaluation to compare the data taken after July 10, 2013, to data taken before that date. The DMR focused the analysis on the three stations most likely to show effects from NAK, WS046.00, WS043.90, and WS041.00. Station WS046 is at the picnic area just downstream of U.S. Route 1, and is 2 miles downstream from NAK. Station WS043.9 is at the town landing, another 0.6 mile downstream and Station WS041 is an additional 1.1 mile further downstream from the town landing near the border between the restricted (prohibited as of April 2015) and conditional areas.

To determine whether there had been any demonstrable changes in bacteria data due to the NAK repair project, it was necessary to use smaller data subsets than the 30 normally used by the DMR for calculations of P90 statistics and geometric means for annual evaluations. Because there were only 3 routine sample dates between the condenser repair and the end of 2013, this analysis was conducted after the end of the 2014 season to increase the post-repair data set to 11 dates. To compare equal data sets, the pre-July 10, 2013 sample set was also limited to the immediately previous 11 dates.

Table 6 provides a summary of the evaluation, along with summary data from the 2013 and 2014 DMR Annual Growing Area Reports. Results of this evaluation show a clear effect of the NAK discharge and repair project on bacteria scores at all three stations. The P90 values and geometric means are dramatically higher in the pre-NAK repair results for all three stations than in either the 2013 or 2014 DMR annual evaluation. The post-NAK repair statistics at all three

sampling stations for all other date ranges are substantially lower for all but the Station WS043.9 P90 score. The WS043.9 geometric mean was back down to the 2013 annual report value, but the P90 score remained relatively high. As will be discussed in the Tidewater Tributaries section below, there may be other sources affecting scores at Station WS043.9, which is at the town landing.

Table 6. Summary of comparative analysis before and after NAK repairs (fecal coliform bacteria in cfu/100mL).

Analysis	WS046.00		WS043.90		WS041.00	
	geomean	P90	geomean	P90	geomean	P90
2013 Annual	61	332	47	381	16	132
2014 Annual	67	426	52	503	16	192
Pre-NAK repair	105	981	90	684	38.5	332
Post-NAK repair	46	281	46	590	8	143

The 2014 Annual Growing Area Report showed moderately higher P90 values for these three stations as compared to the 2013 annual report and thus, an apparent decrease in water quality over time. However, this before and after repair analysis indicates that the data from 2012 leading to July 2013 data are the most elevated in the 5-year data set with the statistics for all three stations being better in the post-NAK repair results. On that basis, it appears that the higher P90 and geometric mean values in the 2014 Annual Growing Area Report are more likely due to lower scores from 2009 dropping out of the analysis rather than worsening data in 2014.

G. Medomak Mobile Home Park investigation:

On October 24, 2013, the DEP, WUD and the Town of Waldoboro conducted an investigation at MMHP, including dye testing. Dye was introduced into an unused sewer hook-up, followed by running a garden hose into the same connection for 20 minutes. No dye was observed within the Skating Pond, on the ground or in the MMHP main manhole for the two hours after dye introduction or in the following days. It is possible that the dye was all pushed through to the WUD sewer system in the evening after the dye test started, or early morning of the next day because those are generally two peak flow times from residential users when they are home from work in the evening or getting ready for work in the morning. At those times, no compliance personnel would have been present to observe the dye. A repeated visit in April 2014 by DEP staff to inspect the shoreline of the Skating Pond confirmed earlier investigations finding no evidence of sewage leakage into the Skating Pond. The FBE/ECS canine detection study described below also investigated the MMHP, and their results found no alerts by the dogs along the shore of the pond by the mobile home park or on water samples from the outlet of the pond. The high bacteria results from the outlet of the skating pond at Station VIL11 are, therefore, apparently not of human origin. In discussions with MMHP management, they confirmed that they have a very strict internal ordinance controlling pets in the park, including proper management of pet waste by residents. These findings discount MMHP as a likely source

of elevated fecal coliform bacteria in the Medomak River, but provide no other explanation for the high fecal coliform results obtained from the outlet of the skating pond. This makes the outlet of the Skating Pond another strong candidate for microbial source tracking.

H. Canine detection study:

The canine detection study was conducted by FBE/ECS on June 9, 2014 in collaboration with members of the Medomak Task Force, and the full report is included as Appendix N. At 18 locations, water samples for canine jar testing were taken with care to prevent human contact with the sample or its container, and concurrent samples were obtained from each site for fecal coliform bacteria analysis by the DEP. The samples for canine jar testing were transported to a neutral location and individually presented to the dogs to determine whether they would alert on any of the samples. The results of the jar testing and fecal coliform testing are shown on Table 7.

Table 7. Canine Detection study results taken from the FBE final report.

Site Name	Site Description	Type of waterbody	Other ID	Sable	Logan	Fecal coliform	Range of past fecal coliform data	Notes
1B	Kelp plant	Main stem	UP05	No	No	19	15 - >1600	Old issue has been addressed
A		Tributary		No	No	--		
B		Tributary		No	No	--		
C		Tributary		Yes	Yes	4		
C1/2		Tributary		Yes	Yes	16		
1A	Subdivision/cemetery	Main stem		Yes	Yes	11		
D		Tributary		No	No	54		
1	Upstream of Route 1	Main stem	UP01	Yes	Yes	36	13 -280	
2	Hannaford trib	Tributary	VIL10	No	No	361	<2 - 700	
3	Picnic area	Main stem	VIL14/46	Yes	Yes	1	5.5 - 1180	
4	Skating Pond culvert	Pond	VIL11	No	No	689	<2 -400	
5	Elm Street	Main stem		Yes	Yes	35		
6	Irving trib	Tributary	VIL08	No	No	32	<2 - 68	
7	Abden's trib	Tributary	VIL07	No	Yes	4	<2 - 340	
9	Mill Street	Main stem		No	No	22		High tide
9	Mill Street	Main stem		Yes	Yes	--		Low tide
10	Bear Hill Hardware	Main stem		Yes	Yes	58		High tide
10	Bear Hill Hardware	Main stem		No	Yes	--		Low tide
11	Landing	Main stem		No	No	102		High tide
11	Landing	Main stem		No	No	--		Low tide
12	Button Factory	Tributary	VIL02	No	Yes	27	<2 - 68	

Orange text indicates bacteria concentrations between 31 – 100 colonies/100mL; Red text indicates bacteria concentrations > 100 colonies/100mL)

In addition to the neutral site jar testing, two stream drainages where consistently high fecal scores had been obtained in the 2013 sampling by the Medomak Project were chosen for the dogs to walk. One was the Medomak Mobile Home Park area adjacent to the Skating Pond

outlet (Station VIL11) and the other was a small stream (Orff Brook) that drains to the main channel of the Medomak at Elm Street (Station VIL07).

After jar testing, sampling for fecal coliform and on-the-ground surveying by the canine team was completed, an event was held at the Town landing to educate the public concerning the Medomak Project and to provide a demonstration of the canine detection techniques by ECS.

The major findings of the study are quoted below in the numbered list, with additional discussion of the results below the list:

- “1. Human sources of bacteria are present in the Medomak River from downstream of the Site 1B: Kelp Plant to upstream of Site 11: Public Landing.
2. Highest bacteria concentrations were found in areas that were NOT found to have human wastewater present (Sites 4: Skating Pond and Site 2: Hannaford Trib). Other sources such as pet and wildlife waste are likely contributors.
3. The open sewer pipe in the structure located in the Mobile Home Park is likely contributing bacteria to the Medomak River during wet weather events.
4. The effect of the tides is difficult to determine through this study. Further investigation will need to be conducted.”

Regarding finding 1, the main stem sample site listed as 1B is the UP05 station, which was sampled regularly during 2013. The lack of human source detection at this site is a good sign, allowing the Task Force to narrow our focus on human sources in the watershed below that point. The detection of human source pollution in the Medomak above U. S. Route 1, and in two tributary streams that cross Depot Street led to sanitary survey work. As described above in Section B(3) several illicit discharges were detected at properties along Depot Street. The worst one of these has been remediated, and the Town is working with property owners on the other situations.

Two unexpected results related to FBE findings 1 and 2 were that the three stations with the highest fecal coliform scores were all negative on human detections by the canine unit, and that the human detections on the main stem samples ended at the “Bear Hill Hardware” site, with no detection at the Town landing, which is only ¼ mile further downstream. It also appears that the elevated fecal coliform values detected in the Skating Pond outlet and the stream by Hannaford do not carry downstream appreciably during dry weather.

The Medomak Mobile Home Park was the subject of on-site detection work with the canine unit. It was very surprising that there were no detections of human input at the outlet of the Skating Pond, any other location around the pond or in the park drainage ways. The only human source detection was inside the old water treatment building at an out-of-service drain from the water treatment unit into the MMHP sewer that had not been capped. FBE’s Finding #3 is not supported by the physical structures, the topography of the area or the sewer elevations. The likelihood of a sewage discharge from this building is extremely remote.

The FBE/ECS study made a number of recommendations, quoted in the following numbered list:

- “**1. Conduct a similar study under wet weather conditions.** Though dry weather investigations are recommended to identify human wastewater inputs to a waterbody, this initial investigation shows potential for human wastewater sources to remain localized during dry weather events and become mobile in stormwater runoff.
- 2. Install a cap** on the open sewer pipe located in the structure at the Mobile Home Park. This area should be investigated during wet weather to determine the extent to which flooding causes inputs from the private sewer manhole at this location.
3. Investigate other potential sources of bacteria from the Mobile Home Park, including pet and wildlife waste. **Conducting microbial source tracking** at Site 4: Skating Pond and Site 2: Hannaford Trib will narrow the search for potential sources.
- 4. Investigate the septic system history** for the houses between Site 1: Upstream of Route 1 and, Site 1B: Kelp Plant particularly near Sites C and C ½. Dye tests may be necessary to determine malfunction. Alternatively, field investigations with ECS may be conducted in this area to further identify sources.
- 5. Investigate the land area draining to Site D.** Human sources of bacteria were not found at this location, but bacteria concentrations were relatively high indicating other potential sources (wildlife or pet waste);
- 6. Continue to conduct regular sampling** on this portion of the Medomak River and its tributaries in an effort to further bracket sources of bacteria and to monitor fluctuations in bacteria concentrations. This sampling should be conducted **under both wet and dry weather** conditions to assess the fluctuation of bacteria concentrations under different weather and flow conditions.
- 7. Investigate potential human sources of bacteria at Site 12: Button Factory** through field investigations with ECS.”

Recommendations 1 and 6 have been addressed, beginning in 2014, and continuing through 2016, although not to the level of detailed diurnal studies of bacteria levels. The second recommendation is unnecessary for the health of the Medomak, but should be done for proper maintenance of the MMHP sewer system. The DEP addressed Recommendations 4 and 5 during 2014 by completing survey work on all houses along Depot Street past the end of the sewer system. Recommendations 3 and 7 were addressed in 2016, when the MTF was successful in obtaining grant funding to conduct MST work across the watershed (see subsection J, below).

I. Village Area Intensive Study:

The Village Area Intensive Study was completed during autumn of 2014, and the results are shown in Table 8. The major findings of the dry weather portion of the study are: 1) although all of the *E. coli* results from Stations 2 through 8 were higher than the P90 fecal coliform standard for open shellfish harvest, the scores were not high enough to be an indication of

significant pollution sources during dry weather, and 2) the *E. coli* results at the float at the Town landing (Station 1) were the lowest values on all three days, ranging from 13 to 22 MPN/100 mL. Even though the results in the main stem above the landing were higher than the open P90 standard, the results at the Town float met that standard, indicating that the bacteria levels were attenuating by the time the water reached the landing. The dry weather series data also indicate that, since there is no location with consistently high scores, there is no evidence of any dry-weather leakage from the municipal sewer system in the section of the river above Main Street.

Table 8. Village Area Intensive Study bacteria results.

<i>Escherichia coli</i> (MPN/100mL)					
	Dry Weather series				
	9/22/2014	9/23/2014	9/24/2014		
Station					
UP05	64	46	40	Winslows Mills -just above bridge	
Site 7	64	40	210	Upstream side of US Rte 1 bridge (also UP01)	
Site 6	57	61	79	Picnic area (also WS046)	
Site 5	32	66	48	Elm Street (near VIL07)	
Site 4	84	40	35	just below Mill Street bridge	
Site 3	54	37	32	down behind Bear Hill Hardware	
Site 2	73	36	84	just above Main Street bridge (near VIL05)	
Site 1	22	17	13	Town landing - off float (Near WS043.9)	
	Wet Weather Series				
	10/17/2014	10/18/2014	10/19/2014		
Site 7	866	54	22	Upstream side of US Rte 1 bridge (also UP01)	
Site 6A	2420	58	39	small stream behind Deb's and the bank	
Site 6	921	61	36	Picnic area (also WS046)	
Site 5A	517	64	35	main stem just below skating pond (near VIL11)	
Site 4A	1986	56	43	Orff Brook at Elm Street (also VIL07)	
Site 4	687	71	43	just below Mill Street bridge	
Site 3A	921	51	38	small trib from west opposite Bear Hill Hardware	
Site 1	45	60	41	Town landing - off float (near WS043.9)	

The wet weather sampling was conducted for three consecutive days in response to a rain event of 1.5"/24 hr on October 16, 2014. The major findings of the wet weather portion of the study are: 1) the 3 stations on tributaries had the highest results of day one; 2) all stations above the town landing showed high scores only on day one, including the flow from upstream of U. S. Route 1; 3) the rain-induced elevated bacteria results disappeared overnight by the time day 2 samples were taken; and 4) the float at the Town landing, while somewhat higher on day one than during the dry weather series (45 MPN/100 mL vs. 22 MPN/100 mL) and 60 MPN/100 mL on day two, never showed a large response in bacteria levels comparable to the stations upstream. The results at the upstream stations were as low or lower on day three after rain

than the dry weather results. The float at the Town landing had also dropped back toward dry weather levels by day three.

During this study, the river and its tributary streams flashed very quickly to elevated bacteria scores upon rainfall, but also dropped back to normal values within a day. The period leading up to this rainstorm had been relatively dry, so it is possible that an appreciable portion of the rainfall soaked into the ground rather than creating runoff. It would be instructive to repeat the rain series during a period when heavy rainfall occurs after the landscape is saturated. It is also interesting that the high bacteria levels upstream were not reflected in a substantial way at the town landing station. This suggests that either a very brief pulse of water with elevated bacteria content passed by the landing overnight between the day 1 and day 2 sample events, or the bacteria levels were somehow largely attenuated before they reached the Town float. If the high bacteria levels are being attenuated before reaching tidewater, then the bacteria levels causing the rainfall closure must be coming from the small streams that enter directly into tidewater.

J. Tidewater Tributaries Intensive Study:

On June 2, 2015, the task force conducted a scoping run by boat on the river to locate the mouths of the tributary streams identified by the Digital Elevation Model (described in the TASK GROUP ACTIVITIES section E(6)). We used a GPS unit to guide ourselves to the coordinates listed on the GIS maps. This scoping run coincided with a rain event that exceeded the $\geq 1''/24$ hr trigger, and even though the group was not able to obtain sample results for this event, the runoff flow made it clear where streams were discharging to tidewater. The scoping run showed that the Digital Elevation Model was quite accurate. Only one proposed station did not have stream flow.

All located streams were marked with wooden survey stakes on which the station ID was written with an indelible marker. During this scoping run, all selected locations were marked except for Station NMEUV00, where no runoff was evident. That station was excluded from further sampling effort, since there was no appreciable flow even during a significant watershed runoff event. On the west side of the conditional area, we found no stream at the new station proposed by DMR (DMR27/WS027-58), so that station was also discontinued. Near Station NMEUH00, along the western shore of the Medomak, we found sufficient flow to sample from two additional small streams not selected from the Digital Elevation Model that had appeared to be too small. These two were identified as New00 and New01 in further sampling and testing. Two additional small streams at the opposite end of the marsh into which the stream at Station NMEUH00 flows also had sufficient flow to sample. These streams were established as Stations XTRA and XTRA1 and added to the study. We also determined that two of the new DMR stations on the western shore would be better sampled by car at their crossings under Dutch Neck Road due to inaccessibility by boat to the freshwater sources above the influence of tides.

Three storm events generated rainfall above the $\geq 1''/24$ hr conditional closure trigger during the study period. On June 21, a rainfall event of $1.53''/24$ hr resulted in sampling runs on June 22, 24 and 26. On August 11, a rainfall of $1.28''/24$ hr resulted in sampling runs on August 12, 14 and 16. On October 29, a rainfall of $1.77''/24$ hr resulted in sampling runs on October 30, November 1 and November 3. Tables 9, 10 and 11 show the results, with all three tables showing the sample stations ordered from upstream to downstream. Table 9 shows the *E. coli* results for tributary stations along the eastern shore. Table 10 shows the *E. coli* results of the tributary stations along the western shore and also includes the Medomak River main channel flow into the estuary. Table 11 shows the fecal coliform results from the DMR routine sample stations plus the new mid-channel stations. Methods for this study are described in detail in Section E(6) of the Task Force Actions section.

Table 9. Tidewater Tributary Stream *E. coli* results (MPN/100 mL) for the east side streams listed from upstream to downstream. Asterisks in the August 14 sample column indicate that, although a sample was collected and analyzed, the water may have been stagnant.

2015 Station ID	EGAD ID	6/22/2015	6/24/2015	8/12/2015	8/14/2015	10/30/2015	11/1/2015
NMEUL00	NMETTEA00	218.7	65.7	791.5	224.7	74.9	27.9
NMEUM00	NMETTEB00	579.4	1553.1	1986.3	1046.2	62.4	51.2
NMEUN00	NMETTEC00	93.2	155.3	>2419.6	dry	70.8	38.8
NMEUO00	NMETTED00	157.6	172.3	>2419.6	dry	272.8	73.8
NMEUP00	NMETTEE00	396.8	260.3	>2419.6	1203.3	142.1	51.2
NMEUQ00	NMETTEF00	1986.3	1553.1	1203.3	>2149.6	under water	under water
NMEUR00	NMETTEG00	31.5	29.2	613.1	103.9	108.1	32.3
NMEUS00	NMETTEH00	123.4	275.5	2419.6	36.3	114.5	42.6
NMEUT00	NMETTEI00	135.4	60.9	1413.6	866.4*	17.3	13.5
NMEUU00	NMETTEJ00	727	547.5	1119.9	no sample	20.9	18.9
NMEUW00	NMETTEK00	37.3	12.2	290.9	193.5	64.4	25.9
NMEUX00	NMETTEL00	155.3	81.6	816.4	193.5*	816.4	517.2
NMEUY00	NMETTEM00	137.4	107.1	1986.3	dry	2419.6	1046.2
DMR3	NMETTEN00	117.8	365.4	2419.6	6.2*	1732.9	1986.3
DMR2	NMETTEO00	105.4	53.8	1046.2	74.9	48.7	27.9
DMR1	NMETTEP00	228.2	60.2	248.9	365.4	214.3	45
Samp1	NMESB00 - Site A	365.4	86	613.1	43.2	228.2	9.6
Samp2	NMESB00 - Site B	579.4	93.4	1732.9	99*	not sampled	not sampled

The color code in Tables 9 and 10 to depict bacteria concentration ranges uses green for MPN values at or below the open area P90 standard (31 cfu/100 mL), yellow between the open and restricted (163 cfu/100 mL) P90 standards, two intermediate lighter and darker orange shades for moderately elevated MPN values, and red being above the >1600 cfu/100 mL limit of the DMR fecal coliform test.

The June results show that many of the tributaries were discharging *E. coli* at levels above the restricted area P90 level on both day 1 and day 3. This could indicate that the rainfall effect in the conditional area may be at times caused by a cumulative landscape effect rather than one

source or a small number of point sources. Comparing these data to the DMR data on Table 11, nearly all of the DMR stations showed some elevation of fecal coliform numbers on day 3, but most of the conditional area stations and three of the four mid-channel stations had recovered to meeting the open geometric mean standard of 14 cfu/100 mL by day 5.

Table 10. Tidewater Tributary Stream *E. coli* results (MPN/100 mL) for the west side streams listed from upstream to downstream, also including the main flow of the river at Main Street. As in Table 9, asterisks indicate possibly stagnant samples.

2015 Station ID	EGAD ID	6/22/2015	6/24/2015	8/12/2015	8/14/2015	10/30/2015	11/1/2015
Main Street		140.1	71.2	547.5	29.8	172.2	122.3
NMEUK00	NMETTWB00	307.6	88.2	980.4	dry	307.6	101.2
NMEUJ00	NMETTWC00	1203.3	325.5	>2419.6	dry	>2419.6	1413.6
NMEUI00	NMETTWD00	49.6	64.4	>2419.6	dry	214.3	79.8
NMEUH00	NMETTWE00	110	35.9	dry	178.2	38.9	31.8
NEW00	NMETTWF00	228.2	378.4	161.6	93.3	167	45.7
NEW01	NMETTWG00	79.8	36.4	dry	no sample	46.4	21.3
XTRA1	NMETTWH00	7.5	2	88.2	15.8	172.2	3.1
XTRA	NMETTWI00	22.6	127.4	52	41.8	5.2	47.3
NMEUG00	NMETTWJ00	83.6	39.3	98.5	no sample	27.8	10.8
DMR5	NMETTWK00	206.4	146.7	>2419.6	980.4	125.9	40.2
DMR6	NMETTWL00	307.6	190.4	>2419.6	110.6	53.7	69.1
DMR29	NMETTWM00	178	272.3	>2419.6	>2419.6	39.7	11.9
DMR7	NMETTWN00	26.5	7.5	228.2	dry	9.8	6.3
DMR28	NMETTWO00	124.6	25.9	13.5	8.5	20.6	13.4
DMR8	NMETTWP00	344.8	112.6	2419.6	dry	46.2	11
DMR9	NMETTWQ00	488.4	187.2	>2419.6	dry	235.9	77.6

The August storm had a smaller rain total, and the preceding weeks had been dry. Even though the samples were taken after a rainfall large enough to trigger a closure, the flows in the tributaries were very low, and in some there was no flow or no water within the stream channel. As seen on Tables 9 and 10, many of the stations showed high bacteria levels, with some above the limit of the Colilert test (>2419.6 MPN/100 mL). Some high results could be from stagnant water samples, or they may indicate a very short, low volume pulse of heavily contaminated water after much of the rainfall had soaked into the ground instead of running off. In the August DMR fecal coliform data (Table 11), there is almost no observable effect of this rainstorm – possibly slight elevations at the landing (Station WS043.9) and at Station WS040 in the conditional area. This is consistent with very small volumes reaching tidewater from the tributaries. Even the relatively high value for the main flow of the Medomak River (see Table 10) does not appear to be reflected in the DMR station data.

The October storm was much larger, but many of the tributaries were discharging at levels below the P90 open area standard (green highlighting), some even on Day 1. The DMR results show that the entire tidewater area studied (prohibited and conditional areas) was elevated for

fecal coliform on day three. By day 5, much of the conditional area had returned to levels within the open area P90 standard, but not to normal background levels (compare to August results). The most interesting aspects of this last storm are that it highlights a small number of streams as serious problems on which to focus future efforts (Stations NMEUJ00, NMEUK00, NMEUQ00, NMEUX00, NMEUY00, DMR3/WS0-New4). In addition, the increased results at Stations WS043.9 and WS041.8 on Day 5 after rain may be evidence of a serious non-rainfall pollution event near the landing.

Table 11. Tidewater Tributary Stream fecal coliform results (cfu/100 mL) for DMR routine and mid-channel stations. Mid-channel station results are accented with stippling.

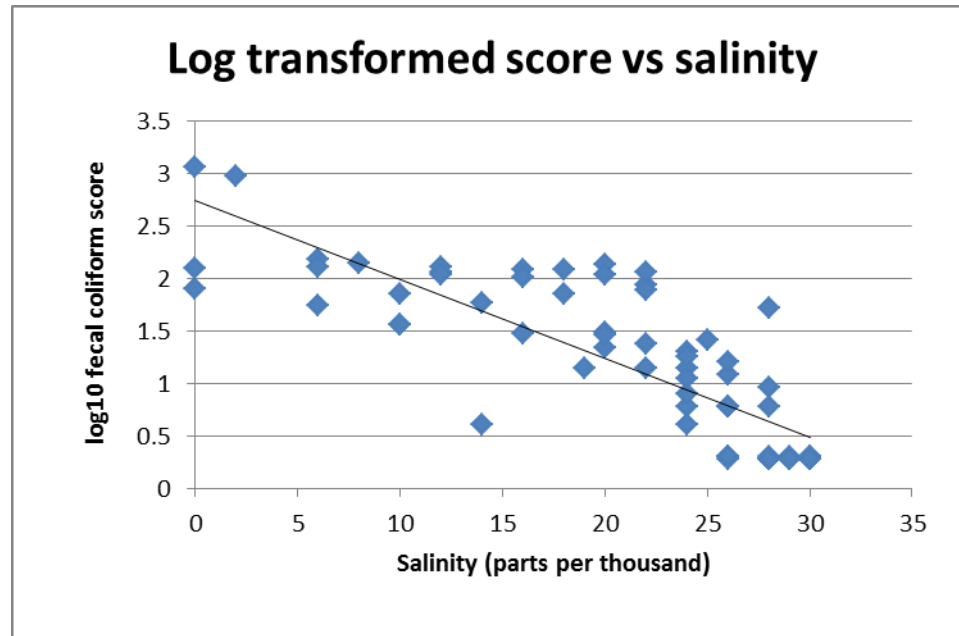
Station	24-Jun-15	26-Jun-15	14-Aug-15	16-Aug-15	01-Nov-15	03-Nov-15
WS043.90	128	36	36	22	125	940
WS041.80	150	14	1.9	8	80	1140
WS041.00	140	31	2	1.9	108	72
WS033-47	31	15	2	1.9	94	48
WS047.30	16	2	1.9	1.9	102	29
WS040.00	122	6	14	14	130	72
WS039.00	26	4	1.9	2	114	58
WS038.50	110	6	6	1.9	122	30
WS033-46	16	7.3	1.9	1.9	70	12
WS038.00	136	6	2	1.9	86	20
WS048.00	6	2	1.9	1.9	116	18
WS033-45	35	2	1.9	2	44	12
WS048.40	1.9	1.9	2	2	78	11
WS037.00	12	1.9	1.9	1.9	52	9.1
WS049.00	24	1.9	2	1.9	56	4
WS033-44	22	1.9	1.9	1.9	62	6

Further analysis of the data shows that there is an inverse correlation between salinity at the sampling station and the fecal coliform result. Figure 10 shows a plot of the logarithm of fecal score versus salinity. The Pearson correlation coefficient for this data set is -0.826, demonstrating a strong inverse correlation. There is a strong cluster of low scores at high salinity, with a much more scattered spread of data points at lower salinities. This result would be expected when the freshwater input to the estuary is the primary source of the fecal coliform bacteria and the freshwater floats on top of the denser seawater and is not rapidly mixed. The lowest salinity values are usually found at the landing and other upstream stations, with a gradual increase in salinity into the conditional area.

Looking across dates, we are able to focus on particular sample stations and therefore tributary watersheds. Starting with the East side results shown on Table 9, the station of greatest concern is NMEUQ00, which was elevated in all samples tested. We were unable to sample this station in the big October rainstorm because it was under water. This tributary stream drains the area near the Marble Oaks subdivision and the stream coming from the Skyview Mobile

Home Park, which was sampled as Station VIL0.5 in the 2013 volunteer sampling. The 2013 data from the VIL0.5 station were frequently elevated, and the 2015 results may be recording a continuation of the same effect, which remains unidentified. As discussed earlier, the watershed of Station VIL0.5 has been surveyed, and the branch of this stream that drains the area around the Marble Oaks development was investigated on December 10, 2015, finding no obvious problems.

Figure 10. DMR routine station and mid-channel station fecal coliform data, $\log_{10}$ -transformed and plotted versus salinity of the sample.

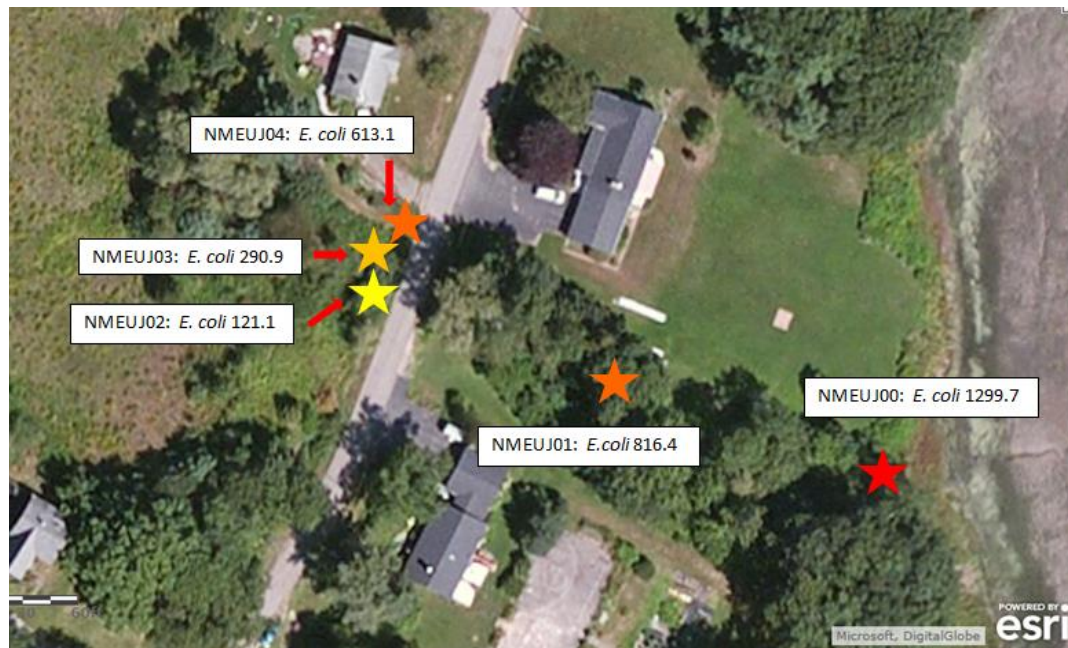


Further downstream, adjacent Stations NMEUX00, NMEUY00 and DMR3 were all elevated, particularly during the October sampling. There are very few houses in the watersheds of these three tributaries, but considerable farm field areas, mostly for haying. To investigate possible causes of the high scores, the watersheds of all three tributaries were surveyed on November 6, 2015, and no problems from the houses were detected. Water samples from locations upstream of the Tidewater Tributaries sample stations were tested, but none of the scores were elevated (see Appendix G). Based on interviewing one of the homeowners, there are large flocks of geese and turkeys in this area, and particularly on one cornfield. There was no evidence of manure spreading on any of the fields. Thus, it appears that wildlife is the cause of these elevated scores, namely geese and turkeys.

The main street results were moderately elevated on both days in June and October, but in August, there was an apparent rapid spike on Day 1 and a return to low level on Day 3. This reflects the pattern seen in the Village Area Intensive study during 2014, but the spike was apparently localized, not being evident anywhere in the DMR samples beyond the town landing (Station WS043.9).

On the west side of the river, the major concern is the stream at Station NMEUJ00. All but one sample from this station showed scores above 1000 MPN/100 mL, indicating that there is a consistent source of fecal pollution in the watershed, at least in response to rainfall. The DMR data also indicates a potentially significant source in this area. Based on DMR data from all years, the landing (Station WS043.9) is often elevated above the limits of the DMR fecal coliform test, the next station downriver, off Pine Point (Station WS041.8) is sometimes elevated during the same run, and the station at the border of the conditional area (station WS041.0) is occasionally elevated. To seek further focus on possible sources, additional sampling for *E. coli* was conducted in the Station NMEUJ00 watershed on November 6, 2015 (see Figure 11), and the properties adjacent to the stream were surveyed, even though the houses in this area are all connected to the Pine Street sewer. The bacteria results showed intermediate levels upstream of Pine Street and increasing levels moving downstream, with the highest score just above tidewater. There were no obvious sources of discharge to the stream from adjacent properties, so we conducted a smoke test of the sanitary sewer on December 10, 2015. No smoke appeared from the ground or other potential problem locations, and the smoke did discharge from all house vent pipes, as one would expect from proper connection to the sewer system.

Figure 11. Aerial photograph of the downstream end of the Station NMEUJ00 watershed, showing the locations and *E. coli* MPN/100 mL results of extra sampling. The location color code within the stars is the same as that used on Tables 9 and 10.



The small stream next to the Town Landing was sampled as Station NMEUK00. This station exhibited the second-worst *E. coli* results from the western shore, always above the open P90 standard. The Town piles snow at the landing and the landing area is used by a number of dog owners to walk their dogs, particularly in the winter. On April 12, 2016, the Waldoboro selectmen sent to a town vote, a proposal to ban pets from the Town Landing and the Picnic

Area across from Hannaford. On April 28, 2016, the voters approved the ban. The Waldoboro Shellfish Committee has also requested that a different location away from the river be used as a snow dump.

K. Watershed sampling by bacteria testing and MST during 2016:

The results of the paired bacteria and MST study are found in Table 12. The first sample run was done during dry weather on July 25, 2016 to determine base flow conditions and to identify any sources that may occur independent of wet weather high flows. Two errors occurred in the July sampling: 1) the most upstream station, labeled “Brook by Tonken”, was inadvertently omitted from the dry weather run, however, based on the low stream flow in this stream during the August rain sample run, there may not have been sufficient water to sample in July; 2) we intended to sample Slaigo Brook, but due to misreading the map, the dry weather sample was taken from the next tributary stream upriver. This error was corrected in the later sampling runs. The three rain event sample runs were conducted on day 1 after rainstorms over 1”/24 hr, on August 23, 2016, October 23, 2016 and October 29, 2016, with rainfall totals of 1.2”, 1.33” and 1.88”, respectively. This year was overall quite dry, which is evident in the sampling results table. During dry weather, only 7 of 21 streams had sufficient water to sample. On the smaller rainfall dates, 6-7 additional streams had flow, but even with a storm of nearly 2”/24 hr, four streams still had insufficient flow to sample.

1. Table 12 overview: Yellow fill color indicates the samples that were processed at UNH for MST. Bolded font indicates the samples that tested positive for human source bacteria. Thick, black borders on the relevant cell indicate positive results for canine source bacteria. Stippling indicates the samples that tested positive for gull source bacteria. No samples were positive for ruminant, indicating no cow, sheep or goat sources in any of the 2016 samples. By contrast, all samples tested for MST were positive for general mammalian genetic markers, indicating that some of the streams have either human-associated sources such as cat litter, horses, pigs, or other non-ruminant animals, or significant mammalian wildlife sources.
2. July dry weather results: For the July dry weather results, 4 of the 7 streams with flow had *E. coli* MPN scores high enough to warrant MST analysis. Of the four samples tested for MST, one had a positive result for the human marker. That stream, NMEUL00, is across from the Town Landing and drains a significant section of the village area. Considerable property surveying had previously been done on this stream above Friendship Road, but not between the road and tidewater. Because of the high score, the stream between Friendship Road and tidewater was inspected, even though all occupied structures in this area are connected to the WUD sewer system. One discharge of sewage was detected on the stream bank and determined to be leakage from one house. We conducted dye and smoke testing of the sewer and the house and determined that the house was the source. We did not determine whether the break was in the lateral connection from that house or the utility district sewer that serves

that house and the old Button Factory. The Button Factory has not been pumping any waste water into the sewer system, so it was not contributing to the discharge.

Table 12. Results of the Paired bacteria and MST testing during 2016. *E. coli* data are presented as MPN/100mL. Samples tested for MST are indicated by yellow shading. MST results are indicated by bold text font, bold cell borders or stippling.

Station ID	Sample dates (day 1 after trigger)				
	7/25/2016	8/23/2016	10/23/2016	10/29/2016	
rainfall (day zero)	none	1.2"/24 hr	1.33"/24 hr	1.88"/24 hr	
brook by Tonken		1413.6	156.5	115.3	
UP01 (Main stem upstream of Rte. 1)	206.4	261.3	101.7	547.5	
Vil10 (stream by Hannaford)	no flow	2419.6	28.8	201.4	
Vil11 (Skating Pond outlet)	no water	104.3	151.5	67.7	
Village area 6A (stream by Deb's Diner)	no water	1203.3	16.1	22.8	
Vil07	686.7	344.1	46.4	686.7	
Village area 3A	96	387.3	162.4	648.8	
Main Street falls	21	50.5	49.6	517.2	
NMEUK00	no water	no flow	no water	2420	
NMEUJ00	no water	no water	no flow	no flow	
NMEUL00	2420	2419.6	84.2	920.8	
NMEUM00	no water	no flow	45.7	no flow	
NMEUP00	no flow	770.1	83.6	178.5	
NMEUQ00	no water	1986.3	96	275.5	
NMEUU00	no water	no flow	no flow	151.5	
NMEUX00	no water	no water	no water	no water	
NMEUY00	no water	no water	no water	1046.2	
DMR5	378.4	579.4	410.6	307.6	
DMR3	no flow	1203.3	55.2	1986.3	
DMR6	no water	no water	no water	307.6	
DMR9	no flow	no water	no water	no water	
Stream by Brookland Cemetery	101.4				
Sampson Cove stream (Slaigo Brook)		1299.7	146.7	343.6	
					Total MST
yellow highlight: tested for MST using PCR with <i>Bacteroides</i>	4	12	6	16	38
bolded numbers: positive for human source <i>Bacteroides</i>	1	6	4	13	24
Thick Box border: positive for dog source <i>Bacteroides</i>	0	0	0	3	3
Stippling: positive for gull source <i>Bacteroides</i>	0	0	0	3	3
General mammalian - all MST samples positive for this source	4	12	6	16	38

3. August wet weather event: For this first wet weather sampling run after a rain event of 1.2"/24 hr, 14 stations had sufficient water to sample for bacteria, and 14 of the 16 samples produced high enough bacteria scores to warrant MST testing. Six of the 14 MST samples were positive for human marker, but none were positive for dog, gull or

ruminant. The bacteria scores were relatively high for nearly all of the samples, whether they tested positive for human marker or not. With this being the first large rain storm since early June, the high scores may have been due to significant accumulation of fecal material on the landscape to be scoured into the runoff. It is interesting to note, however, that even with relatively high bacteria counts and positive human marker results for the upstream Medomak main stem and village area tributaries, the bacteria result at the main stem falls was relatively low.

Three sample stations (brook by Tonken, Village area 6A and NMEUQ00) were above 1000 MPN *E. coli*, but negative for human, dog, ruminant or gull, indicating significant input from other mammalian sources. Station Vil07 and Village area 3A were both positive for human marker, even though the portions of these drainages closest to the main stem contain properties largely connected to the WUD sewer system. Station DMR3/WS0-New4 was positive for human marker, which is curious because there is a very low residential density, and no human sources were detected during the survey in late 2015. Slaigo Brook was also positive for human marker and above 1000 MPN for *E. coli*. Slaigo Brook is another watershed that was previously surveyed, most recently during 2013.

The stream at NMEUL00 was high in this data set because we were still in the process of identifying the source of sewage input to the stream. The stream by the Hannaford market was right at the upper limit of the Colilert test for *E. coli* and positive for human marker. The store was being rebuilt, including changes to the sewer connection. There may have been an escape of sewage during the change-over from old to new piping. Because of the positive human marker result, the stream adjacent to Hannaford was surveyed, but no ongoing discharges were detected.

4. First October wet weather event: This sampling run occurred after a rain event of 1.33"/24 hr, slightly higher than the August storm. One additional stream had sufficient water to sample for this event, so 15 streams were tested for *E. coli*. Of the 15 samples, only 6 produced high enough scores to warrant MST testing. Four of the six MST samples were positive for human marker, but none were positive for dog, ruminant or gull. At all but one station, the *E. coli* results were lower, and some were nearly 100-fold lower, than in the August samples. Even with the lower scores, three samples were newly positive for human marker: the brook by Tonken, main stem upstream, and DMR 5/WS0-New5. The brook by Tonken enters the main stem of the Medomak less than half a mile above the main stem upstream station (UP01), so the human positive in UP01 may be a result of the flow from the brook by Tonken. DMR5/WS0-New5 was positive for human after this event, even though the bacteria score was marginally lower. Village area 3A continued positive for human marker. Slaigo Brook, although tested for MST, did not register positive for human marker in this sampling run, even though it had been positive in August. NMEUL00, Vil07 and DMR3 were low for bacteria, so not sent for MST testing. These three were positive for human marker in

the August samples before these low bacteria tests, so might have been positive for human had they been tested.

5. Second October wet weather event: This sampling run occurred after the biggest rain event of the year, 1.88"/24 hr. As one would expect, more streams had enough flow for sampling, so 18 streams were tested for *E. coli*, and 16 produced high enough bacteria scores to warrant MST testing. Thirteen of the 16 samples were positive for human marker, and we saw our first positive tests for both dog and gull, but still no positive tests for ruminants. The positive tests for dog marker were found at the brook by Tonken, Village area 3A and NMEUQ00 and these samples were also positive for human. The positive tests for gull marker were found at both Medomak freshwater main stem sites and Vil10, which is adjacent to the Hannaford Market. The gull positives were also positive for human, but there was no overlap between the positive dog and gull samples.

The Main Street falls station appears to strongly correlate with the UP01 station in this sample set, with the *E. coli* scores very similar and both positive for gull. The very large rainfall may have caused high flows to affect the entire reach of the stream. The UP01 station and the Vil10 station are not far apart, and are both positive for gull marker.

Four stations, Vil10, Vil07, NMEUL00 and DMR3/WS0-New4, showed a return to human marker after low bacteria scores in the previous storm led to them not being tested for MST. These four may well have been positive for human marker in the first October sampling event, even though their bacteria scores were below our threshold for MST sampling. Both the Village area 3A and DMR5/WS0-New5 samples remained positive for human marker, and both were moderately elevated for bacteria.

There were four stations with new human marker positive results: Main Street falls, NMEUQ00, NMEUY00 and DMR6/WS0-New6. The Main Street falls site was discussed above. The NMEUQ00 watershed contains a small subdivision of apartment buildings with a private pump station, a large mobile home park, and hayfields. The earlier high bacteria score (August event) with only general mammalian marker and the presence of a private pump station warrant careful investigation of the watershed, even though it has been surveyed in the past. The NMEUY00 and DMR6/WS0-New6 stations did not have sufficient water to sample until this storm, so these watersheds may have sources that are only carried to the streams during very large events.

Slaigo Brook was off and on for both bacteria and human markers during 2016. The moderate to high bacteria scores, together with human marker warrant a new look at this watershed, even though it is outside the rainfall conditional area boundary.

6. Quantitative PCR (qPCR) results: The qPCR results are shown on Table 13, with the marker copy numbers representing an estimate of the amount of the marker in the original sample. The scientific notations shown in the table as E+03, E+04 or E+05

indicate that the marker results ranged from 3.57 E+03, which is 3,570 copies, to 7.83 E+05, which is 783,000 copies. These marker copy counts do not necessarily correlate with *Bacteroides* counts because there can be more than one copy per bacterial cell. However, the relative values can be instructive. Also, the marker copy numbers are for *Bacteroides*, not for *E. coli*, so any apparent mismatch between the *E. coli* score and the marker copy number is not relevant.

Table 13. Quantitative PCR results for selected sample sites, showing marker copy numbers for human and bird DNA markers.

Site	Date	Human Marker Copy Number/100 mL	Bird Marker Copy Number/100 mL
NMEUL00	7/25/2016	1.28E+05	N/A
DMR 5	8/23/2016	N/A	1.55E+04
DMR 3	8/23/2016	1.48E+04	9.67E+03
VIL 10 (Hannaford)	8/23/2016	6.95E+03	N/A
Slaigo Brook	8/23/2016	1.51E+04	N/A
Village area 3A	8/23/2016	3.57E+03	N/A
VIL 07 (Orff Brook)	8/23/2016	7.53E+03	N/A
NMEUL00	8/23/2016	1.61E+05	N/A
brook by Tonken	10/23/2016	5.15E+03	N/A
UP 01 (main stem upstream)	10/23/2016	6.18E+03	N/A
Village area 3A	10/23/2016	7.83E+05	N/A
DMR 5	10/23/2016	5.34E+03	1.54E+04
brook by Tonken	10/29/2016	1.46E+04	N/A
UP 01 (main stem upstream)	10/29/2016	2.09E+04	N/A
VIL 10 (Hannaford)	10/29/2016	7.53E+03	N/A
VIL 07 (Orff Brook)	10/29/2016	7.90E+03	N/A
Village area 3A	10/29/2016	9.15E+03	N/A
Main Street falls	10/29/2016	1.51E+04	N/A
NMEUL00	10/29/2016	1.88E+04	N/A
NMEUQ00	10/29/2016	1.12E+04	N/A
NMEUY00	10/29/2016	3.24E+04	1.27E+04
DMR 5	10/29/2016	8.88E+03	1.39E+04
DMR 3	10/29/2016	1.72E+04	2.88E+04
DMR 6	10/29/2016	5.61E+03	2.73E+04
Slaigo Brook	10/29/2016	6.89E+04	N/A
Greater than 10 ⁵			
10 ⁴ to 10 ⁵			
Less than 10 ⁴	No Fill		
N/A	Not Analyzed		

Twenty-five of the 38 samples were further analyzed by the qPCR method. The highest copy number for human marker in the dataset is the Village area 3A value in the October 29th sampling run. Even though the overall *E. coli* result for this sample was not extremely high, the qPCR indicates a strong source. The other two very high qPCR samples are both from NMEUL00, for which the obvious source has been remediated.

The UP01 site is marginally higher in human marker copy number than the brook by Tonken on both sample dates, which indicates that there may be some other upstream source of human waste in addition to the brook by Tonken.

The bird marker copy data were derived for a more general marker than the original MST work that was specific to gull. This new marker was generated due to concerns that some of the lower watershed sites, and NMEUY00 and DMR3/WS0-New2 specifically, may harbor significant populations of waterfowl or turkeys. The gull marker samples were not re-run for this new marker, but the new bird marker was detected at substantial levels in the NMEUY00, DMR3/WS0-NEW2, DMR5/WS0-New5 and DMR6/WS0-New6 samples.

7. Overview of the 2016 study: The most important dry weather result was that one stream station, NMEUL00, returned both an off-scale *E. coli* result and a positive for human marker. The source of that pollution was identified through spot surveying and remedial action was completed by December 2016 to eliminate the sewage discharge. John Fancy, of WUD, worked with the homeowner to redirect the internal plumbing, install a small pump station and connect the discharge to the WUD main sewer that serves Friendship Street. The cross-country sewer from the Button Factory is being abandoned. This work was completed in December 2016, so the stream should be tested during 2017 to determine whether this was the only source.

Six of the 21 streams were flowing during dry weather, indicating that they likely also provide a greater volume of water to the Medomak during rain events.

During dry weather and on day 1 after the two smaller rain events, the bacteria results are consistently fairly low at the Main Street falls station, no matter what the UP01 (upstream main stem) or upstream tributary scores are. Unless the timing of our samples missed the plug of water with higher scores, the river must be cleaning up between the U.S. Route 1 bridge and the falls when flow rates are low to moderate. After the largest storm, however, the results did show similar bacteria scores and presence of DNA markers from UP01 and Main Street falls. Either the flow rates are high enough to overwhelm any self-cleansing processes, or to bring a pulse of contaminated water to the Main Street site more quickly.

Because of the ubiquity of dogs, it was surprising that no dog markers were detected until the largest rain event at the end of October, and even then, on only three streams. However, the biggest surprise was the widespread detection of human markers, even though extensive sanitary survey work has been done in the Medomak watershed for many years, and many of the properties have their sewage conveyed to the WUD sewer system. Based on the bacteria numbers, and especially the detections of the human marker in many of the streams, the future actions section below will outline a list of streams that warrant further, more detailed water sampling and re-surveying. On the

other hand, due to lack of water, low bacteria levels and lack of concerning markers, a number of sites can be excluded from further study. These streams had no flow during any of the storms (NMEUJ00, NMEUX00 and DMR9), only one date with flow and low *E. coli* scores with no human marker (NMEUM00 and NMEUU00), or moderate bacteria numbers with no human marker (VIL 11, Village area 6A and NMEUP00). Stream NMEUJ is an interesting case. In the 2015 work, the *E. coli* levels in that stream were routinely high, causing us to do survey work and smoke testing of the town sewer in the street. By contrast, in the 2016 study, stream NMEUJ never had sufficient water for sampling. This change leaves us wondering if there was an illicit discharge that was eliminated without involvement of the MTF or the Town.

The gull marker detections at the UP01 site and Vil10, along with the downstream main channel sample site at Main Street falls presents an interesting pattern. There are no other detections of gull marker, which seems to indicate a localized attractor near the Hannaford Market, the convenience stores along U.S. Route 1, or the picnic area just across Route 32. Monitoring of this area may show whether this is the case, and implementation of some remedial measures to reduce any attraction for gulls may help bacteria scores in the river.

L. Public Relations and Outreach:

1. Press: In the autumn of 2013, the Town of Waldoboro sent out a press release describing the activities and results of the Medomak Project up to that time. The press release focused on the partnerships and the strong involvement of local volunteers and officials in the group, as well as accomplishments of the group. A copy of the press release can be found in Appendix O.

On June 11, 2014, the Lincoln County News published an article describing the canine detection study that was conducted by FB Environmental, Environmental Canine Services and the Medomak Task Force. A full copy of the article can be found in Appendix P. This article also describes the public demonstration of canine identification techniques described below. Also during 2014, the Waldoboro Shellfish Committee posted an article on the Town of Waldoboro website entitled: "Waldoboro Works Together for to Improve Medomak River Water Quality". That article has received over 3,000 "hits".

During early 2016, several articles were published concerning the Medomak River Growing Area due to an intense public discussion on the pet waste issue at the Town Landing. In with readily available trash barrels and signage, many dog owners were not cleaning up their pets' droppings. With high bacteria numbers in the River in the vicinity of the Town Landing, the Waldoboro Shellfish Committee was very concerned that the dog waste may be contributing to the closure of the shellfish growing area to harvest. Articles in the Lincoln County News (3/30/16) and the Courier-Gazette were published

and can be found in Appendices J and K. The Bangor Daily News also picked up the Lincoln County News article and re-published it on April 1, 2016.

2. *Outreach in conjunction with canine detection project:* At the end of surveying on June 9, 2014 by the canine team, an event was held at the Town landing to educate the public concerning the Medomak Project and a demonstration of the canine detection techniques by ECS. This event led to the June 11, 2014 press coverage mentioned above.
3. *Additional outreach:* Information about ongoing water sampling activities is regularly reported by MVLTL to its membership, through quarterly newsletters, email announcements and at its annual meeting in December. At the 2013 annual meeting, Waldoboro Shellfish Committee member Glen Melvin attended for a more in-depth report on the history of pollution issues in the river and the work of the Medomak Project. Glen also makes regular reports about the Medomak Task Force's progress to the Waldoboro Shellfish Committee. In the summer of 2014, information about sampling in the village was presented at the Waldoboro Farmers' Market.
4. *Presentations:* Several presentations of the Medomak Project results have been made to various groups. On December 4, 2013, interim results were presented at an issues briefing of the Joint Environmental Training Coordinating Committee. This talk focused on the interesting NAK cleanup story. On March 3, 2016, the results of the past 3 years of work by the MTF were presented at the annual Fisherman's Forum. On March 29, 2016, Phil Garwood presented the MTF results at the Maine Sustainability and Water Conference in Augusta. On April 12, 2016, Phil Garwood again gave the presentation of the Medomak Task Force results to the Waldoboro Select Board and a public audience. This presentation was covered by articles in the Lincoln County News and the Courier-Gazette, both on April 13, 2016. The MTF Project results were also presented to the DEP Division of Environmental Assessment on May 4, 2016.

INTERIM CONCLUSIONS:

Over the course of four and a half years, the Medomak project has involved extensive sampling efforts to document bacterial water quality. Fecal coliform and *E. coli* testing began as broad-scale efforts and were augmented with spot sampling or focused studies. While water quality has improved, the watershed is still reactive to rain events to the extent that the rainfall closure has not been eliminated and only marginally reduced in area by the end of 2016. Addition of source ID methods, first using canine ID of human sources, and subsequently microbial source tracking (MST) with DNA analyses, has refined our knowledge of sources. In particular, there were no detections of ruminant DNA in any samples. The primary ruminant source is cattle, so it appears that farms are not an important bacterial pollutant source in the Medomak watershed. The two main surprises of the MST analyses were 1) dog waste was only a factor in a small number of samples and only during the largest storm of 2016, and 2) human waste was

evident in many samples, even though repeated property surveys of the watersheds of these samples has not revealed any obvious sources. Identifying the sources of this widespread human waste will be a much more intensive process than has been employed in the past.

Several broad-based house-to-house surveys of septic system status, together with spot-sampling based on knowledge of property status or on bacteria sampling results have resulted in the elimination of close to a dozen human sewage sources. The largest single source of elevated bacteria in the Medomak was not an external source, but rather the regrowth of river bacteria within an industrial cooling/condenser system. This source was affecting bacteria levels in the conditional shellfish area and it has been eliminated.

Based on sampling results, a number of streams are considered to be free of significant sources of bacterial pollution, allowing focus on the remaining streams. Areas at and above Winslows Mills now contribute very little pollution affecting the conditional shellfish growing area. Several streams that discharge directly into the conditional area need more detailed sampling and surveying. On both shores of the conditional area, there are streams that appear to convey significant contamination from birds, particularly during the autumn. The primary birds of concern are turkeys and geese. The Task Force, or the Town should work to develop control measures to reduce the potential impact of these bird populations.

ONGOING AND FUTURE ACTIONS AND RECOMMENDATIONS:

A. DMR routine growing area sampling:

Obviously, the DMR will continue routine sampling for fecal coliform bacteria under its NSSP mandate. However, based on concerns with the recent fecal coliform results and consideration of the importance of the Medomak Growing Area, the DMR once again committed to accelerated sampling. The goal for 2017 was to obtain 12 routine sample sets (roughly monthly) for the Medomak Growing Area, rather than the normal 6 sample sets.

B. Additional water quality sampling:

With the background laid by the previous four years of work, the Medomak Task Force would like to continue with the paired bacteria sampling and MST. This will require some additional funding, whether from internal Town sources or from granting agencies.

1. *Streams of concern:* The paired bacteria/MST testing results from the 2016 study led to a refinement of sampling priorities. The first list below contains the streams that tested positive for MST markers or exhibited elevated bacteria scores. These streams should be sampled more intensively, either on a diurnal basis or at multiple sites in the watershed. The water sampling should be either augmented by additional property survey work, or the results of sampling may point to locations for more detailed examination.

- a. Brook by Tonken: human marker, dog marker and elevated bacteria – refused access in the past.
- b. Main Stem Medomak River – above U.S. Route 1: it appears that there may be additional sources of human waste discharging to the main stem between U.S. Route 1 and Winslows Mills.
- c. VIL10 – stream beside Hannaford: Two of three samples during 2016 were positive for human marker. This warrants additional sampling. However, the area has been surveyed, with no human sources found.
- d. VIL07 (Orff Brook): This stream has had high bacteria scores off and on, and had elevated human marker results during 2016. The area downstream of U.S. Route 1 has been surveyed, but the area above the Town Office should be surveyed.
- e. Village area stream 3A: This stream was routinely clean in 2013 and 2014, but now is both elevated for bacteria and positive for human marker. Detailed survey work and multiple site sampling should be conducted in this watershed.
- f. NMEUL00 – Button Factory stream: This stream was polluted during dry weather and the problem was documented and fixed by December 2016. This stream should at least be checked during 2017 to confirm that no other sources exist.
- g. NMEUK00 – stream adjacent to Town Landing: This stream had a high bacteria score, but only general mammalian marker. Surveying should be conducted to look for evidence of pollution from non-marker mammals. The surveying could be augmented by sampling at multiple stations on the stream.
- h. NMEUQ00 – stream below Marble Oaks: This stream had high bacteria scores during 2015 and 2016, and was positive for both human and dog markers. Additional detailed property survey should be done. This small subdivision is connected to the WUD sewer system with its own privately-owned and maintained pumping station. The maintenance contractor for the private pump station should be contacted regarding maintenance and repair history and issues.
- i. NMEUY00: There was no flow in this stream in 2016 sampling events until the big October storm, but it was positive for human marker in that storm, and positive for bird in the qPCR testing. The properties in this watershed should be re-surveyed, and some thought should go to controlling bird populations.
- j. DMR5/WS0-New5: This stream enters the conditional area just below its upper boundary. The bacteria scores were moderately elevated in all samples, including dry weather. Human marker was detected in the two October events, and bird marker was evident from qPCR analysis for all rain events. This is a fairly large watershed which should be re-surveyed in late summer and possibly sampled at multiple sites.
- k. DMR3/WS0-New4: This stream had elevated bacteria scores on two dates, coupled with positive human marker. The qPCR results also indicate bird

marker. This watershed has few homes, which should be re-surveyed. Along with the watershed of NMEUY00, some thought should go to controlling bird populations.

- l. DMR6/WS0-New6: There was no flow in this stream in 2016 sampling events until the big October storm, but it was positive for human marker in that storm, and positive for bird in the qPCR testing. The properties in this watershed should be re-surveyed, and some thought should go to controlling bird populations.
- m. Slaigo Brook: This stream had moderate to high *E. coli* scores and was positive for human marker on two dates. Even though it is not in the rainfall conditional area, work to identify the sources is warranted.

2. Streams that can be excluded from further testing:

- a. Village area 6A (adjacent to Deb's Diner)
- b. VIL11 (Skating Pond outlet)
- c. NMEUJ00
- d. NMEUM00
- e. NMEUP00
- f. NMEUU00
- g. NMEUX00–
- h. DMR9/WS0-New9

C. Property surveys:

Based on review of bacteria sampling results from the four years of this project, there are several areas that may be targeted for small-scale property surveys during 2017. These watersheds are also the focus of water sampling, as described above.

- 1. Brook by Tonken: The properties bordering the brook by Tonken should be surveyed, or in several cases, re-surveyed to investigate the positive human marker result for this stream.
- 2. Orff Brook: From sampling results in the first three years of the Medomak Project, it appeared that there may be an intermittent or seasonal pollution source discharging to Orff Brook. From Orff Brook sampling during 2014, it appears that the properties above U.S. Route 1 that drain to this stream should be investigated. The 2016 sampling results confirm the intermittent high bacteria scores and added positive human marker results to the picture. At least the area above the Town Office should be surveyed.
- 3. Village area 3A: The watershed of this stream has been largely surveyed, although two properties not on the sewer system have not been investigated. Some of the properties in the upper reaches were last surveyed in 2004, so new malfunctions may have occurred in that area. There is also a large private pump station serving a group of

condominium buildings. The maintenance contractor for this pump station should be interviewed to determine whether there have been any discharges from this pump station to the watershed. This stream also was positive for dog marker in the last storm, so there may be educational opportunities regarding disposal of dog wastes.

4. NMEUQ00: This watershed has a private pump station, areas of dense development and agricultural lands. *E. coli* scores have been elevated, and after the last event, human marker was detected. Careful survey of the watershed and investigation of the maintenance of the Marble Oaks private pump station are warranted.
5. NMEUY00 and DMR3/WSO-New4: These adjacent east shore watersheds both discharge directly to the conditional area and responded differently to rain events, but both were positive for human marker and general bird marker.
6. DMR5/WSO-New5 and DMR 6/WSO-New6: These adjacent west shore watersheds both discharge directly to the conditional area and produced results similar to NMEUY00 and DMR3/WSO-New4. Even though the watersheds have been surveyed, a re-survey of the properties is warranted, and an effort to document bird populations should be made, with an effort to develop methods to minimize bird waste as a source of bacteria to the conditional area.
7. Slaigo Brook: This stream was intermittently positive for human marker and had moderate to elevated bacteria scores in the 2016 results. Even though this stream discharges to a seasonal closure rather than rainfall, and the properties have been surveyed, a re-survey is warranted.
8. Follow-up from sampling results: If any sources or potential sources are indicated on the basis of the bacteria sampling efforts or MST work as recommended in A or B, above, focused surveys should be conducted to identify the property or properties involved and initiate implementation of solutions.

D. Applications for grant funding or other sources of support for sampling:

1. SeaGrant: The MTF received funding from the Sea Grant program during 2016 to support the addition of MST analyses to bacteria testing focused on the Medomak main stem and a number of its tributaries. Even though the amount received from Sea Grant was relatively small (\$4,900), it enabled the Task Force to make significant progress in our effort to identify sources of pollution causing the rainfall closures. The MTF should apply again to seek additional funding from SeaGrant to support continued MST study.
2. Non-point source program grants: The Medomak Valley Land Trust took the lead on behalf of the Town of Waldoboro to develop a proposal for a NPS planning grant. The Town contracted with FB Environmental to finalize and submit the grant proposal.

E. Public outreach efforts:

The Town has created an informational flyer to include in mailings to all dog license holders in the Town of Waldoboro. That flyer attempts to inform people of the potential for dog waste to create serious pollution problems and public health impacts. It will urge people to practice disposal methods that will contain the waste and prevent problems. The Town and MVLTL will continue to disseminate information with posters, mailings and presentations at community events, such as Waldoboro Days, regarding the importance of the Medomak River shellfish growing area to the economic vitality of Waldoboro.

This report and other significant developments in grant funding or project outcomes will be presented to the Waldoboro selectmen and posted on the Town's website. The MTF will continue to seek out opportunities to convey our message regarding stewardship and pollution control, particularly in regard to waste disposal, to the press, both locally and statewide.

F. Collaboration:

The Northeast Sustainability Consortium (NEST) was awarded a Maine Economic Improvement Fund (MEIF) grant to fund a graduate student and to conduct work within the Medomak River to create a hydrodynamic model of the water flows and tidal circulation within the river. In the work of the MTF over the past four years, there has been no measurement of flows, either within the main stem of the Medomak, or in any of the tributaries. Without flow data, the absolute or relative loadings of bacteria from the various sources are unknown. If the hydrodynamic model involves sufficient detailed flow monitoring, particularly on some of the tributaries, a clearer picture of the bacteria loadings to the shellfish growing area may be possible. Because of common interests in water quality aspects of shellfish growing areas and the Medomak River in particular, valuable contacts and collaboration have been established with researchers from UMaine and UNH. Our intent is to explore and build upon these collaborations, as well as to seek other collaborators and partners.

G. Updates to this Report:

The Medomak Task Force views the results described in this report as part of an ongoing effort. Although we have done extensive sampling and have investigated many properties in the Town of Waldoboro, our mission is not yet accomplished. As of the end of 2016, the rainfall condition had not been eliminated. We expect that additional work will be done in the coming years that will warrant adding updates to the report to describe the new work and any significant changes to the status of the river. It is our great desire that the final story of identifying the causes of the rainfall closures and implementing control measures will be told, and the Medomak River will no longer need rainfall conditional areas.

2017 UPDATE:

A. Grant Funding:

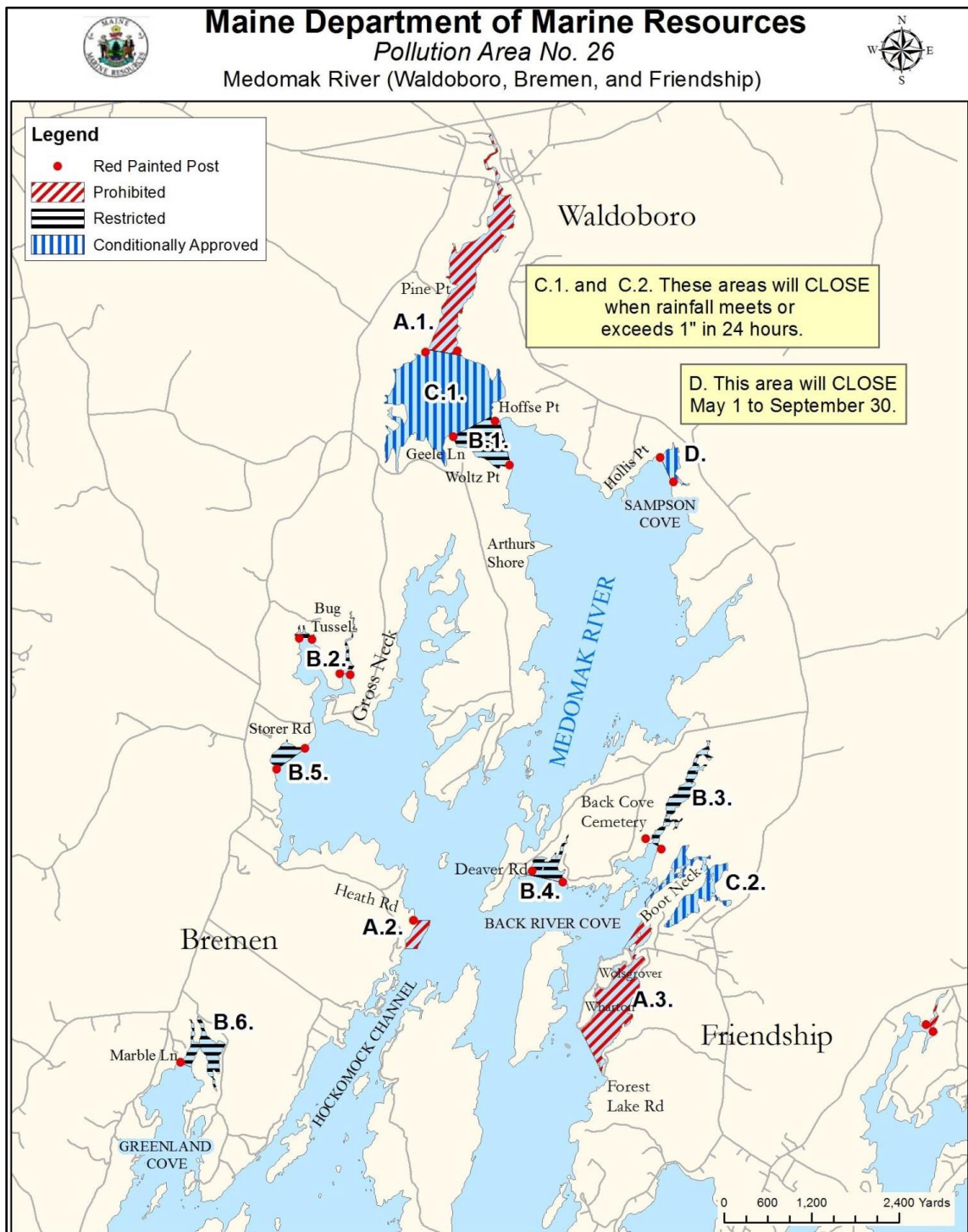
1. Non-Point Source Program Planning Grant: The Medomak Task Force recommended that the Town of Waldoboro apply for a Non-Point Source (NPS) planning grant to build on the work done over the past 4 years by the MTF. A successful planning grant will lead to the possibility of a larger implementation grant in the future that may allow much greater funding to be applied to remediating the causes of water quality impairment. MVLТ took the lead in working with FB Environmental to develop and submit an application to DEP for the planning grant on April 26, 2017.
2. SeaGrant funding: Word was received in mid-May 2017 that the request for SeaGrant funding was approved. With this funding, additional MST sampling can be scheduled to document effects from rainstorms of sufficient intensity to trigger conditional area closures.

B. Status of the Conditional Areas:

The DMR Growing Area Scientist responsible for the Medomak reviewed the data for the conditional area after requests from the Waldoboro Shellfish Committee, and wrote an Addendum to the Growing Area report for the Medomak. The analysis of water quality data warranted opening nearly half of the main conditional area labeled C.1 on the growing area map. See Figure 12. The area opened consists of 297 acres and is the entire portion of C.1 seaward of the triangular restricted area around “Tom’s Shore”. The official emergency rule for this change was issued on June 16, 2017. The announcement of the opening of almost half of the main conditional area received considerable positive press for Waldoboro and the efforts of the Medomak Task Force.

With the nearly simultaneous departure of 3 heavily-involved MTF members to new employment in mid-2017, and very few large rainfalls, no sampling or MST work was conducted in the Medomak during the year.

Figure 12. DMR Growing Area map for the Medomak River as of June 16, 2017.



C. Property surveying:

DEP staff conducted follow-up surveys on June 27 and 28, 2017 based on the bacteria/MST results from 2016. The areas covered were the watershed of sampling stations VA3 and VIL12, the watersheds of DMR5/WS0-New5 and DMR6/WS0-New6, the watershed of Orff Brook above the town office, properties adjacent to Slaigo Brook and upstream of NMEUT00, NMEUU00, NMEUY00 and NMEUY01. No malfunctioning systems were found, although one new leach field had been installed on one of the properties bordering the watershed above VIL12. One greywater system was found that needed repairs and another property owner had plans to replace the leach field. Based on this survey work, there were no obvious causes discovered that could explain the elevated bacteria scores or human marker positive results from 2016.