DEPARTMENT OF AGRICULTURE, CONSERVATION AND FORESTRY

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NEW ENGLAND INTERCOLLEGIATE GEOLOGICAL CONFERENCE

108th Annual Meeting

Guidebook for Field Trips along the Maine Coast from Maquoit Bay to Muscongus Bay

Edited by

Henry N. Berry IV and
David P. West, Jr.

Hosted by

The Maine Geological Survey and
The Middlebury College Geology Department

October 14-16, 2016

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The cover photograph is by Arthur M. Hussey II, to whom this guidebook is dedicated. Arthur Hussey was an accomplished photographer and his numerous photo collections highlighted many aspects of the natural beauty of southwestern Maine. The photo was taken by Arthur at a location about a kilometer south of Lookout Point along the western shore of Harpswell Neck. Arthur first began mapping in this area in 1962, and his 1965 NEIGC field trip visited exposures nearby. The view in the photo is towards the south and the exposures are east-dipping metamorphosed Ordovician volcanic rocks of the Cushing Formation. Arthur's hammer for scale.

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STREAM MORPHOLOGY AND WATER QUALITY IN A DENSELY DEVELOPED WATERSHED, TOPSHAM FAIR MALL, MAINE

By

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GENERAL GEOLOGY AND BACKGROUND

This trip will survey the hydrologic alterations to a small stream in a densely developed watershed, and compare some characteristics of this watershed to a less densely developed, adjacent watershed with fewer restrictions on streamflow and less alteration of cover. The surficial geology in both watersheds is similar, with nearshore sands of the Presumpscot Formation dominating the upper sections, and increasing amounts of alluvial material along the streams as one progresses downstream, as shown in Figure 1. These sands are generally fine to medium grained, and provide substantial storage of relatively cold water for streams in this area during the summer and early fall. Streams are typically deeply incised, with steep and fairly loose banks, and relatively narrow floodplains, and frequently have eroded down to more resistant strata, in this area commonly either a basal till or silty deposits of the Presumpscot Formation. The flat surfaces provided by many of these marine sand plains have proven to be good locations for development, due their generally good drainage, ease of excavation, and favorable topography. However, these characteristics also increase the potential for impacts on groundwater quality and changes in the runoff/recharge ratio in the area that can adversely affect stream functions and values. Development in the watershed also increases the potential for alteration of the channel, as the dense development and deep drainages can require significant construction and use of fill for stream crossings (See Figure 2).

We will examine conditions at five out of the seven principal restrictions on streamflow along the approximately 1.2 mile (1.9 km) length of this stream. We will be proceeding generally from upstream to downstream, and measuring specific conductance and temperature in the main stem and tributaries as we proceed. Because of recent dry conditions and dense vegetation in some places along the main channel and tributaries, it may not be possible to access or collect data at all locations, but participants are invited to bring any portable meters or other equipment to examine the condition of the stream under low-flow conditions. Because we will be walking in fairly active parking lots and along busy roads, participants might want to bring safety vests or other high-visibility clothing.

SURFACE WATER CLASSIFICATION AND IMPARED STREAMS

Maine's Water Classification Program (38 MRS Article 4-A § 467-469), pursuant to requirements of the Clean Water Act, establishes water quality goals for all state surface waters and groundwater. Table 1 summarizes the major elements of surface water classification in Maine statute. The Maine Department of Environmental Protection conducts regular surveys of the physical, chemical, and biological condition of surface waters in order to determine whether or not those water bodies meet the criteria required for the classification they are assigned under the Water Classification Program. In the event that monitoring shows that the physical, chemical, and biological conditions are better than the requirements for the assigned classification, the classification waterbody could be upgraded if approved by the Legislature. If this monitoring demonstrates that a waterbody does not meet the criteria required for its class, it is considered an impaired waterbody and is listed as required by Section 303(d) of the Clean Water Act, and measures must be taken to improve water quality. In general, these measures may include elimination or improved treatment of point discharges, but, where water quality is adversely impacted by non-point discharges, measures to improve water quality are more complex and may require cooperation among many landowners and stakeholders in the watershed, resulting in, among other outcomes, development of a Watershed-Based Plan for management of water quality improvements. In the case of this stream, the watershed-based plan is described by FB Environmental (2014), and currently includes assessment of the causes of impairment and development of restoration and implementation measures, and criteria for measuring success of the implementation measures. This 2014 plan "has an immediate time horizon of four years, with further implementation to be developed following an adaptive management approach" (FB Environmental, 2014, p. v) and the time line to implement all elements of the restoration plan is estimated as ten-to-fifteen years; relevant elements of the plan will be discussed in more detail in the field.

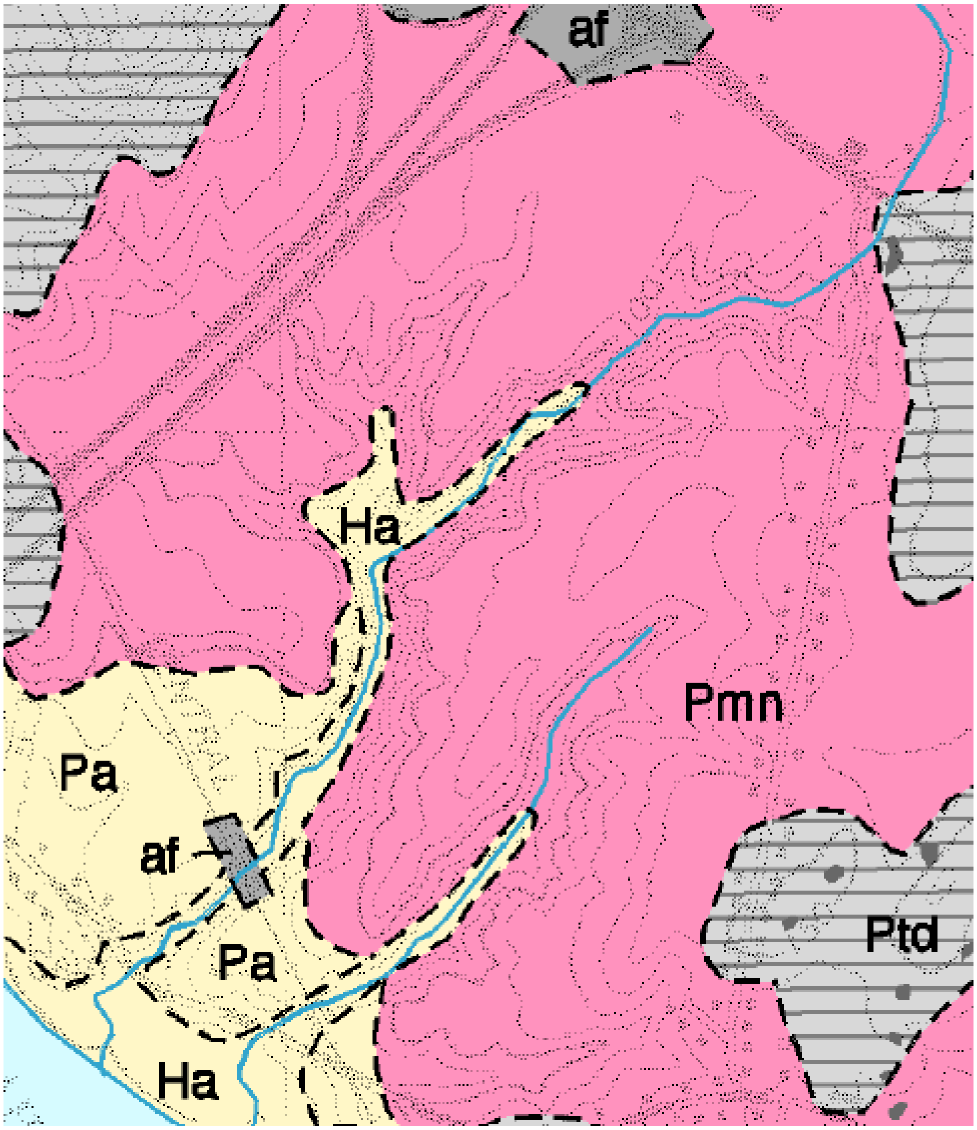

Figure 1: Portion of the Brunswick 7.5-minute Surficial Geology Map (Weddle, 2002) showing the area of the Topsham Fair Mall Stream. The area shown is slightly over one kilometer in width. Ptd: Pleistocene thin drift; Pmn: Pleistocene nearshore deposits; Pa: Pleistocene braided stream alluvium; Ha: Holocene alluvium; af: artificial fill.

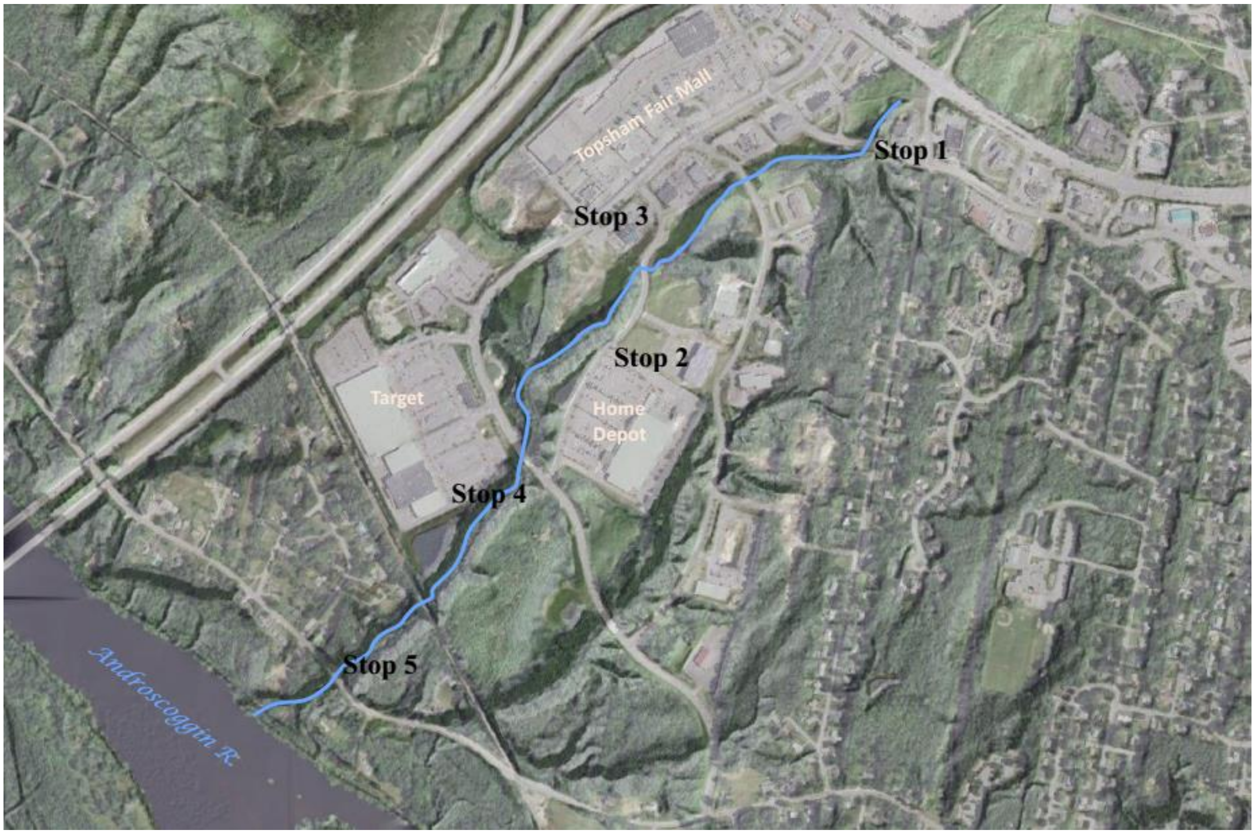

Figure 2: Aerial photography and LIDAR imagery of the site, covering the same general area as Figure 1, and showing the density of development and locations of stops on this trip.

Many surface waters in developed areas of Maine show impairment of water quality and macroinvertebrate populations due to hydrologic alteration, increased sediment loading, and elevated chloride concentrations (Danielson et al., 2016). On this trip we will have the opportunity to see and discuss examples of most or all of these types of stream degradation. Hydrologic alterations include not only changes to stream channels by straightening and filling of the channel, but also result from restrictions to flow, changes to floodplains, and increased peak flows and longer duration of high flows that result from changes to cover type in the watershed. Increased sediment loads result from scour in the stream channel and natural and artificial contributing drainages (See Figure 3 A and B), and also from winter sand and erosion from construction sites and other disturbed areas. Elevated chloride concentrations occur in spring runoff, but the adverse effects of these high chloride levels in the spring may be reduced by the high volume of spring flows. Data collected by the Department from several watersheds in Maine indicate that storage of high-chloride concentration waters in sandy fill and sandy overburden, and intentional infiltration of stormwater runoff in thicker sand and gravel deposits, may have more significant impacts on surface waters during low-flow conditions, when macroinvertebrates and other species are exposed to much less diluted chloride concentrations from baseflow. Groundwater quality downgradient of several infiltration facilities routinely exceeds the chloride drinking water standard and frequently approaches or exceeds the chronic water quality criterion (Maine Department of Environmental Protection, unpub. data; Hopeck, 1996; Hopeck and Holden, 2014), and shows depression of dissolved oxygen concentrations compared to upgradient groundwater, indicating that infiltration of runoff from developed areas with large impervious surface may not be appropriate if the intention of infiltration is to support low-flow conditions.

Class	Management Objectives	Dissolved Oxygen	Bacteria (*E. coli*)	Biological Standards and Habitat Characteristics
AA*	Highest-quality water, minimal human interference; No discharges allowed; No impoundment allowed	As naturally occurs	As naturally occurs	Habitat shall be characterized as free-flowing and natural; Aquatic life shall be as naturally occurs
A*	High-quality water with limited human interference; Discharges limited to noncontact process water or highly treated wastewater of quality equal to, or better than, the receiving water; Impoundments allowed (see Management and Biological Standard)	7 ppm or 75% saturation	As naturally occurs	Habitat shall be characterized as natural; Aquatic life shall be as naturally occurs
B	Good-quality water; Discharge of well-treated effluent with ample dilution permitted; Impoundments allowed (see Management and Biological Standard)	7 ppm or 75% saturation October 1–May 15: 9.5 ppm	May 15 to September 30–Geometric mean: 64/100 ml Instantaneous (single sample): 236/100 ml	Habitat shall be characterized as unimpaired; Discharges shall not cause adverse impacts to aquatic life; Receiving water shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community
C	Acceptable water quality, achieves the interim goals of the Clean Water Act (fishable–swimmable); Discharge of well-treated effluent permitted; Impoundments allowed	5 ppm or 60% saturation; D.O sufficient to support salmonid spawning, incubation, and survival in identified areas	May 15 to September 30–Geometric mean: 126/100 ml Instantaneous (single sample): 236/100 ml	Habitat for fish and other aquatic life; Discharges may cause some changes to aquatic life provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving water and maintain the structure and function of the resident biological community
Impound-ments in Classes A and B.	Riverine impoundments managed for hydropower generation and not classified as Great Ponds	Same as for the assigned class except where stratification occurs	Same as for the assigned class	Support all species of fish indigenous to those waters and maintain the structure and function of the resident biological community

*The narrative aquatic life standard is the same for Class AA and Class A.

Table 1: Maine’s tiered narrative, aquatic life, and habitat criteria and numeric dissolved oxygen and bacteria criteria for rivers and streams; USEPA-adopted aquatic life criteria for toxic substances apply to all classes (modified from Davies et al., 2016).

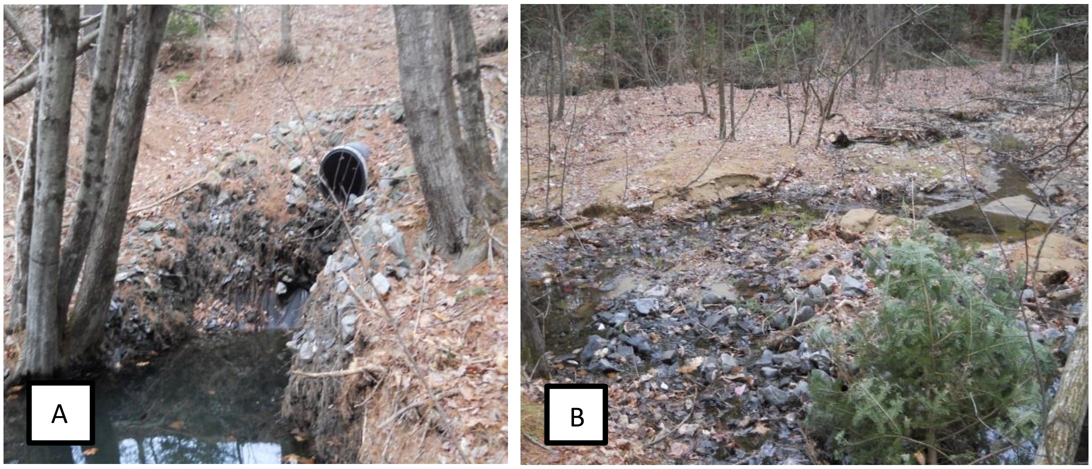

Figure 3: 3A: Scour at outlet of stormwater drainage; 3B: additional erosion and deposition of sediment downstream of the outlet shown in 3A. Note the rock washed out of the plunge pool at the outlet scattered down slope toward and in the eroded channel, suggesting that the outlet may be experiencing higher flows than anticipated in the design. Main channel of Topsham Fair Mall Stream is visible in the background.

Use of infiltration at the Topsham Fair Mall is limited by the relatively fine sands in many areas, particularly toward the southern end of the site (Maine Department of Environmental Protection, unpublished data). One attempt to manage infiltration and chloride at this side was employed at the Home Depot, which directs roof runoff to four large slow-rate infiltration wells, but diverts parking lot runoff to a wet pond that discharges to the stream. Even in the absence of direct infiltration, however, the amount of incidental infiltration and leakage or other discharges from the stormwater system to groundwater in the subsurface may be significant. The importance of baseflow and stream hydrology and morphology to maintenance of surface water classification, and the potential for adverse impacts on groundwater quality and baseflow from developed areas, even in the absence of localized subsurface discharges, has become increasingly obvious in Maine, and Maine DEP geologists have played a progressively larger role in assessment of surface water quality.

Terrain conductivity surveys conducted by Maine DEP have identified areas of elevated conductivity on the west side of the stream that are not clearly associated with the stormwater system but may be related to elevated specific conductance readings observed in the stream under low-flow conditions. Specific conductance profiles of the stream from Route 196 to Topsham Fair Mall Road show very localized increases and decreases in specific conductance (See, for example, Figure 4). Most, but not all, decreases in specific conductance appear to be associated with tributaries to the stream, while localized increases appear to relate to loci of high-conductivity baseflow discharge. Increases in temperature generally reflect ponding upgradient of flow restrictions at the major crossings, while decreases are related to tributaries or local increases in baseflow.

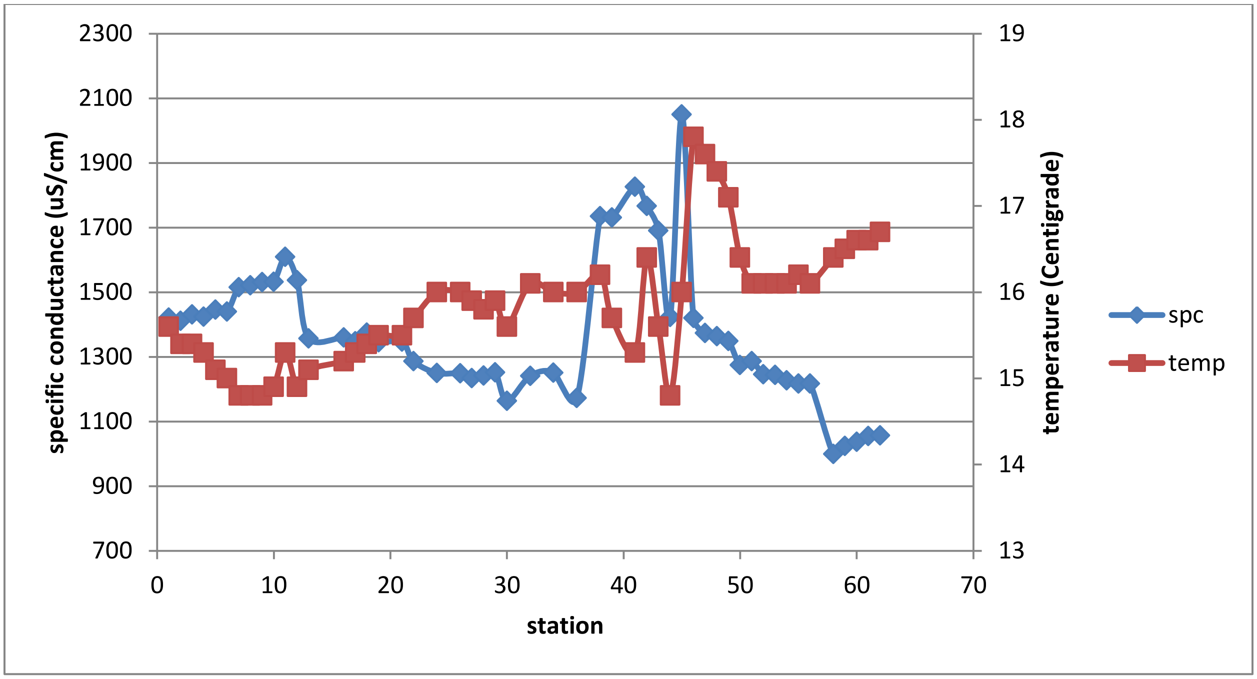

Figure 4: Longitudinal specific conductance profile of Topsham Fair Mall Stream; Station 0 is the most upgradient accessible location; Station 61 is near the upgradient end of the culvert seen at Stop 4. Data collected by Maine DEP in Spring 2016. The data suggest that inputs of baseflow with elevated specific conductance, considered to indicate elevated chloride concentrations, occur over two relatively distinct reaches of the stream. Temperature increases appear to be associated with exposure of the main branch and tributaries in areas of lower vegetation and ponding upstream of restrictions in the channel.

ACKNOWLEDGMENTS

Thanks to Kristin Feindel and Wendy Garland of the Bureau of Water Quality, Maine Department of Environmental Protection, for information and data used in the preparation of this guide.

ROAD LOG

Meet at 1:00 p.m. in the Hannaford parking lot near the intersection of Topsham Fair Mall Road and Monument Place (south of the Wendy's). There should be plenty of parking in the main lot near Topsham Fair Mall Road. We will walk down Monument Place to the first road crossing of the stream south of Route 196.

STOP 1. Stop 1 provides a general overview of the upper portion of the site, and, due to the low vegetation, is a good place to compare conditions upstream and downstream of this first major channel restriction south of Route 196. Prior to surfacing on the upstream side of this crossing, the stream travels through a long culvert under Route 196 after passing through an industrial area on the north side of the road. Historic monitoring date in Department files show elevated specific conductance in the stream but relatively low to moderate values of this parameter in groundwater within the industrial site. The headwaters of the stream are in an area bounded by this industrial site, Interstate 295, and Route 201. As shown in Figure 4, specific conductance in the stream is clearly elevated even before it enters the section of the watershed downgradient of the mall and associated development. If there is sufficient water in the channel, we will collect specific conductance and temperature data in the stream upgradient and downgradient of the crossing; Department geologists have shown (Maine DEP, unpub. data) that specific conductance in streams is often significantly elevated downgradient of road crossings even in late summer and autumn, hypothetically due, at least in part, to storage of dissolved salt in the fill. This has not been clearly demonstrated at this site, however.

Return to vehicles and proceed to Stop 2.

Figure 5: View looking south from approximate location of Stop 1, showing wetland developed in sediment deposited upstream of Park Drive crossing. Midway Drive crossing is visible in background. We will walk down the powerline beyond Midway Drive to the main stream and some tributaries draining the western half of the site and areas adjacent to the highway as part of Stop 3.

(**Note**: Due to the short distances between stops, and the amount of unloggable distance we will be driving in parking lots, it is likely that odometer-measured distances will vary from the rounded measurements shown here, and the distances given are <u>between stops on main roads (such as entrances and exits for parking lots) only</u>; no cumulative distance is given because distances driven within parking lots will be significant compared to the length of the trip. The stops are close enough, however, that there is little danger of losing the trip route.)

0.0 Turn right out of the Hannaford lot and proceed to the intersection with Midway Drive.
0.1 Turn left onto Midway Drive (toward Home Depot). Proceed to the Home Depot parking lot.
0.4 Take the first left into the parking lot and park in spaces close to Midway Drive.

STOP 2. At this stop we will examine the stormwater quality and quantity control pond for the Home Depot, and review the design and function of the injection wells and the water-quality rationale for separating roof runoff from parking lot and roadway runoff. We will then proceed down the outlet channel from the detention/ retention pond to the main stem of the stream, considering the stability of the outlet control structure and outlet channel, and the confluence of the outlet channel and the stream.

0.0 Return to vehicles and leave the parking lot, turning left to continue on south on Midway Drive.
0.2 Turn right onto Topsham Fair Mall Road.
0.5 Turn left into parking lot; park in areas near Panera Bread.

STOP 3. From this parking lot, walk southwest along Topsham Fair Mall drive to examine tributary streams to the main stem, which drain the area adjacent to the highway and along the west side of the development. Specific conductance in these streams is usually lower than the values of this parameter obtained from the main stream on the same date, and we will compare these values on the day of the trip. Return to the parking lot exit and cross Topsham Fair Mall Road and walk across the undeveloped (at the date of writing) lot toward the powerline. Find one of the small trails that will lead south and down toward the tributary stream. We will discuss the morphology and water quality of this tributary and follow it toward the main channel; we should reach the main channel upstream of the Home Depot pond outlet. Walk downstream along the stream and examine changes in stream morphology and bottom sediment. Some sections of the channel bottom along this reach are pebbly, and this may indicate the presence of till at or near the stream bed. This may, in turn, relate to elevated specific conductance values sometimes obtained in this area, if the till layer is acting to force more chloride-rich groundwater to the surface. The Department has collected available geotechnical data from the developments throughout the watershed, and is attempting to develop a better understanding of the subsurface controls on water quality and quantity in the watershed; preliminary results of this analysis may be available for discussion by the date of this trip. Proceeding downstream, it should be possible to observe the gradual changes resulting from accumulation of sediment and restriction of flow behind the Topsham Fair Mall Road crossing (Figure 5). Conditions permitting, we will walk to this crossing to consider conditions there and possible alternate designs, and then return to the road and the vehicles by the most convenient route.

0.0 Return to vehicles and exit the parking lot, turning right onto Topsham Fair Mall Road.
0.3 Turn right into Target parking lot and park in the southeast corner (the closest corner) of the lot.

STOP 4. From here descend along the embankment adjacent to the road crossing, and walk downstream. We will examine the significant change in morphology at this location, shown in Figure 6, compared to the upstream side of the crossing, and will again be considering the gradual changes in the floodplain and channel due the restriction at the railroad culvert at the end of this reach. This railroad culvert was installed many years before the present development, and the morphology of the floodplain that resulted from this restriction is now being altered by the more recent changes to the stream hydrograph and floodplain. Sections of this reach are now relatively deeply incised into floodplain sediment accumulated upstream of the railroad culvert (Figure 7), and Field (2013) describes tree stumps and roots buried in this material that are now exposed in the channel bottom as a result of the more recent scour. We will proceed downstream as far as possible given time and conditions; this section of the floodplain is often difficult to traverse due to wet conditions and accumulated vegetation, particularly downstream of the outfall from the Target detention/retention pond. Return to the Target parking lot and the vehicles by climbing the slope adjacent to this outfall, considering the stability and water quality impacts of this structure as you proceed.

Figure 5: Wide floodplain sediment deposits at end of the reach of stream explored on Stop 3. Note lack of clearly defined channel and impact on vegetation.

Figure 6: Culvert outlet at opposite end of the crossing seen in Figure 5; note definite channel and rocky substrate.

Figure 7: Incised channel typical of most of the main stem of stream in the area of Stop 4. Field (2013) describes tree stumps and roots exposed in this channel as evidence of sediment deposition upstream of a narrow railroad culvert at the downstream end of this reach and more recent erosion due to changes in flow volume and velocity.

0.0 Return to vehicles and exit parking lot, turning right onto Topsham Fair Mall Road.

0.6 Turn right onto Winter Street, which becomes River Road. Proceed along this road approximately 0.4 miles, crossing railroad tracks and another small stream, to where the road crosses Topsham Fair Mall Stream. The road is narrow and sight distances are poor, so safe parking spaces at the stream crossing may be difficult to find. We will be backtracking to the small stream east of Topsham Fair Mall Stream, so if you see a safe parking space in that area, you might want to take it.

Stop 5. The culverts at this stop are the last restriction in the floodplain before the stream reaches the Androscoggin River. Note the unusual arrangement of the culverts, installed relatively recently to manage high flows and reduce the risk of road washouts. It is generally difficult to walk very far upstream from this point, due to wet soils and dense vegetation, but we can compare the condition of the stream at this crossing to the smaller stream immediately to the east, that we crossed to reach this stop. We will also compare water quality data at the two locations.

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