Geological Society of Maine Summer Field Trip
July 25-26, 2026

Geology of Eastern Washington County and Cobscook Bay

Contributors: John Breedlove, Richard Cambpell, Myles Felch, Andrew Reeve

Compiled and edited by Andrew Collins



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PREFACE

Today we know the East Coast as a passive margin. Stable, relict. But as geologists we know that a tumultuous history is recorded in the rocks beneath our feet. Volcanoes, earthquakes, continental collisions, and—more recently—sculpting by ice sheets have all left their signatures in the rock record. In few places is this record better exposed than Downeast Maine. As the dense forests and bogs of the interior yield to a windswept and rocky coastline, lava flows can be seen intermingling with alluvial and fossiliferous marine sediments. A stratigraphic sequence showing the transition from convergent to extensional volcanism over the course of the Silurian and Devonian is on full display, overprinted by the advance and retreat of erosive glaciers. All this calamity makes for some delightful eye candy in the present, and some puzzles that have yet to be solved.

This year's Geological Society of Maine field excursion will focus on the geology of the Coastal Maine Volcanic Belt, the influence of Pleistocene glaciation on the modern landscape, and the complex relationship between human activity and landscape evolution. Our stops will span a wide range of geologic settings, from volcanic and tectonic features preserved in the bedrock to glacial deposits, wetlands, and coastal environments that reflect much more recent events. Over the course of the weekend, we will explore the throughlines of these features and events to understand how Maine's Downeast landscape came to be.

The Geological Society of Maine (GSM) executive board wishes to thank the contributors to this guide for sharing their time and expertise, and those who have given permission for us to access their properties. And many thanks to you for joining us on this trip.

In the spirit of learning and exploration,

Andrew Collins
GSM Vice President

IMPORTANT NOTES

Private Property

Many of the stops we will visit during this field trip are located on private property. Please tread lightly and respectfully. Future access to these sites is not implied and should not be assumed. Any future visits will require permission of the landowner.

Politics

In interactions with landowners, we may encounter a variety of political viewpoints and politically-themed signage. Please be respectful.

Field Conditions

We will walk distances of up to a mile over uneven ground. Terrain covered will include unmown fields and meadows, forest, dirt, gravel, bedrock, beachland, and asphalt. Please understand your abilities and use your discretion in deciding whether to participate in a stop.

The weather Downeast can be extremely variable. Daytime temperatures in the 50s with fog or rain are just as likely as temperatures in the 80s with sun. Bring layers, snacks, plenty of water, sunscreen, bug spray, and rain jacket. It's also advised to conduct a cursory tick check at the end of each stop and a thorough one at the end of each day.

Directions and Map

Directions, mileage, and coordinates are provided for each stop. Mileage may not be exact.

If you prefer, you can scan this QR code with your phone to open the Field Trip map in Google Maps and navigate with your phone's GPS. You can navigate by touching the stops on the map or by entering the GPS coordinates provided in this guide.

SCHEDULE

Saturday, July 25

Stop #	Time	Stop Location	Duration	Mileage	Cumulative Mileage
	7:30	*Breakfast at Cobscook Bay State Park* *44.84033, -67.15007*	*1:00*		
	8:30	*Depart*			*0.0*
		Transit	0:20	13.4	
1	9:00	Big Hill Zinc Prospect 44.96286, -67.20909	1:30		13.4
		Transit	0:05	1.9	
2	10:30	Leighton Formation Outcrop 44.95024, -67.17978	0:30		15.3
		Transit	0:05	1.9	
3	11:00	Hersey Formation Outcrop 44.96180, -67.15948	0:30		16.8
		Transit	0:10	3.2	
4	11:30	Sipp Bay Preserve, *with picnic lunch* 44.93931, -67.12480	1:30		20.0
		Transit	0:30	16.7	
5	13:30	Meddybemps Gravel Pits 45.03586, -67.38300	0:30		36.7
		Transit	0:05	1.3	
6	14:00	Eastern Surplus/N'Tolonapemk/Charlotte Smith 45.03850, -67.35836	2:30		38.0
		Transit	0:30	22.3	
	17:00	*Return to Cobscook Bay State Park* *44.31542, -69.77508*			60.3
	18:00	*Group Dinner at Cobscook Bay State Park*			

SCHEDULE

Sunday, July 26

Stop #	Time	Stop Location	Duration	Mileage	Cumulative Mileage
	7:30	*Breakfast at Cobscook Bay State Park* *44.840329, -67.150070*	1:00		
7	8:30	Cobscook Bay State Park	1:30		0.0
		Transit	0:30	18.7	
8	10:30	Quoddy Neck Bog 44.81241, -66.97710	1:00		18.7
		Transit	0:30	1.3	
9	11:30	Quoddy Head State Park, *with picnic lunch* 44.81598, -66.95227	2:00		20.0
	13:30	*Adjourn*			

OVERVIEW OF THE COASTAL MAINE VOLCANIC BELT

Myles Felch, Maine Mineral & Gem Museum

John Breedlove, Maine Department of Environmental Protection

The volcanic rocks comprising the Coastal Maine Volcanic Belt (CMVB) are exposed along the coast of Downeast Maine (Figure 1) and formed between approximately 430 and 415 million years ago during the Silurian Period, when the northern Appalachian Mountains were beginning to form. During that time the region occupied an active tectonic margin where ancient continents and volcanic island chains were converging. Volcanic eruptions produced thick sequences of lava flows, volcanic ash and debris, that accumulated in shallow marine and coastal environments. Geochemical studies indicate that the oldest volcanic rocks (Dennys, Edmunds, and Leighton Formations) formed above a subduction zone, whereas the younger volcanics (Eastport Formation) record a transition to a more extensional setting as continental collision progressed (Piñán-Llamas and Hepburn, 2013). The Quoddy formation represents the oldest volcanic succession, although its precise tectonic setting remains uncertain.

The Devonian Perry Formation, composed primarily of nonmarine red beds, conglomerates, and minor basalt flows, lies unconformably above the Eastport Formation. The Perry Formation records a transition from Silurian volcanism to Late Devonian continental sedimentation, while the associated basalt flows indicate that continental extension continued after the Acadian Orogeny.

Base and precious metal mineralization occurs within several of the older Silurian volcanics. For example, the Big Hill deposits in Pembroke have been interpreted as epigenetic mineralization, although a syngenetic volcanogenic massive sulfide (VMS) origin has also been proposed.

During the course of the weekend, we will visit Silurian volcanics representing much of the stratigraphic succession. On Saturday we will visit the younger sequences, followed by older units on Sunday.

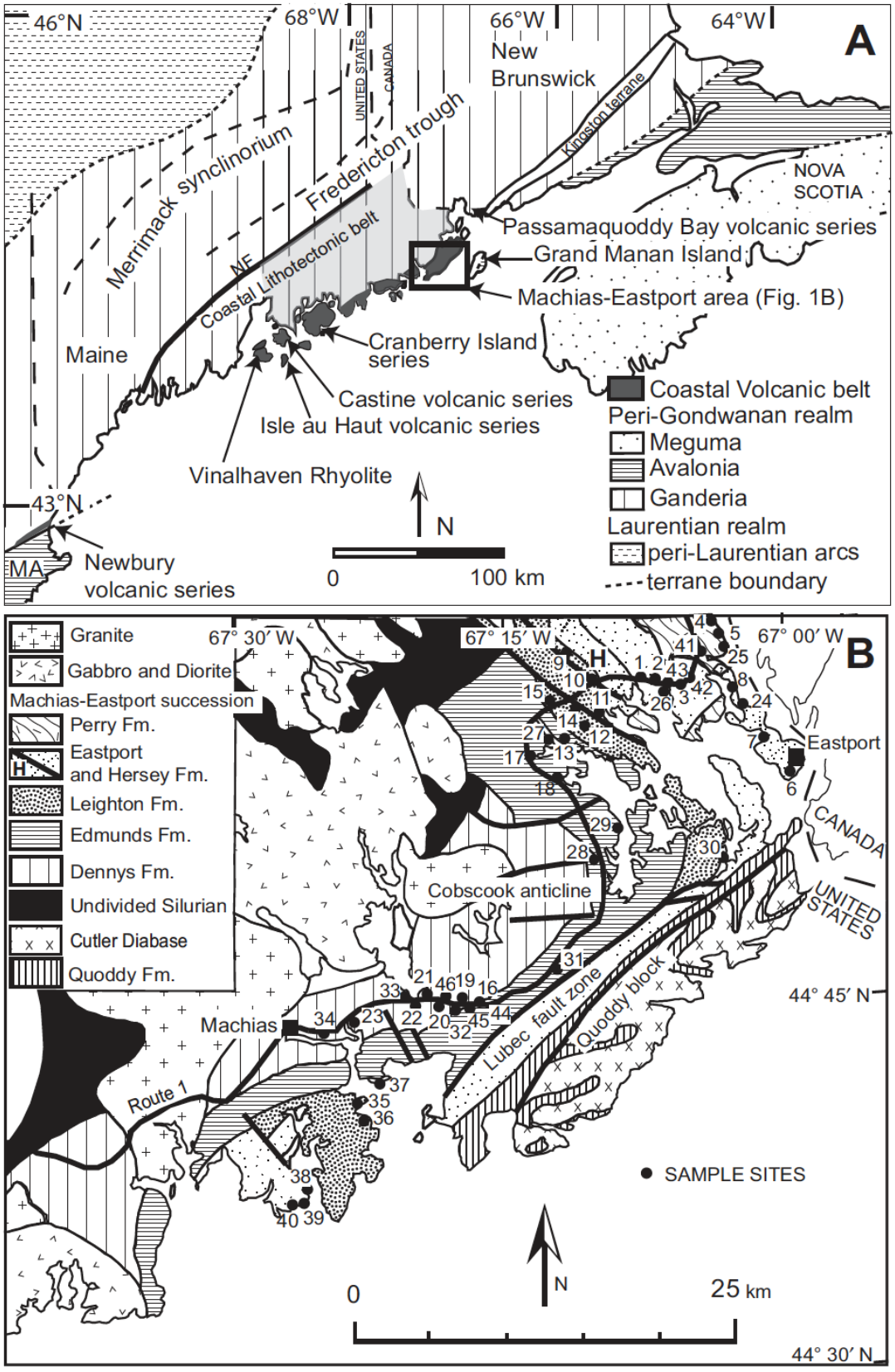


Figure 1. Location map of the Coastal Maine Volcanic Belt from Piñán-Llamas and Hepburn (2013)

STOPS AND DESCRIPTIONS

Saturday, July 25

Directions to Stop 1

0.0 Exit Cobscook Bay State Park via the main entrance.

1.3 After passing the gate house, take a left onto South Edmunds Road.

1.8 Turn right onto Route 1.

11.4 Turn left onto ME-214/Ayers Junction Road.

13.3 Turn right onto Cross Road.

13.4 Proceed a short distance beyond the intersection with ME-214 and look for parking on the side of the road. Be sure to pull completely off the road. We will assemble near the Cross Road/ME-214 stop sign before hiking approximately ½ mile to the stop.

Stop 1. Big Hill Zinc-Silver Prospect

44.96286, -67.20909

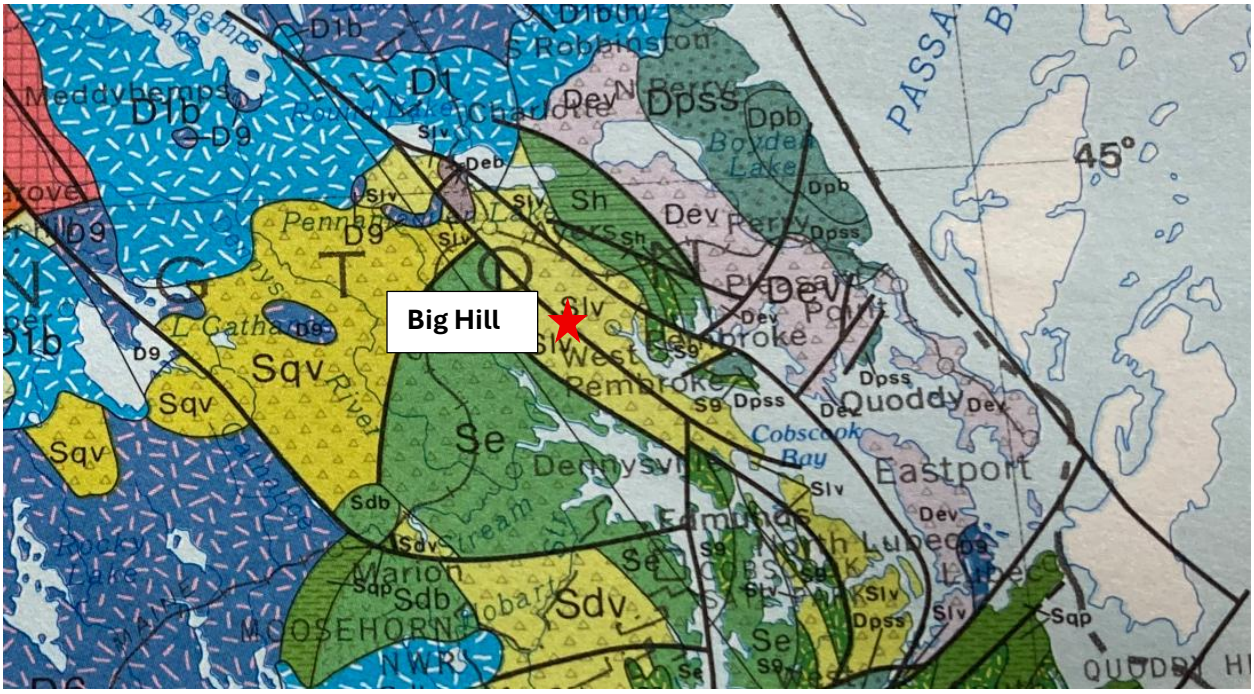
Stop Leader: John Breedlove, Maine Department of Environmental Protection

Big Hill, also known as Big Silver, was mined for zinc and lead in local pits in the mid-late 1800s and early 1900s. More modern exploration was conducted in the1960s by Dolsan Mining, in the late 1970s and early 1980s by Scintilore Exploration, in the early 2000s by Golden Hope Mining, and in the early 2020s by Wolfden, Ltd.

The prospect occurs within the Silurian-Devonian Coastal Volcanic Belt. Host rocks are part of the early Silurian Leighton Fm volcanics and compositionally range from mafic to intermediate to felsic volcanics. These rocks formed within an arc related tectonic environment during the convergence of the Avalonia terrane and the Laurentian craton in the early Silurian (Piñán-Llamas and Hepburn, 2013). Mineralization is fault and fracture controlled and occurs within felsic volcanics, volcaniclastics, and siliciclastic sediments. Locally, mineralization extends laterally into permeable horizons and structures.

We will walk into and stand on the old tailings pile of oxidized rock. Pyrite, sphalerite, galena, tetrahedrite, and chalcopyrite can be observed in the tailings.

****Bring hammer, safety glasses, and hand lens! Rocks are to be broken and studied.****



Geologic map showing the Big Hill zinc-silver prospect

Directions to Stop 2

13.4 Return to ME-214 and turn left.

15.3 Turn right just before the intersection with Route 1 to park in the parking lot for Coastal Subs.

Stop 2. Leighton Formation Outcrop

44.950241, -67.179779

Stop Leader: John Breedlove, Maine Department of Environmental Protection

These are Leighton formation volcaniclastic rocks and sediments. The poorly sorted tuffaceous breccia may be the result of a submarine avalanche that flowed onto the muddy bottom of the sea floor. The lower contact is a contorted mixture of shale and tuff-breccia mark the base. The tuff-breccia grades upwards into Hersey formation sediments to the east.



Leighton Formation sediments and volcaniclastic rocks



Leighton Formation tuffaceous rocks in contact with sediments

Directions to Stop 3

15.3 From Coastal Subs, head north on Route 1.

16.8 After crossing the bridge over the Pennamaquan River, look for a large parking lot in front of a barn on the right side of the road. From here we will backtrack west on Route 1 approximately ¼ mile to the outcrop.

Stop 3. Hersey Formation Outcrop

44.961804, -67.159484

Stop Leader: John Breedlove, Maine Department of Environmental Protection

These are Late Silurian Hersey Formation sediments mapped by Osberg (1985). Hersey Formation sediments lie above Leighton Formation volcanics and sediments. They consist of pelitic rocks that grade laterally and upward into later Eastport Formation volcanics. At this stop Hersey Formation sediments are intruded by an ophitic gabbro.



Hersey Formation outcrop just east of the Pennamaquan River

Directions to Stop 4

16.8 Proceed east on Route 1 for 2.2 miles.

19.0 Take a sharp right onto Burby Road. After approximately 0.5 miles, the road becomes dirt.

20.0 Burby Road ends in a loop. Keep right and park along the side of the road.

Stop 4. Hersey Formation Outcrop at Sipp Bay Preserve Lunch Stop

44.939314, -67.124802

Stop Leader: John Breedlove, Maine Department of Environmental Protection

Hersey Formation sediments at Sipp Bay consist of maroon siltstones and shales interbedded with sandstones and intruded by basalt sills. These were mapped as late Silurian by Gates (1987). Pelecypod, gastropod, and ostracod fossils indicate that these rocks were deposited in a shallow or brackish water environment.

Directions to Stop 5

20.0 Return to Route 1 via Burby Road.

21.0 Turn left to head west on Route 1.

24.6 Turn right onto ME-214/Ayers Junction Road.

34.5 At the stop sign, continue straight. ME-214 becomes ME-191/Main Street.

35.7 Turn right onto Green Hill Road (dirt).

36.7 After approximately 1 mile, keep right at the fork and park along the side of the road.



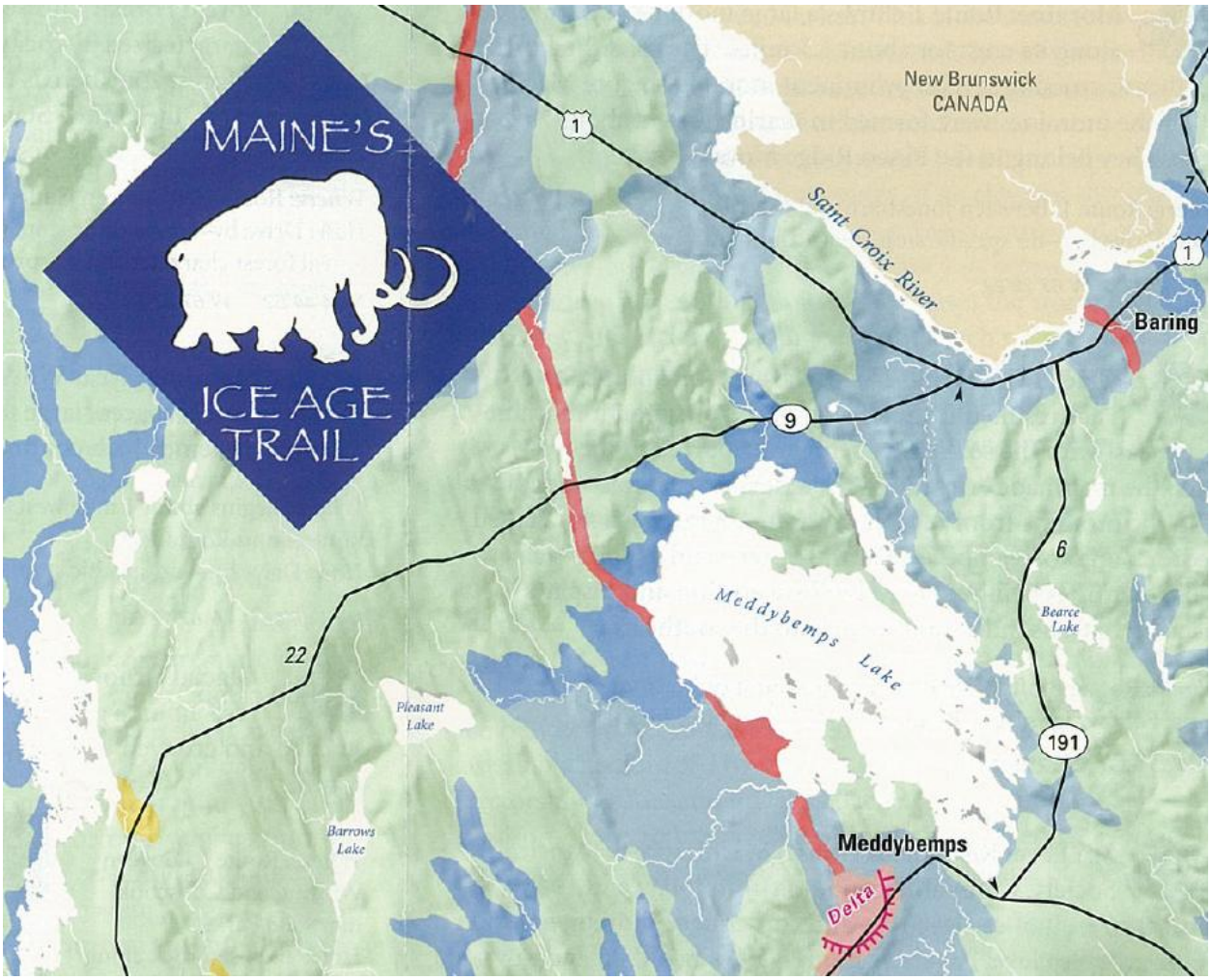
Hersey Formation sediments at Sipp Bay Preserve

Stop 5. Sand and Gravel Deposits in Meddybemps

45.035861, -67.383000

Stop Leader: Richard Campbell, Campbell Environmental Group

Remnants of the Laurentide Ice Sheet are present in sand and gravel deposits in Meddybemps Maine. This area is mapped as an esker which terminates in a delta deposit which was likely formed during the Pleistocene and Holocene. You will be able to view cross bedding and some unique bedding features in the various pits. Variations in grain sizes and sorting are displayed in each of the three pits. If still present, you may want to hypothesize on the methods of some of the sedimentary structures hopefully observable in some of the pits.



Inset from Maine's Ice Age Trail map (University of Maine, 2006). Red stripes represent eskers, light green is till, light blue is marine clay, and dark blue represents swamp, bog, or marsh sediments.

Directions to Stop 6

36.7 Return to ME-191/Main Street via Green Hill Road.

37.7 Turn left onto ME-191/Main Street.

38.0 Just before crossing the bridge, turn left. Enter the site through a gate in the chain link fence and park on the right side of the road.



Stratified esker delta deposits in Meddybemps gravel pits

Stop 6. N’Tolonapemk, Eastern Surplus Superfund Site, and Charlotte Smith Property

45.0385, -67.35836

Stop Leader: Richard Campbell, Campbell Environmental Group

N’Tolonapemk and Eastern Surplus Superfund Site

Location and general property description

The Eastern Surplus Superfund site, known as N’Tolonapemk (“my relative’s place”) to the Passamaquoddy Tribe, consists of approximately 4 acres located adjacent to Maine State Route 191, on the southern shore of Meddybemps Lake, in Meddybemps, Maine. The Charlotte Smith site and the Dennys River borders the property to the east-southeast.



N'Tolonapemk, Eastern Surplus, and the Charlotte Smith property. N'Tolonapemk and Eastern Surplus are in the left portion of the photograph and the former Charlotte Smith residence is at the lower right corner.

The Dennys River flows approximately 20 miles southeast from Meddybemps Lake to Cobscook Bay and constitutes vital habitat for a variety of species, including waterfowl, rare freshwater mussel species, nesting bald eagles, and Atlantic salmon. Numerous organizations have invested in conservation and management efforts associated with habitat on and adjacent to the Dennys River. This includes the preservation of thousands of acres and the involvement of organizations including but not limited to the Maine Department of Marine Resources, Natural Resources Council of Maine, Downeast Coastal Conservancy, Maine Atlantic Salmon Commission, Downeast Salmon Federation, and the Moosehorn National Wildlife Refuge. The Maine Department of Marine Resources manages the dam and fishway located at the outlet of Meddybemps Lake adjacent to N’Tolonapemk, which is in the process of being modified. Water levels are managed to support salmon habitat and are also important to the local Alewife population. The Dennys River constitutes one of eight rivers left in the United States supporting the endangered Atlantic salmon.

The species is federally protected and the Maine Atlantic Salmon Commission continues to work with federal agencies to restore and manage this important population. The Maine Atlantic Salmon Commission has assisted in the management of the dam to optimize downstream salmon habitat and provide sufficient passage for migratory smolts and adults.

Acquisition History

Most recently, N'Tolonapemk was included in a larger parcel of land owned and operated by the Eastern Surplus Company. Between 1946 and the early 1980s N'Tolonapemk was used as a storage and salvage yard, containing a variety of items including materials and equipment acquired from the U.S. Department of Defense. In 1984, the Maine Department of Environmental Protection (MEDEP) inspected N'Tolonapemk and identified significant environmental issues including strong chemical odors, heavily stained surface soils, and hundreds of miscellaneous drums and containers of stored and leaking chemicals. Emergency response actions were initiated, and by 1986, the United States Environmental Protection Agency (USEPA) had assumed a lead role in response and removal activities at N'Tolonapemk. Subsequent investigation identified significant impacts to soil and groundwater at N'Tolonapemk and in 1996, the property was formally included on the National Priorities List (federal Superfund program). In September 2000, the USEPA issued a Record of Decision (ROD) outlining further remedial requirements, land use restrictions, and long-term monitoring requirements at N'Tolonapemk. In October 2017, after additional sampling, USEPA deemed N'Tolonapemk safe for occupancy and recreational use.

In order to comply with a 1999 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Consent Decree, the owners of N'Tolonapemk transferred title of the land to the State of Maine. The State in 2021 transferred N'Tolonapemk back to the Passamaquoddy Tribe.

N'Tolonapemk has significant historic, cultural, and ecological importance to the tribal community and the primary goal is to preserve N'Tolonapemk for passive use and the cultural enrichment of future generations. This includes compliance with all required land use restrictions and long-term monitoring obligations, as well as cooperation with other interested parties.

Cultural and Historical Land Use

Native Americans have lived and camped at N'Tolonapemk for more than 10,000 years. It is centrally located within ancestral Passamaquoddy territory and was historically used as a vital hub connecting coastal regions in Passamaquoddy Bay to interior regions. N'Tolonapemk was an ideal setting to utilize the adjacent alewife spawning run as well as fishing for perch, sucker, and eels. It was also a perfect location for hunting large mammals and trapping beaver, muskrat, woodchuck, and turtles.

N'Tolonapemk is sacred Passamaquoddy land and represents the largest archeological site in the history of Washington County, Maine. Countless artifacts were destroyed during initial environmental remediation efforts, triggering the National Historic Preservation Act, which required mitigation of the adverse effects of clean-up activities at the property.

Consequently, the University of Maine at Farmington Archaeology Research Center, in collaboration with the Passamaquoddy Tribe, conducted data recovery excavation at N'Tolonapemk in 2000 and

2001. Over 220 square meters were excavated and a wide range of cultural materials were discovered. Thousands of artifacts were recovered from the site including stone tools, stone flakes, pottery, calcined animal bones, charred plant remains, and features providing evidence of hearths, house pits, and refuse pits.

In 2006, the USEPA worked with the Passamaquoddy tribe to construct a plaza featuring four commemorative plaques. The plaza incorporated a symbolic motif designed by a tribal member. Birch trees and fire-cracked rock from the 2000-2001 archaeological excavation were used to line the walkway leading up to the plaza. On November 4, 2012, the plaza was dedicated during an open house hosted by USEPA.

Between 2012 and 2014, a N'Tolonapemk exhibit was also on display at the Abbe Museum in Bar Harbor, Maine, and portions of the exhibit continue to be available online as a PDF, accessible through the museum's website (https://www.abbemuseum.org/blog/2017/2/7/ntolonapemk-our-relatives-place).



N'Tolonapemk archaeological site



Plaza at N'Tolonapemk

A variety of literature documenting the Tribes' rich history at N'Tolonapemk has also been produced, including;

- Donald Soctomah, 2005, *A Visit to Our Ancestors Place: Meddybemps-N'Tolonapemk Village*, Passamaquoddy Tribal Historic Preservation Office.
- Various Contributors, 2002, *N'Tolonapemk: An Ancient Native American Village on Meddybemps Lake, Maine*, Passamaquoddy Tribe and University of Maine at Farmington Archaeology Research Center.

The USEPA has listed N'Tolonapemk on the National Register of Historic Places, a list established as part of the National Historical Preservation Act of 1966 and overseen by the National Park Service.

Environmental Conditions

N'Tolonapemk's adverse environmental history reportedly began as a salvage yard in 1946. This land use resulted in a range of hazardous chemicals impacting soil and groundwater at N'Tolonapemk, prompting a response from state and federal authorities in the 1980s. MEDEP, USEPA, and the Department of Defense participated in initial response efforts including the inspection and removal of approximately 120 electrical transformers, 16,800 pounds of calcium carbide, 10 cubic yards of asbestos, 2,674 compressed gas cylinders, and miscellaneous chemicals including 312 fifty-five gallon drums, 24 thirty-gallon containers, 1,226 five-gallon cans, and 1,193 smaller containers. In addition to removal activities, regulatory agencies supervised the excavation and disposal of soils impacted by polychlorinated biphenyls and volatile organic compounds.

Site investigations identified two distinct contaminated groundwater plumes. The northern plume is situated in the northern half of the site north of Route 191. The southern plume started just north of Route 191, flowed beneath the highway, and migrated underneath the southern area of the Site. Most of the contamination in the northern plume was in the bedrock with dense non-aqueous phase liquid (DNAPL) possible, whereas the major contamination in the southern plume was in the overburden and shallow bedrock. Sampling of monitoring wells across (east of) the river from the northern plume showed sporadic and low levels (single digit parts per billion [ppb]) of tetrachloroethene (PCE), suggesting a possible bedrock pathway.

In the northern plume, sampling results indicated PCE was the major contaminant, both in terms of frequency of detection and maximum concentrations. PCE was detected in 20 of 22 locations during the site investigation with a maximum concentration of 6,700 ppb. Other volatile organic compounds (VOCs) detected above the performance standards in the northern plume included trichloroethene (TCE), cis-1,2-dichloroethene (cis-DCE), 1,1,2-trichloroethane, xylene, and methylene chloride. Much of the contamination was believed to be discharging to the Dennys River.

In the southern plume, sampling results were generally of lower concentrations than the northern plume. PCE was detected at a maximum concentration of 1,100 ppb. The southern plume was also believed to be discharging to the Dennys River.

As required by the 2000 USEPA ROD, groundwater wells were installed to allow for the extraction and treatment of impacted groundwater. In 2003 USEPA completed three in-ground applications of

permanganate to accelerate the groundwater cleanup. Long-term monitoring of groundwater and surface water continued.

Biota sampling was conducted in 1997 and in 2003. US Fish and Wildlife Service concluded that when compared to national, regional, and other Maine contaminant studies, highly elevated levels of metals or PCBs were not detected in the fish and mussel tissue from Meddybemps Lake or Dennys River. Comparison to the reference location did not suggest major site-related impacts to fish or mussels.

The southern extraction system was deactivated in November 2010 because the objective for that area had been attained for all site contaminants except PCE and the PCE concentrations have stabilized at its regulatory standard.

In 2012, per CERCLA, MEDEP became the lead agency for the site and continued the long-term monitoring. USEPA, in consultation with MEDEP, as further source control efforts, conducted first a bench-scale study and then a pilot-scale study of enhanced in-situ bioremediation (EISB). This was initiated because the effectiveness of the pump and treat system had decreased and the application of permanganate had shown only temporary decreases in PCE concentrations. Based on applications at other sites, EISB offered extended residence time for the injection material and, therefore, could improve the degradation of the residual VOCs present in the bedrock fractures and rock matrix.

The pilot-scale post-injection sampling events, November 2012 and June 2013, demonstrated a strong response to the EISB injections. Exceedances of TCE, cis-DCE, and vinyl chloride were detected either in the four injection wells or in nearby wells, while the below-exceedance detections were farther from the injection wells, indicating that reductive degradation was progressing further in the pilot study area than in the rest of the plume.

In 2017, USEPA issued a decision document that formally changed the clean-up approach from pump and treat to EISB. Additional bedrock wells were drilled and packer tests conducted to determine optimal injection zones. The full-scale EISB design was completed in 2018 and two additional injection events were performed.

Environmental monitoring activities at N'Tolonapemk remain ongoing. However, with the exception of established land use restrictions, N'Tolonapemk has been deemed safe for reuse and occupancy with the provision against groundwater use. Recent sampling of sediments and surface water from the Dennys River also indicates contaminants of concern are continuing to decrease and do not pose an unacceptable risk to human health or ecological receptors.

Charlotte Smith Property

The Charlotte Smith property is east and south of the Eastern Surplus (Harry Smith) Superfund site across the Dennys River. The geology of the site consists of till and silty soil characterized as the Presumpscot Formation which has low permeability and poor drainage. The underlying bedrock is Devonian-age Meddybemps granite. The surficial tills at the site are relatively thin, and the relatively low relief of the area keeps the water table close to the surface. The groundwater flow is west-southwest of the site. Boring logs from monitoring wells drilled in October 2004 indicated

approximately 20 feet of fill or silt existed over till until bedrock was encountered between 22 and 28 feet below grade.

In 2000 a USEPA contractor working at the Eastern Surplus Site reported that there were drums of chemicals located in the basement of the Charlotte Smith residence. In January 2002, the USEPA was granted permission to enter the basement of Charlotte Smith's residence accompanied by Harry Smith. USEPA personnel noted drums and containers of liquid chemicals. Some contents from labels were noted as petroleum products, fungicides, ketone, and perchloroethylene (PCE). USEPA did not pursue removal of the chemicals at the time. However, in 2002 when Maine Department of Environmental Protection (MEDEP) requested permission to access and remove the chemicals, they were denied permission by both Harry and Dawn Smith. On June 3, 2004, MEDEP obtained a search warrant allowing access to the Charlotte Smith property. On June 8, 2004, MEDEP conducted an initial inventory of the site. During the search MEDEP identified hazardous waste in the basement, in the barn/garage, and on the grounds of the site. The waste materials and their containers were found to be in generally poor condition, some of the containers having discharged their contents. According to the MEDEP, more than 200 5-gallon containers of solvents, including PCE, were removed from the basement of the home. USEPA conducted a preliminary assessment of the site and collected 11 samples from concrete dust, soil gas and subsurface soil analysis of VOCs. Most of the samples were collected from the house basement.



Charlotte Smith property prior to demolition

The results of the soil sampling indicated the presence of cis-DCE, TCE, and PCE. The highest cis-1,2-DCE concentration was 340 parts per billion by volume (ppb/v). The highest TCE concentration was 1,940 ppb/v and the highest PCE concentration was 642,000 ppb/v. The results of air sampling indicated the presence of PCE at a highest concentration of 10,700 ppb/v. Cis-1,2-DCE and TCE were not detected in the Summa canister analytical testing. Field screening of the concrete dust samples indicated the presence of PCE. The highest concentration was 110,500 micrograms per kilogram (ug/kg). PCE was detected in all of the soil samples with the highest concentration being 2,300,000 ug/kg. Sampling of site soils had previously shown isolated areas with VOC, polycyclic aromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCB) contamination. Groundwater sampling showed minimal impact from historical site practices.

Demolition of the residence and barn occurred during the last two weeks of December 2021. Prior to demolition, 40.78 tons of solid wastes, including typical household items, clothes, books, tools, an old freezer, clean and PCB-free transformer casings, generators, shelving, former empty tanks, perforated gas cylinders, perforated fire extinguishers, and metal equipment remnants from the former dam and hydroelectric plant were removed and disposed. Several mercury thermostats were removed prior to demolition. A large number of car and truck tires were also disposed of at the Marion Transfer Station.



Demolition in progress at the Charlotte Smith property



Excavation to remove contaminated soil

During the final week of December 2021 and the first week of January 2022, the concrete floor of the residence and two feet of soil located below the concrete floor were removed for off-site disposal as hazardous waste. A total of 149. 84 tons of soil and concrete hazardous waste were removed. Starting on January 6, following the removal of soil and concrete as well as subsequent confirmation sampling, the southern concrete wall of the basement was broken into pieces and knocked into the base of the excavation. Clean fill was then placed onto the broken concrete and filled to the surface level, leaving the north, east, and western concrete walls in place below surface grade. The soil was compacted using the excavator.

On January 4 through January 6, 2022, soil at the base of the concrete was sampled using MEDEP protocols for headspace analysis. Twenty-four samples were collected at depths that ranged from 0.25 to 2 feet below grade. The samples were heated in a vehicle and the soil temperature was measured at the time of analysis. VOC concentrations were relatively low. Five soil samples and one duplicate sample were collected from below the basement foundation following the soil removal. Since one sample had a PCE concentration of 14 milligrams per kilogram (mg/kg), which exceeded the MEDEP cleanup criteria of 1 mg/kg, MEDEP elected to authorize the removal of the clean fill and excavate additional soil from below the broken concrete layer.

In March, 28 tons of additional soil were removed from the south, west, and central portions of native soil located below the broken concrete surface. Soil that was originally two feet south of the foundation was also removed. Following the soil removal, additional samples were collected at depths that ranged from 0 to 0.5 feet below the new grade. The analytical results for these samples exceeded the MEDEP cleanup criteria 1 mg/kg for PCE. The concentration in the highest sample was 1.3 mg/kg. Therefore, an additional 28.5 tons of soil was removed on March 18, 2022. Two additional soil samples were collected from the subsequent excavated area and analyzed for VOCs. The results for these samples were below the MEDEP cleanup criteria. Once analytical results were confirmed, the excavation was again filled using clean fill that was previously removed. Concrete from the formerly vertical south and western walls was also used as fill. Additional clean fill was added to compensate for the 56.5 tons of soil that was disposed of off-site. The depth of excavation reached approximately 14 feet below original grade.

Characterization of soil for PCBs was completed using a 10-foot grid surrounding the PCB-impacted area previously identified by MEDEP. Approximately 117 characterization samples were collected to establish the lateral and vertical extent of PCB-impacted soils with concentrations greater than 1 milligram per kilogram (mg/kg). Following the characterization, remediation by excavation of the PCB-impacted soil commenced. PCB impacted soil was excavated and disposed off-site. Immediately following the excavation, confirmation cleanup soil samples were collected on a 1.5-meter grid so that the soils would not freeze prior to collection. Approximately one foot of soil was removed in areas where the PCB concentrations were greater than 1 mg/kg. Excavation exceeded 1-foot thick in many areas due to the depth of frost at the time of excavation. The perimeter of the excavated area was estimated at 7,940 square feet. Excavation and disposal of PCB-impacted soil ended when the area was within the occupancy cleanup goal of 1 mg/kg. A total of 566.21 tons of soil classified as PCB Remediation Waste were transported to the licensed Crossroads and Juniper Ridge waste disposal facilities.

Directions to Cobscook Bay State Park Campground

38.0 Turn left onto ME-191/Main Street.

39.0 At the fork, keep right to continue on ME-214/Ayers Junction Road toward Pembroke.

49.0 Turn right on Route 1.

58.6 Turn left on South Edmunds Road.

59.1 Turn right onto Park Road to enter Cobscook Bay State Park. Follow signs for the campground and group sites.

60.3 Park in designated parking space at one of the two group sites.

STOPS AND DESCRIPTIONS

Sunday, July 26

Directions to Stop 7

0.0 If you stayed in the campground last night, just congregate wherever people are congregating. Otherwise, you're on your own for this one.

Stop 7. Cobscook Bay State Park

44.840329, -67.150070

Stop Leader: Myles Felch, Maine Mineral & Gem Museum

The Silurian (Ludlow) age Edmunds formation consists of mafic, intermediate, and felsic volcanic rocks interbedded with shales (fossiliferous) and siltstones. This sequence is interpreted to have formed in a continental-arc setting above a NW subducting Avalonian microcontinent that was converging with the composite Laurentian margin (Piñán-Llamas and Hepburn, 2013).

The sequence of rocks in this formation records a volcanic landscape that was partly submerged beneath the sea. Explosive eruptions produced volcanic ash, breccias, and debris flows that accumulated alongside marine sediment in the marine basin.

At Cobscook Bay State Park we will view examples of rhyolitic tuffs on the shores of Whiting Bay. For a complete overview of the rock types exposed at Cobscook Bay State Park, please see the Johnson (2000) Geologic Fact Locality guide published by the Maine Geological Survey.

****Please do not deface rocks at this location as this is within a Maine state park property. This is a hammer-free zone.****

Directions to Stop 8

0.0 Exit Cobscook Bay State Park via the main entrance.

1.3 After passing the gate house, take a left onto South Edmunds Road.

1.8 Turn left onto Route 1.

6.0 Shortly after the Whiting Store, take a left on ME-189/Lubec Road.

15.0 Just before the Shell gas station, turn right on Maple Tree Road.

16.6 Turn right onto South Lubec Road at the T.

18.7 Park in the gravel lot (or grass) on the left side of the road. From here we will walk west up the beach to the peat exposure.

Stop 8. Quoddy Neck Bog

44.30016, -69.82246

Stop Leader: Andrew Reeve, University of Maine

Quoddy Neck Bog

South Lubec Road passes through the Quoddy Neck Bog, a Plateau Bogs, that is being eroded by rising sea level. Peat is exposed along an eroding bluff north of the road. Most of the peat exposure has been covered with rip rap to slow erosion and protect the road, however, some peat is still exposed along the east edge of the rip rap (Figure 8.1). Images of the now covered surface can be seen in the Maine Ice Age Trail map (University of Maine, 2006). At this exposure, sediments shift from marine clay, to sedge and woody fen peat, and then to moss dominated bog peat. This exposure provides information of the recent (past 13,000 years) environmental history of Maine. Radiocarbon dates suggest basal peat began accumulation approximately 11,400 years ago and radiocarbon dates of marine fossils in the Presumpscot Formation indicate the underlying silt clay was deposited approximately 15,000 years ago (University of Maine, 2006). In the West Quoddy Bog, located approximately 1.5 km to the east, peat deposits began accumulating about 8000 years ago with the underlying Presumpscot Formation deposited directly over bedrock.

Background Information

<u>Peatland Classification</u>

Peatlands are generally classified as fens or bogs, and these different peatland types often coexist within a peat basin. Peatland classification is typically based on vegetation characteristics wherein the vegetation is controlled by water chemistry and depth to the water table. Bogs are typically peat domes containing near-surface waters that are nutrient-poor, acidic (pH less than 4.2), and have low concentrations of inorganic solutes (e.g., Ca less than 2 mg/kg). Bogs generally have a low species diversity dominated by *Sphagnum* mosses. Fens have a flat or slightly dipping surface with waters characterized by higher pH (greater than 4.2) and greater concentrations of inorganic solutes than found in bogs. Fens typically contain a greater plant diversity than bogs. These differences suggest that bogs are isolated from surface water and groundwater inputs, with nutrients supplied from the atmosphere and precipitation. Bogs in a thin zone near the coast of Washington County, Maine contain flat central plateaus instead of a domed surface that is typical of inland peat bogs. Damman (1977) suggested that this difference in topography is due to differences in snowpack thickness or summer wetness (more fog, lower summer temperatures).

<u>Paleoenvironmental Interpretation from Maine Bogs</u>

More detailed analysis of peat cores have been completed in Caribou Bog (between Orono and Bangor, Maine), documents the shift from lake (12,500 to 8500 years ago) to sedges fen (8000 years ago) (Hu and Davis, 1995). The shift from a terrestrial to fen environments occurred within 500 years. The sedge fen evolved into a wooded fen (7000 years ago), and then finally to a *Sphagnum* bog (5500 years ago). Interpretation of cores from Caribou Bog suggest 1) increased plant productivity approximately 10,400 years ago, perhaps due to warming, and 2) a drop in water table



Figure 8.1. Peat exposure along the northern edge of Quoddy Neck Bog

position approximately 8000 years ago due to dryer conditions. Early workers suggested water in peatlands was supplied through capillary action 'wicking' water up through the peat to the peat surface. Ingram (1983) demonstrated that capillary action could not be responsible for the supply of water to pools observed within peatlands and suggested that water within and at the surface of peatlands was controlled by a balance between precipitation into and drainage out of the peat. The dry peat face observed at this exposure supports this model, where the hydraulic properties of peat allow groundwater mounds to form under favorable climatic conditions.

Peatlands and the Carbon Cycle

Northern peatlands cover only a small portion of the Earth's surface but store 500 (±100) GtC of carbon, representing about a third of the global soil carbon pool and two-thirds of all the carbon stored in the atmosphere (Gorham, 1991; Yu, 2012; IPCC, 2013). Peat and lake sediment deposits are the largest carbon pool in previously glaciated northern temperate regions, accounting for over 80% of the fixed carbon pool across the Highlands Lake Region (Wisconsin and Michigan) despite covering only 20% and 13% of the land area (Buffam et al., 2011). Peatlands also influence local and global carbon cycles by emitting carbon gasses (methane and carbon dioxide) and contributing to particulate and dissolved organic carbon in aquatic systems. Atmospheric methane concentrations, in particular, are strongly influenced by natural and artificial wetlands with

northern peatlands accounting for about 12% of the global atmospheric methane flux (Wuebbles and Hayhoe, 2002).

Peatlands as a Resource

Cameron et al. (1984) estimated 6000 to 8000 peat deposits occur within Maine covering 500,000 to 750,000 acres (Figure 8.2). They investigated 48 economical peat deposits in Washington county covering 15,000 acres and estimated they contained 32 million air-dried tons of peat. Peat deposits are a 'mineral' resource that has been used as a fuel throughout history and have more recently been used for horticultural purposes (e.g. soil and compost additive). In 2024, 350,000 metric tons of peat were produced in the USA, with Maine among the top three peat-producing states (Brioche, 2025). Worcester Peat currently operates in Washington County and annually extracts 200,000 to 300,000 cubic yards of peat from an 860-acre peatland (Worcester Peat, undated).

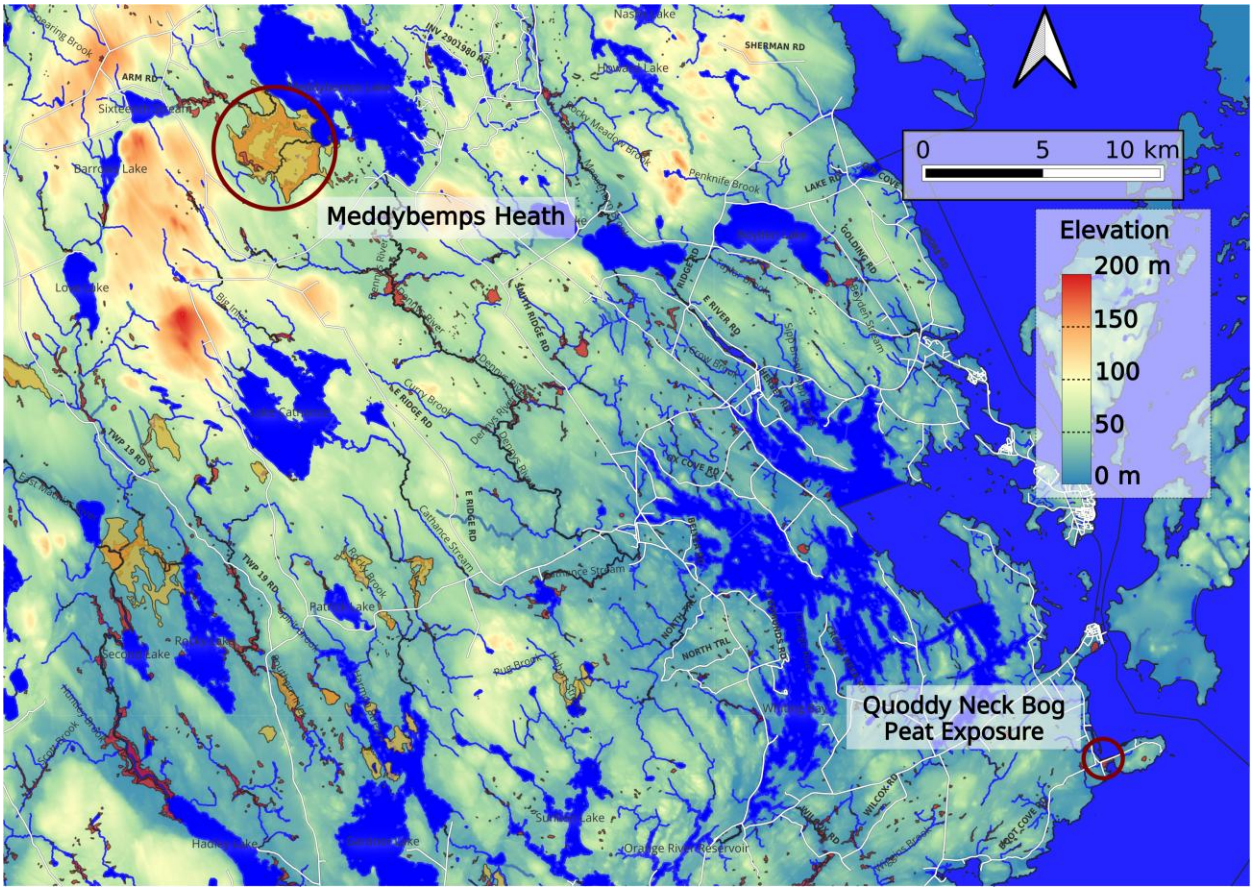


Figure 8.2. Peatland deposits in the southeastern portion of Washington Country, Maine. Peatlands identified by Cameron et al. (1984; Maine Geological Survey, 2019) are indicated by orange shaded polygons. Red polygons identify saturated or seasonally saturated palustrine shrub-scrub wetland types (U.S. Fish and Wildlife Service, 2004) that also overlap with peatlands identified by Cameron et al. (1984) and may indicate where smaller peat deposits occur.

Directions to Stop 9

18.7 Continue east on South Lubec Road.

20.0 Keep left after the road turns to dirt. Park in the parking lot at the end of the road.

Stop 9. Quoddy Head State Park
Lunch Stop

44.81598, -66.95227

Stop Leader: Myles Felch, Maine Mineral & Gem Museum

The Quoddy formation is sequence of magmatic (basaltic and gabbroic) and sedimentary (argillites and shales) rocks that are believed to contain some of the earliest volcanic rocks in the region of Silurian (Late Llandovery) age. The formation appears to be highly intruded by the Cutler Diabase and together these comprise a fault block referred to as the "Quoddy block", which is situated to the southeast of a major structural feature, the Lubec Fault (Piñán-Llamas and Hepburn, 2013). The relation of the Quoddy block with other CMVB rock to the west of the Lubec Fault remains unclear.

The Quoddy Shale Type Section (site 48 of White and Hussey, 1989) is located along the northern coastline of Quoddy Head where reportedly sedimentary (siltstones, shales, sandstones) rocks, at times fossiliferous, are exposed.

We will visit the location of site 43 of White and Hussey (1989) (Figure 9.1) at the West Quoddy lighthouse in Quoddy Head State Park. Exposures of gabbros and diabase intrude the Quoddy shale.

****Please do not deface rocks at this location as this is within a Maine state park property. This is a hammer-free zone.****

Following this stop, the field trip will adjourn. Feel free to use the remainder of the afternoon to explore the hiking trails and shoreline of Quoddy Head State Park, pop over to Lubec and Campobello Island, or take the scenic route home via the Cutler Coast and Route 1.

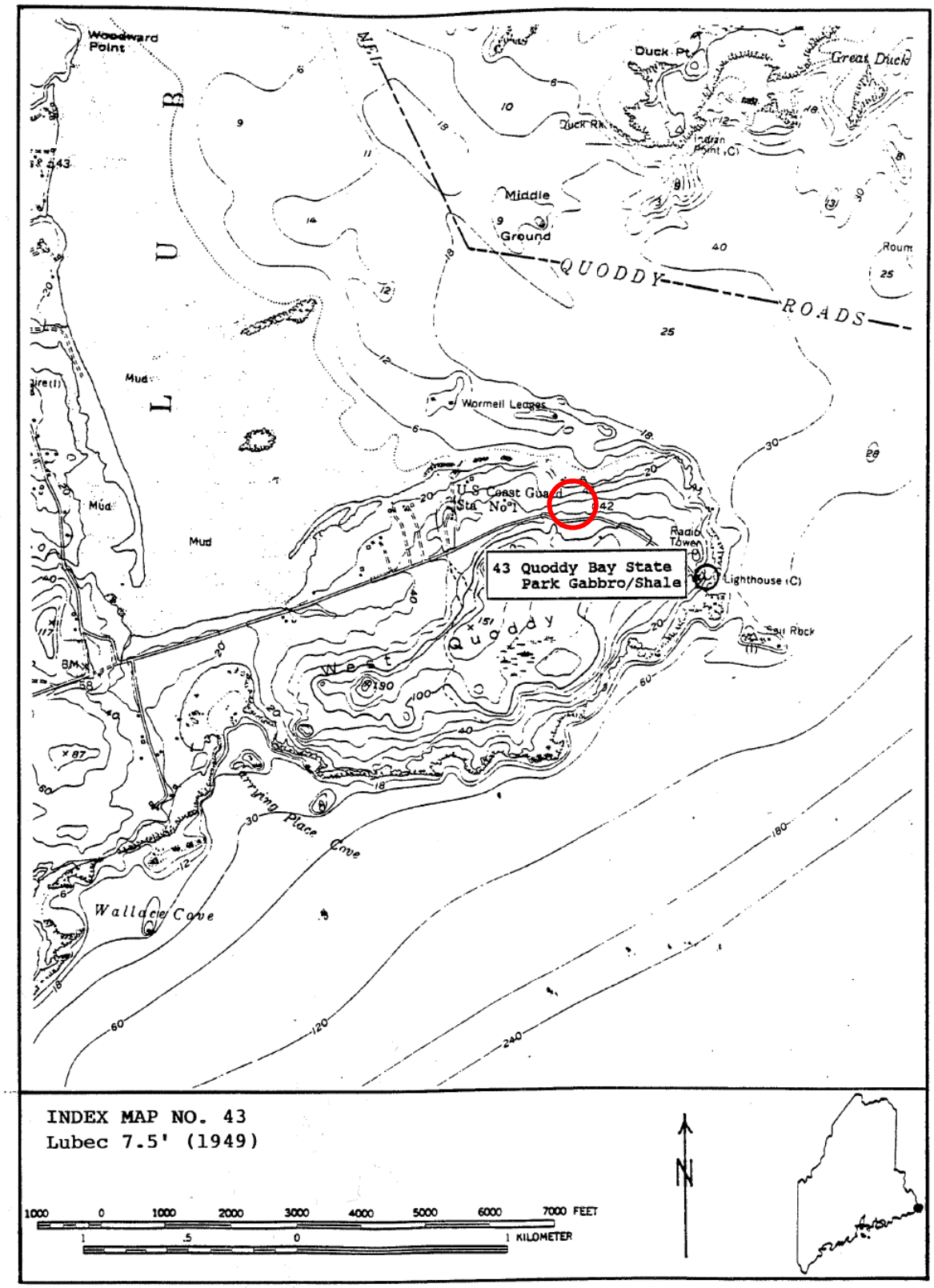


Figure 9.1. Location of bedrock stop at Quoddy Head State Park. Red circle marks the location of "site 48" of White and Hussey (1989). We will not visit this location on the trip. Image from White and Hussey (1989).

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