



# Maine Commodity Flow Study of Hazardous Materials

Final Report



## Maine Commodity Flow Study of Hazardous Materials

IEM is a global security consulting firm dedicated to building a safe, secure, and resilient world. A minority, woman-owned enterprise, IEM works with government agencies and private sector organizations around the world to improve protection and security for lives and infrastructure and to help states, regions, and communities prepare for and recover more quickly from disasters. We integrate science, technology, and real-world experience to provide each of our customers with solutions that work and outcomes that matter. IEM's publications do not necessarily reflect the opinions of its research clients and sponsors.

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## Executive Summary

The Maine Emergency Management Agency (MEMA) contracted IEM to conduct a statewide Commodity Flow Study of Hazardous Materials. The purpose of the study was to provide a comprehensive view of hazardous materials (HazMats) to help local, regional, state, and Federal authorities understand the volume and nature of the movement of HazMats into, out of, and through the State of Maine. Table 1 lists 17 priority study commodities with total annual volumes by mode.

**Table 1: Priority Hazardous Materials Annual Volumes (in Pounds) by Mode**

Hazardous Materials	Truck (× 1,000)	Rail (× 1,000)	Ship (× 1000)	Pipeline (× 1 million)
Anhydrous Ammonia	76	7,340		
Chlorine	55	9,360		
Crude oil		988,934,000		19,016
Compressed Natural Gas	170,553			
Ethanol	687,653		858,039	
Formaldehyde	5,033			
Hydrochloric Acid	39,628	141,270		
Hydrofluoric Acid	255			
Hydrogen Peroxide	22,535	28,800		
Methanol	12,419			
Nitric Acid	4,459			
Nitrogen, Liquid	40,898			
Potassium Cyanide	38			
Sodium Cyanide	3,513			
Sodium Hydroxide	270,583	41,862	133,796	
Sodium Chlorate	1,566	118,005		
Sulfuric Acid	218,615	151,020		

## Findings

The Maine Turnpike is the main artery for freight transport in Maine, including HazMats. Many of the commodities in Maine are transported by motor carrier, but the higher volumes are transported by pipeline, barge, and rail. There are no Class I railroads in Maine, but the study included annual volumes of priority HazMats transported by short-line railroad. Three of the eight short-line railroads participated in the study.

## *Hazardous Materials Transport*

- Crude oil is the highest volume HazMat transported in Maine from South Portland to Montreal by pipeline and to the oil refinery in St. John, New Brunswick, by rail, for a total of 1.8 trillion pounds.
- Ethanol is the second highest volume HazMat transported to Maine by barge and throughout Maine by truck for blending and transport to retail gas stations for a total of 1.6 billion pounds.
- Sodium hydroxide is the third highest volume HazMat transported in Maine by rail, motor carrier, and barge for a total of 446 million pounds.

IEM used half-mile corridors around priority HazMat routes by mode to determine affected overall population, sensitive populations, critical infrastructure, and sensitive environmental receptors. The following findings summarize these results within each hazard corridor by county.

## *Population*

- Cumberland County has the highest population within the half-mile hazard corridors at 86,661 people, followed by Penobscot County at 60,420 people and Androscoggin County at 48,415 people.
- Piscataquis County has the lowest population within the half-mile hazard corridors at 3,341 people, followed by Lincoln County at 4,955 people and Washington County at 6,391.

## *Sensitive Population Receptors*

Sensitive populations include correctional facilities, employers with more than 250 employees, fire and emergency medical services, hospitals, nursing homes, public and private schools, police stations, and public gathering places with more than 250 person capacity.

- Cumberland County has the highest number of sensitive population receptors within the half-mile hazard corridors at 300, followed by Penobscot County at 174 and York County at 159.
- Piscataquis County has the lowest number of sensitive population receptors at 9, followed by Washington County at 35 and Sagadahoc County at 41.

## *Critical Infrastructure*

- Penobscot County has the highest number of critical facilities at 57, followed by Cumberland County at 53 and Kennebec County at 45.
- Piscataquis County has the lowest number of critical facilities at 10, followed by Sagadahoc County at 14, and Knox County at 16.

## *Sensitive Environmental Receptors*

- **Aquaculture sites** within the half-mile hazard corridors are limited to Cumberland (1), Lincoln (3), Washington (1) and York (2) Counties.
- **Aquifers**: Oxford County has the highest number of aquifers within the half-mile hazard corridors at 236, followed by Penobscot County at 162 and Franklin County at 159.
- **Water intakes**: Public drinking water sites within the half-mile hazard corridors include wells, surface intakes, and reservoirs. Androscoggin County has 51 public water sites, followed by Washington County at 47 sites and Kennebec County at 46 sites.
- **Wildlife habitat**: Penobscot County has by far the largest wildlife habitat area within the half-mile hazard corridors at 18,903 acres, followed by Washington County at 8,805 acres and Somerset County at 5,311 acres.
- **Agriculture areas**: Aroostook County has the most agricultural area within the half-mile hazard corridors at 22,250 acres, followed by Kennebec County at 13,587 acres and Somerset County at 10,797 acres.
- **Wetlands**: Waldo County has the most wetlands area within the half-mile hazard corridors at 23,981 acres, followed by Somerset County at 22,313 acres and Knox County at 20,559.

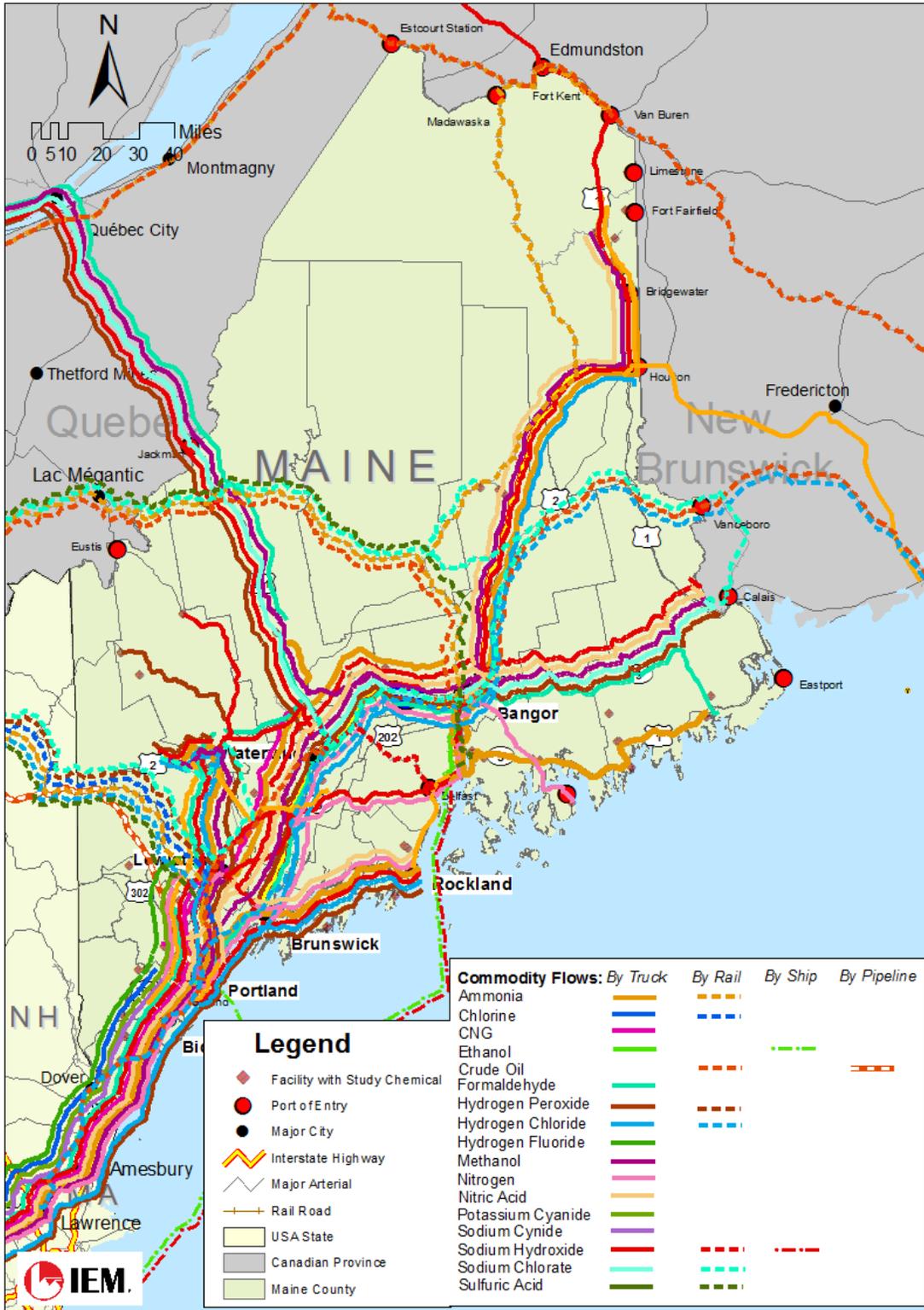
## Recommendations

IEM synthesized the results of the study to recommend strategies for improving HazMat preparedness as follows:

- Emergency managers and local emergency planning committees (LEPCs) should work closely with HazMat facility managers to become familiar with how chemicals are transported in their counties. Particular attention should be paid to toxic inhalation hazards like ammonia and chlorine.
- Local fire departments should tour HazMat chemical facilities at least annually to become familiar with plant operations and protocols.
- The evacuation versus shelter-in-place decision-making process should be fully documented in the concept of operations section of each county's HazMat annex.
- Local and regional responders need to enhance relationships with the major handlers of HazMats in their jurisdictions. HazMat facilities should be included in planning, training, and exercise opportunities.
- Local hospitals and healthcare facilities must be included in planning, training, and exercise activities.
- Urban area LEPCs should consider conducting HazMat risk assessments.

Map 1 illustrates the extent to which the 17 priority HazMats are transported into and out of Maine by motor carrier, rail, pipeline, and barge.

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Map 1: Composite Priority Hazardous Materials

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## Introduction

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The Maine Emergency Management Agency (MEMA) contracted IEM to conduct a statewide Commodity Flow Study of Hazardous Materials. The purpose of the study was to provide a comprehensive view of hazardous materials (HazMats) to help local, regional, state, and Federal authorities understand the volume and nature of the movement of HazMats into, out of, and through the State of Maine. This study updates previous studies conducted by the Greater Portland Council of Governments between 2002 and 2008.

## Steering Committee

The study was guided by a steering committee comprising representatives from various state agencies and industry (Table 2).

**Table 2: Maine Hazardous Materials Study Steering Committee**

Member	Affiliation
Robert Gardner	Maine Emergency Management Agency
Faith Meyer	Maine Emergency Management Agency
Jon Burbank	Maine Emergency Management Agency
Mark Hyland	Maine Emergency Management Agency
Peter Blanchard	Maine Department of Environmental Protection—Response
Skip Pratt	Sappi Fine Paper
Dwight Doughty	Maine Department of Transportation
Shawn Currie	Maine State Police

## Methodology

IEM used a mixed-method study methodology to identify the best available data sources and collect quantitative and qualitative data to support generating evidence-driven facts, findings, and recommendations to meet the scope of the study. These serve as the catalyst for action by all stakeholders and facilitate improvements in chemical emergency policy, planning, hazard mitigation, prevention, and response.

Quantitative data included existing regulatory data sets, digital geographic data, and chemical storage and transportation data from chemical companies and carriers. Qualitative data was collected from the members of the steering committee, chemical storage facilities, carriers, and other stakeholders, including Maine’s Department of Environmental Protection, Department of Transportation, and Department of Labor and Transport Canada.

Qualitative data collection began with a kickoff meeting with the steering committee on December 15, 2014. IEM coordinated every aspect of this study with Robert Gardner, Technical Hazards Coordinator with MEMA. The primary source of information on

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commodity flows was Tier II data from CAMEO. MEMA staff provided this information to IEM in December 2014.

MEMA drafted a letter of support to use with industry and carrier outreach in which MEMA described study goals and objectives. This letter was used throughout the study process to obtain additional data.

In January 2015, IEM developed the Maine HazMat Facilities Map (see Map 1) and a study summary to send to rail carriers and other stakeholders for data collection. IEM and MEMA also prepared letters to eight rail carriers, three of whom agreed to provide data for the study:

- New Brunswick & Maine Railways (NBM) (consisting of New Brunswick Southern Railway, Eastern Maine Railway, and Maine Northern Railway)
- Central Maine & Québec Railway (CMQ)
- Genesee and Wyoming Inc. (G&W)

HazMat import data for this study were obtained by U.S. Customs and Border Patrol. This information is included in the total volumes for each chemical on the commodity flow maps in this document (Map 3 through Map 19). Export data were not available despite repeated attempts to contact Transport Canada, the Canada Border Services Agency, and Statistics Canada.

To obtain large-employer data (i.e., data for employers with 250 employees or more), IEM signed a nondisclosure agreement with the Maine Department of Labor. This information is displayed using point locations on county and urban profile maps (Appendix B and Appendix C).

Once information on companies that transport or store the 17 HazMats identified as priority in the state was obtained, IEM used Tier II information submitted by industry to determine shipments by mode, volume, frequency, and route. In most cases, IEM was able to obtain route information within the state but not necessarily origin or destination. Where the data was unclear or incomplete, IEM contacted facilities and carriers directly.

Transportation corridors—highways, railroads, pipelines, port facilities, waterways, and sea lanes—for each priority HazMat were then determined and plotted on maps, which also identified the known annual volume of each HazMat along each corridor. The 17 individual commodity flow maps were then combined into one statewide composite flow map (Map 20) identifying all HazMat corridors. One-half mile buffer zones were plotted along each corridor to help identify hazard receptors (i.e., the population at large, sensitive populations, critical infrastructure, and sensitive environmental receptors) located in proximity to each corridor. Simultaneously, IEM researched data to support the hazard receptor identification process.

### *Hazard versus Risk*

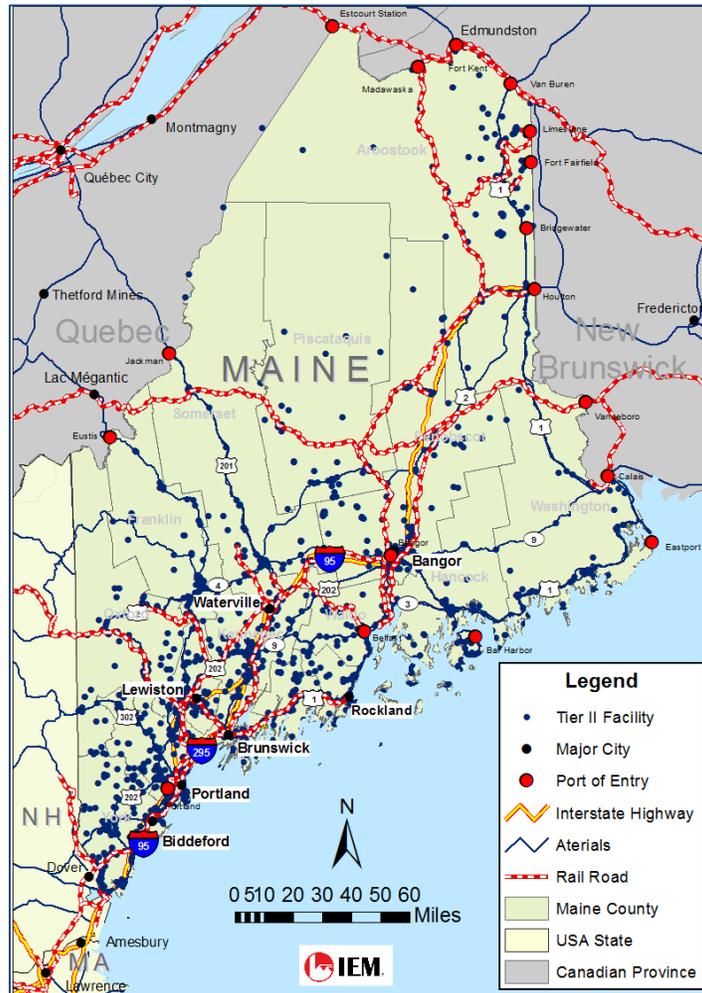
This report identifies chemical hazards, not risks, because chemical release data were not obtained to calculate probability. Risk can be determined when information is available about the consequences of a hazard harming a receptor and the probability that it will occur. Risk is also dependent on the proximity between a hazard and any receptor.

A hazard with no receptors presents no risk. However, a hazard with many receptors presents considerable risk. In a future study, it may be possible to obtain historical chemical release data to determine chemical release probability. Then the consequence of a hazard

harming a receptor can be determined using the isolation protection zone (IPZ) of a particular chemical. Examples of this type of risk assessment include HazMat risk assessments conducted in three North Carolina counties in 2014.<sup>1</sup>

## Hazardous Materials Facilities

The basis for determining commodity flows of HazMats was identification of facilities that store or transport HazMats. Most of these facilities are located on rivers for the sake of transportation, and all are connected by short-line railroads. Map 2 shows all of Maine's Tier II facilities, all of which store or transport the 17 priority HazMats investigated for this study.



**Map 2: Maine Tier II Hazardous Materials Facilities**

<sup>1</sup> The North Carolina HazMat Risk Assessment is being conducted for 15 urban areas over 5 years between 2014 and 2018. To date, risk assessments have been completed for three counties in eastern North Carolina.

## Data Sources

Principally, chemical information for this study was obtained from 2014 Tier II data submitted by industry to the State of Maine. There were some discrepancies in the manner by which various companies reported the route, mode, and related information, and some of the route information was incomplete. However, IEM was able to identify or estimate the volumes of the 17 priority chemicals shipped to and from these facilities by mode. This process did not include the seasonality of shipments.

The state’s statutory definition of “facility” goes beyond the Federal Emergency Planning and Community Right-to-Know Act (EPCRA) that exempts reporting of chemicals in transportation and includes sites where motor vehicles, watercraft, rolling stock, and aircraft are present for more than 12 hours. No exclusively transportation-related sites were identified in the Tier II data for the priority HazMats beyond what would have been reported under the Federal definition of “facility.”

More than 50 datasets were reviewed for the study. Each dataset was evaluated based on metadata where available and the quality of the data it contained. Table 3 lists each dataset by source and provides an evaluation of the data.

**Table 3: Data, Source, and Evaluation**

Data Inputs	Sources	Evaluation
<b>Base Layers</b>		
Base Maps	2014, Esri and Maine Office of GIS (MEGIS)	<ul style="list-style-type: none"> <li>• Best available</li> </ul>
State and County Boundaries	2014, Esri	<ul style="list-style-type: none"> <li>• Best available</li> </ul>
Cities	2014, Esri	<ul style="list-style-type: none"> <li>• Best available</li> </ul>
Water Features	2014, Esri	<ul style="list-style-type: none"> <li>• Best available</li> </ul>
Railroads	2014, National Geospatial Intelligence Agency (NGA), Homeland Security Infrastructure Program (HSIP) Gold, and MEGIS	<ul style="list-style-type: none"> <li>• Best available</li> <li>• Some recent changes to ownership have yet to be updated in the data.</li> </ul>
Roads and Highways	2014, Esri	<ul style="list-style-type: none"> <li>• Best available</li> </ul>
<b>Chemical Data</b>		
Tier II Chemical Inventory	2014, Tier II Submit (provided by Maine Emergency Management Agency)	<ul style="list-style-type: none"> <li>• Data taken into CAMEO software and converted into Excel files.</li> <li>• Calls made to facilities to clarify data as needed.</li> <li>• Submitters inconsistently reported transportation data.</li> </ul>

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Data Inputs	Sources	Evaluation
Crude Oil Data	Maine Department of Environmental Protection (ME DEP) for 2013 to early 2015	<ul style="list-style-type: none"> <li>Includes a combination of 2013, 2014, and 2015 data, depending on the carrier.</li> <li>Data included rail and pipeline.</li> <li>Crude oil not included in Tier II reporting.</li> </ul>
Ethanol Data	2015, IEM primary data	<ul style="list-style-type: none"> <li>Calls were made to fuel terminals in the state to identify ethanol imports, volume, modes, and routes.</li> </ul>
Import and Export (of Chemicals) through Ports and Railroads	2015, U.S. Customs	<ul style="list-style-type: none"> <li>Data provided by U.S. Customs was for imports into Maine at all ports of entry.</li> <li>Data provided by Transport Canada for exports.</li> <li>No data was identified on pass-through other than for crude oil.</li> </ul>
<b>Transportation Mode Data</b>		
Airports	2014, HSIP Gold and MEGIS	<ul style="list-style-type: none"> <li>Best available</li> </ul>
Pipelines	2014, HSIP Gold	<ul style="list-style-type: none"> <li>No data on flow, volume, or products (this data was obtained in other data sets).</li> </ul>
Ports	2014, HSIP Gold	<ul style="list-style-type: none"> <li>Best available</li> </ul>
Sea Lanes	2009, Massachusetts Office of Coastal Zone Management, GIS Files	<ul style="list-style-type: none"> <li>Lanes are not delineated on final maps but were used to plot corridors with the buffer in the Atlantic Ocean, coastal waters, and rivers.</li> </ul>
<b>Receptor Data—Sensitive Populations</b>		
Population Data	2010, U.S. Census Bureau data layer from ESRI	<ul style="list-style-type: none"> <li>Best data available</li> </ul>
Correctional Facilities	2014, MEGIS	<ul style="list-style-type: none"> <li>Best data available</li> </ul>
Employers with more than 250 employees	2014, Maine Department of Labor (ME DOL) employer data	<ul style="list-style-type: none"> <li>ME DOL proprietary data—no names can be listed on maps or in report based on nondisclosure agreement.</li> </ul>
Fire and Emergency Medical Services	2014, MEGIS	<ul style="list-style-type: none"> <li>Best available</li> </ul>
Hospitals and Nursing Homes	2014, HSIP Gold and MEGIS	<ul style="list-style-type: none"> <li>Best available</li> <li>IEM added nursing homes because many are specialized hospitals for the elderly and disabled and both are impossible to rapidly evacuate.</li> </ul>

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Data Inputs	Sources	Evaluation
Special Needs Facilities with more than 25 Beds	No data identified	<ul style="list-style-type: none"> <li>No data set or GIS files identified in search that specifically identified special needs.</li> <li>No information available on capacity in a few related yellow pages listings.</li> <li>State 211 system has no list of facilities with more than 25 beds.</li> <li>No response from state Department of Health and Human Services.</li> </ul>
Schools (public and private)	2014, HSIP Gold and MEGIS	<ul style="list-style-type: none"> <li>Best data available</li> </ul>
Police Stations	2014, MEGIS	<ul style="list-style-type: none"> <li>Best data available</li> </ul>
Public Gathering Spots for more than 250 People	2014, HSIP Gold	<ul style="list-style-type: none"> <li>Attribute data does not distinguish number of people who may gather at identified gathering places. This is a data deficiency for lack of attributes in HSIP. A review of sites supports the assertion that they can support more than 250 people.</li> </ul>
<b>Receptor Data—Sensitive Environments</b>		
Aquaculture Locations	2014 Maine Department of Marine Resources	<ul style="list-style-type: none"> <li>Best data available</li> </ul>
Aquifer Polygons	2014, MEGIS	<ul style="list-style-type: none"> <li>Best data available</li> </ul>
Commercial Agricultural Areas	2014, National Agricultural Statistics Service—Crop Data Layer	<ul style="list-style-type: none"> <li>Best data available, but extensive</li> <li>Aroostook County is the state's most significant crop-producing county.</li> <li>Very detailed dataset with every conceivable crop represented</li> <li>Generalization was necessary to maintain a reasonable process.</li> </ul>
Eelgrass Beds	MEGIS	<ul style="list-style-type: none"> <li>Best data available</li> </ul>
Inland Water Fowl Habitat	MEGIS	<ul style="list-style-type: none"> <li>Best data available</li> </ul>
Molluscan Shellfish Areas	MEGIS	<ul style="list-style-type: none"> <li>Best data available</li> </ul>
Municipal, Commercial, and Institutional Wells	MEGIS	<ul style="list-style-type: none"> <li>With more than 47,000 wells, it made sense to only plot commercial, institutional, and municipal wells.</li> <li>Eliminated domestic, farm, irrigation, test, and “other” categories.</li> </ul>
Mussel Seed Conservation Areas	MEGIS	<ul style="list-style-type: none"> <li>Best data available</li> </ul>

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Data Inputs	Sources	Evaluation
Piping Plover and Roseate Tern Essential Habitat	2014, MEGIS	<ul style="list-style-type: none"> <li>• Best data available</li> <li>• These endangered species are the only two that have identified essential habitat in Maine.</li> </ul>
Public Drinking Water Intakes	2014, ME DEP, Google Earth KML file converted to GIS layer	<ul style="list-style-type: none"> <li>• Potable intakes from surface water sources</li> <li>• Actual intake point locations were not provided, but 1,000-foot buffers surrounding intakes are in the KML file.</li> </ul>
Public Drinking Watersheds	2014, ME DEP, Google Earth KML files converted to GIS layer	<ul style="list-style-type: none"> <li>• Surface water supplies</li> <li>• Gained secure access to obtain file.</li> </ul>
Shorebird Habitat	2014, MEGIS	<ul style="list-style-type: none"> <li>• Best data available</li> </ul>
Water Reservoirs	2014, HSIP Gold	<ul style="list-style-type: none"> <li>• Best data available</li> <li>• Reservoirs share locations with impoundments and dams.</li> </ul>
Water Impoundments and Dams	2014, MEGIS	<ul style="list-style-type: none"> <li>• Best data available</li> </ul>
Wetlands	2014, U.S. Fish and Wildlife Service, National Wetlands Inventory, and MEGIS	<ul style="list-style-type: none"> <li>• Best data available</li> </ul>
<b>Other</b>		
Metropolitan Planning Organization (MPO) Boundaries	2014, MEGIS	<ul style="list-style-type: none"> <li>• Best data available</li> </ul>

## Priority Hazardous Materials

The steering committee selected 17 priority commodities for this study. In a previous study, the Maine study team identified 15 extremely hazardous substances (EHS) and 15 non-EHS; for this study, 9 EHS and 8 non-EHS were identified as study priorities. Table 4 lists each commodity, identifies the primary uses for each, and indicates whether it is extremely hazardous.

**Table 4: Priority Hazardous Materials**

Hazardous Material	Use	Extremely Hazardous Substance?
Anhydrous Ammonia	Fertilizer, chemical manufacturing, refrigerant	Yes
Chlorine	Water treatment, paper treatment	Yes
Crude Oil	Feedstock for refined petroleum, chemicals	No
Compressed Natural Gas	Fuel and heating systems	No
Ethanol	Fuel and fuel additive	No
Formaldehyde	Materials and chemical manufacturing, glues, sterilization	Yes
Hydrochloric Acid	Rubber manufacturing chemicals, gasoline refining	No
Hydrofluoric Acid	Polishing stone, semiconductor manufacturing	Yes
Hydrogen Peroxide	Bleaching, paper industry, refining metals	Yes
Methanol	Chemical manufacturing, solvent for paint, plastics, anti-freeze for propane tanks	No
Nitric Acid	Explosives, fertilizers, and dyestuffs	Yes
Nitrogen, Liquid	Freezing products, cooling pumps, manufacturing	No
Potassium Cyanide	Metal plating, precious metal refining	Yes
Sodium Cyanide	Metal plating, precious metal refining	Yes
Sodium Hydroxide	Plastics, soaps, paint removal, etching, processing	No
Sodium Chlorate	Bleaching paper, herbicide	No
Sulfuric Acid	Steel and chemical manufacturing, fertilizers, refining, batteries	Yes

*Hazardous Materials Total Volume Summary by Mode*

- Crude oil is the highest volume HazMat transported in Maine from South Portland to Montreal by pipeline and to the oil refinery in St. John, New Brunswick, by rail, for a total of 1.8 trillion pounds.
- Ethanol is the second highest volume HazMat transported to Maine by barge and throughout Maine by truck for blending and transport to retail gas stations for a total of 1.6 billion pounds.
- Sodium hydroxide is the third highest volume HazMat transported in Maine by rail, motor carrier, and barge for a total of 446 million pounds.

Table 5 depicts total volumes for all 17 priority HazMats by mode of transportation.

**Table 5: Priority Hazardous Materials Annual Volumes (in Pounds) by Mode**

Hazardous Materials	Truck (× 1,000)	Rail (× 1,000)	Ship (× 1,000)	Pipeline (× 1 million)
Anhydrous Ammonia	76	7,340		
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Hydrogen Peroxide	22,535	28,800		
Methanol	12,419			
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Nitrogen, Liquid	40,898			
Potassium Cyanide	38			
Sodium Cyanide	3,513			
Sodium Hydroxide	270,583	41,862	133,796	
Sodium Chlorate	1,566	118,005		
Sulfuric Acid	218,615	151,020		

The following pages contain additional details on descriptions, health hazards, fire hazards transportation routes and import data for the 17 priority commodities. Each commodity is described with a corresponding map depicting annual volumes of priority hazards by motor carrier (blue), rail (red), pipeline (purple), and barge (green).

## Anhydrous Ammonia

Anhydrous ammonia ( $\text{NH}_3$ ) is a clear, colorless gas with a strong odor and is shipped as a liquid under its own vapor pressure. Its density (as a liquid) is 6 pounds per gallon.  $\text{NH}_3$  can be used as a fertilizer, as a refrigerant, and in the manufacture of explosives, pesticides, detergents, and other chemicals.

### *Health Hazards*

Vapors cause irritation of the eyes and respiratory tract. Liquid will burn skin and eyes.  $\text{NH}_3$  is poisonous and may be fatal if inhaled. Contact may cause burns to skin and eyes. Contact with liquid may cause frostbite.

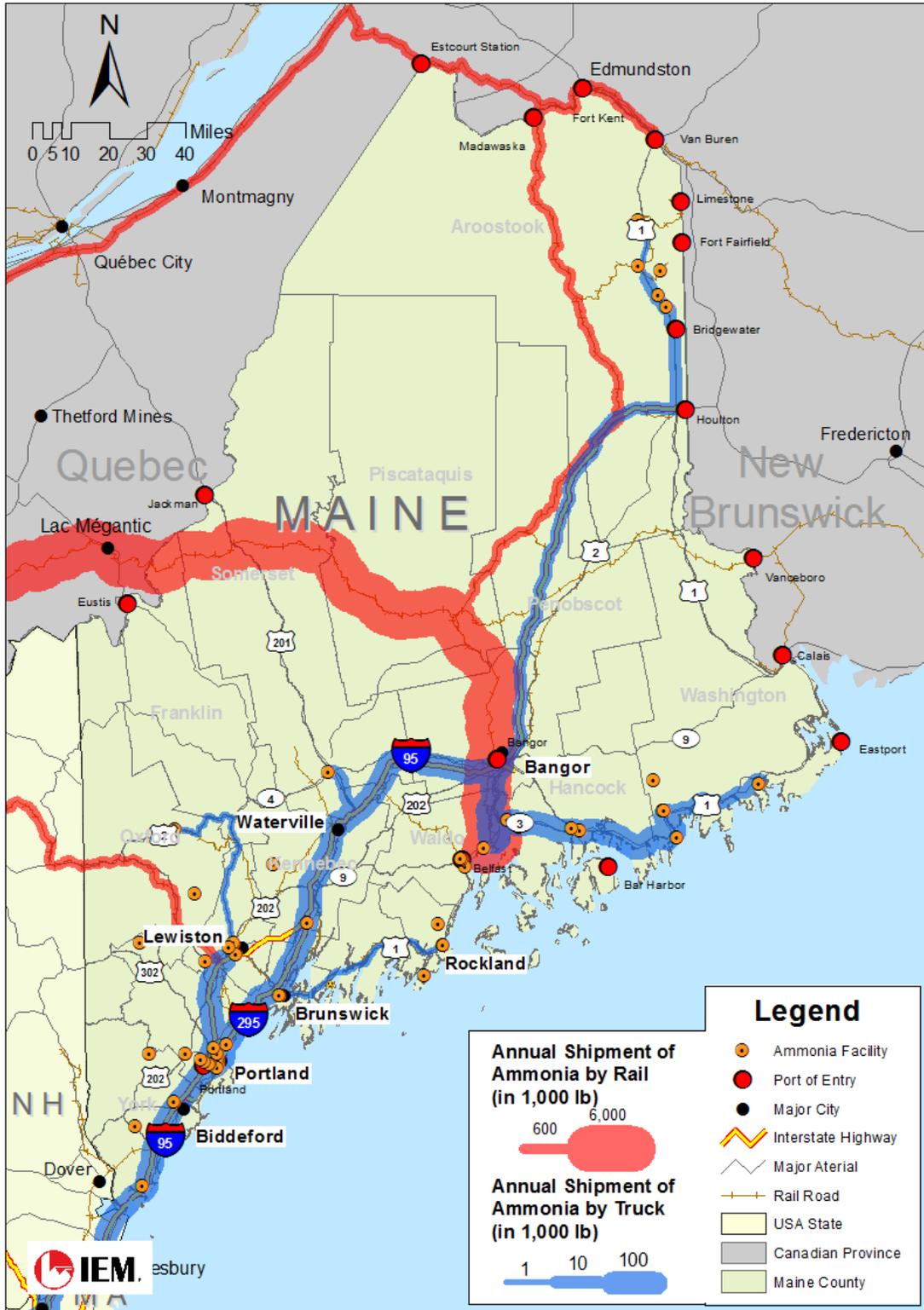
### *Fire Hazards*

Wear a positive-pressure breathing apparatus and full protective clothing. With small fires, use a dry chemical or carbon dioxide ( $\text{CO}_2$ ). For large fires, use water spray, fog, or foam. Move the container away from the fire, if this can be accomplished without risk to personnel. Stay away from the tank ends. Cool containers that are exposed to flames with water from the side until well after the fire is out. Isolate the area until the gas has fully dispersed.

### *Transportation*

Of the 48 facilities in Maine that report storage of  $\text{NH}_3$ , 2 are manufacturing industries, and nearly all of the rest are refrigeration facilities that produce ice or for cold storage of food products. One facility is a chemical manufacturer that receives rail tank car loads 60 times per year. Fourteen truck shipments of  $\text{NH}_3$  were made to refrigeration facilities in Maine in 2014. Most refrigeration facilities do not need yearly shipments and only need to top off small amounts of refrigerant every few years. More than half a million pounds of  $\text{NH}_3$  has been imported into Maine through the Van Buren land port of entry by rail in the year ending February 2015.

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Map 3: Annual Shipments of Anhydrous Ammonia

## Chlorine

Chlorine is a greenish-yellow gas with a pungent, suffocating odor. It is toxic by inhalation and liquefies at -35°C (-31°F) and by pressure applied at room temperature. Its density (as a liquid) is 13 pounds per gallon. Chlorine supports combustion, and its vapors are much heavier than air. It is used to purify water, bleach wood pulp, and make other chemicals. Chlorine is also used as a cleaner and disinfectant in many industries, including water and sewage treatment. Its odor threshold is 3.5 parts per million (ppm).

### *Health Hazards*

Chlorine is poisonous and may be fatal if inhaled. Contact may cause burns to skin and eyes.

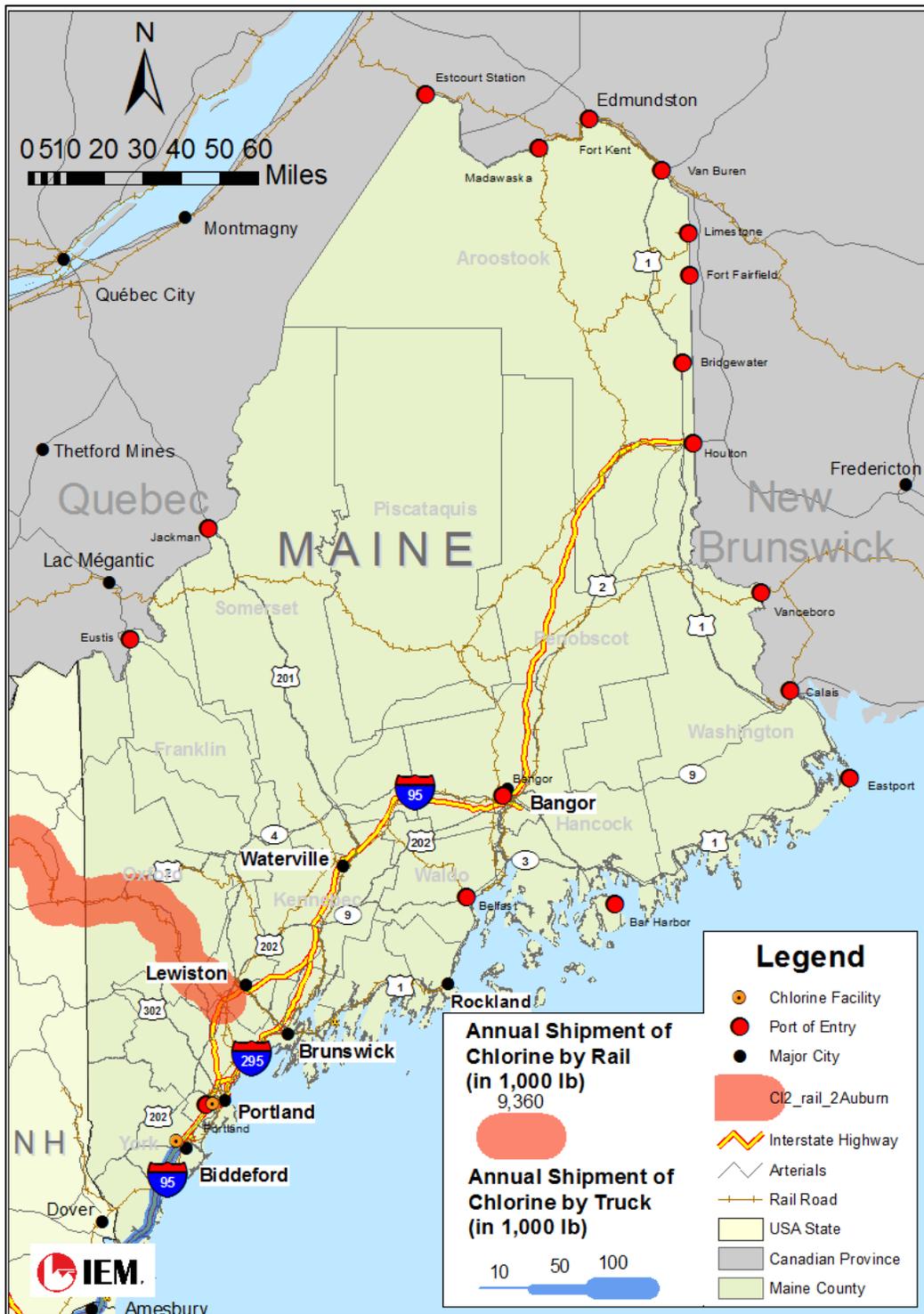
### *Fire Hazards*

Evacuate the area that is endangered by gas and stay upwind. Wear a positive-pressure breathing apparatus and full protective clothing. Move the container from the fire area, if it can be done without risk. Spray cooling water on containers that are exposed to flames. Chlorine will not burn, but most combustible materials will burn in chlorine. Flammable gases will form explosive mixtures with chlorine. Use a dry chemical, CO<sub>2</sub>, water spray, fog, or foam.

### *Transportation*

Chlorine is used and transported in Maine for wastewater treatment at the one treatment facility that continues to use gaseous chlorine. Chlorine is used at two semiconductor manufacturing facilities in the production of semiconductors. Seventy-one shipments of chlorine were made in 2014; eight of these shipments were of six 1-ton cylinders for water treatment and the rest were smaller cylinders. All were carried by truck. Genesee and Wyoming Inc. shipped 52 carloads of chlorine by rail in 2014.

Maine Commodity Flow Study of Hazardous Materials



Map 4: Annual Shipments of Chlorine

## Compressed Natural Gas

Compressed natural gas (CNG) is transported in Maine in pressurized tubes on tube trailers. Due to the expected growth of CNG due to the domestic availability of natural gas, CNG will become a significant hazard source in the state, requiring specialized response equipment and training for local responders.

### *Health Hazards*

Vapors may cause dizziness or asphyxiation without warning. Some may be irritating if inhaled at high concentrations. Contact with gas or liquefied gas may cause burns, severe injury, and/or frostbite. Fire may produce irritating and/or toxic gases.

### *Fire Hazards*

CNG is extremely flammable. It will be easily ignited by heat, sparks, or flames, and it will form explosive mixtures with air. Vapors from liquefied gas are initially heavier than air and spread along ground. Cylinders exposed to fire may vent and release flammable gas through pressure-relief devices. Containers may explode when heated. Ruptured cylinders may rocket.

### *Transportation*

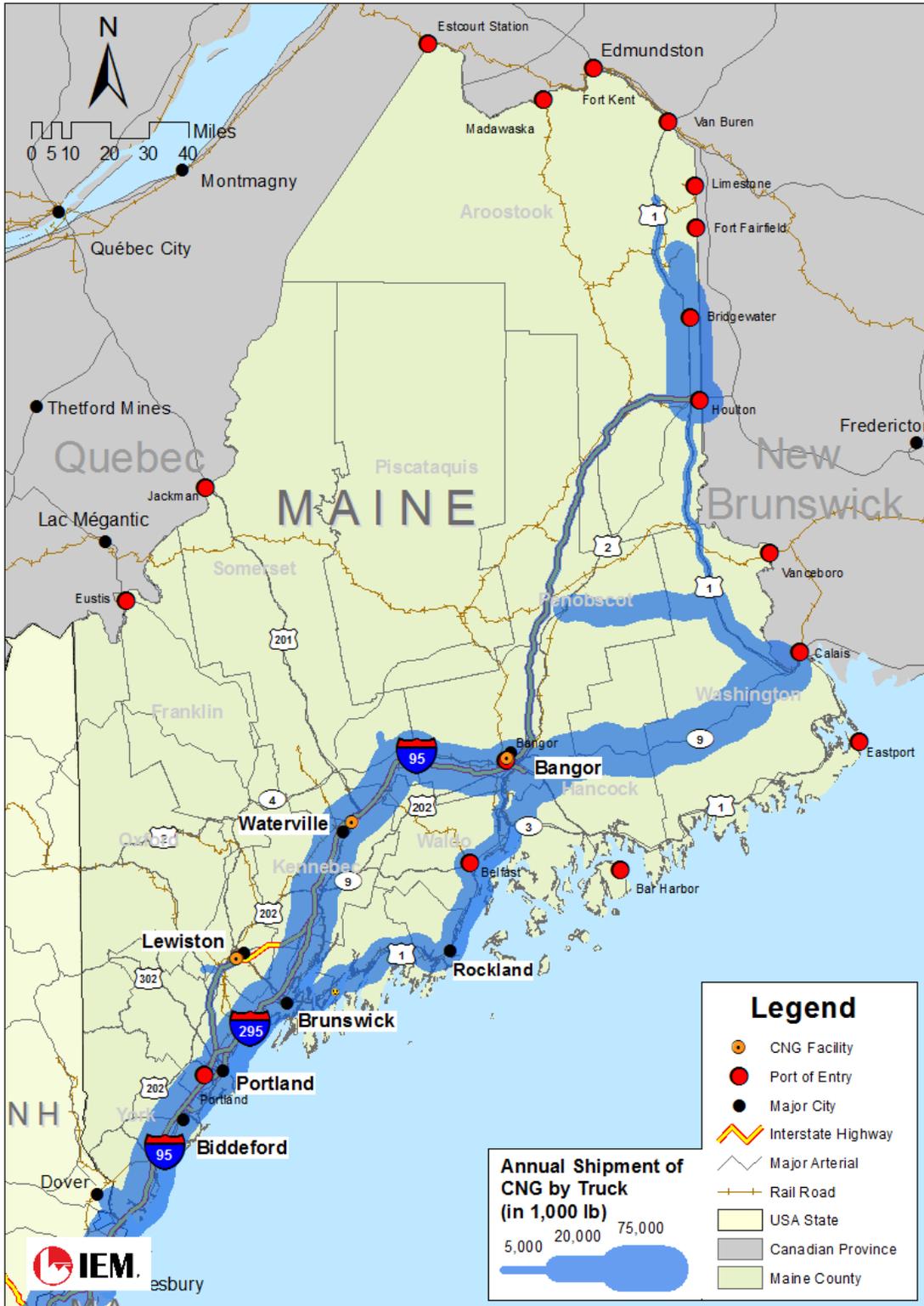
CNG is delivered locally by tube trailers in Maine, and more delivery routes have been established since this study began.<sup>2</sup> Major routes include the Maine Turnpike, Route 1, and Route 9. As of this writing, annual volumes in Maine total 170,553,000 pounds transported by truck. For the year ending February 2015, the state imported 1,508 truckloads of CNG through Houlton, Maine. The U.S. Energy Information Administration reports 303 million cubic feet of CNG were imported from Canada to Houlton in 2014.<sup>3</sup>

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<sup>2</sup> A CNG compressor facility has been built in Baileyville, Maine. Xpress Natural Gas is building a natural gas compressor station in Washington County that will be operational in 2015.

<sup>3</sup> Maine Port Authority data from March 2014 to February 2015

Maine Commodity Flow Study of Hazardous Materials



Map 5: Annual Shipments of Compressed Natural Gas

## Crude Oil

In recent years, crude oil shipped through and around Maine by rail has been shale oil. This is due largely to the recent availability of domestic crude oil and natural gas from the Bakken oil fields in North Dakota. Bakken oil is characterized as light and sweet, which means it contain “light ends,” or butane, propane, and ethane gas. It is therefore highly flammable oil with a low flash point. Table 6 shows crude oil shipment data for 2013.

**Table 6: Crude Oil Shipments (2013)**

All Crude Oil Shipments	Barrels	Pounds
Portland Pipeline	52,775,324	19,015,611,040
Maine Central Railroad	1,210,453	436,141,395
Montreal, Maine and Atlantic	3,034,514	1,093,373,447
<b>Total Crude Oil</b>	<b>57,020,291</b>	<b>20,545,125,882</b>

### *Health Hazards*

Inhalation or contact with crude oil may irritate or burn skin and eyes. Fire may produce irritating, corrosive, and/or toxic gases. Vapors may cause dizziness or suffocation. Runoff from fire control or dilution water may cause pollution.

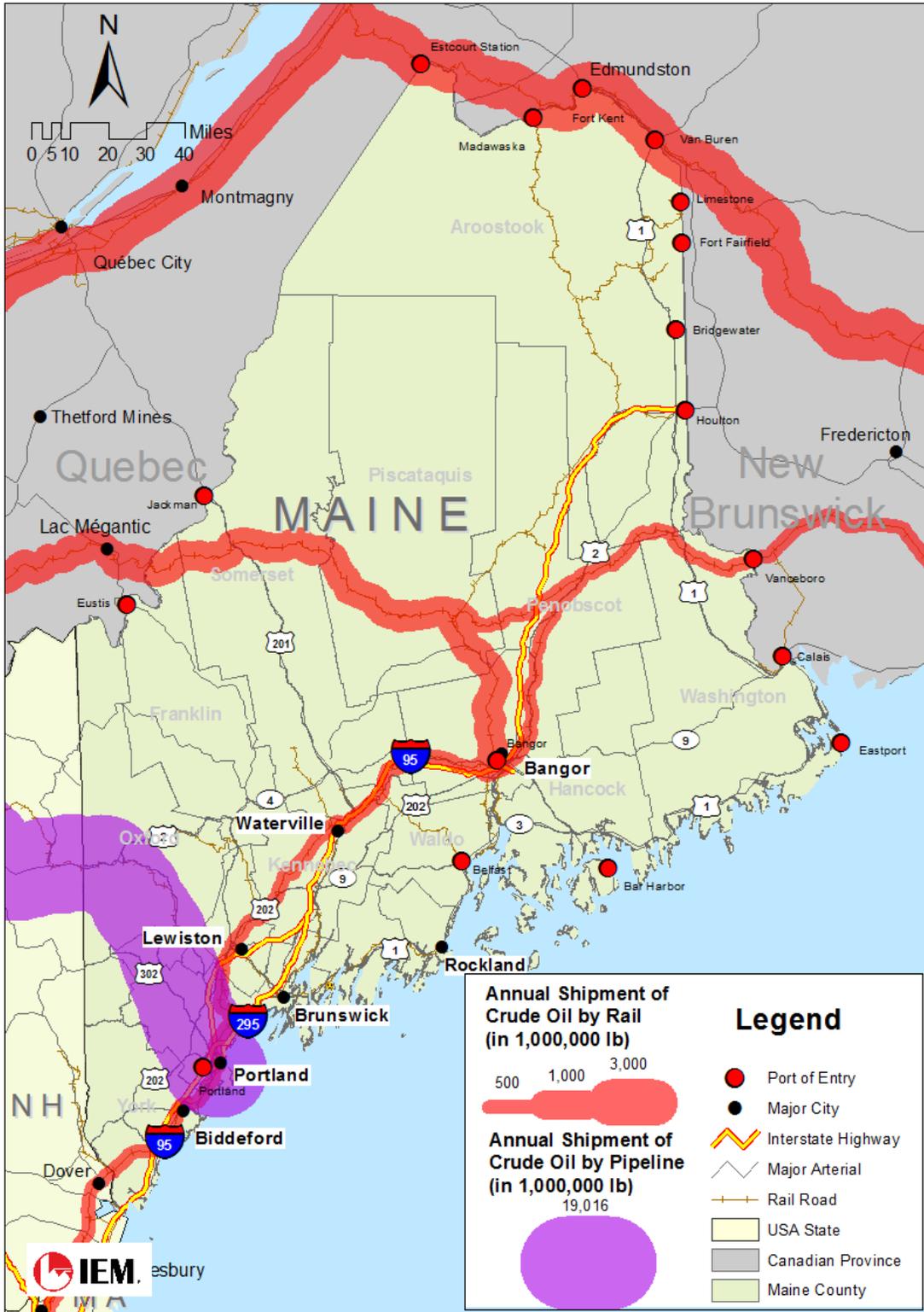
### *Fire Hazards*

Bakken crude oil is highly flammable and will be easily ignited by heat, sparks, or flames. This is particularly true with the heat generated from a derailment. Vapors will form explosive mixtures with air and can travel to a source of ignition and flash back. Most vapors are heavier than air. They will spread along the ground and collect in low or confined areas (e.g., sewers, basements, tanks).

### *Transportation*

Crude oil is mostly transported through or around Maine to Canadian destinations by pipeline and rail. In 2014, the Portland pipeline received crude oil from tanker ships in South Portland and transported 52,775,324 barrels to Montreal. Since the rail disaster in Lac Mégantic, Quebec, on July 6, 2013, no crude oil has been transported by Maine by rail. However, in May 2014, the newly-formed Central Maine & Québec Railway has transported 60 rail tank cars through the state, in cooperation with New Brunswick & Maine Railways (NBM). Maine Central Railroad (PanAm) transported 15,545 barrels in 2014, also in cooperation with NBM.

Maine Commodity Flow Study of Hazardous Materials



Map 6: Annual Shipments of Crude Oil

## Ethanol

Ethanol, also known as grain alcohol, is made from fermenting corn or sugar cane products. Since U.S. regulations require 10 percent of all gasoline sold to be blended with at least 10 percent ethanol, it has become second only to crude oil as the state's primary rail HazMat commodity. In Maine, ethanol is transported to the state by barge, where it is blended with gas before being distributed by tanker truck trailers to retail stations statewide.

### *Health Hazards*

Ethanol is irritating to eyes, nose, and throat. The liquid is not considered harmful.

### *Fire Hazards*

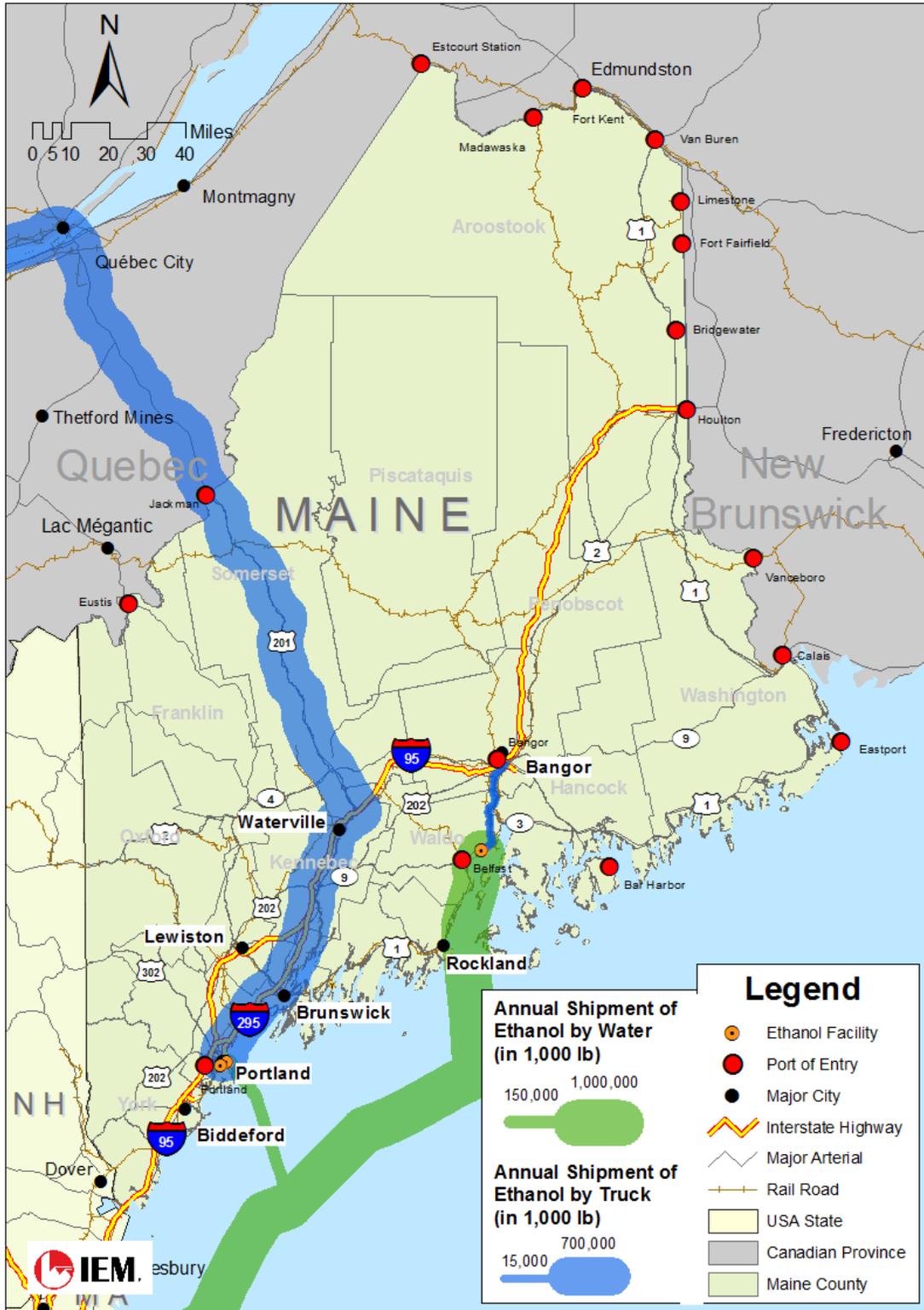
Ethanol has a very low flash point. Use of water spray when fighting fire may be inefficient. For small fires, use dry chemical, CO<sub>2</sub>, water spray, or alcohol-resistant foam. For large fires, water spray, fog, or alcohol-resistant foam is preferred over using straight streams. Move containers from fire area if you can do so without risk.

### *Transportation*

Six ethanol facilities reported data in the Tier II inventory. All documented volumes of ethanol entering the state for delivery at these facilities is used for fuel blending with gasoline. Most large volumes of ethanol transiting Maine come in by ship or barge. Ethanol is stored in Searsport and in two facilities in South Portland. The facility in Searsport receives ethanol by tanker ship or barge, some of which is shipped by tank truck to Bangor. Two facilities in South Portland receive ethanol by barge and blend it with gasoline onsite.

Barges offload only one-fifth of their load in Searsport, up to the capacity of shore-side tankage. There were at least 368 shipments of ethanol in Maine of any significant scale, 8 by ship or barge and 282 by truck. Trucks transported more than 15 million pounds of ethanol from Searsport to Bangor in at least 270 shipments. More than 660,000 pounds of ethanol was imported into Maine from Canada in 12 truck shipments through Jackman during the year ending February 2012.

Maine Commodity Flow Study of Hazardous Materials



Map 7: Annual Shipments of Ethanol

## Formaldehyde

Formaldehyde solution is a colorless aqueous solution of formaldehyde, which is a gas in ordinary conditions. The solution is denser than water, and its vapors are heavier than air and are highly irritating to the nose. It is used to make plastics, other chemicals, and fertilizers and as a preservative and a corrosion inhibitor.

### *Health Hazards*

The probable oral lethal dose for humans is 0.5–5 gallons per kilogram or between 1 ounce and 1 pint for a 150-pound person. Acute exposure falls below 1 ppm, with the odor perceptible to most. At 4–5 ppm, increased discomfort and mild lacrimation occur.<sup>4</sup>

### *Fire Hazards*

Toxic vapors, such as carbon dioxide and carbon monoxide, are generated during combustion. When aqueous formaldehyde solutions are heated above their flash points, the potential for an explosion hazard exists. Stay upwind and keep out of low areas. Isolate for half a mile in all directions if a tank car or truck is involved in the fire and wear a self-contained breathing apparatus. Use water spray carefully in the vicinity of dusts so as not to create dust clouds.

### *Transportation*

There are nine aquaculture, laboratory, and plastics facilities that store formaldehyde in Maine. Of these 9, only 2 have a significant enough volume to receive the compound by tank trailer in 51 shipments in 2014. One facility reported receiving very small quantities by air. The remaining facilities received formaldehyde in smaller quantities by common carrier. Only the largest facility reported receiving formaldehyde in a pure form, but like the rest of the facilities, it likely receives formalin (a formaldehyde mixture in water). More than 3,067,000 pounds of formaldehyde were imported into Maine from Canada through the Jackman port of entry in 52 shipments during the year ending February 2014.

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<sup>4</sup> Lacrimation is the production of tears.

Maine Commodity Flow Study of Hazardous Materials



Map 8: Annual Shipments of Formaldehyde

## Hydrochloric Acid

Hydrochloric acid is a colorless, watery liquid with a sharp, irritating odor. It consists of the gas hydrogen chloride dissolved in water. The solution sinks and mixes with water and produces irritating vapor.

### *Health Hazards*

Inhalation of fumes results in coughing, a choking sensation, and irritation of nose and lungs. The liquid causes burns.

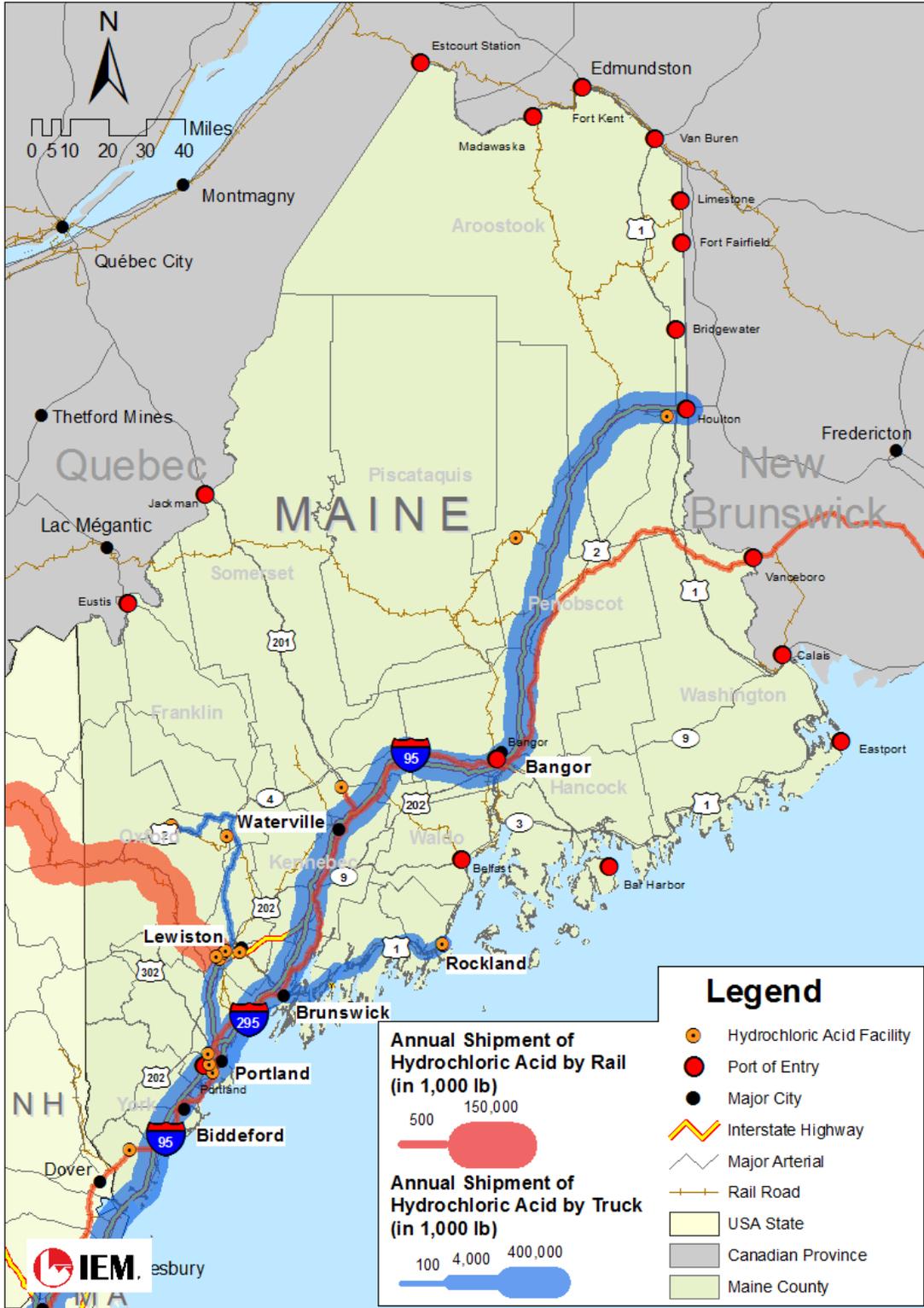
### *Fire Hazards*

Toxic and irritating vapors are generated when heated. Some foams will react with the material and release corrosive/toxic gases. For large fires, use water spray, fog, or alcohol-resistant foam. Move containers from fire area if you can do it without risk. Use water spray or fog; do not use straight streams. Dike fire-control water for later disposal; do not scatter the material. In fires involving tank cars or tank trailers, fight the fire from maximum distance or use unmanned hose holders or monitor nozzles. Always stay away from tanks engulfed in fire.

### *Transportation*

There are 19 facilities that store reportable quantities of hydrochloric acid in Maine. Of these, three are wholesale distributors and the rest are manufacturing facilities, semiconductor industries, and one laboratory. Five of these facilities store relatively low volumes, and 3 have a high-volume exceeding 100,000 pounds in an average 24-hour period. One of the large wholesale distributors receives 30 shipments per month of hydrochloric acid by rail car, 2 receive hydrogen chloride gas in cylinders 48 times per year between them, 1 receives hydrogen chloride gas in a tube trailer twice a year, and the rest receive it by tank truck in 241 loads per year between them. More than 32.5 million pounds of hydrochloric acid was imported into Maine in 591 shipments via the Houlton port of entry by truck during the year ending February 2014.

Maine Commodity Flow Study of Hazardous Materials



## Hydrofluoric Acid

Hydrofluoric acid is a colorless fuming mobile aqueous solution with a pungent odor. It is corrosive to metals and tissue and highly toxic by ingestion and inhalation.

### *Health Hazards*

Fumes are highly irritating, corrosive, and poisonous. Exposure to fumes or very short contact with liquid may cause severe painful burns. It may penetrate skin to cause deep-seated ulceration that may lead to gangrene.

### *Fire Hazards*

Hydrofluoric acid is noncombustible, and the substance itself does not burn. However, it may decompose upon heating to produce corrosive and/or toxic fumes. Vapors may accumulate in confined areas (basement, tanks, hopper/tank cars etc.). Substance may react with water (some violently), releasing corrosive and/or toxic gases and runoff. Contact with metals may evolve flammable hydrogen gas. Containers may explode when heated or if contaminated with water.

### *Transportation*

There are six facilities in Maine that store hydrofluoric acid, several with multiple listings of the chemical in various products and containers. None of these chemicals are in a pure gaseous form as hydrogen fluoride. One of these facilities is a chemical wholesaler, and the rest are in the semiconductor industry. All hydrofluoric acid is shipped by truck. No hydrofluoric acid was imported into Maine through any of its ports of entry during the year ending February 2014. All hydrofluoric acid shipments are significant, but one facility ships large quantities twice a month by tanker truck.

Maine Commodity Flow Study of Hazardous Materials



Map 10: Annual Shipments of Hydrofluoric Acid

## Hydrogen Peroxide

Hydrogen peroxide is a colorless liquid. Vapors may irritate the eyes and mucous membranes. Under prolonged exposure to fire or heat, containers may violently rupture due to decomposition. Hydrogen peroxide is used to bleach textiles and wood pulp, in chemical manufacturing, and in food processing.

### *Health Hazards*

Hydrogen peroxide is a toxic substance, and inhalation, ingestion, or contact (skin, eyes) with vapors, dusts, or substance may cause severe injury, burns, or death. Contact with combustible materials may result in their spontaneous ignition.

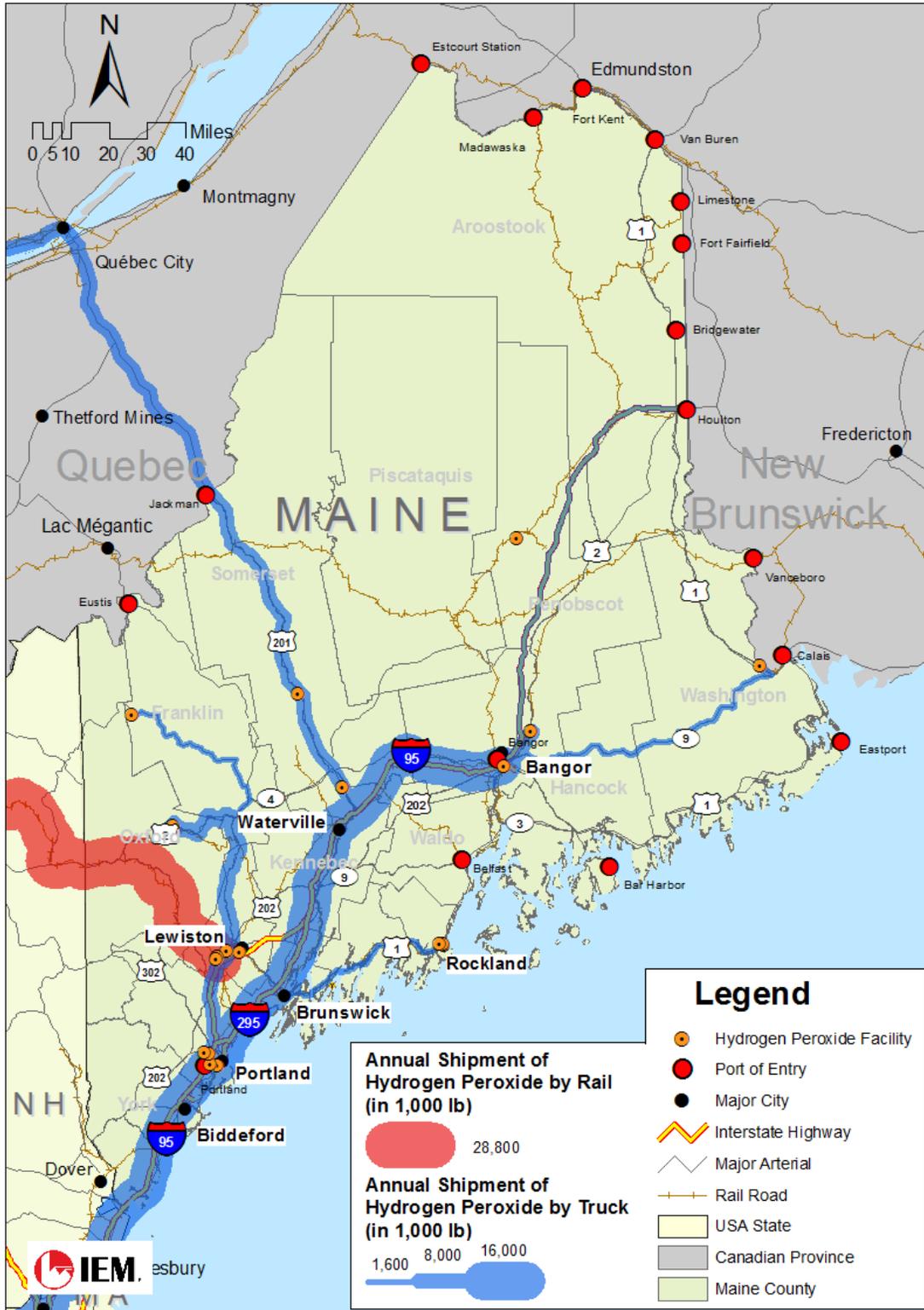
### *Fire Hazards*

Fire may produce irritating and/or toxic gases. Toxic fumes or dust may accumulate in confined areas (basement, tanks, hopper/tank cars, etc.). For small fires, use water; do not use dry chemicals or foams. For large fires, flood fire area with water from a distance. Do not move cargo or vehicle if cargo has been exposed to heat. Move containers from fire area if it can be done without risk. Do not get water inside containers: a violent reaction may occur. CO<sub>2</sub> or Halon® may provide limited control. If tank, rail car, or tank truck is involved in a fire, isolate for 800 meters (half a mile) in all directions.

### *Transportation*

There were more than 1,000 shipments of hydrogen peroxide by all modes in 2014. Nearly 12 percent of those were by rail tank car to one wholesaler facility and the rest were by tank truck. Close to 11 million pounds of hydrogen peroxide were imported into Maine from Canada during the year ending February 2014 in 17 truck tanker loads through the Houlton port of entry.

Maine Commodity Flow Study of Hazardous Materials



Map 11: Annual Shipments of Hydrogen Peroxide

## Methanol

Methanol is a colorless fairly volatile liquid with a faintly sweet pungent odor like that of ethyl alcohol. Methanol in the paper industry is a byproduct of pulp production and is recovered from the black liquor. The methanol must be stripped from the black liquor because of environmental regulations and can be used as a fuel source. Paper mills with an established methanol energy system often require additional methanol to meet their energy needs. All large consumers of methanol are paper or fiber industries.

### *Health Hazard*

Exposure to excessive vapor causes eye irritation, headache, fatigue, and drowsiness. High concentrations can produce central nervous system depression and optic nerve damage. 50,000 ppm will probably cause death in 1 to 2 hours. Methanol can be absorbed through skin. Swallowing may cause death or eye damage.

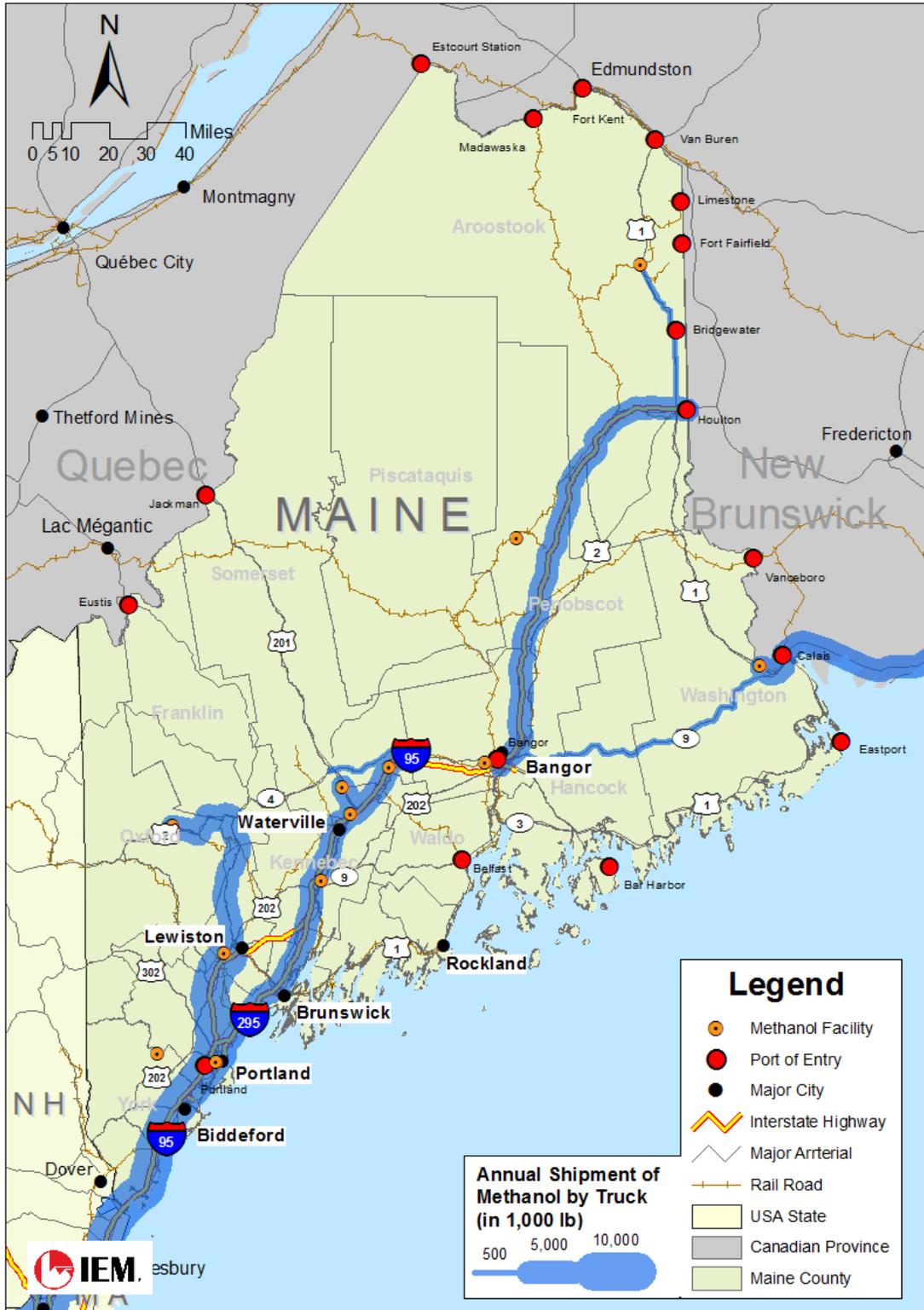
### *Fire Hazard*

Any accumulation of methanol vapors in confined spaces, such as buildings or sewers, may explode if ignited. For large fires, use spray, fog, or alcohol-resistant foam. Move containers from fire area if you can do it without risk. For fires involving tanks or trailers, use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. Always stay away from tanks engulfed in fire.

### *Transportation*

A total of 13 facilities stored methanol in Maine in 2014. Most facilities are either paper and fiber industries or propane dealers, though there are a few in other manufacturing industries. Methanol is also used as an anti-icing agent in propane tanks. Small amounts are added by propane distributors with each fill prior to and during the winter season to prevent icing of valve components. Half of the methanol is shipped by common carrier and the other half by tanker truck. There are close to 300 shipments per year of methanol in Maine. Almost 13 million pounds of methanol was imported into Maine from Canada in 2014 in 274 truck shipments through Jackman and 30 shipments through Calais and Houlton.

Maine Commodity Flow Study of Hazardous Materials



Map 12: Annual Shipments of Methanol

## Nitric Acid

Nitric acid is a pale yellow to reddish brown liquid generating red-brown fumes and having a suffocating odor. It is very toxic by inhalation and corrosive to metals or tissue. Prolonged exposure to low concentrations or short-term exposure to high concentrations may result in adverse health effects.

### *Health Hazard*

Nitric acid is very toxic, and inhalation, ingestion, or contact (skin, eyes) with vapors, dusts, or substance may cause severe injury, burns, or death. Reaction with water or moist air may release toxic, corrosive, or flammable gases.

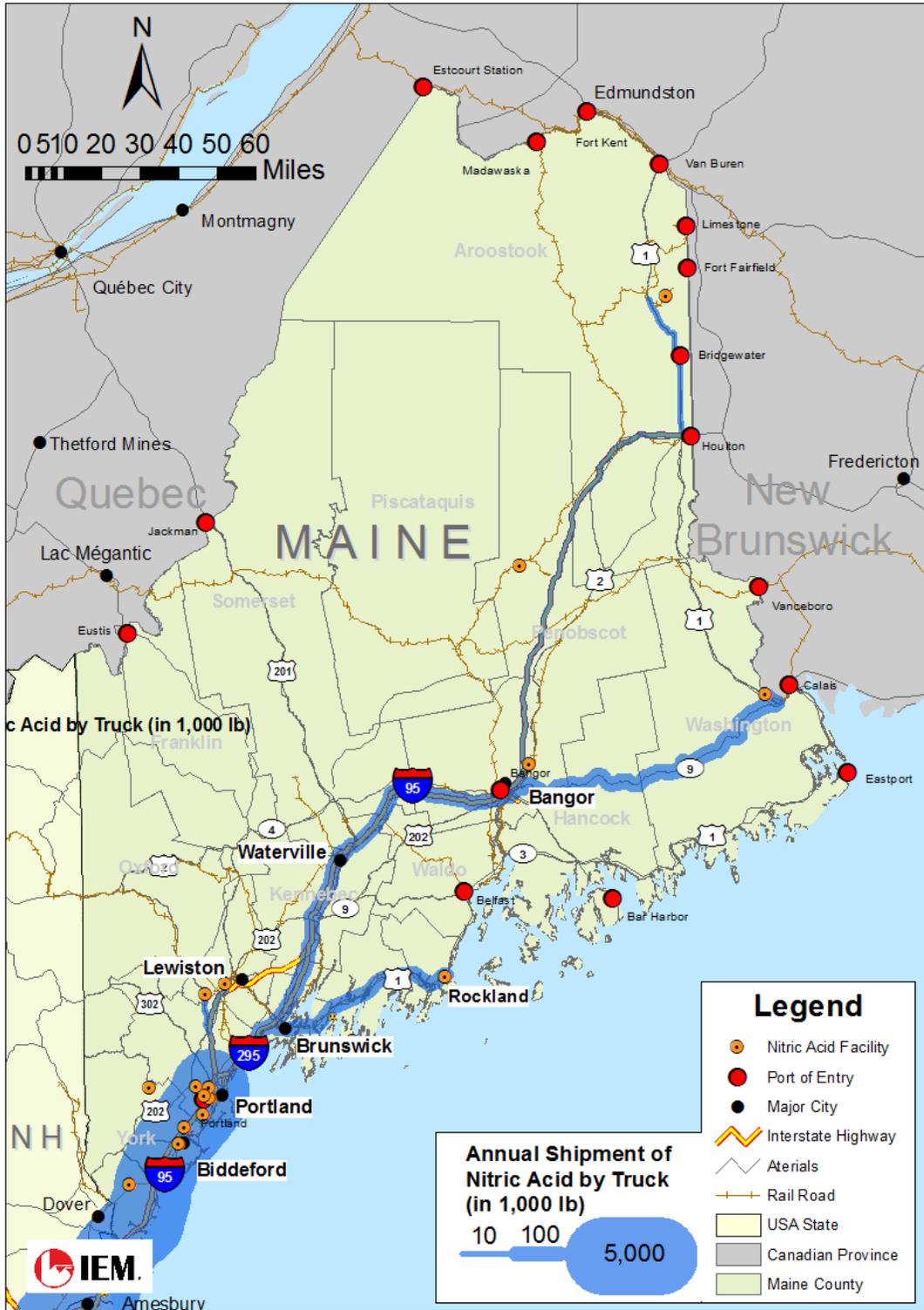
### *Fire Hazard*

Fire will produce irritating, corrosive, and/or toxic gases. Reaction with water may generate significant heat that will increase the concentration of fumes in the air. Vapors may accumulate in confined areas (basement, tanks, hopper/tank cars, etc.). Nitric acid may react with water (some violently), releasing corrosive and/or toxic gases and runoff. Contact with metals may evolve flammable hydrogen gas. Containers may explode when heated or if contaminated with water.

### *Transportation*

There were 19 facilities in Maine that stored nitric acid in 2014. One of these facilities makes other nitric acid compounds. One facility received 207,000 pounds per year in 12 shipments by tank trailer. All other facilities received shipments by truck in just over 300 shipments per year. These facilities were in the fiber and paper, manufacturing, semiconductor, water bottling, and food production industries. There were no imports of nitric acid into Maine.

Maine Commodity Flow Study of Hazardous Materials



Map 13: Annual Shipments of Nitric Acid

## Nitrogen, Liquid

Liquid nitrogen is a colorless, odorless liquid and very cold. Contact may cause frostbite. Under prolonged exposure to heat or fire, containers may rupture violently and rocket. Liquid nitrogen is used to freeze foods, to preserve whole blood and other biologicals, and as a coolant.

### *Health Hazards*

Inhalation of nitrogen fumes can cause asphyxiation if the atmosphere does not contain oxygen. Dizziness, unconsciousness, or even death can result. Contact of liquid with skin or eyes causes frostbite burns.

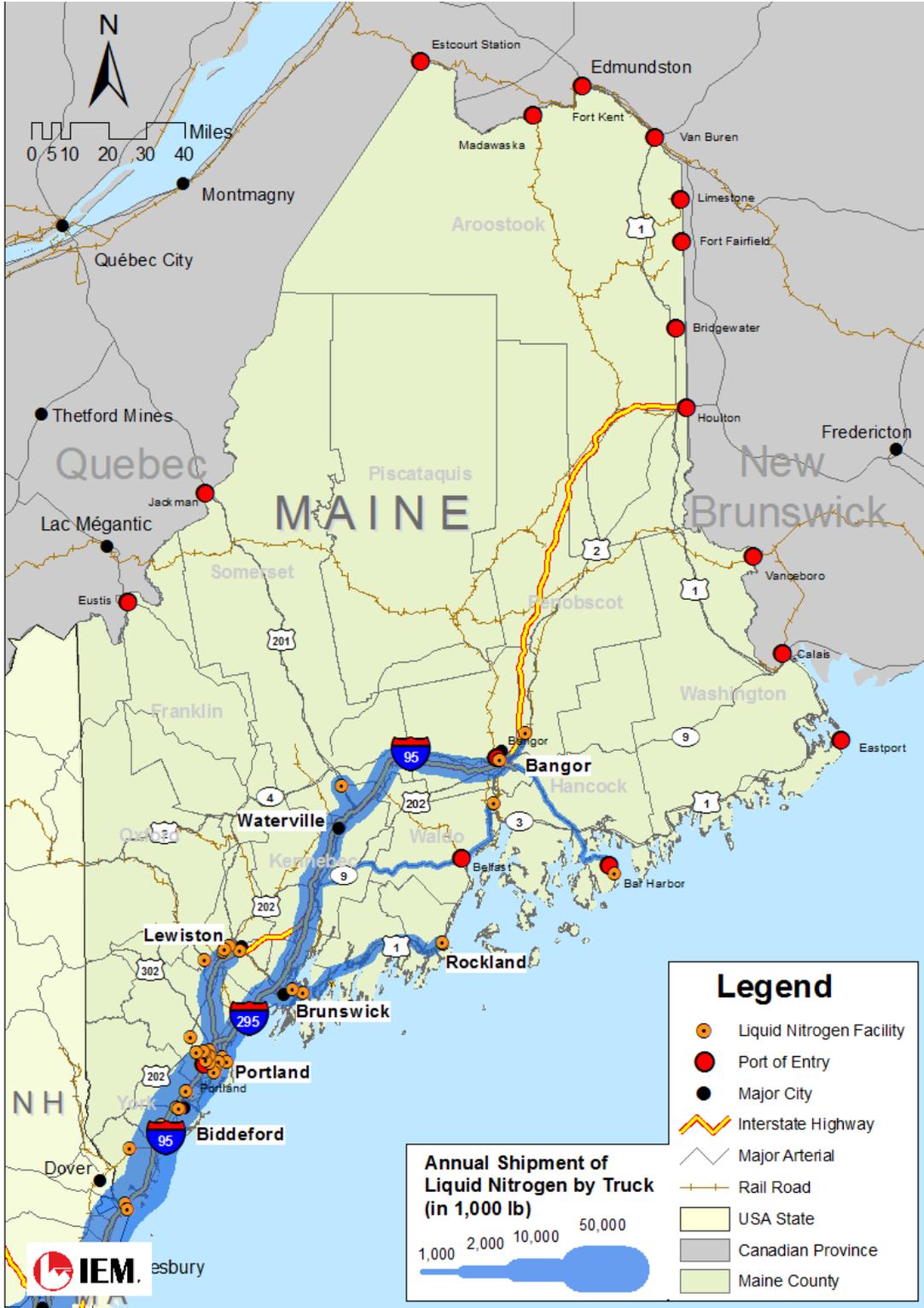
### *Fire Hazards*

Liquid nitrogen containers may explode when heated. If a tank, rail car, or tank truck is involved in a fire, isolate for 800 meters (half a mile) in all directions; also, consider initial evacuation for 800 meters in all directions. Use extinguishing agent suitable for type of surrounding fire. Move containers from fire area if it can be done without risk. Damaged cylinders should be handled only by specialists. Do not direct water at source of leak or safety devices; icing may occur.

### *Transportation*

Almost 39 million pounds in more than 1,300 shipments were made to 29 facilities that store liquid nitrogen in Maine in 2014. A total of 25 of these facilities receive shipments by tank trailer, and the rest receive shipments by tank truck. These included industries in semiconductor, food, paper and fiber, and metals manufacturing. There were no imports of liquid nitrogen into Maine during the year ending February 2014.

Maine Commodity Flow Study of Hazardous Materials



Map 14: Annual Shipments of Liquid Nitrogen

## Potassium Cyanide

Potassium cyanide is characterized by white amorphous lumps or a crystalline mass with a faint odor of bitter almonds. It is toxic by skin absorption through open wounds and by ingestion. Heating to decomposition produces toxic fumes. It is used for gold and silver extraction, in chemical analysis, to make other chemicals, and as an insecticide.

### *Health Hazard*

This chemical is classified as super toxic. Probable oral lethal dose in humans is less than 5 milligrams per kilogram or less than a taste (7 drops) for a 150-pound person. It is an eye and skin irritant. Potassium cyanide is poisonous in very small quantities; a taste is lethal.

### *Fire Hazard*

Contact with acid releases highly flammable hydrogen cyanide gas. Moisture may cause this material to volatilize as hydrogen cyanide. When heated to decomposition, it emits very toxic fumes of cyanide and nitrogen oxides. This chemical reacts with acids to produce hydrogen cyanide gas.

### *Transportation*

There were no imports of sodium cyanide into Maine during the year ending February 2014. Six facilities reported storing potassium cyanide in 2014; of these, 1 made the solution in house and the other 5 had almost 154,000 pounds of the solid material shipped to them, all by truck in 54 shipments. One of these facilities is a chemical wholesaler and the rest are manufacturers that use the chemical for metal plating.

Maine Commodity Flow Study of Hazardous Materials



Map 15: Annual Shipments of Potassium Cyanide

## Sodium Chlorate

Sodium chlorate is an odorless pale yellow to white crystalline solid. It is appreciably soluble in water and heavier, so it may be expected to sink and dissolve at a rapid rate. Excessive heat, as in fires, may cause evolution of oxygen gas that may increase the intensity of fires and may also result in explosions. Mixtures with combustible materials are very flammable and may be ignited by friction. It is used for making herbicides, explosives, dyes, matches, inks, cosmetics, pharmaceuticals, defoliants, paper, and leather.

### *Health Hazards*

Ingestion of a toxic dose (at least half an ounce) leads to severe gastroenteric pain, vomiting, and diarrhea. Possible respiratory difficulties may develop, including failure of respiration. Kidney and liver injury may also be produced. The lethal oral dose for an adult is approximately 15 grams. Contact with eyes causes irritation.

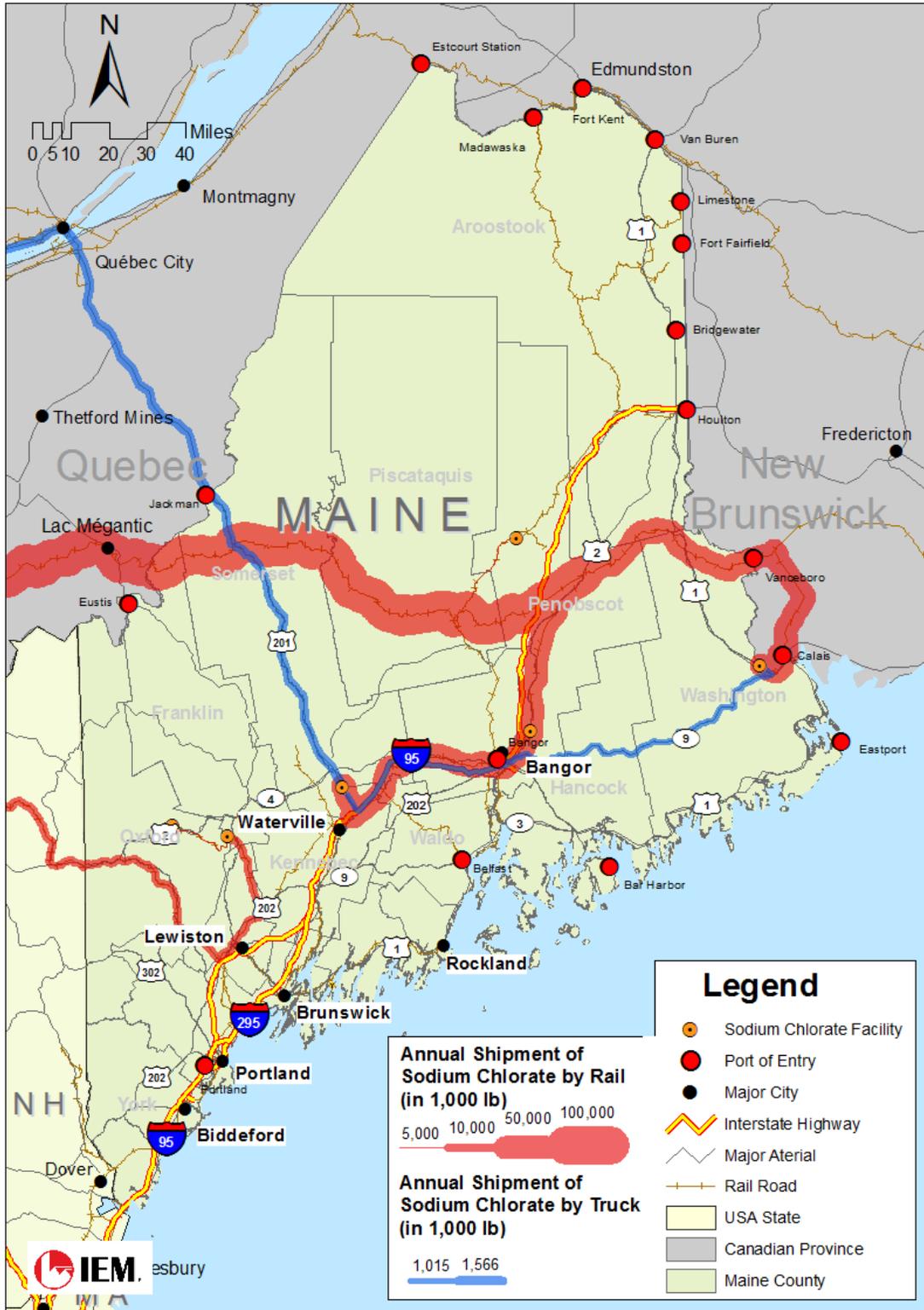
### *Fire Hazards*

In fires, sodium chlorate melts then decomposes to release oxygen gas that may increase the intensity of fire. It liberates explosive chlorine dioxide gas; heating a moist metal chlorate and a dibasic organic acid liberates chlorine dioxide and carbon dioxide. As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids. If a tank, rail car, or tank truck is involved in a fire, isolate for 800 meters (half a mile) in all directions; also, consider initial evacuation for 800 meters in all directions.

### *Transportation*

Seven facilities reported storing sodium chlorate in Maine. One facility produces it onsite. The other six facilities received it in more than 750 shipments of more than 239 million pounds by a combination of tank cars, rail cars, and tank trucks and trucks that shipped both liquid and solid forms of the chemical. These facilities are in the paper and fiber and chemical manufacturing industries. More than 16.8 million pounds of sodium chlorate was imported into Maine in 158 shipments by rail car through Jackman during the year ending February 2014.

Maine Commodity Flow Study of Hazardous Materials



Map 16: Annual Shipments of Sodium Chlorate

## Sodium Cyanide

Sodium cyanide is a white crystalline solid, lump solid, or powder. It is a deadly human poison by ingestion. The chemical is also toxic by skin absorption through open wounds, by ingestion, and by inhalation of dust.

### *Health Hazards*

Sodium cyanide is considered super toxic; probable oral lethal dose in humans is less than 5 milligrams per kilogram or a taste (less than 7 drops) for a 70-kilogram (150-pound) person. Sodium cyanide produces deadly and flammable hydrogen cyanide gas

### *Fire Hazards*

Sodium cyanide is not combustible itself, but contact with acids releases highly flammable hydrogen cyanide gas. Fire may produce irritating or poisonous gases. As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids. Full protective clothing including self-contained breathing apparatus, rubber gloves, boots, and bands around legs, arms, and waist should be provided. No skin surface should be exposed. Use water, dry chemical, carbon dioxide, water spray, or foam for small fires, water spray, fog, or foam for large fires.

### *Transportation*

Five facilities reported storing sodium cyanide in 2014. One of these facilities reported receiving no shipments. There were 32 shipments to the other 4 facilities of just more than 32,500 pounds of a solid form of the chemical by common carrier. One of these four is a chemical wholesaler, and the rest are in the metal plating industry. There were no imports of sodium cyanide into Maine during the year ending February 2014.

Maine Commodity Flow Study of Hazardous Materials



Map 17: Annual Shipments of Sodium Cyanide

## Sodium Hydroxide

Also commonly known as “caustic soda,” sodium hydroxide is a dark, thick liquid that is denser than water. Contact may severely irritate skin, eyes, and mucous membranes.

### *Health Hazards*

Sodium hydroxide causes severe burns of eyes, skin, and mucous membranes. While the substance itself does not burn, it may decompose upon heating to produce corrosive and/or toxic fumes.

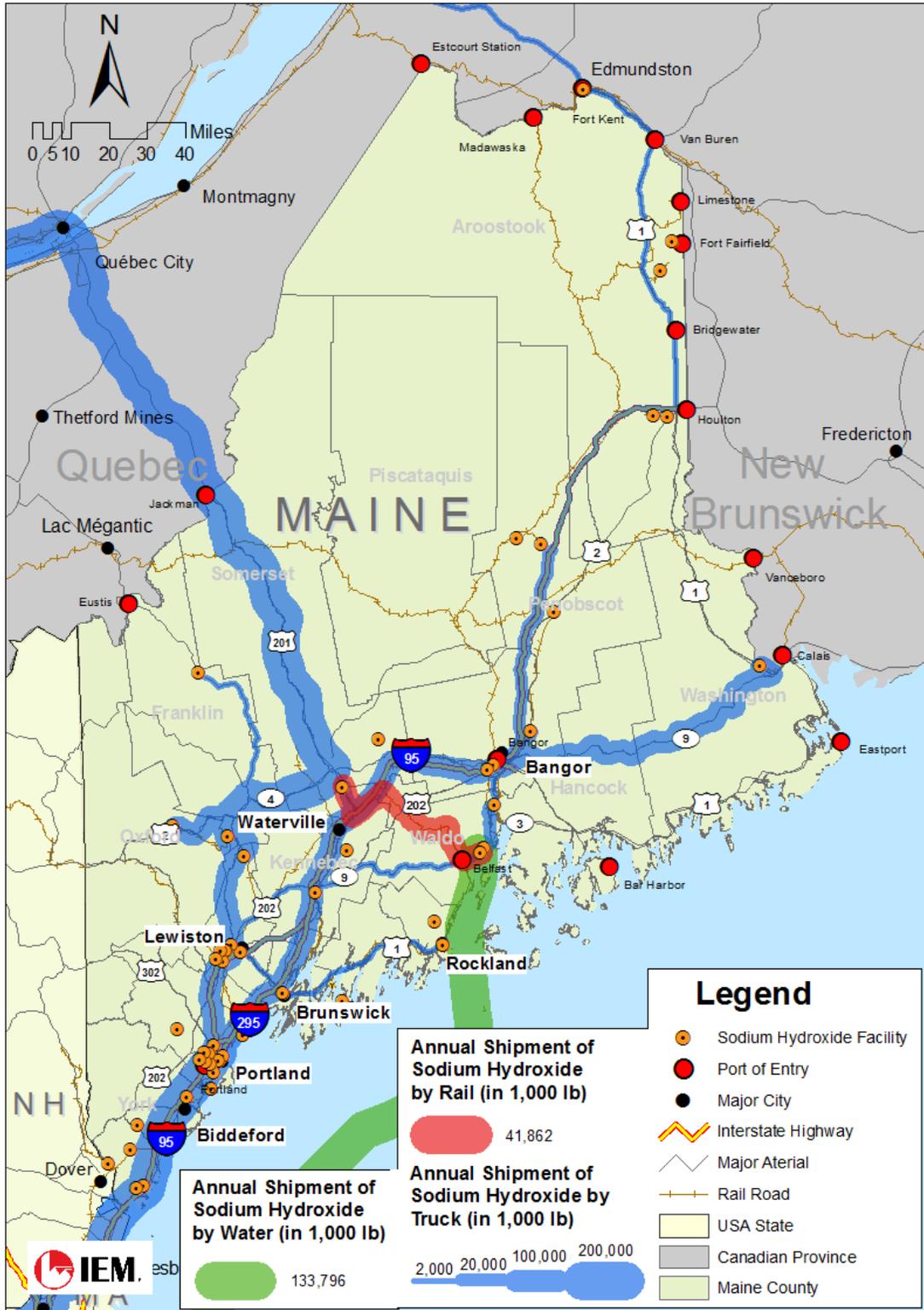
### *Fire Hazards*

Contact with metals may evolve flammable hydrogen gas. Containers may explode when heated. If a tank, rail car or tank truck is involved in a fire, isolate for 800 meters (half a mile) in all directions; also, consider initial evacuation for 800 meters in all directions. For small fires, use dry chemical, CO<sub>2</sub> or water spray. For large fires, use chemical, CO<sub>2</sub>, alcohol-resistant foam, or water spray. Move containers from fire area if it can be done without risk. Dike fire-control water for later disposal; do not scatter the material.

### *Transportation*

Sixty-five facilities reported storage of sodium hydroxide in 2014. These facilities received more than 506 million pounds of this chemical in 8,400 shipments. Two facilities were chemical wholesalers. One facility reported manufacturing the chemical onsite, but the rest received shipments by truck tank trailer. One facility received 86 rail cars of the chemical. These facilities are in the paper and fiber, energy, wastewater treatment, semiconductor, food production, laboratory, metal plating, chemical manufacturing, and beverage bottling industries. During the year ending February 2014, more than 241 million pounds of sodium hydroxide were imported into Maine in 364 tank truck shipments through Jackman, and just more than 239 million pounds were imported in 18 shipments into the port of Bangor/Belfast by ship.

Maine Commodity Flow Study of Hazardous Materials



Map 18: Annual Shipments of Sodium Hydroxide

## Sulfuric Acid

Sulfuric acid is a colorless oily liquid that is soluble in water with the release of heat. It is corrosive to metals and tissue. It will char wood and most other organic matter on contact, but is unlikely to cause a fire. It is used to make fertilizers and other chemicals, in petroleum refining, and in iron and steel production, among other uses.

### *Health Hazards*

Long-term exposure to low concentrations or short-term exposure to high concentrations can result in adverse health effects from inhalation. It is corrosive to all body tissues. Inhalation of vapor may cause serious lung damage. Contact with eyes may result in total loss of vision. Skin contact may produce severe necrosis. Between 1 teaspoonful and half an ounce of the concentrated chemical is fatal to an adult. Those with chronic respiratory, gastrointestinal, or nervous diseases and any eye and skin diseases are at greater risk.

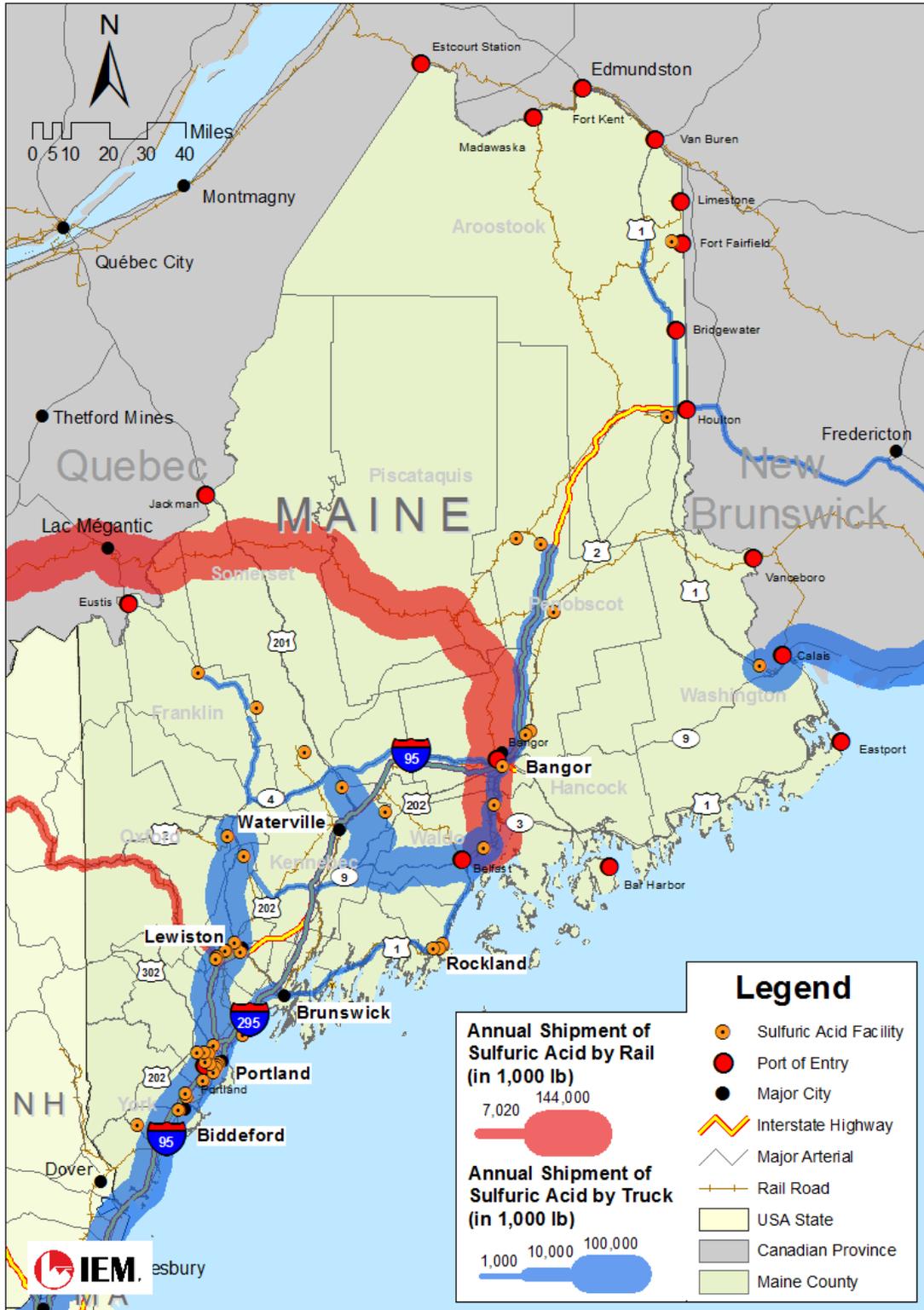
### *Fire Hazards*

Sulfuric acid is highly reactive and capable of igniting finely divided combustible materials on contact. When heated, it emits highly toxic fumes. Avoid heat, water, and organic materials. Sulfuric acid is explosive or incompatible with an enormous array of substances. It can undergo violent chemical change at elevated temperatures and pressure. Sulfuric acid may react violently with water. When heated, it emits highly toxic fumes. Hazardous polymerization may not occur.

### *Transportation*

In Maine, 430 facilities store sulfuric acid, 250 of which in lead-acid batteries. Of these, 190 are cell phone towers or repeaters; the rest are batteries for fork lifts, equipment, or vehicles. Only 1 wholesale chemical distribution facility receives sulfuric acid in rail tank cars 77 times per year, totaling more than 15.25 million pounds of acid. A second wholesaler and 26 other facilities ship or receive just more than 1.4 million pounds by truck or tank trailer in more than 4,000 shipments. These include large industrial facilities such as paper mills, utilities, and semiconductor manufacturers. Close to 31 million pounds is imported from Canada via 400 tanker truck shipments at Calais, 250 rail cars via Van Buren, 75 rail cars via Jackman, and 12 rail cars via at an unknown entry point.

Maine Commodity Flow Study of Hazardous Materials



Map 19: Annual Shipments of Sulfuric Acid

## Composite Flow Map

The composite flow map (Map 20) combines the flows for all 17 priority chemicals (Map 3 through Map 19) into one map that identifies the EHS routes within the state of Maine. The legend depicts by which mode HazMats are transported.

# Maine Commodity Flow Study of Hazardous Materials



Map 20: Composite Flows of Priority Hazardous Materials in Maine

## Identification of Hazard Receptors

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Four types of hazard receptors were identified for this study: the population at large, sensitive populations, critical infrastructure, and sensitive environments. Each is described briefly below; Table 7 summarizes sensitive population, critical infrastructure, and sensitive environmental receptors.

### Population

The population estimate for Maine in 2014 is 1,330,089 people.<sup>5</sup> A total of 399,342 people or 26 percent of the state population lives within the half-mile hazard buffers surrounding the HazMat corridors for priority chemicals in this study.

**Table 7: Sensitive Receptors and Critical Infrastructure**

Sensitive Population Receptors	Critical Infrastructure Facilities	Sensitive Environmental Receptors
Correctional facilities	Emergency services locations (e.g., police, fire, emergency medical services)	Agriculture
Employers with more than 250 employees	Utility companies	Aquaculture
Hospitals	Transportation centers (e.g., train stations, bus stations, airports, ports)	Public water intakes, wells, and reservoirs
Nursing homes and other elder-care facilities	Tunnels, bridges, and other critical transportation assets	Sensitive habitats
Schools (public and private)	Military bases and armories	Aquifers
Public gathering places for more than 250 people (e.g., shopping centers, places of worship, colleges and universities)	Nuclear power plants	Wetlands

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<sup>5</sup> US Census QuickFacts for Maine, 2014 population estimate, <http://quickfacts.census.gov/qfd/states/23000.html>

Sensitive Population Receptors	Critical Infrastructure Facilities	Sensitive Environmental Receptors
Emergency services locations (e.g., police, fire, emergency medical services)	Emergency operations centers	
Mental health facilities	Tier II facilities	
Childcare facilities		

## Sensitive Populations

During the course of this study, IEM identified 1,443 sensitive population receptors, defined as any group or gathering of people that are significantly or totally dependent on others for decisions pertaining to well-being, are critical community resources, are especially sensitive to chemical exposures, or are difficult to evacuate or shelter. The following locations were included as sensitive populations:

- **Correctional facilities:** These sites are difficult to evacuate, especially those that are larger and intended to house inmates for extended periods. Evacuating these facilities takes extensive specialized resources and manpower and may take days to accomplish.
- **Employers with more than 250 employees at a given site:** Large employer sites are difficult to evacuate quickly.
  - **Note:** Though many large employers in Maine have work locations for smaller numbers of employees, only those work locations with more than 250 employees onsite are included in this study and indicated on the maps.
- **Hospitals:** Many hospital patients are too ill or involved in some kind of medical procedure (e.g., surgery, other medical treatments) to be moved easily or quickly. Patients are admitted to hospitals because they need the active and specialized resources a hospital offers, and this specialized care is challenging to maintain in the event of movement of patients. Evacuating the medically fragile also requires specific resources, including equipment and trained manpower, and significant lead time, sometimes as much as weeks in advance. In all events, the potential to cause harm to patients during a move is always prevalent; in a HazMat emergency, moving patients should be avoided if at all possible.
  - Nursing homes pose many of the same challenges as hospitals in a HazMat event.
  - No data was available for special needs facilities with more than 25 beds.
- **Public and private schools:** Children in general have an increased sensitivity to exposure to many of the chemicals reviewed for this study. As with hospitals and nursing homes, significant time and resources are needed to evacuate a school.
- **Public gathering places with the capacity to hold more than 250 people:** This includes shopping centers, hotels, places of worship, community centers, and colleges and universities. The sheer number of people involved during a HazMat emergency presents significant challenges to protecting this population.
  - **Note:** Public gathering places are identified and mapped, but no data is available on the capacity of these locations.

## Critical Infrastructure

IEM identified 441 critical infrastructure receptors in the state. This category includes fire, police, and medical facilities; utility companies; transportation facilities (e.g., train stations, airports); armories; military bases; ports; and Tier II facilities.

## Sensitive Environmental Receptors

Sensitive environmental receptors are those environmental resources in a community that can be harmed or are particularly sensitive to HazMat exposure or contamination. They include a diverse set of resources that are needed to support human society or are valued economic or natural resources:

- Agriculture, e.g., farms, orchards
- Aquaculture, e.g., fish farming
- Endangered species, e.g., roseate tern, piping plover
- Public water intakes, wells, and reservoirs
- Sensitive habitats, e.g. beaches and seashores; rivers, lakes, and other freshwater water bodies; forests, grasslands, and other wildlife habitats
- Aquifers
- Wetlands
  - Freshwater wetlands, e.g., swamps, marshes, bogs
  - Coastal wetlands, e.g., tidal and sub tidal lands

## Findings and Recommendations

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### Overview

This section presents study findings and recommendations. Table 8 summarizes the general population, sensitive populations, critical infrastructure, and sensitive environmental receptors to be found along the half-mile corridors surrounding priority HazMat transport routes in Maine. Totals include the number of receptors or, in the case of wetland and agriculture areas, total affected acreage. For the purposes of this study, agriculture land includes all agricultural land combined regardless of crop.

County profile maps in Appendix B and urban profile maps in Appendix C show hazard receptors along the half-mile HazMat transport corridors.

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**Table 8: Impacted Sensitive Populations and Sensitive Environmental Receptors**

County	Total Hazard Corridor Population	Sensitive Population Receptors	Critical Infrastructure Receptors	Sensitive Environmental Receptors					
				Aqua-culture Sites	Aquifers	Water* <sup>6</sup>	Habitat (acres)	Agriculture Area (acres)	Wetland Area (acres)
Androscoggin	48,415	117	30	0	98	51	2,203	7,313	9,984
Aroostook	20,461	87	20	0	80	43	2,958	22,250	15,119
Cumberland	86,661	300	53	1	38	23	3,459	4,167	17,009
Franklin	12,714	47	23	0	159	32	3,334	5,368	7,982
Hancock	6,518	45	18	0	16	29	3,914	1,932	6,334
Kennebec	42,919	117	45	0	65	46	3,101	13,587	18,374
Knox	12,780	75	16	0	0	14	518	1,470	20,559
Lincoln	4,955	42	18	3	5	28	1,860	1,383	5,804
Oxford	11,867	51	23	0	236	32	388	3,389	5,832
Penobscot	60,420	174	57	0	162	43	18,903	7,545	40,989
Piscataquis	3,341	9	10	0	30	10	3,496	910	11,335
Sagadahoc	13,645	41	14	0	5	12	1,844	2,659	5,550
Somerset	17,923	74	21	0	120	37	5,311	10,797	22,313
Waldo	12,665	70	34	0	33	36	4,240	6,130	23,981
Washington	6,391	35	32	1	67	47	8,085	4,215	15,407
York	37,669	159	27	2	22	30	1,061	2,413	8,810

<sup>6</sup> "Water" includes public drinking water (wells, surface intakes, reservoirs)

## Findings

### *Hazardous Materials Transport*

- Crude oil is the highest volume HazMat transported in Maine from South Portland to Montreal by pipeline and to the oil refinery in St. John, New Brunswick, by rail, for a total of 1.8 trillion pounds.
- Ethanol is the second highest volume HazMat transported to Maine by barge and throughout Maine by truck for blending and transport to retail gas stations for a total of 1.6 billion pounds.
- Sodium hydroxide is the third highest volume HazMat transported in Maine by rail, motor carrier, and barge for a total of 446 million pounds.

### *Population*

- Cumberland County has the highest population within the half-mile hazard corridors at 86,661 people, followed by Penobscot County at 60,420 people and Androscoggin County at 48,415 people.
- Piscataquis County has the lowest population within the half-mile hazard corridors at 3,341 people, followed by Lincoln County at 4,955 people and Washington County at 6,391.

### *Sensitive Population Receptors*

- Cumberland County has the highest number of sensitive population receptors within the half-mile hazard corridors at 300, followed by Penobscot County at 174 and York County at 159.
- Piscataquis County has the lowest number of sensitive population receptors at 9, followed by Washington County at 35 and Sagadahoc County at 41.

### *Critical Infrastructure*

- Penobscot County has the highest number of critical facilities at 57, followed by Cumberland County at 53 and Kennebec County at 45.
- Piscataquis County has the lowest number of critical facilities at 10, followed by Sagadahoc County at 14, and Knox County at 16.

### *Sensitive Environmental Receptors*

- Aquaculture sites within the half-mile hazard corridors are limited to Cumberland (1), Lincoln (3), Washington (1) and York (2) Counties.
- Aquifers: Oxford County has the highest number of aquifers within the half-mile hazard corridors at 236, followed by Penobscot County at 162 and Franklin County at 159.

## Maine Commodity Flow Study of Hazardous Materials

- Water intakes: Public drinking water sites within the half-mile hazard corridors include wells, surface intakes, and reservoirs. Androscoggin County has 51 public water sites, followed by Washington County at 47 sites and Kennebec County at 46 sites.
- Wildlife habitat: Penobscot County has by far the largest wildlife habitat area within the half-mile hazard corridors at 18,903 acres, followed by Washington County at 8,805 acres and Somerset County at 5,311 acres.
- Agriculture areas: Aroostook County has the most agricultural area within the half-mile hazard corridors at 22,250 acres, followed by Kennebec County at 13,587 acres and Somerset County at 10,797 acres.
- Wetlands: Waldo County has the most wetlands area within the half-mile hazard corridors at 23,981 acres, followed by Somerset County at 22,313 acres and Knox County at 20,559.

## Recommendations

IEM synthesized the results of the study to recommend strategies for improving HazMat preparedness. These recommendations include the following:

- Emergency managers and local emergency planning committees (LEPCs) should work closely with HazMat facility managers to become familiar with how chemicals are transported in their counties. Particular attention should be paid to toxic inhalation hazards such as ammonia and chlorine.
- Local fire departments should tour HazMat chemical facilities at least annually to become familiar with plant operations and protocols.
- The evacuation versus shelter-in-place decision-making process should be fully documented in the concept of operations section of each county's HazMat annex.
- Local and regional responders need to enhance relationships with the major handlers of HazMats in their jurisdictions. HazMat facilities should be included in planning, training, and exercise opportunities.
- Local hospitals and healthcare facilities must also be included in planning, training, and exercise activities.

Once transportation and facility hazards have been identified, it is possible to conduct a HazMat risk assessment. Below are some suggested steps to accomplish this for priority urban areas where there are the most hazards and the most sensitive populations.

- Assign initial protection zones (IPZs) to each facility and corridor based on the longest IPZ for each source and map these IPZ zones.
- Collect chemical release statistics and conduct a release probability analysis
- Calculate release probabilities based on North American Industry Classification System (NAICS) codes that are assigned to every source.
- Identify consequence indicators: Determine and map as appropriate a set of consequence indicators that help define both risk and the mitigation actions necessary to reduce it and conduct a consequence assessment for each source.
- Conduct the risk assessment by combining the probability and consequence of a release for each source. Identify and prioritize high risk sources for each community.

## Maine Commodity Flow Study of Hazardous Materials

- Work with LEPCs, industry, transporters, first responders, and other stakeholders to identify mitigation strategies to reduce either or both the probability and consequences of a chemical release from priority high-risk sources and to identify and address gaps in response plans, capabilities, and resources.
- Conduct mitigation hierarchy and gap assessment: Integrate actionable mitigation strategies into facility response plans, state, and county hazard mitigation plans and state and county training and exercise plans. Include priority gaps in the state Threat and Hazard Identification and Risk Assessment completed for the U.S. Department of Homeland Security.
- Include local stakeholders in the mitigation assessment process.

### *Protection and Detection Zones*

This section supplements the risk assessment recommendation and provides additional background on the importance of protection and detection zones for planning purposes.

The U.S. Department of Transportation (DOT) and Transport Canada produce and maintain the *Emergency Response Guidebook* (ERG) for first responders. This book contains recommendations for the ICS system to establish an isolation zone immediately surrounding a HazMat release; an area we have identified as the Isolation Protection Zone IPZ. The IPZs in the ERG are based on the level of concern for each chemical, modeling by the Sandia National Laboratory.

Most IPZ distances are in the 75- to 100-foot range, even for many extremely hazardous substances (EHS). Those EHS that are also toxic inhalation hazards (TIHs) are the exception; they generally have IPZs ranging from 100 to 3,000 feet. For example, chlorine has one of the longest IPZ distances at 1,500 feet.

There are three distances that are important to the Incident Commander (IC): the High Hazard Zone (HHZ), the Protection Zone (PZ) and the Detection Zone (DZ) (Figure 1). The HHZ is also considered the IPZ and represents the area surrounding the source where the responsible party and/or the population need to take immediate lifesaving actions, such as evacuation, and where sheltering would not be protective. This area would already be affected by the time first responders arrive, and protective actions would have to be self-initiated or automatic based on facility warning systems and/or community training. When first responders arrive on scene, they must rapidly isolate the release in all directions, regardless of wind direction.

The PZ is that area downwind where an exposure can surpass the level of concern and cause an adverse health impact or death but where sheltering in place can be effective for up to one and a half hours before the outdoor and indoor air concentrations of an airborne chemical equalize in most modern buildings. This area helps define the population at substantial risk if the release is not terminated within an hour and fifteen minutes. Sheltering in this area is only possible if the first responders arrive within 40 to 45 minutes and can take action to control the release within the remaining 20 to 35 minutes. This zone begins at the IPZ limit and extends outward from the source in all directions and stops where the DZ begins. Protective actions in this zone are effective including sheltering the population immediately downwind from the source and evacuating adjacent parts of the community using a keyhole evacuation approach.

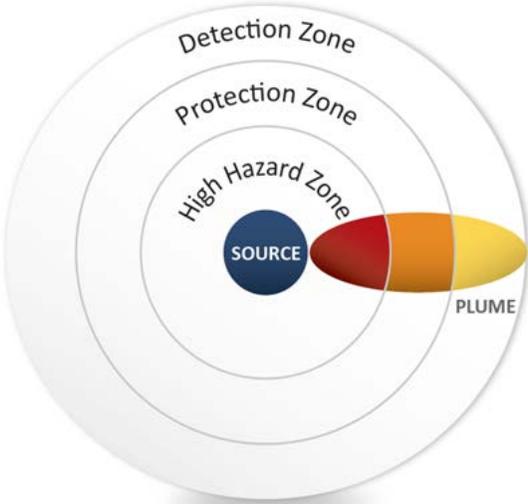


Figure 1: Hazardous Materials Hazard Zones

## Appendix A: Stakeholders and Facility Contacts

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**Table 9: Stakeholders**

Stakeholder	Advisory Committee Member
Maine Emergency Management Agency	Robert Gardner (207) 624-4400
Maine Emergency Management Agency	Faith Meyer (207) 624-4400
Maine Emergency Management Agency	Jon Burbank (207) 624-7278
Maine Emergency Management Agency	Mark Hyland (207) 624-4443
Maine Department of Environmental Protection— Response	Peter Blanchard (207) 287-7190
Sappi Fine Paper	Skip Pratt (207) 238-3129
Maine Department of Transportation	Dwight Doughty (207) 592-6646
Maine State Police	Shawn Currie (207) 624-8932

**Table 10: Railroad Facility Contacts**

Railroads	Contacts
New Brunswick & Maine Railways (NBM) (consisting of New Brunswick Southern Railway, Eastern Maine Railway, and Maine Northern Railway)	Coleen Gorman-Asal (506) 635-6673
Central Maine & Québec Railway (CMQ) (formerly Montreal, Maine and Atlantic Railway)	Tom Tardif (207) 848-4200 x4246
Genesee & Wyoming Inc. (G&W) (formerly St. Lawrence & Atlantic Railroad)	Jason Birkel (514) 273-4704

Maine Commodity Flow Study of Hazardous Materials

**Table 11: Hazardous Materials Facilities Contacts**

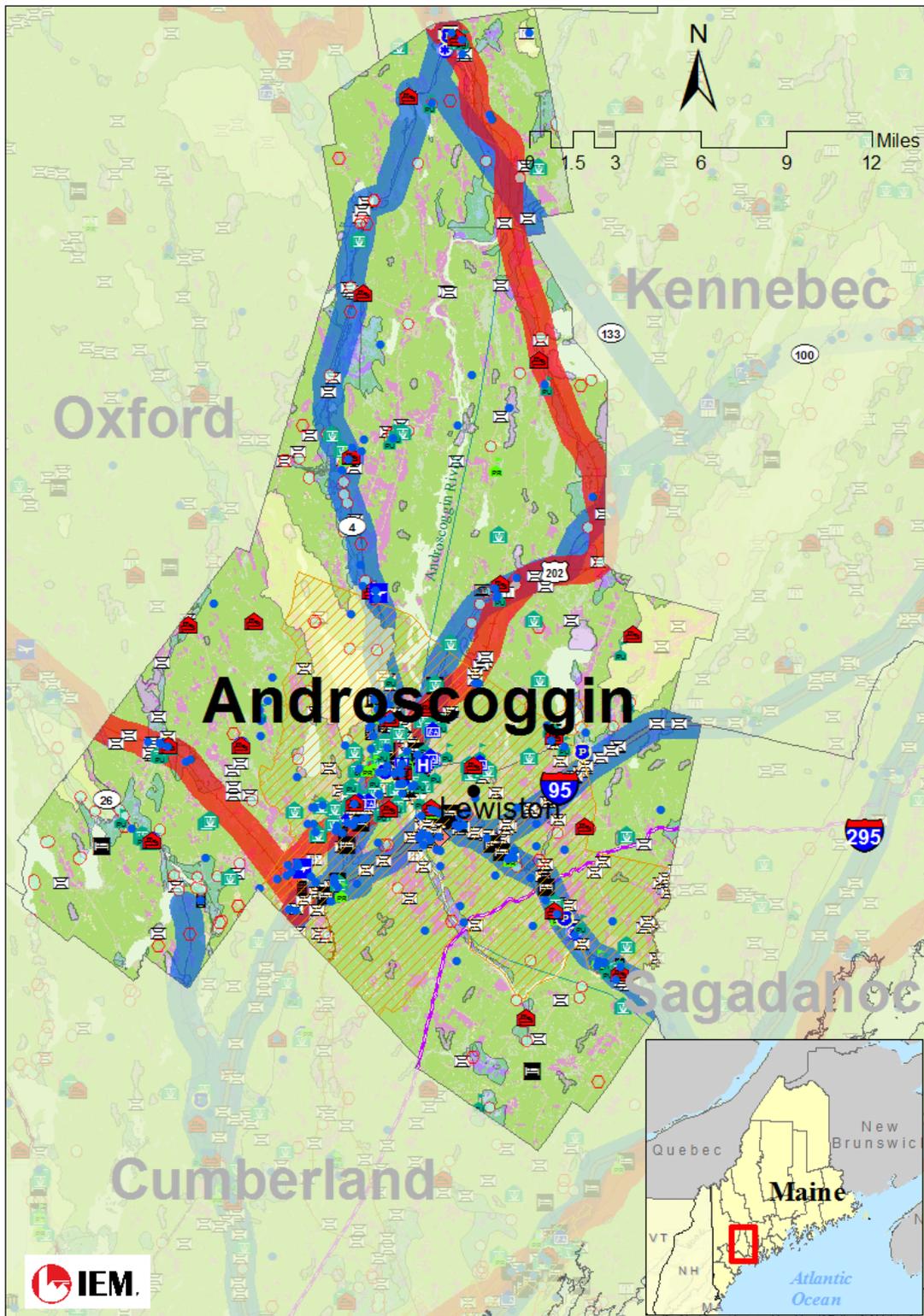
Hazardous Materials Facilities	Contacts
Citgo Terminal	Jack McCrossin (207) 799-3394
Gulf Oil Terminal	Terry Sullivan (207) 799-5561
Irving Oil	Drake Bell (506) 202-3000
Rumford Paper Co.	Scott Reed (207) 364-4521
Suburban Propane – Fairfield	Paul Saucer (800) 776-7263
Linde LLC	Steve Boyle (207) 439-2400
Maine Water Co – Biddeford Saco Div.	Stephen Cox (207) 282-1543
Penobscot McCrum LLC	Gregory Paul (207) 338-4360
GAC Chemical Co	David Colter (207) 548-2525

## Appendix B: County Profile Maps

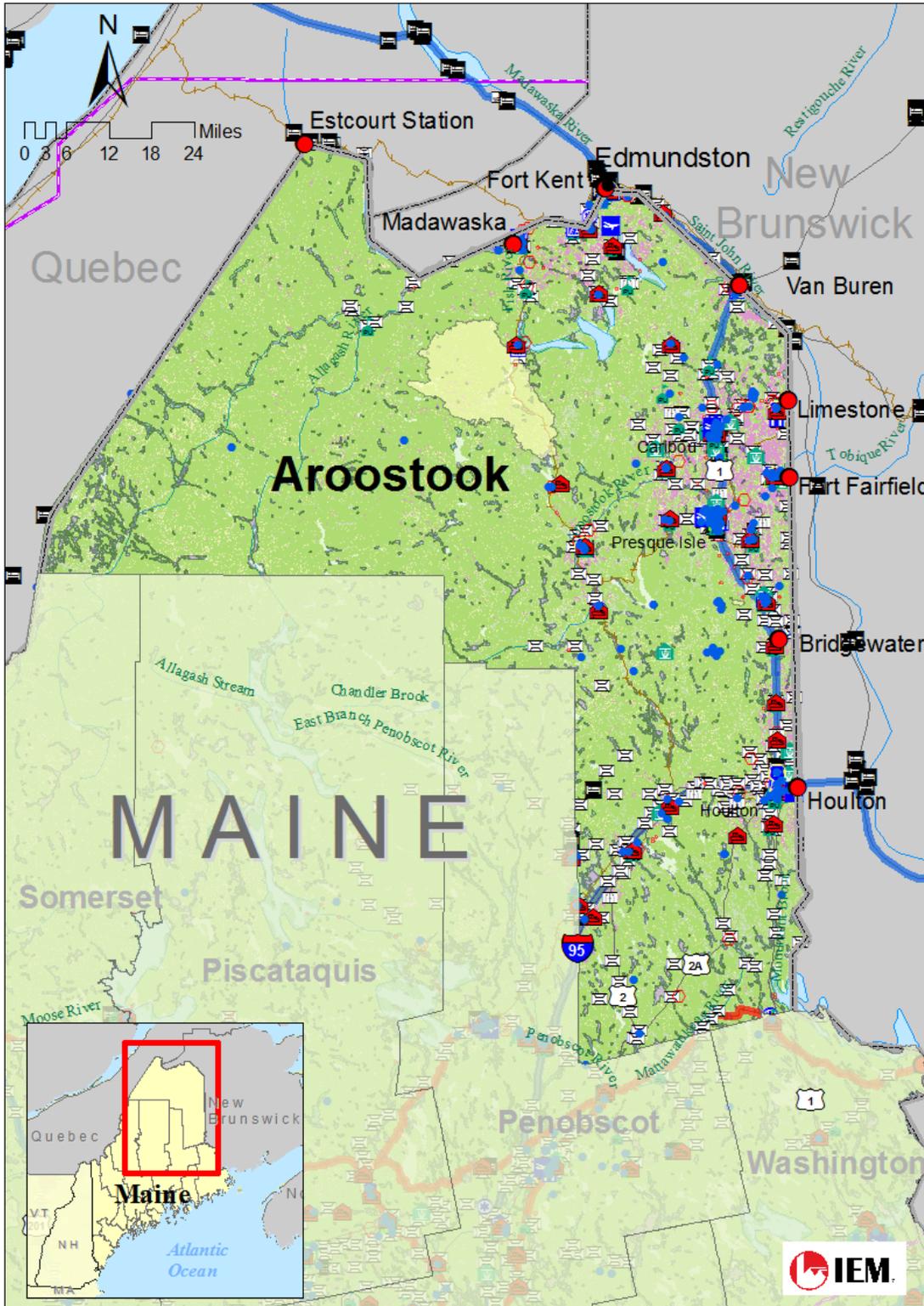
The following maps show, by county, hazard receptors (sensitive populations, critical infrastructure, and sensitive environmental receptors) along half-mile corridors around priority hazardous materials routes in Maine. Refer to the legend below for the maps' symbology.



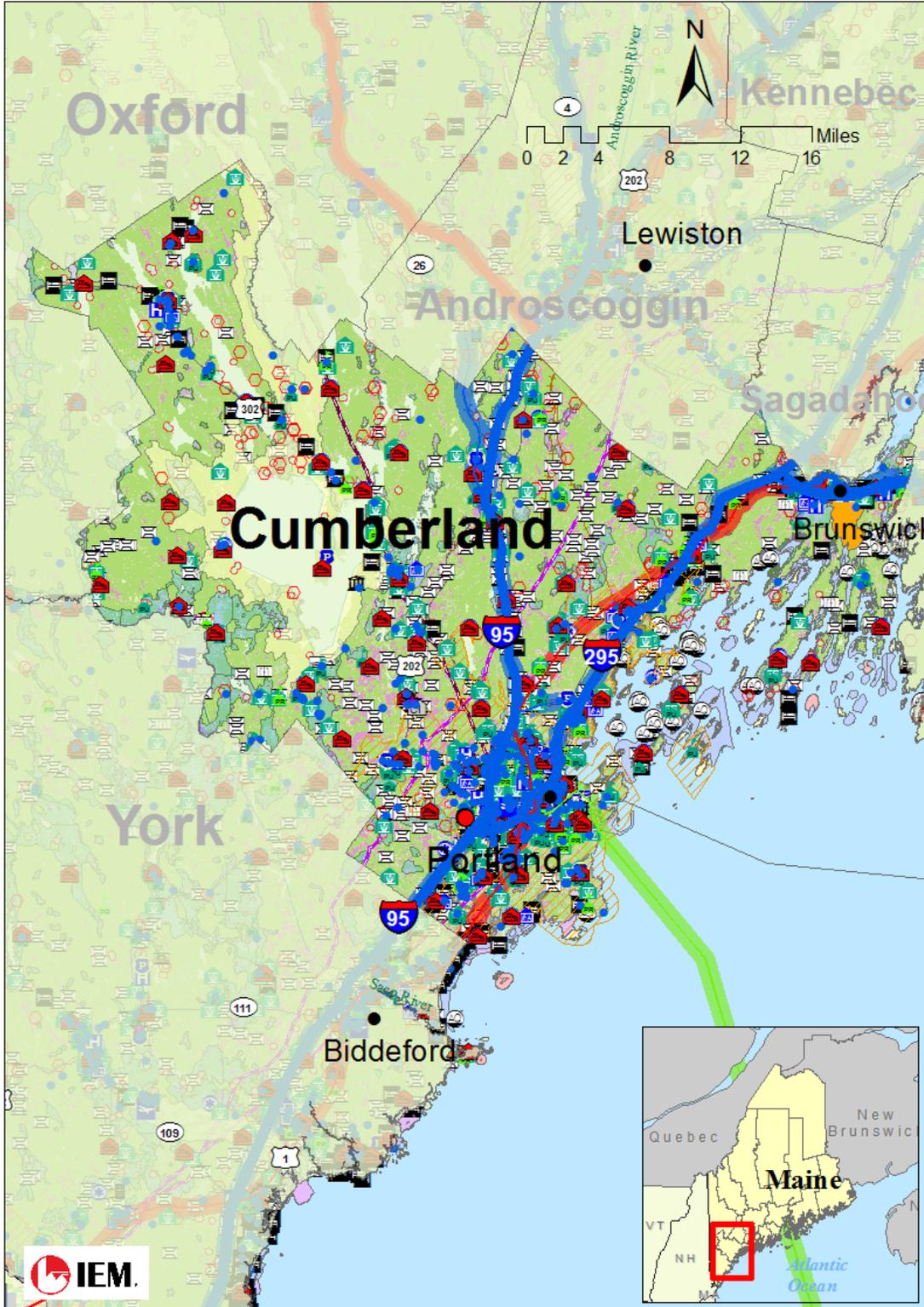
Maine Commodity Flow Study of Hazardous Materials



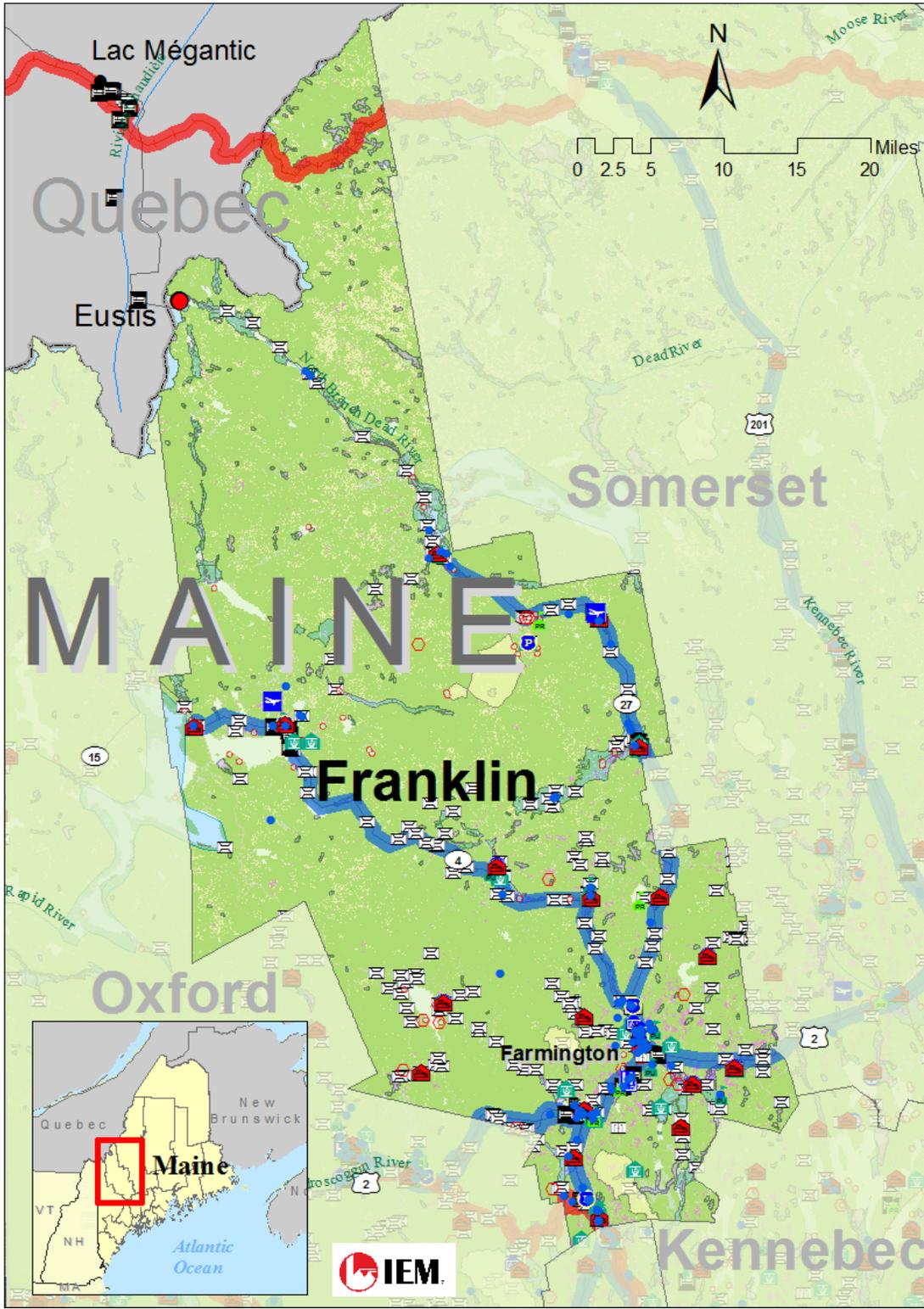
Map 21: Androscoggin County



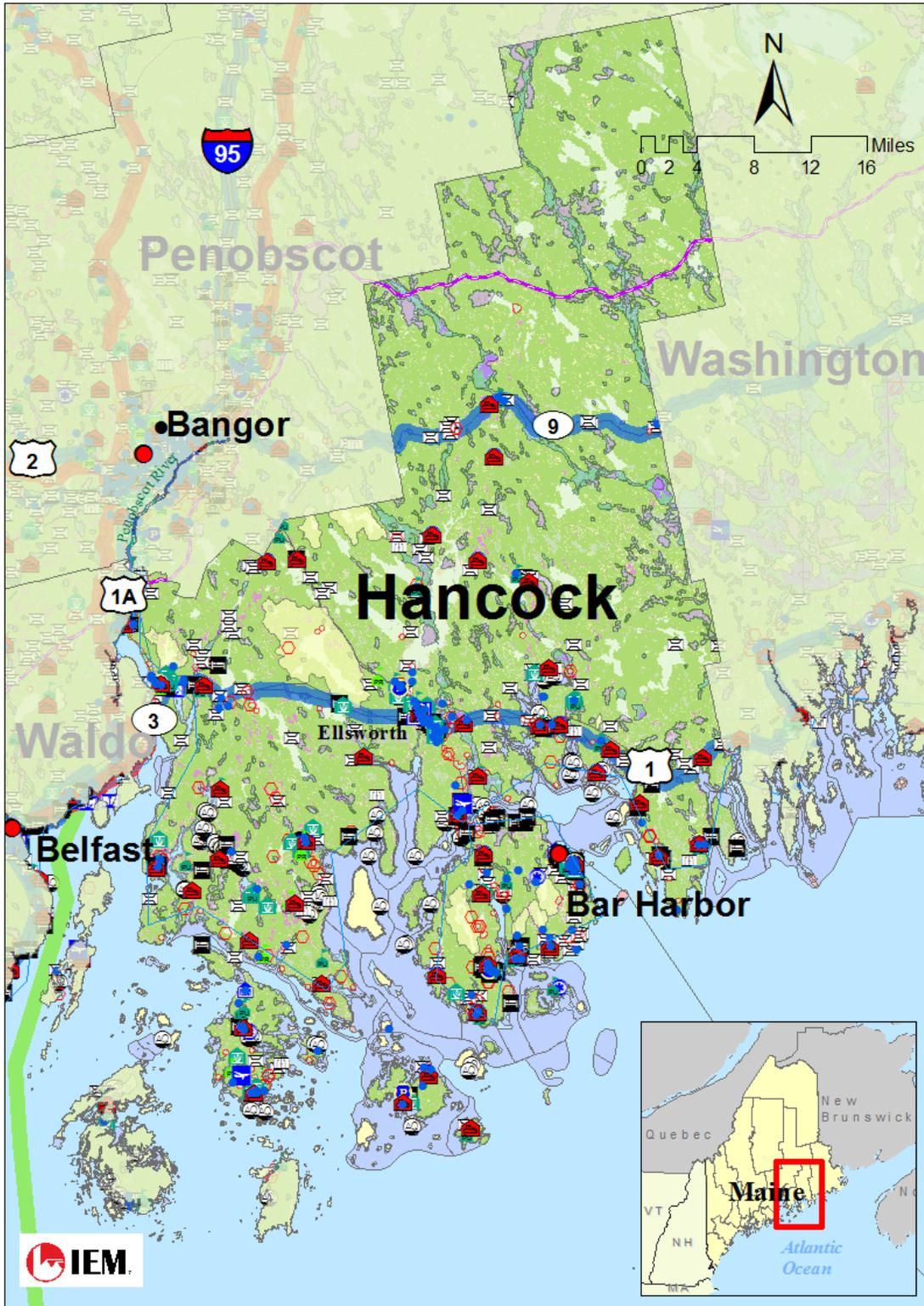
Map 22: Aroostook County



Map 23: Cumberland County

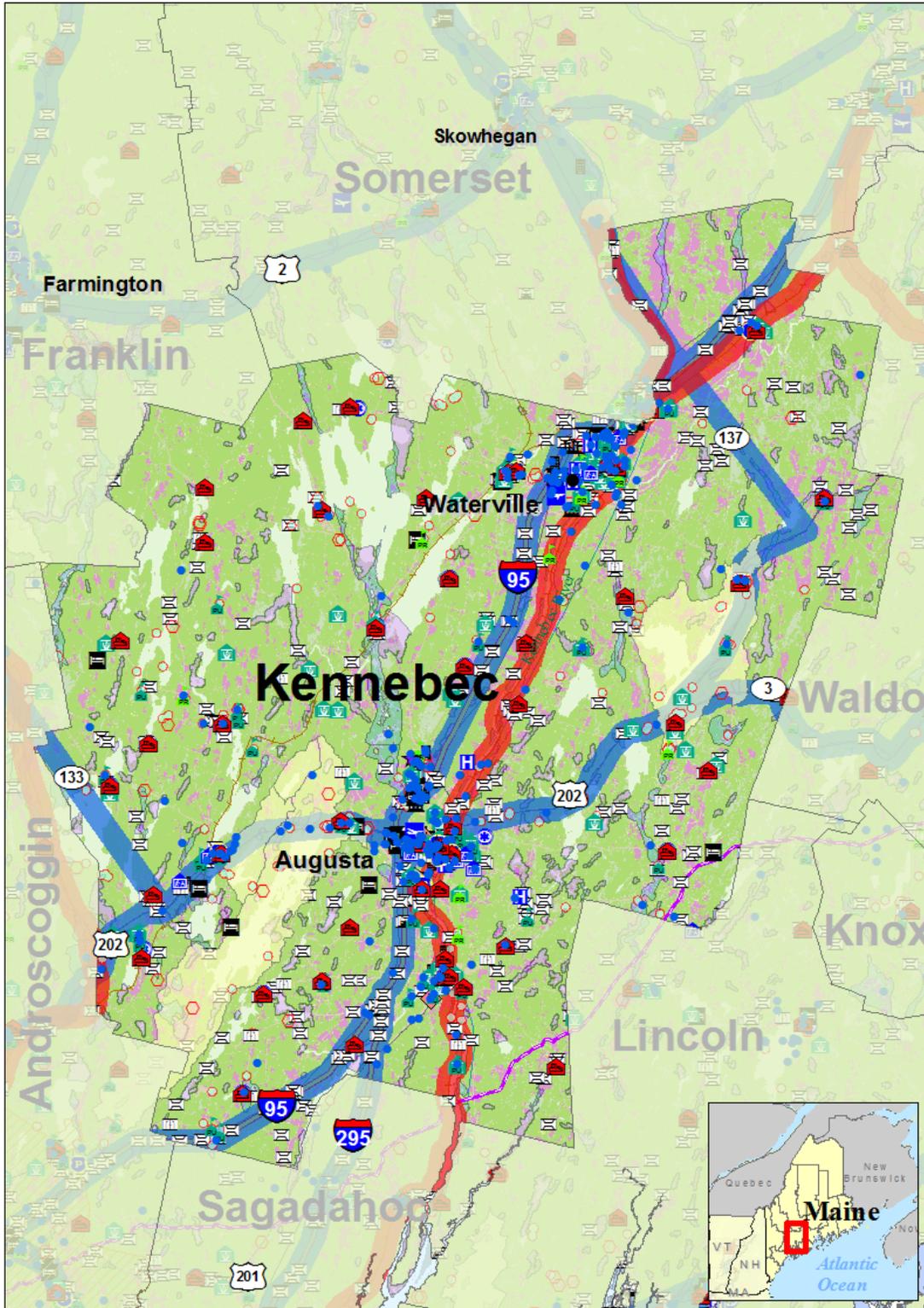


Map 24: Franklin County



Map 25: Hancock County

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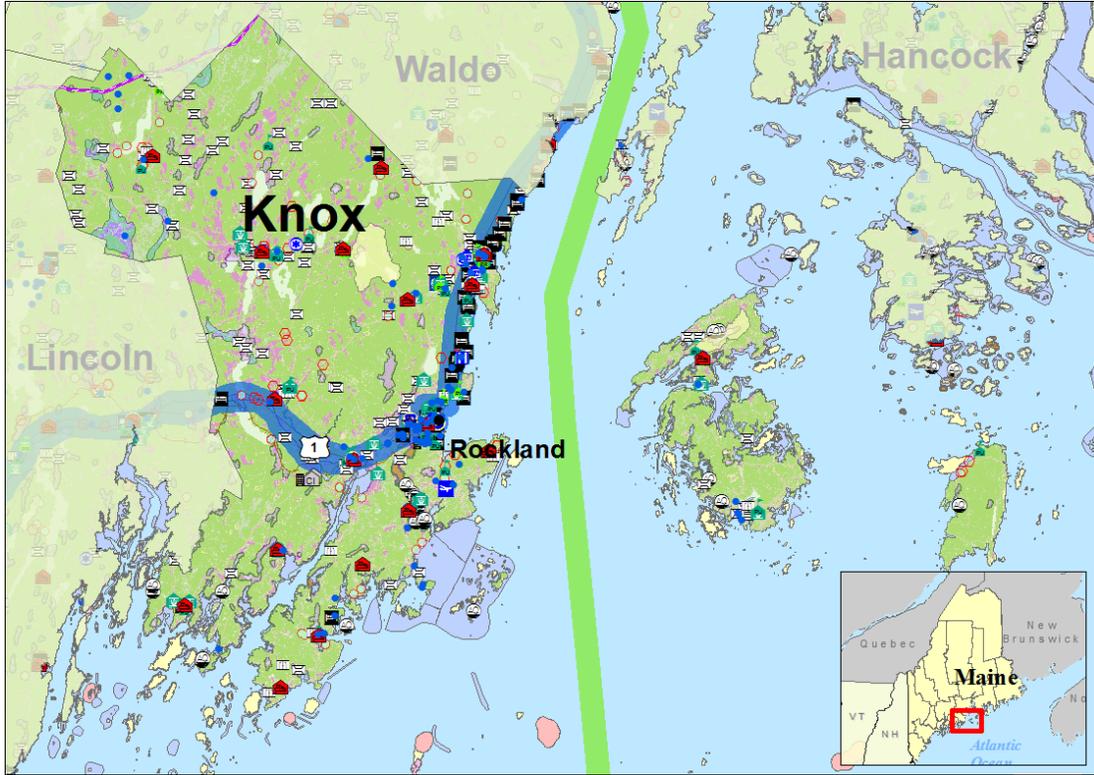
Map 26: Kennebec County

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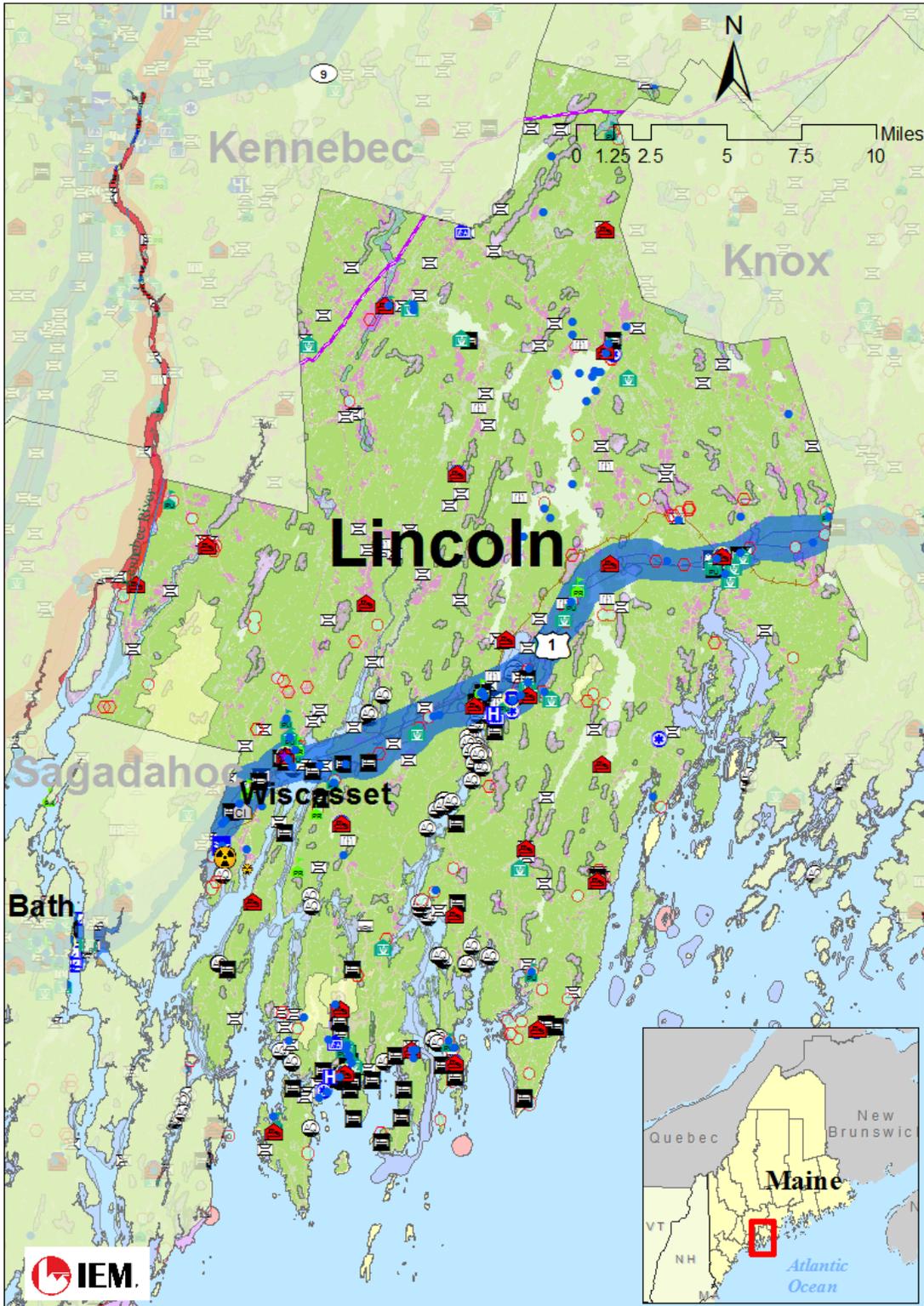


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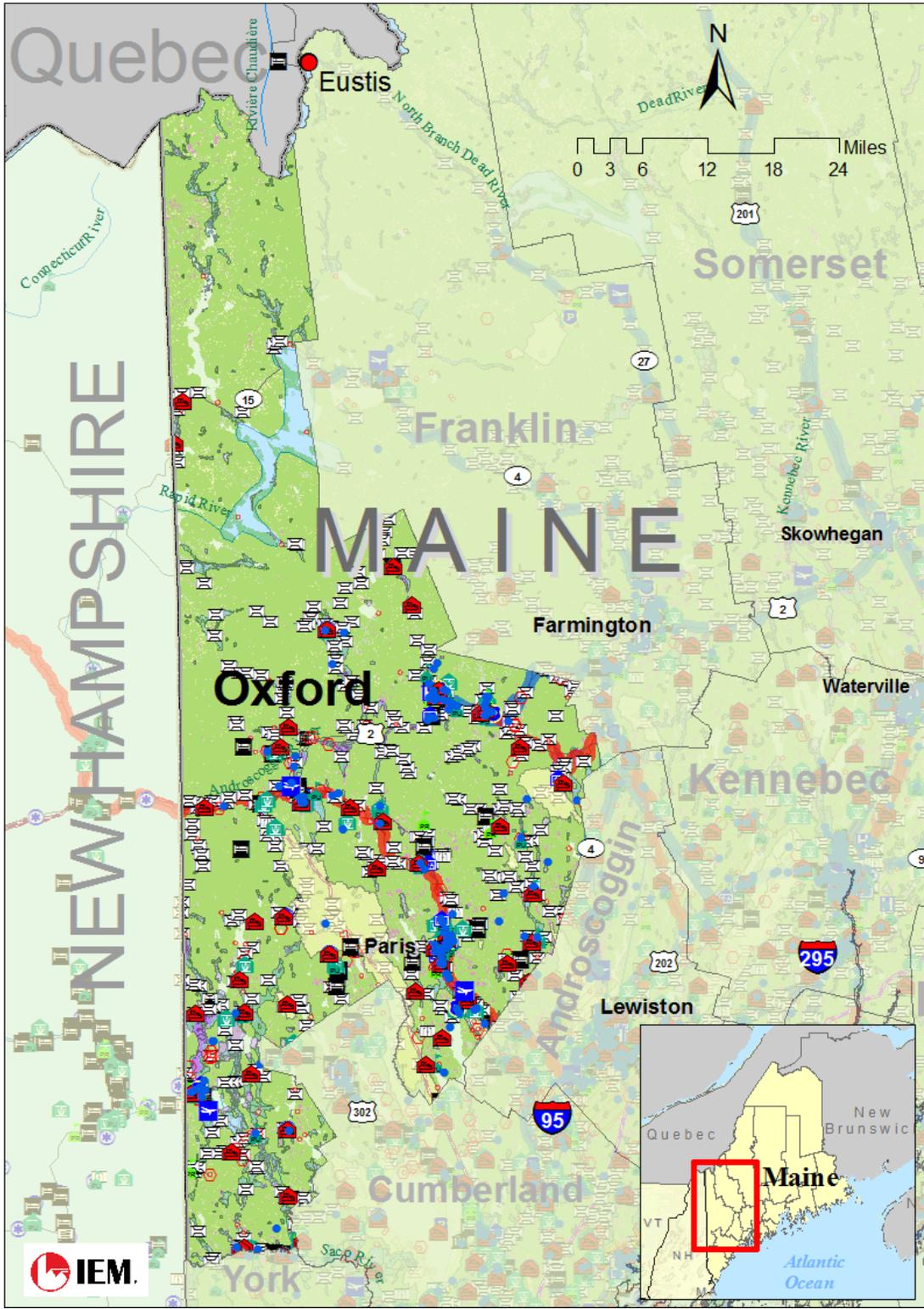
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Map 27: Knox County

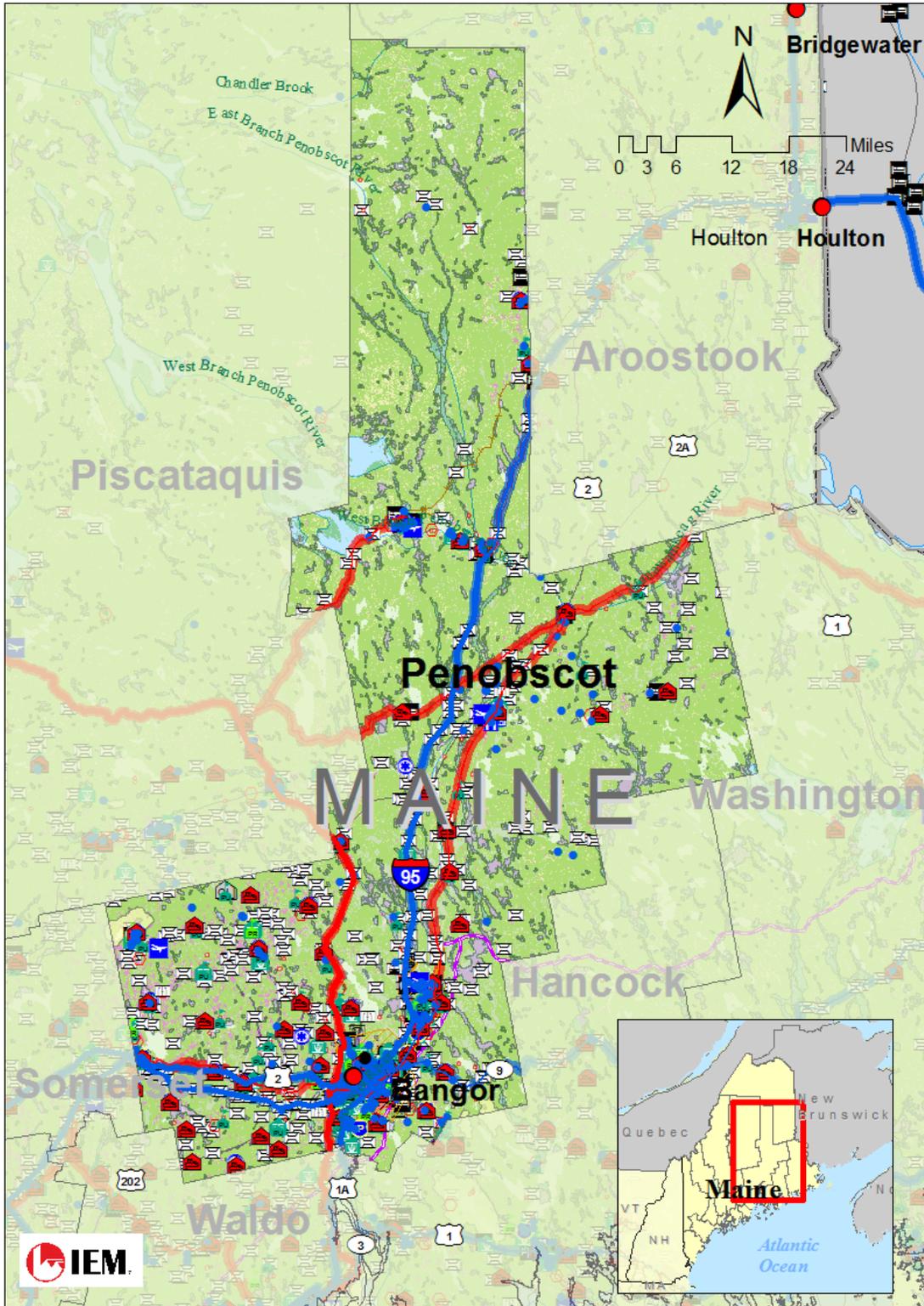


Map 28: Lincoln County



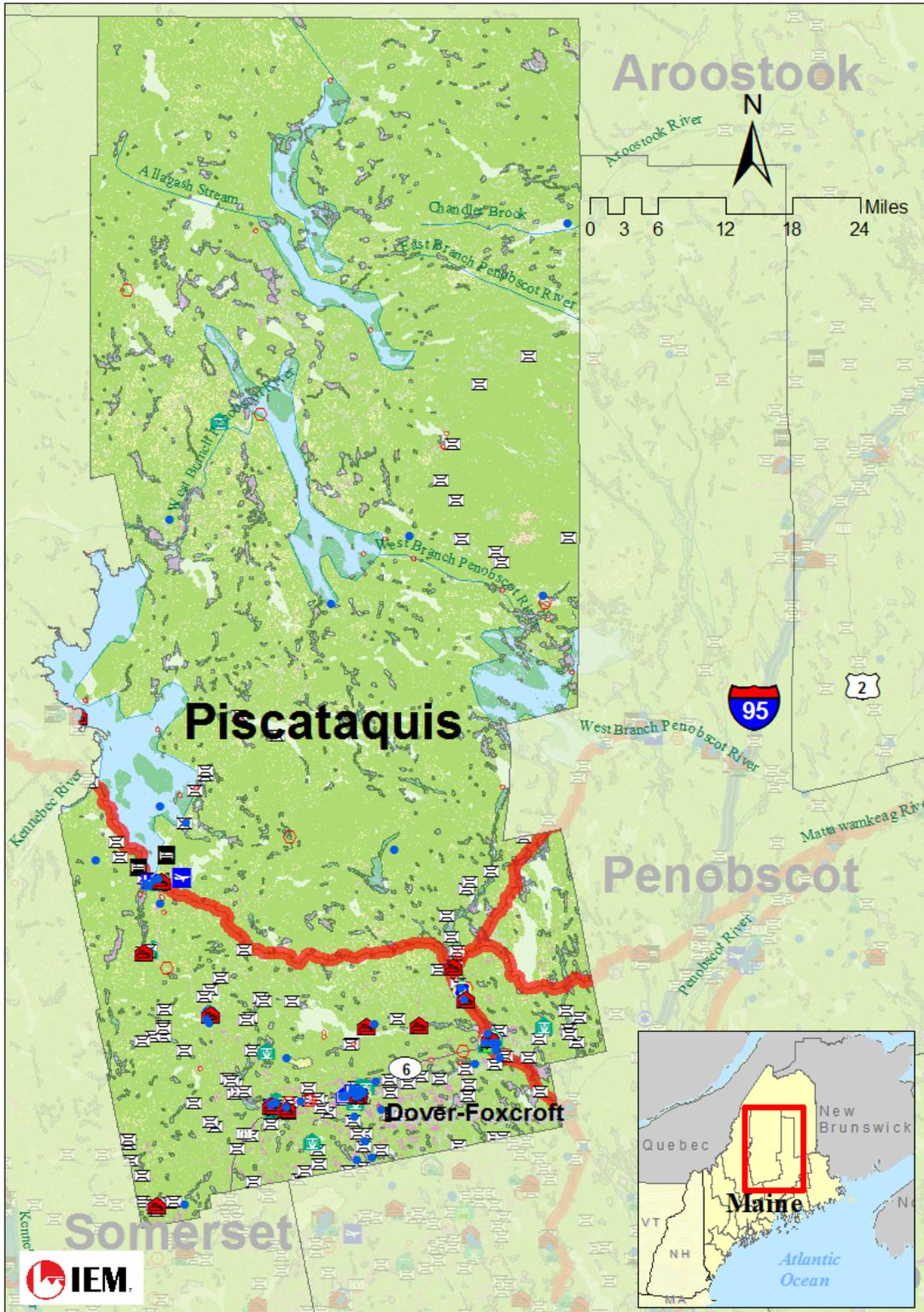
Map 29: Oxford County

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Map 30: Penobscot County

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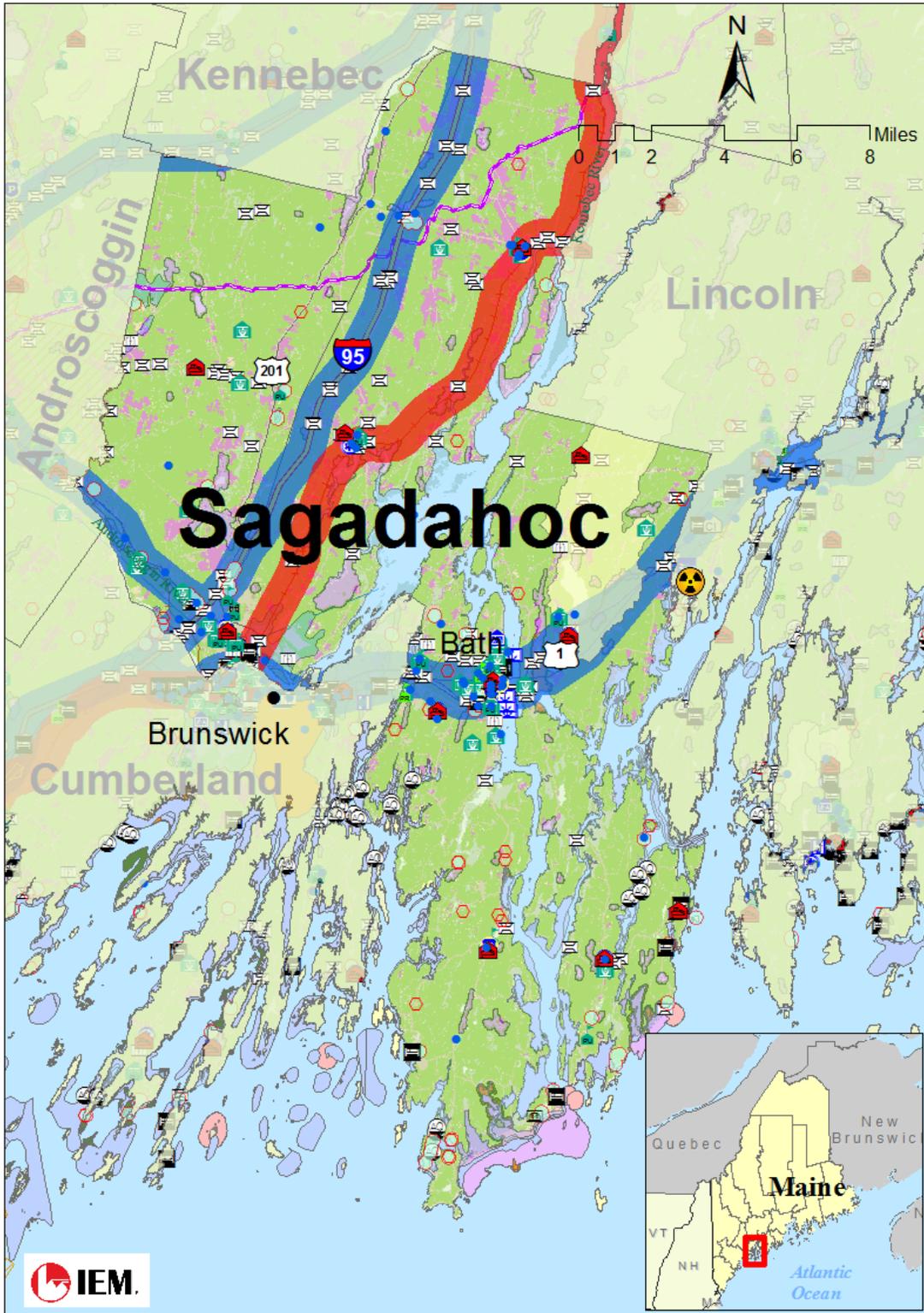


Map 31: Piscataquis County

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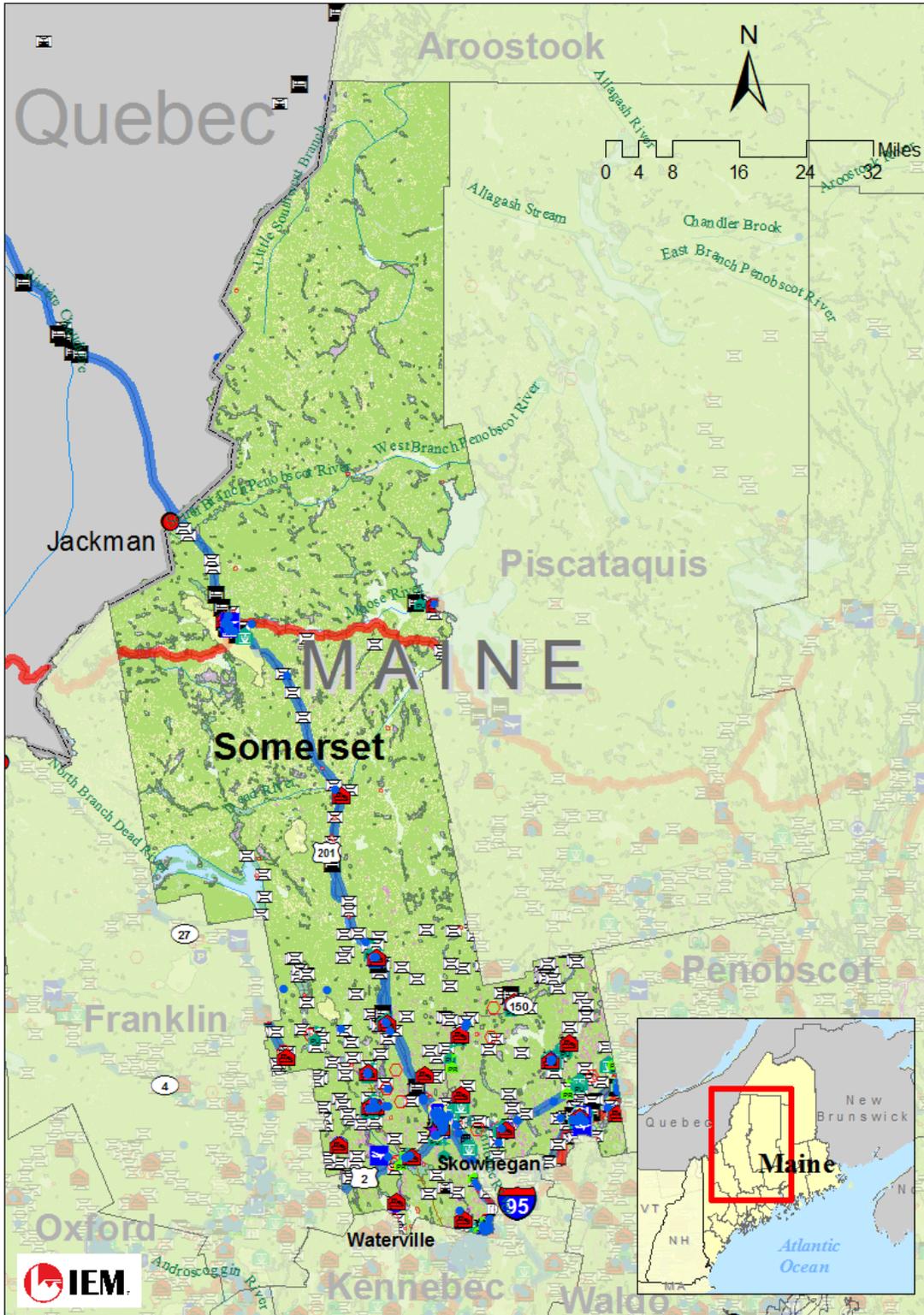


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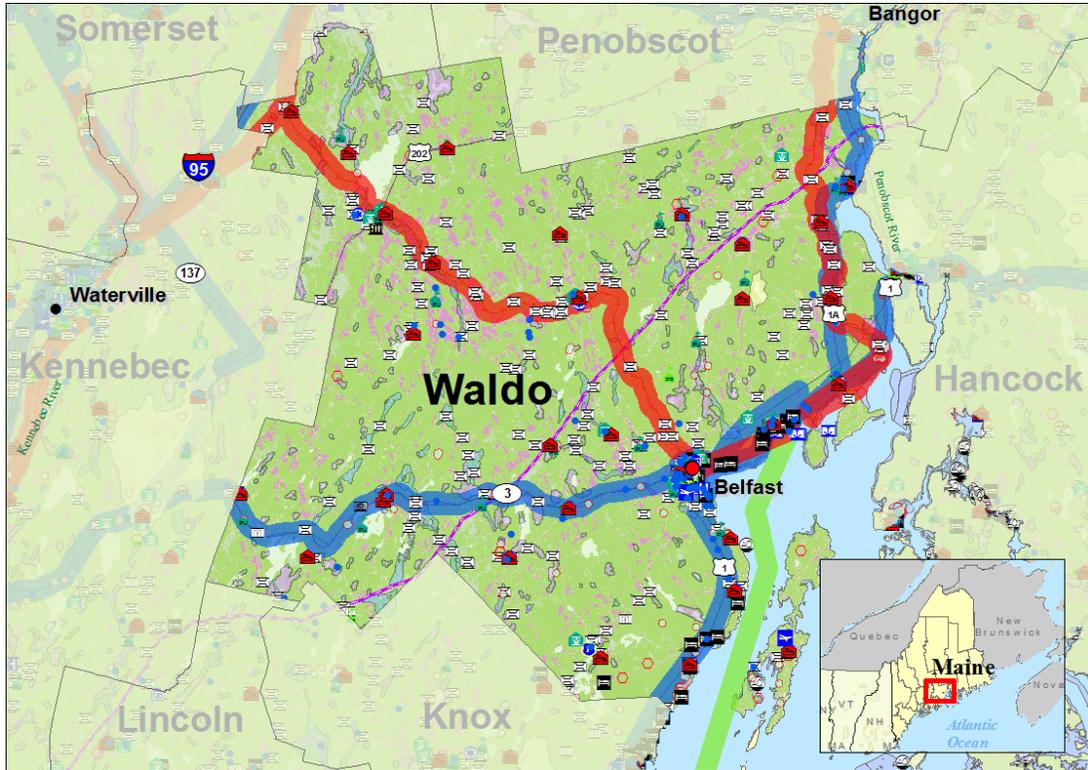
Map 32: Sagadahoc County

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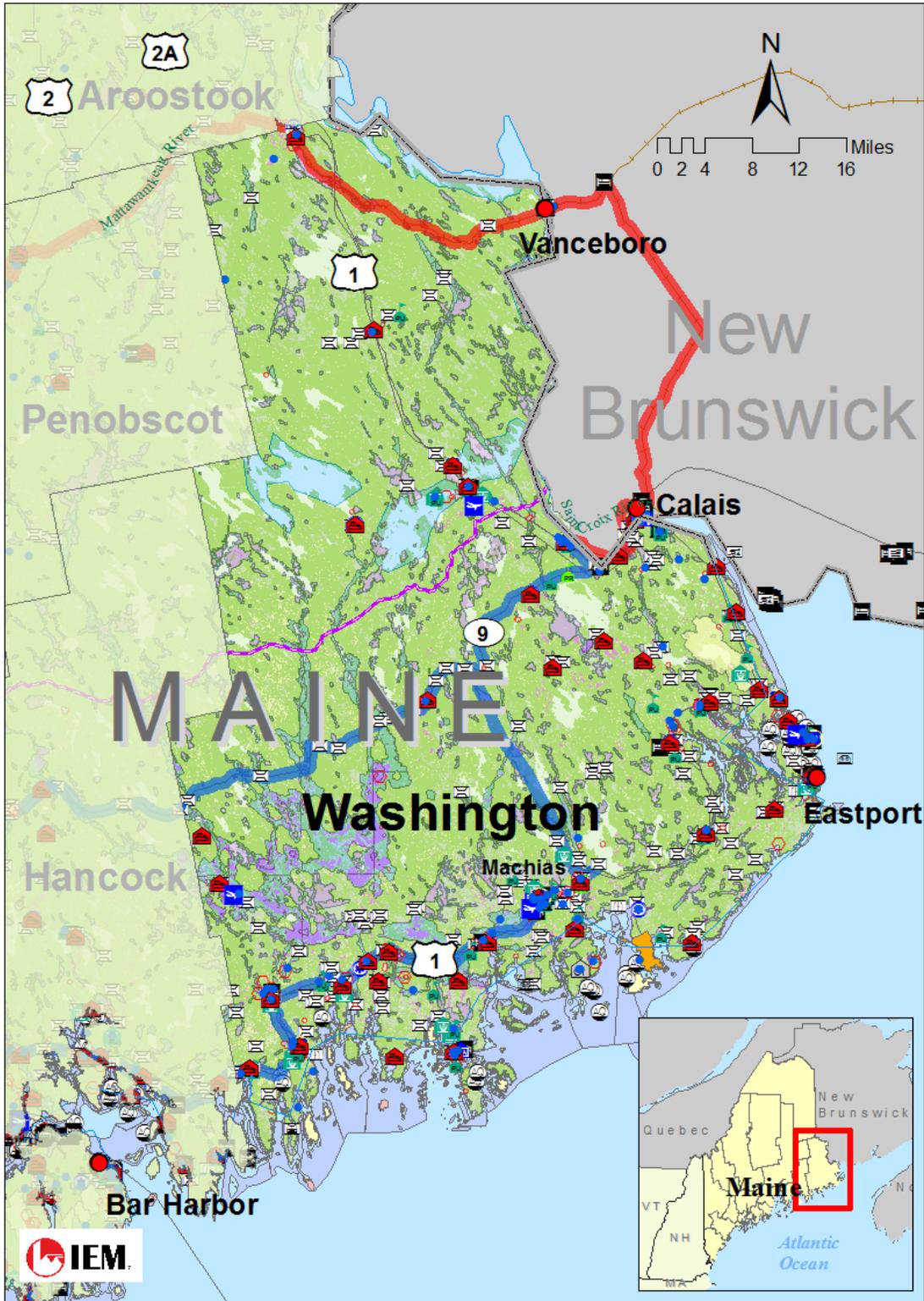
Map 33: Somerset County

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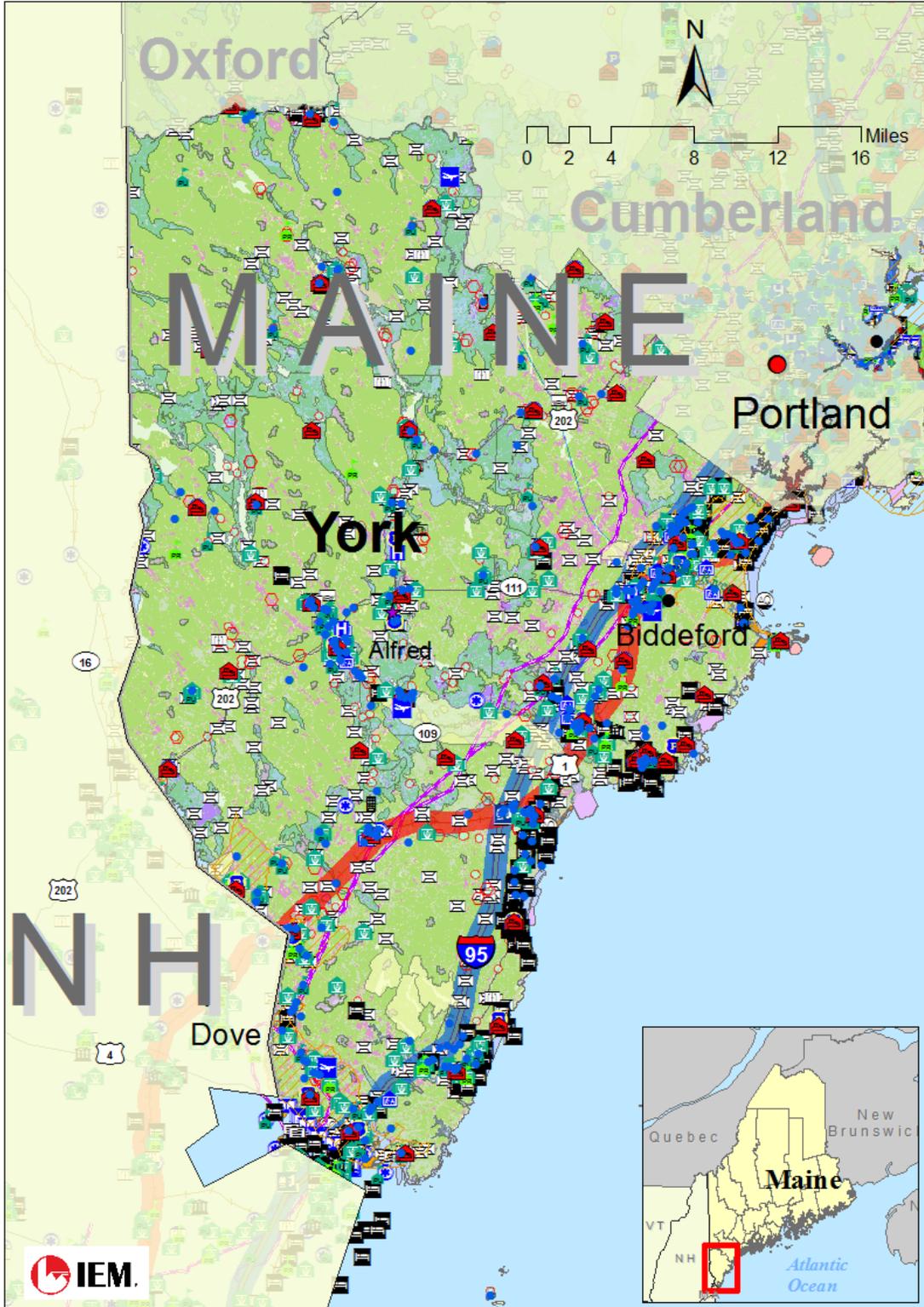
Map 34: Waldo County

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Map 35: Washington County

Maine Commodity Flow Study of Hazardous Materials



Map 36: York County

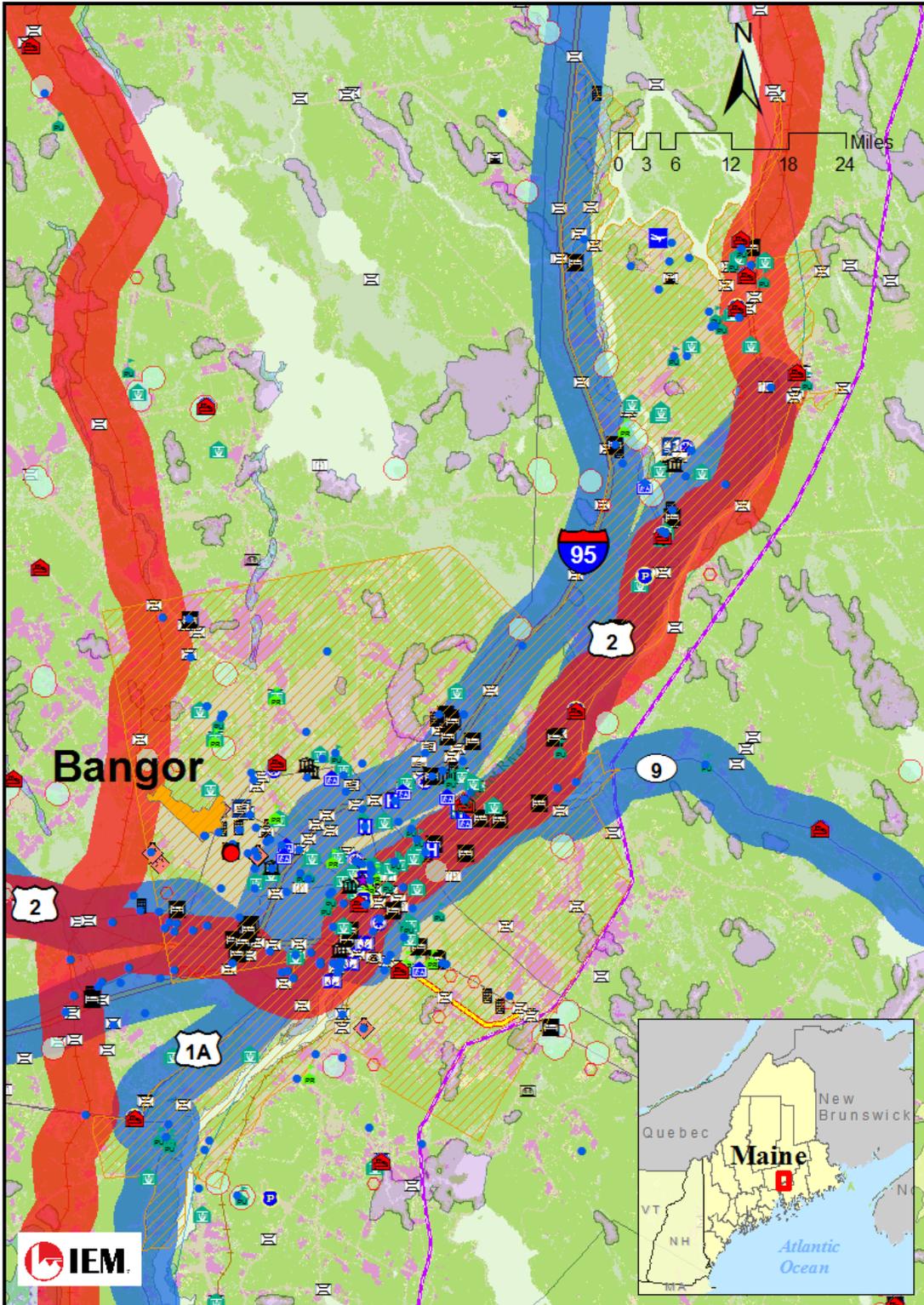
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## Appendix C: Urban Area Maps

The following maps show, by Metropolitan Planning Organization (MPO) area, hazard receptors (sensitive populations, critical infrastructure, and sensitive environmental receptors) along half-mile corridors around priority hazardous materials routes in Maine. Refer to the legend below for the maps' symbology.



Maine Commodity Flow Study of Hazardous Materials



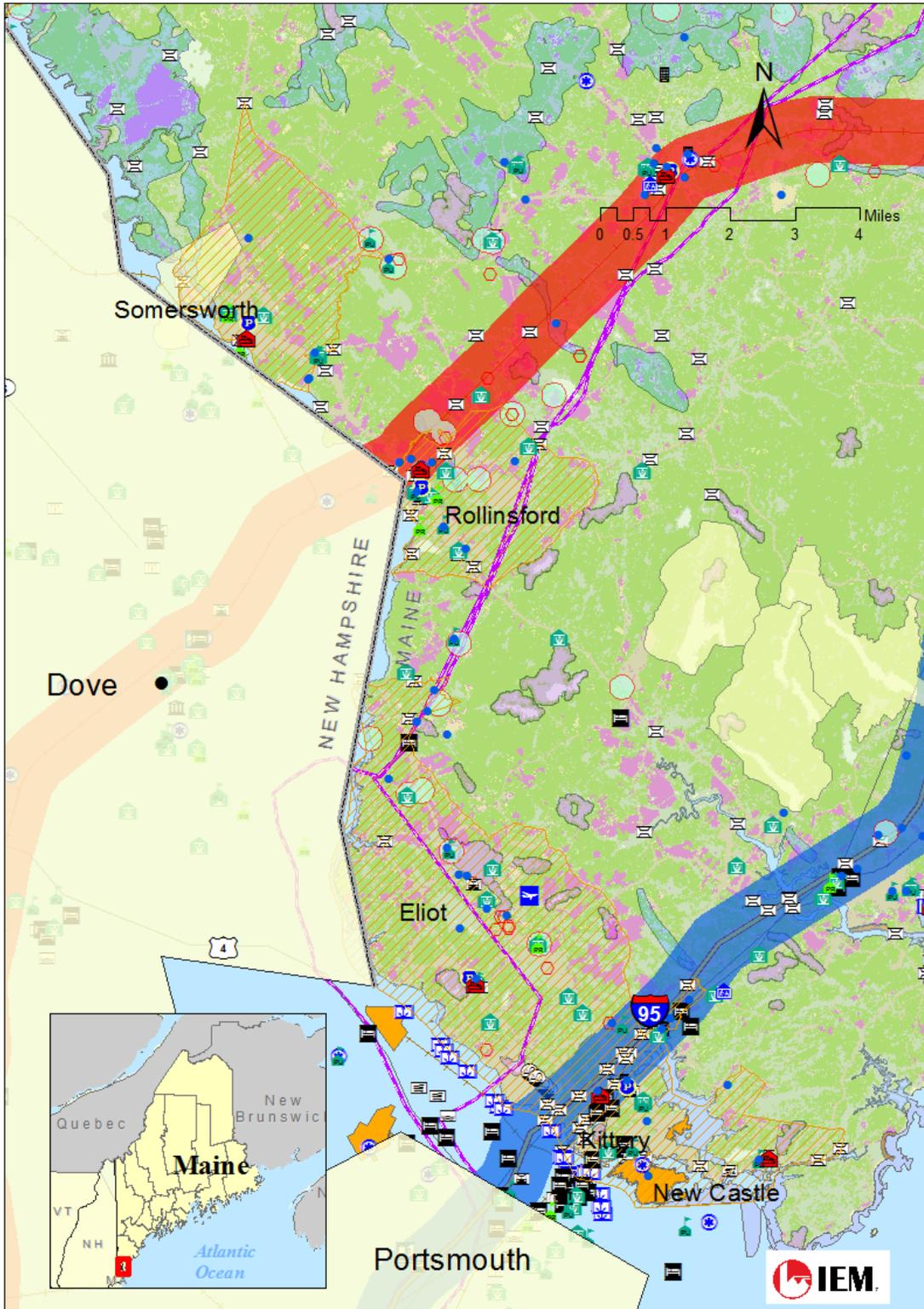
Map 37: Bangor MPO Area

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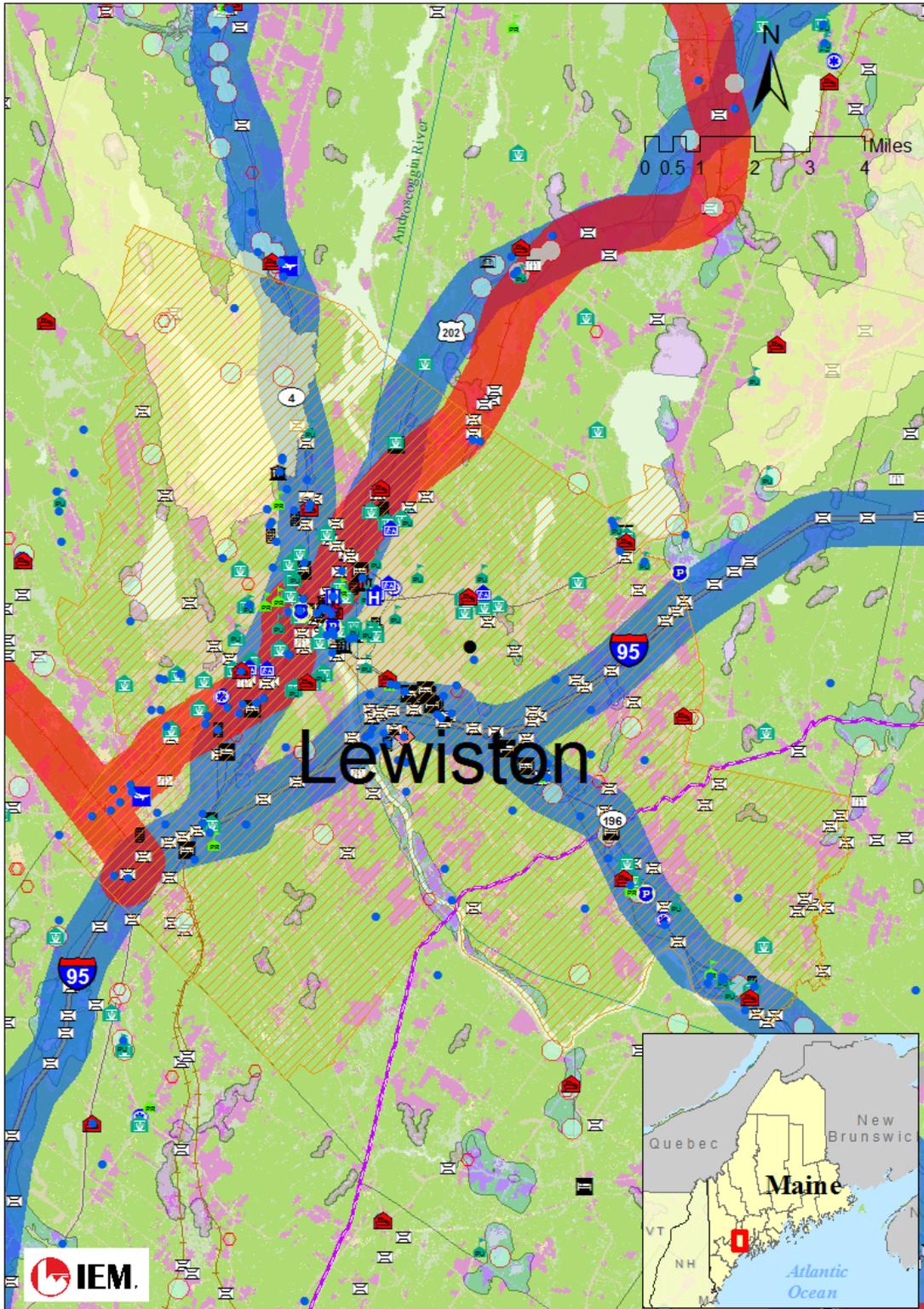
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Maine Commodity Flow Study of Hazardous Materials



Map 38: Kittery MPO Area

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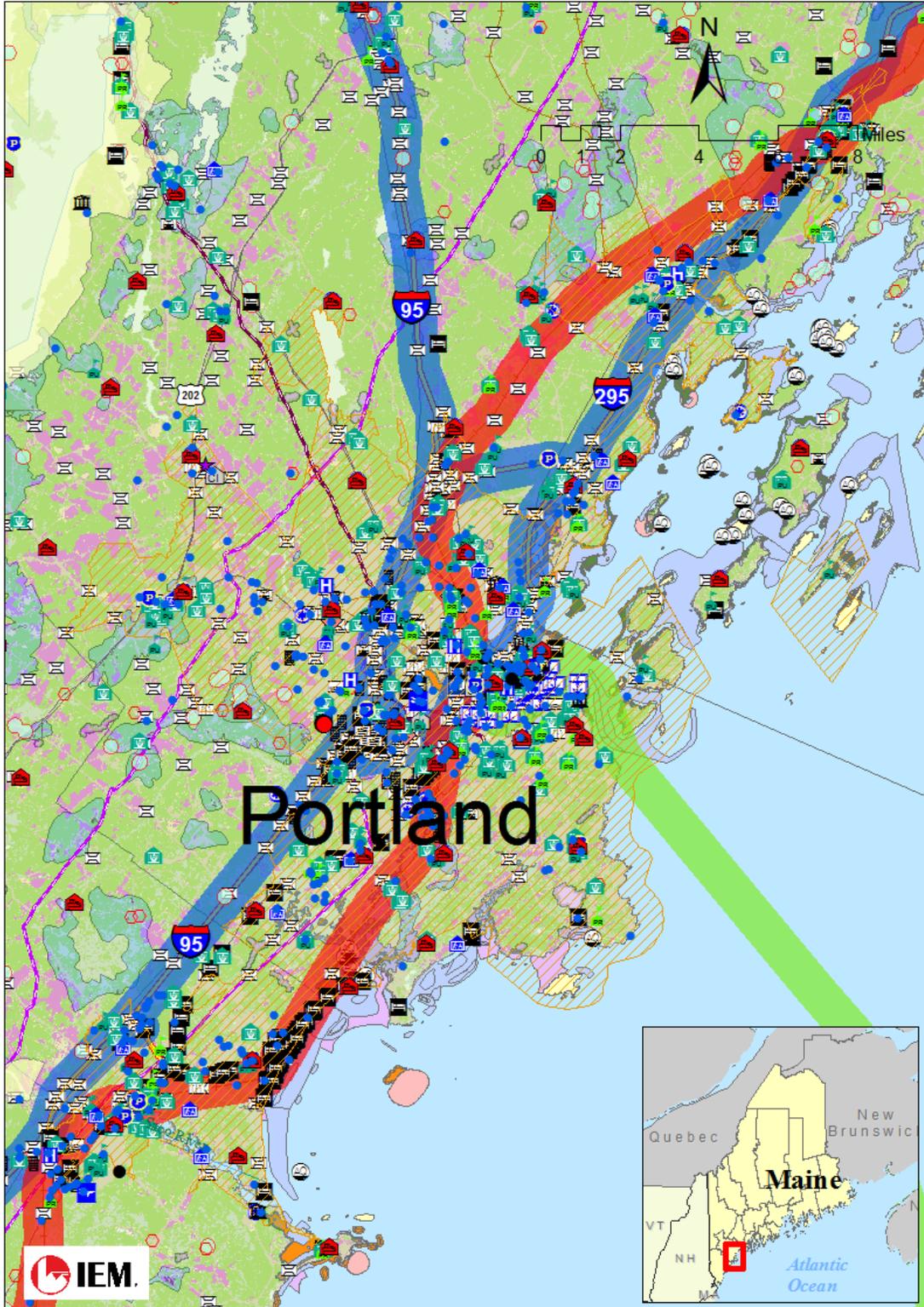
Map 39: Lewiston-Auburn MPO Area

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Map 40: Portland MPO Area

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