The Penobscot River and Environmental Contaminants:

Assessment of Tribal Exposure Through Sustenance Lifeways

U.S. EPA Region 1
Regionally Applied Research Effort

Final RARE Report
August 2015

EPA-901-R-15-002

PREFACE

This study demonstrates EPA New England's strong commitment to build partnerships with EPA Office of Research and Development (ORD), EPA laboratories and toxics experts throughout the agency and other federal agencies while fully supporting the principles outlined in EPA's Indian Policy (Ruckelshaus, 1984; reaffirmed in January 09, 2014). On January 9, 2014, Gina McCarthy, EPA Administrator, issued an All EPA Employee Memorandum reaffirming the Indian Policy, below is an excerpt from that reaffirmation memorandum.

> "The U.S. Environmental Protection Agency in 1984 became the first federal agency to adopt a formal Indian Policy. Today, I am proud to formally reaffirm that policy. By my action, the EPA reiterates its recognition that the United States has a unique legal relationship with tribal governments based on the Constitution, treaties, statutes, executive orders and court decisions. The EPA recognizes the right of the tribes as sovereign governments to self-determination and acknowledges the federal government's trust responsibility to tribes. The EPA works with tribes on a government-to-government basis to protect the land, air and water in Indian Country. . . .
>
> The reaffirmation of the Indian Policy articulates the importance of our tribal programs and our relationship with tribal governments. Our work in Indian Country is crosscutting and affects all aspects of the EPA's day-to-day functions. The environmental challenges we face are many. We must protect our precious water resources and address chemical safety. And we must continue taking common-sense steps to reduce the harmful carbon pollution that fuels climate change. Only through continued partnership with tribes can we truly achieve a cleaner, healthier and more prosperous America today and for future generations.
>
> It is an important time in our partnership with tribes as the EPA builds on past successes and strives to meet current and future environmental challenges in Indian Country. Please join me in advancing our strong partnership with tribal governments to protect human health and to safeguard the environment in Indian Country."

Disclaimer

This report was funded wholly or inpart by the United States Environmental Protection Agency (EPA). This report has been subjected to EPA's peer review process and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use. All research projects making conclusions or recommendations based on enviromental data and funded by EPA are required to participate in the Agency's Quality Assurance Program. This project was conducted under an approved Quality Assurance Project Plan. This report includes peer-reviewed scientific conclusions about environmental quality; it does not include EPA policy determinations about whether or how to respond to those conclusions.

FINAL REPORT

Regional Applied Research Effort (RARE) Project

August 2015

The Penobscot River and Environmental Contaminants: Assessment of Tribal Exposure through Sustenance Lifeways

Investigative Organizations

US Environmental Protection Agency
US Geological Survey
Agency for Toxic Substances and Disease Registry
US Fish and Wildlife Service
Bureau of Indian Affairs
Penobscot Indian Nation – Department of Natural Resources

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Acknowledgements

Dan Kusnierz, Robert Lent, Steve DiMattei, Dave McDonald, Alan Van Arsdale, Gary Perlman, Jim Lazorchak, Larry D. Claxton, Linda S. Birnbaum, Jason Mitchell, Jan Paul, Joe Dana, Kristin Peet, Michele Attean, Jason Sockbeson, Dan Morse and, Leann Jensen.

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Abstract

EPA in collaboration with the Penobscot Indian Nation, U.S. Geological Survey (USGS), Agency for Toxic Substances and Disease Registry (ATSDR), and the U.S. Fish and Wildlife Service (USF&WS) collectively embarked on a four year research study to evaluate the environmental health of the riverine system by targeting specific cultural practices and using traditional science to conduct a preliminary contaminant screening of the flora and fauna of the Penobscot River ecosystem. This study was designed as a preliminary screening to determine if contaminant concentrations in fish, eel, snapping turtle, wood ducks, and plants in Regions of the Penobscot River relevant to where PIN tribal members hunt, fish and gather plants were high enough to be a health concern. This study was not designed to be a statistically validated assessment of contaminant differences among study sites or among species.

The traditional methodology for health risk assessment used by the U. S. Environmental Protection Agency (EPA) is based on the use of exposure assumptions (e.g. exposure duration, food ingestion rate, body weight, etc.) that represent the entire American population, either as a central tendency exposure (e.g. average, median) or as a reasonable maximum exposure (e.g. 95% upper confidence limit). Unfortunately, EPA lacked exposure information for assessing health risks for New England regional tribes sustaining a tribal subsistence way of life. As a riverine tribe, the Penobscot culture and traditions are inextricably tied to the Penobscot River watershed. It is through hunting, fishing, trapping, gathering and making baskets, pottery, moccasins, birch-bark canoes and other traditional practices that the Penobscot culture and people are sustained. The Penobscot River receives a variety of pollutant discharges leaving the Penobscot Indian Nation (PIN) questioning the ecological health and water quality of the river and how this may affect the practices that sustain their way of life.

The objectives of this Regional Applied Research Effort (RARE) study were to:

- Develop culturally sensitive methodologies for assessing the potential level of exposure to contaminants that Penobscot Indian Nation tribal members may have from maintaining tribal sustenance practices.
- Conduct field surveys and laboratory analysis on targeted flora and fauna for chemical exposure to dioxins/furans, polychlorinated biphenyls (PCBs), total mercury and methyl-mercury.
- Assist the Agency for Toxic Substances and Disease Registry (ATSDR) by providing the necessary data to conduct a Public Health Assessment for the Penobscot Indian Nation.
- Establish protocols for assessing the level of exposure to PCBs, dioxins/furans and mercury to PIN tribal members as a consequence of gathering tribal plants for medicinal and nutritional purposes; as well as consuming fish, wood duck, and snapping turtle as a primary source of nutrition.
- Survey surface water, drinking water, and sediment from the Penobscot River and Indian Island to assess the exposure of PIN tribal members to environmental genotoxicants that continue cultural sustenance practices.

This research initiative collected and analyzed sediment and biota to determine the level of contaminant exposure to Penobscot tribal members. Natural resource utilization patterns and exposure pathways were identified based on discussions with the Tribal elders. Identification of Tribal exposure factors (exposure pathways and contaminant concentrations) was essential for accurately assessing potential long-term Penobscot Indian Nation tribal members' exposure.

Based on this study, ATSDR's Public Health Assessment (PHA) concluded that the Penobscot Indian Nation (PIN) tribal members who eat fish and snapping turtle at the ingestion levels suggested in the Wabanaki Traditional Cultural Lifeways Exposure Scenario Report (Wabanaki Exposure Scenario) may be exposed to harmful levels of mercury, dioxins/furans, dioxin-like PCBs, and other PCBs. ATSDR is most concerned about mercury in fish and snapping turtle taken from the Penobscot River. Mercury is most harmful to children and developing fetuses. It is especially important for pregnant and breastfeeding women, women who may become pregnant, and children to limit their consumption of fish and snapping turtle in order to decrease their risk of neurological damage due to mercury exposure. The ATSDR recommends that Penobscot Indian Nation tribal members follow the existing Penobscot Indian Nation Department of Natural Resources' fish advisory and the State of Maine Safe Eating Guidelines for all fish caught in the Penobscot River and limit their consumption of snapping turtle. ATSDR recommends that PIN members eat only 1-2 fish meals per month from the Penobscot River, and limit their consumption of snapping turtle to 2-3 meals per month. If Penobscot River fish and turtle are both eaten, ATSDR recommends no more than some combination of 1-2 (10 oz.) servings of fish, or 2-3 (8 oz.) servings of turtle per month.

The EPA preliminary risk assessment is consistent with ATSDR's PHA recommendations because it indicates that consumption of fish (especially eel) and snapping turtle at the Wabanaki Exposure Inland Non-Anadromous tribal consumption rates is associated with a risk of potential concern. (See Exposure Assessment Section)

ATSDR indicates that PIN tribal members who eat wood duck, fiddlehead fern, or medicinal roots at the Wabanaki Exposure Scenario-suggested ingestion rates from the areas where the samples were collected for this study should not be exposed to harmful levels of mercury, PCBs, dioxins/furans or dioxin-like PCBs. As shown in the Exposure Assessment section, EPA's preliminary risk assessment is consistent with these ATSDR recommendations. ATSDR also indicates that incidental ingestion of, and dermal exposure to, Penobscot River sediment should not pose a human health hazard.

The *Salmonella* mutagenicity assay was used to assess the mutagenic potencies of organic extracts of the Penobscot River water and sediment, as well as of drinking water samples. Mutagenicity is a statistical indicator of some cancer-causing (carcinogenic) chemicals. Most samples were either not mutagenic or, compared to published data for comparable extracts, had low to moderate mutagenic potencies. Thus, there is little evidence that extracts of these environmental media have mutagenic activity that might be due to the classes of compounds that this assay readily detects, such as polycyclic aromatic hydrocarbons, nitroarenes, and aromatic amines.

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Executive Summary

This study was designed to assess potential exposure to contaminants and the concentrations of those contaminants along the Penobscot River in areas frequented by Penobscot tribal members while gathering, hunting and fishing. This is a preliminary screening that determined if contaminant concentrations in fish, snapping turtle, wood duck, and plants in regions of the Penobscot River relevant to where PIN tribal members hunt, fish and gather plants were high enough to be a health concern. Based on the limited funds available, this study was not designed to be a statistically validated assessment of contaminant differences among study sites or among species.

As a riverine tribe, the Penobscot culture and traditions are inextricably tied to the Penobscot River watershed. It is through hunting, fishing, trapping, gathering and making baskets, pottery, moccasins, birch-bark canoes and other traditional practices that the Penobscot culture and people are sustained. If these traditional activities are not continued, the very words of the Penobscot language that describe these practices will be lost. The ability to preserve the PIN's Native American culture is being lost. The ecosystems that support the flora and fauna to sustain the PIN's subsistence way of life are contaminated by toxic pollutants discharged in the air, water, and land on and near the Tribes' trust and reservation lands. The PIN Tribal Council is very concerned that engaging in traditional cultural activities is harming tribal members. Some members are not continuing to sustain a traditional lifestyle due to the fear of the harmful health effects and depleted resources; especially since the PIN's rates for lung and cervical cancer are some of the highest in the State of Maine (Valcarcel 1994 and Miller 1994).

The Regional Applied Research Effort (RARE) is an ORD program that provides funding to the Regions to enter into innovative research partnerships with ORD and address near term research needs. RARE projects address a wide array of environmental science issues critical to ORD's regional partner communities and address regional and national research priorities. The goals of the program are to:

- Provide the regions with near-term research on high-priority, region-specific science needs;
- Improve collaboration between regions and ORD laboratories and centers; and,
- Build a foundation for future scientific interaction between ORD and the regions.

This RARE study was designed to provide the scientific information needed to link the science to policy and regulatory decision-making within Indian Country. This RARE project is a significant multi-Agency study that was designed in a collaborative initiative with 10 partners, i.e., US EPA [Region 1 Boston and Chelmsford, Office of Pesticide Programs (OPP), Office of Research and Development (ORD)], and the National Center for Environmental Assessment (NCEA), USF&WS, ATSDR, USGS [Maine Water Science Center and the Columbia Environmental Research Center (CERC)], and PIN. The purpose of the RARE study was to identify unique exposure pathways so that scientifically sound data could be collected and culturally sensitive methodologies could be developed for assessing the level of harm the PIN may be exposed to by maintaining tribal sustenance practices.

This research initiative examined the potential adverse risks of exposure of the PIN tribal members to contaminants in sediment and biota through ingestion. The approach for this research project combined some of the elements of consumption surveys such as interviewing Tribal elders to determine recent natural resource utilization patterns with careful identification of Tribal exposure factors (contaminant concentrations, pathways of exposure). Collaborating with numerous scientists and ATSDR assured the scope and procedures identified for this project met the objectives of the PIN and that the

methodologies employed were accepted within the scientific community. To ensure the highest quality and reliability, a process of internal and external peer review by both cultural and scientific experts was followed.

The process used was culturally sensitive, respectful, drew on traditional environmental knowledge (such as the observational expertise of elders), and was developed in partnership with tribal cultural and technical experts.

The data collected for this preliminary screening can assist the PIN when developing health advisories, making decisions regarding PIN's tribal members' health, and the PIN's environmental resources. This study enables the PIN to make decisions based on tribal consumption and exposure rates rather than relying on rates developed for the average American, which is the standard typically applied by EPA regulators. Since EPA has been working with Tribal Nations to develop models for Native American culturally based exposure risk assessments, this study may be transferable to Tribal Nations across the country. Both the exposure pathways identified and the detection limits of the analytical methods used for this study are transferable to Tribal Nations that have diets similar to those studied in this report.

Study Design

The research approach for this study was comprised of two parts: identifying the flora and fauna used by the PIN in sustaining their traditional way of life, and selecting specific geographical locations (reaches) along the Penobscot River to collect flora, fauna, surface water and sediment. Six reaches deemed ecologically representative were selected along 87 miles (140 kilometers) of the Penobscot River between Old Town and Medway, Maine. The reaches were chosen based on previous sediment mapping conducted by the USGS in 1999 (Dudley and Giffen, 2001). The 1999 mapping effort involved the use of ground-penetrating radar data to characterize the bed-sediment composition in selected reaches of the Penobscot River. Sampling locations were chosen on the basis of the mapping information and other river characteristics including wading and swimming areas, depositional zones within the channel, and sites upstream and downstream of river features that control or potentially impact sediment transport (such as dam structures and impoundments). The reference (control) reach included both free flowing (East Branch Penobscot) and natural lake waters (Salmon Stream Lake) that were within the upper Penobscot watershed and upstream of any known pollution point sources other than regional air deposition.

Field sampling of sediment, fish, duck, turtle and plants occurred from May 2008 to October 2009**.** All sampling procedures followed EPA-approved protocols as outlined in the Quality Assurance Project Plan (QAPP) for this project (Orazio, 2008). The EPA ORD also conducted several audits of the field work to ensure compliance with the project QAPP. The river locations sampled represent a variety of conditions, ranging from relatively undisturbed, undeveloped conditions (e.g., East Branch of the Penobscot River) to more developed conditions (e.g., the dam impounded area north of Old Town).

Shallow-water sediment composites consisting of two to five grabs were collected at each of the six reaches. Sediments were collected from areas where PIN tribal members typically wade in the water when hunting, fishing and gathering medicinal plants.

Small-mouth bass (*Micropterus dolomieu*), chain pickerel (*Esox niger*), white perch (*Morone americana*), yellow perch (*Perca flavescens*), brown bullhead (*Ameiurus nebulosus*) and American eel (*Anguilla rostrata*) were collected from each of six reaches. Fish were collected by boat electro-shocking, gill netting, trap netting and hook and line. For each reach, one composite

sample was prepared of each species (a "species composite") consisting of three to five fish of similar size of each species.

A total of seven composite fiddlehead fern samples were obtained, representing five of the six reaches and one field duplicate sample. A total of five composite medicinal plant samples were collected representing four reaches and one duplicate.

Snapping turtles (*Chelydra serpentina*) are an important tribal food. Snapping turtles are a long-lived, upper trophic level aquatic species that readily accumulate contaminants. Seven snapping turtles from five of the six reaches were collected for the study.

Wood duck (*Aix sponsa*) were collected and analyzed because wood duck are currently the most hunted duck species by PIN tribal members. Since wood duck are a common breeder on the Penobscot River, they are more likely to reflect local contaminant levels than other waterfowl that use the river more seasonally. Sixteen wood ducks were collected, representing five composite samples from four of the six river reaches.

Samples collected for chemical analysis in this study were taken from the biota identified above and river sediment. Labs analyzed samples for dioxins/furans; PCB congeners (including dioxin-like PCB congeners); methyl mercury (Me Hg); and, total mercury (Hg). Labs provided 2,3,7,8-TCDD toxic equivalent (TEQ) values for dioxins/furans and dioxin-like PCBs.

Samples collected for mutagenicity analysis in this study included river water, drinking water, and river sediment. River water samples were taken at three locations: (1) at an upstream control headwater location; (2) immediately below the effluent discharge of a municipal and/or industrial site, and; (3) a downstream (dam) site. Drinking-water samples were taken from a convenient tap at the PIN laboratory. River sediment samples were taken at approximately the same sites as the river water samples and at Indian Island.

For this report, EPA considered cancer risks of 1E-06 or less and non-cancer Hazard Quotients of one or less to be of "no concern" and risks greater than these levels to be of "potential concern". These risk management criteria were selected because they are consistent with a variety of EPA regulatory programs.

Findings

With the flora and fauna data collected from this study, ATSDR conducted a Public Health Assessment (PHA) for the Penobscot Indian Nation and EPA conducted a preliminary risk assessment. EPA compared the concentrations in biota to risk-based concentrations to determine the level of risk to the Penobscot Indian Nation tribal members that maintain cultural practices and sustenance lifeways associated with the Penobscot River. EPA's risk results are consistent with ATSDR's consumption recommendations. EPA risk results are based upon a preliminary risk assessment that can be found in the Exposure Assessment Section of this report. The results from EPA's preliminary risk assessment suggest that the consumption of each animal species except duck at the Wabanaki Exposure Scenario consumption rates is associated with a risk of potential concern. Therefore, ATSDR's PHA recommendations limiting fish consumption to 1-2 meals per month from the Penobscot River and snapping turtle consumption to 2-3 meals per month are not inconsistent with EPA's preliminary risk assessment. EPA also concurs with ATSDR's conclusion that mercury was not found at levels of health concern in wood duck, fiddlehead fern, or medicinal plants.

ATSDR concluded that the Penobscot Indian Nation (PIN) tribal members who eat fish and snapping turtle at the ingestion levels suggested in the Wabanaki Traditional Cultural Lifeways Exposure Scenario Report (Wabanaki Exposure Scenario) may be exposed to harmful levels of mercury, dioxins/furans, dioxin-like PCBs, and other PCBs.

ATSDR is most concerned about mercury in fish and snapping turtle taken from the Penobscot River. Mercury is most harmful to children and developing fetuses. Therefore, it is especially important for pregnant and breastfeeding women, women who may become pregnant, and children to limit their consumption of fish and snapping turtle in order to decrease their risk of neurological damage due to mercury exposure. Tribal members should follow the existing Penobscot Indian Nation Department of Natural Resources' fish advisory and the State of Maine Safe Eating Guidelines for all fish caught in the Penobscot River. To be safe, ATSDR recommended that PIN members eat only 1-2 fish meals per month from the Penobscot River and limit their consumption of snapping turtle to 2-3 meals per month. If Penobscot River fish and turtle are both eaten, ATSDR recommended no more than some combination of 1-2 (10 oz.) servings of fish, or 2-3 (8 oz.) servings of turtle per month.

ATSDR concluded that PIN tribal members who eat wood duck, fiddlehead ferns, or the medicinal plants similar to the ones tested for this study and in the same locations where the samples for this study were taken will not be exposed to harmful levels of mercury, PCBs, dioxins/furans or dioxin-like PCBs. ATSDR also found that incidental ingestion of, and dermal exposure to, Penobscot River sediment in the same locations where the samples for this study were taken do not pose a human health hazard.

The findings from the mutagenicity testing showed that most of the collected samples were not mutagenic or had a low to moderate response. Mutagenicity is a feature of some cancer-causing (carcinogenic) chemicals. The main conclusions were that the drinking water, Penobscot River water, and Penobscot River sediments exhibited little mutagenicity. Based on these results, there is not a concern for the presence of mutagenic compounds that this assay detects, e.g., polycyclic aromatic hydrocarbons (PAHs), nitro-PAHs, and dyes, in any of the samples tested.

Recommendations

The preliminary study indicates that contaminant concentrations are high enough to warrant further investigation of both human health and ecological risk. Therefore, EPA recommends additional study to statistically characterize how contaminants are related to type, size, and location of fish to support risk-based recommendations to PIN members concerning consumption of fish at different river locations. EPA also recommends that the unused, frozen fish tissues (offal) be analyzed to estimate the contaminant concentrations in whole fish that would be consumed by fish-eating wildlife (e.g. mink, eagle, snapping turtle) to evaluate ecological risk to higher trophic level predators. The additional data could also serve as a baseline for tracking changes in contaminant concentrations over time. Any further studies should be coordinated with the PIN Health Department in their effort to correlate the health results with fish consumption and track changes in fish consumption behavior through education and issuance of health advisories to PIN members.

Background

The Relationship of the Penobscot River to the Penobscot Indian Nation

Mount Katahdin and the Penobscot River

Generating a research study of this nature requires field scientists to understand the intricate connections between the ecology of a riverine system and the people that sustain life from this ecosystem. The Penobscot River is of great importance to the Penobscot people and has been the center of the Tribe's existence for thousands of years. The Penobscot Indian Nation dates back approximately 9,500 years. Important burial and ceremonial sites are located upon these islands, which are generally forested and low-lying, with extensive floodplains and forested wetlands. Traditional activities take place on and around the islands including hunting, fishing, trapping, gathering, boating, camping, sweat lodges and ceremonies. The floodplains support an annual household and commercial harvest of fiddlehead ferns. Indian Island, near Old Town, Maine, is the primary residence and the seat of tribal government for the PIN.

Penobscot Indian Nation sustenance fishing rights were reserved through historical treaties with Massachusetts and Maine, and the 1980 Maine Indian Land Claims Settlement Act. The PIN acquired its status as a federally recognized Indian Nation in 1980 from the BIA. As part of the statutory provisions granting recognition, the PIN is entitled to protect and preserve the natural resources of its recognized trust and reservation lands. These regulations provide that the PIN shall have exclusive authority to promulgate and enact ordinances regulating hunting, trapping, fishing or other taking of wildlife within their respective Indian territory.

However, fish contamination prevents this right from being fully exercised and may seriously threaten the health of community members and their traditional lifeways. The ecosystems that support the flora and fauna historically used by the PIN are contaminated by air, water, and land pollution so that many of these traditional activities cannot be carried out without fear of harmful health effects. PIN tribal members are fearful of carrying out their traditional practices such as gathering medicinal plants from the Penobscot River. They fear eating natural foods such as turtle and duck meat. They fear using raccoon

fat to make their birch bark canoes. If these traditional activities are not continued, the very words of the Penobscot language that are used to describe these practices will be lost. If tribal members lose the ability to make baskets, pottery, moccasins, birch-bark canoes, gather medicinal plants, engage in traditional fishing, and much more, then they lose the ability to preserve their Native American culture by preserving and passing along traditional lifeways to future generations.

Basket making by the Penobscot tribal members is a revered cultural practice as well as a source of economic income. The reeds used for basket making come from the Penobscot River ecosystem.

Description of the Study Area

Penobscot River Watershed: The Penobscot River Basin is centrally located within the borders of Maine. The Penobscot Watershed is one of the largest watersheds in Maine. Many of the waterways in this Basin retain their Penobscot names. It is home to the Penobscot people that live on Indian Island, located in the southern portion of Penobscot River (See Figures 1-2). Because Indian Island is located in the downstream portion of the watershed, the PIN is potentially affected by the cumulative impacts of the many point and non-point sources of pollution to the River.

The **Penobscot River** /pəˈnɒbskət/ is New England's second largest river system. The Penobscot River drains approximately one-quarter of the State and has a drainage area of 8,588 square miles (22,243 km^2) at its mouth (Fontaine, 1981). Its West Branch rises near Penobscot Lake on the Maine/Quebec border; the East Branch Pond near the headwaters of the Allagash River (See Figure 1-2). The main stem is 264 miles in length and empties into Penobscot Bay near the town of Bucksport. The landscape of the watershed includes Maine's highest peak, Mt. Katahdin, rolling hills and extensive bogs, marshes and wooded swamps. There is a rich history of cultural, social, and economic tradition associated with the Penobscot River. The Penobscot River is best known for its large historic salmon run (50,000 or more adults) and its much smaller contemporary run, which is the largest Atlantic salmon run remaining in the United States (1,000-4,000 adults in recent decades).

Figure 1: Penobscot River Basin and Surrounding Watersheds

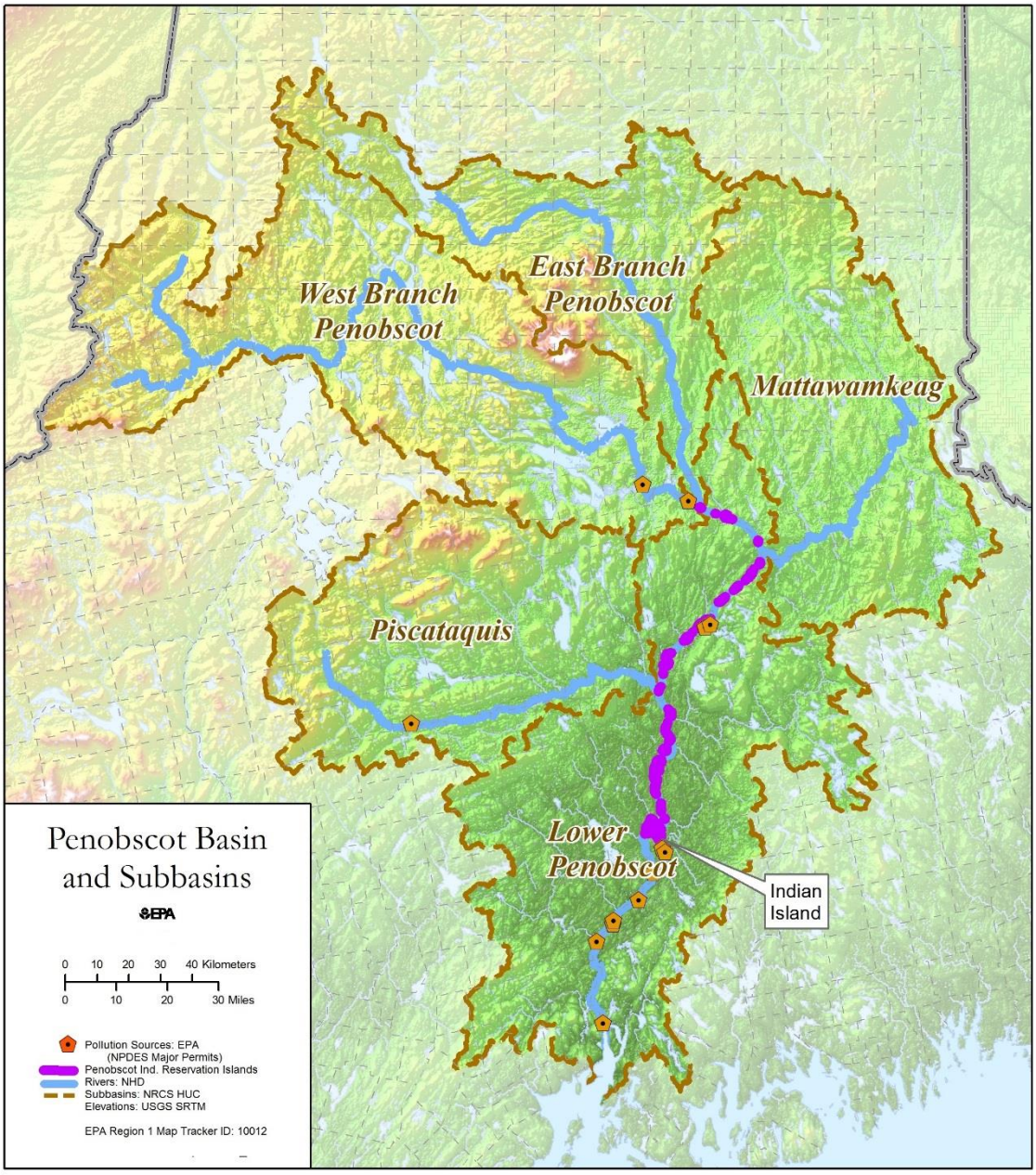


Figure 2: Penobscot River Basin and Sub-Basins

Physical Setting

Study Area

The study area is located within the Penobscot River Watershed as depicted in Figures 1-2 above. The study area includes selected reaches along 87 miles (140 km) of the Penobscot River between Old Town and Medway, Maine. The six sampling areas for the study were chosen to include three of the same sites surveyed by USGS in 1995-96 and 1999, as well as new sites where there were known or potential areas of fine-grained sediment deposition (See Figures 4-5). The selection of reaches for this study was further limited by the proximity of motor-boat launch sites to river reaches deep enough for navigation.

Demographics

The combined population of the towns along the Penobscot River in the study area is approximately 26,000 people. About 40 percent of this population (11,200) is distributed at the downstream limit in the towns of Old Town and Milford and in part of the Penobscot Indian Nation Reservation. The Penobscot Indian Nation Reservation includes the islands and surrounding waters upstream from the Milford Dam - totaling more than 200 islands. At present, the only permanent settlement, as well as the seat of government of the Penobscot Indian Nation, is on Indian Island at Old Town. According to the PIN, the current number of Penobscot tribal members is 2,397. The current total population of Indian Island is 606, of which 455 are tribal members. The towns of Lincoln and Chester have the next largest population group with a combined population of 6,300. The remaining population is distributed among small towns, farms, and sprawling suburban developments.

Climate

The climate in the Penobscot River Basin is typically characterized by mild summers and cold winters. The average annual temperature is 41°F (5 ^{o}C) at a National Weather Service (NWS) station in Millinocket, about 10 miles west of Medway, and 43°F (6 ^{o}C) at a NWS station near Old Town. Mean monthly temperatures range from 13°F (-10 ^{o}C) in January to 68°F (20 ^{o}C) in July at Millinocket and 17°F (-8 ^{o}C) in January to 67°F (19 ^{o}C) in July near Old Town. The average annual precipitation in the basin is about 40 inches (101 cm) and is evenly distributed throughout the year (U.S. National Oceanic and Atmospheric Administration, 1995 and 1998).

Geomorphology

The Penobscot River valley can be separated into four distinct geomorphic units. From the headwaters of the East and West Branches of the Penobscot River downstream to the town of Medway is a mountainous upland area. This area is characterized by high-relief topography which results in high-energy stretches of the river that are popular with white-water rafters and kayakers. This mountainous terrain, which is characteristic of the New England central highlands (Denny, 1982), has many ponds and tributary streams. Many of these ponds and streams are or have been affected by dams for the generation of hydroelectric power and flow control for log driving (Kelley and others, 1988). The high-energy white-water characterization is not true of the dam impoundments in this region. Water movement in the impoundments is significantly slower than in the high-energy reaches of the river, enabling fine-grained sediments to settle out and accumulate on the bottom.

The second section of river, running through the New England coastal lowlands (Denny, 1982) from Medway to Old Town has a broad floodplain and a wider channel than the upstream section. This section of the river is characterized by numerous low-profile depositional islands and sand bars. Bedrock outcrops and rapids are rare. Aerial photographs of this part of the river show historical meandering and braiding of the river channel and indicate formation of islands by erosion and deposition (Kelley et al., 1988). The West Enfield Dam is located about midway on this second river reach.

The third section of the Penobscot River, from Old Town to Bangor, is characterized by numerous rapids and common bedrock outcrops. The Milford Dam is located at the beginning of this river reach. Bluffs of unconsolidated material dominate the riverbanks, and raised terraces are well developed in several locations (Kelley et al., 1988).

The fourth section of the river, below Bangor, is tidally influenced and passes through a geomorphic area classified as the New Brunswick highlands (Denny, 1982). This part of the river is characterized by bluffs of unconsolidated material and bedrock cliffs, with fringing salt marshes in protected areas (Kelley et al., 1988).

Hydrology

The Penobscot River originates as two main branches, the East Branch and West Branch. The drainage divide at the headwaters of the West Branch constitutes the Maine-Canadian border (Figure 1). At the confluence of the two branches at Medway (Figure 2), the East Branch has a drainage area of approximately 1,200 square miles (2,900 km^2) and the West Branch drains approximately 2,130 square miles (5,517 km^2). From Medway, the Penobscot River flows south for approximately 112 miles (180 km) to the Gulf of Maine where it discharges into the Atlantic Ocean. The Penobscot River drains about one-quarter of the State of Maine and has a drainage area of 8,588 square miles (22,243 km^2) at its mouth (Fontaine, 1981). Streamflow in the Penobscot River Basin vary seasonally with high flows typically in early spring and late fall and low flows generally in the summer and early fall.

The Mattaseunk Dam, originally built in 1937-40 in the town of Mattawamkeag, is a run-of-the-river hydroelectric facility producing 19.2 megawatt (MW) of electrical power (Dana Murch, Maine Department of Environmental Protection, Bureau of Land and Water Quality, oral communication, 2000). The drainage area of the Penobscot River above the dam is 3,355 square miles (8689 km^2; Fontaine, 1981). The Mattaseunk Dam impoundment has a surface area of 1,685 acres and a gross storage of approximately 915 million ft^3 (Dana Murch, oral communication 2000).

The West Enfield Dam was originally built in 1894. In 1986, this dam was replaced by another dam constructed immediately downstream from the 1894 structure. The West Enfield Dam is a run-of-the-river hydroelectric facility producing 13MW of electrical power (Dana Murch, oral communication, 2000). The drainage area of the Penobscot River above the dam is 5,217 square miles (Fontaine, 1981). The West Enfield Dam Impoundment has a surface area of 1,125 acres and a gross storage of approximately 490 million ft^3 (Dana Murch, oral communication, 2000). The Piscataquis River joins the Penobscot River about 1 mile downstream from the dam and drains 1,453 square miles (Fontaine, 1981).

The study reach in the towns of Old Town and Milford includes areas near Olson Island in the Milford Dam Impoundment. The Milford Dam, originally built in 1905-06 in the town of Milford, is a run-of-the-river hydroelectric facility licensed to produce 8 MW of electrical power (Dana Murch, oral communication, 2000). The drainage area of the Penobscot River upstream from the dam is 7,325 square miles (Fontaine, 1981). The Milford Dam Impoundment has a surface area of 235 acres and a gross storage of approximately 98 million ft^3 (Dana Murch, oral communication, 2000).

Penobscot River, Milford Dam downstream of Indian Island

Penobscot River Watershed-wide Issues

There are approximately 116 dams in place in the Penobscot River basin, 14 of which are major hydropower projects that have generally inadequate fish passage. Public and private facilities discharge 150 million gallons of wastewater/day to the river, which is equivalent to ~2% of the river's average daily outflow. Five major NPDES licensed outfalls discharge into the Penobscot River and affect the study area (Figure 3). Some known constituents being discharged include suspended solids, heat, oxygen-depleting substances, chlorinated organics, chromium, copper, dioxin, lead, mercury, phenols, vanadium and zinc. State fish consumption advisories for mercury, PCBs, and dioxins are in place for the Penobscot River (See http://www.maine.gov/dhhs/mecdc/environmental-health/eohp/fish/2kfca.htm). Thermal loading throughout the entire watershed affects the migration/resting behaviors of mature adult salmon during spawning.

West Branch*:* This vast area occupies 25% of the land in the entire basin. The Penobscot name for the West Branch is Kettetegwewick, meaning "the main branch." This is the canoe route to Katahdin, the highest mountain in Maine and the Tribe's most sacred place. Drainage in the West Branch is heavily manipulated for hydropower generation. It contains the largest privately owned hydroelectric complex in the country, and it receives wastewater from two pulp and paper mills and two municipalities. Portions are listed as not attaining water quality standards (WQS) for bacteria, aquatic invertebrate communities, and dissolved oxygen. PIN data indicate significant algal/cyanobacteria blooms that originate here and affect the entire main stem of the Penobscot downriver (~75 miles or 120 kilometers).

East Branch: This remote area occupies 13% of the land in the entire basin and is extremely important to the restoration of self-sustaining populations of Atlantic salmon (*Salmo salar*). The Penobscot name for this section of the river is Wassategwewick, perhaps meaning "place where torches used to fish" or "place where light first touches." This is an important fishing area for the Tribe. The watershed, including pristine Grand Lake Mattagamon, is threatened by non-point source pollution and air deposition from within and beyond the region. Sources include forestry activities (e.g. timber harvesting and associated roads) camps and other development.

Mattawamkeag: This tributary is named for the gravel bar that marks the river's confluence with the main stem of the Penobscot. The area occupies 17% of the land in the entire basin. The lower-most segment of this reach does not attain WQS for bacteria due to untreated wastes.

Piscataquis: This area occupies another 17% of the land in the entire basin. This "little branch stream" was an extremely important Penobscot travel route and contains significant Atlantic salmon-spawning habitat. This drainage is affected by discharges from two large municipal treatment plants, a textile mill, non-point source pollution from agricultural and forestry operations, and at least six dams. Significant turbidity and suspended solids within the river are caused by erosion in or near poorly constructed haul roads, skid trails, and stream crossings. More than 12 livestock farms have no manure storage facilities and more than 2,000 acres of cropland adjacent to surface waters are highly erodible. Excessive macrophyte and algae growth downstream of one treatment plant suggest the need for additional controls at the facility.

Lower Penobscot: This area occupies 28% of the land in the entire basin and bears the rock drops (now dammed) that are the basis for the name of the river and the Tribe. Two pulp and paper mills discharging here result in fish consumption advisories for dioxins, furans and PCBs. Several segments do not attain bacteria standards due to untreated residential and municipal combined sewage overflow wastes. Several tributaries do not attain Water Quality Standards for dissolved oxygen because of agricultural activities. With point sources accounting for 94% of the total phosphorus loads entering the river, observed and model-predicted results indicate that ~51 Class B river miles will not meet their dissolved oxygen standards. HoltraChem, a chlor-alkali plant closed in 2000, was located on the lower Penobscot. Sediments downstream contain the highest concentrations of mercury in Maine and possibly the country. The plant was licensed to discharge up to 5 pounds of mercury/year directly to the Penobscot River and hundreds of pounds/year to the air. The Lower Penobscot area is the location of Indian Island, the home of the PIN.

Health Advisories

In 1987, the State of Maine issued health advisories limiting the consumption of fish from the Penobscot River. This advisory was for dioxin discharges specific to pulp and paper mills that discharge industrial waste directly into the Penobscot Indian Nation's reservation.

In 1997, the State of Maine revised the fish advisories in the Penobscot River to include Polychlorinated biphenyls (PCBs) and mercury. PIN's Natural Resources and Health departments began issuing Tribal specific health advisories for the Penobscot River in 1998. PIN - DNR - Fish Consumption Advisory

The PIN DNR and the State of Maine Health Advisories both recommend the following:

> Pregnant and nursing women, women who may get pregnant, and children under age 8 SHOULD NOT EAT any freshwater fish from Maine's inland waters. Except, for brook trout and landlocked salmon, 1 meal per month is safe.
>
> All other adults and children older than 8 CAN EAT 2 freshwater fish meals per month. For brook trout and landlocked salmon, the limit is 1 meal per week.

As stated in the State of Maine health advisory:

> "It's hard to believe that fish that looks, smells, and tastes fine may not be safe to eat. But the truth is that fish in Maine lakes, ponds, and rivers have mercury in them. Other states have this problem too. Mercury in the air settles into the waters. It then builds up in fish. For this reason, older fish have higher levels of mercury than younger fish. Fish (like pickerel and bass) that eat other fish have the highest mercury levels.
>
> Small amounts of mercury can harm a brain starting to form or grow. That is why unborn and nursing babies, and young children are most at risk. Too much mercury can affect behavior and learning. Mercury can harm older children and adults, but it takes larger amounts. It may cause numbness in hands and feet or changes in vision. The Safe Eating Guidelines identify limits to protect everyone.
>
> **Warning: Some Maine waters are polluted, requiring additional limits to eating fish.**
>
> Fish caught in some Maine waters have high levels of PCBs, Dioxins or DDT in them. These chemicals can cause cancer and other health effects. The Maine Center for Disease Control and Prevention recommends additional fish consumption limits on the Penobscot River below Lincoln to 1-2 fish meals a month." Maine CDC Freshwater Fish Safe Eating Guidelines

The Maine DEP web site explains that mercury is a heavy metal that is used in the manufacture of many consumer goods and is found naturally in small amounts in oceans, rocks, and soils. Large amounts of mercury also become airborne through manmade processes such as burning coal, oil, wood, or natural gas as fuel, incinerating mercury-containing garbage, and through industrial production processes that utilize mercury. Once in the air, mercury can fall to the ground with rain and snow, contaminating soils and water bodies.

Once mercury is released into the environment it can change to methyl mercury, a highly toxic compound. Methyl mercury is easily taken up in living tissue and bioaccumulates (builds up) over time, causing serious health effects such as neurological and reproductive disorders in humans and wildlife. Since mercury does not break down in the environment, it has become a significant health threat to humans and wildlife. Mercury levels in Maine fish, loons, and eagles are among the highest in North America. This has led the Maine Bureau of Health to issue a statewide advisory recommending that pregnant women, women of childbearing age, and young children limit their fish consumption based on the type of fish they consume. The advisories have been in place since 1994 and remain in effect today because mercury levels in fish have not decreased. See Maine Department of Environmental Protection web site http://www.maine.gov/dep/mercury/

PCBs are mixtures of up to 209 individual chlorinated compounds (known as congeners), differing in number and positions of chlorine atoms. There are no known natural sources of PCBs. Bulk formulations of PCBs are either oily liquids or solids that are colorless to light yellow. PCBs are semivolatile chemicals and can exist as a vapor in air. Trace levels of PCBs have no known smell or

taste. Many commercial PCB mixtures are known in the U.S. by the trade name Aroclor. PCBs do not readily break down in the environment and thus may remain there for very long periods of time. Although PCB production was banned in the late 1970s, approximately 30 to 70% of what was ever produced is still in use or in the environment (See Advances in Modern Environmental Toxicology, Volume XXI, Princeton Scientific Publishing Co., Princeton, NJ 1992). PCBs can travel long distances in the air and be deposited in areas far away from where they were released. PCBs are relatively insoluble in water; however, a small amount of PCBs may remain dissolved. In an aquatic system such as a river, most PCBs stick to organic particles and bottom sediments. PCBs also bind strongly to soil. Fish accumulate PCBs from the water column, from sediment where they lay their eggs, and from consuming other prey in the food web of the river system. Terrestrial animals that eat PCB contaminated aquatic organisms accumulate PCBs. PCB bioaccumulation can be a chronic issue in long-lived animals such as turtles, reaching levels that may be many thousands of times higher than in water. Bioaccumulation in fatty tissue and biomagnification up the food chain results in the highest concentrations being found in top predator species.

Polychlorinated dibenzo-*p*-dioxins (PCDD) are a family of 75 different compounds and polychlorinated dibenzofurans (PCDF) are a family of 135 different compounds that have various levels of biological activity. Dioxins/furans are divided into eight groups based on the number of chlorine atoms, which are attached to the dioxin/furan molecule at any one of eight positions. The name of each dioxin or furan indicates both the number and the positions of the chlorine atoms. For example, the dioxin with four chlorine atoms at positions 2,3,7, and 8 on the molecule is called 2,3,7,8- tetrachlorodibenzo-*p*-dioxin (2,3,7,8- TCDD, or TCDD), which is the most toxic of the dioxins to mammals and has received the most attention (ATSDR, 1998). Only those congeners having chlorine substitutions in at least the four lateral (2, 3, 7, 8) positions have toxic effects mediated through binding to the arylhydrocarbon receptor protein. Similarly, certain PCBs lacking chlorine substitution in the ortho-position and some of their mono- and di-ortho chlorine analogs are isostereomers of 2,3,7,8,-TCDD and have a common mode of action to that of the dioxins. This similarity is the basis for their common measure of toxicity, namely, toxic equivalents (TEQ). Twelve PCB congeners fall into a category of "dioxin-like" PCBs. Because of their structure and mechanism of action, they exhibit toxicity similar to that of chlorinated dibenzo-*p*-dioxins. However, their toxicities are 0.00001 to 0.1 times lower than the most toxic dioxin, 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (TCDD). A toxic equivalency factor (TEF) approach to evaluating health hazards has been developed and used to some extent to guide public health decisions (see EPA, 1996 and ATSDR, 2000 for more details). In short, the TEF approach compares the relative potency of individual congeners with that of TCDD, the best-studied member of the dioxin chemical class. The concentration or dose of each dioxin-like congener is multiplied by its TEF to arrive at a toxic equivalent (TEQ), and the TEQs are added to give the total toxic equivalency. The total toxic equivalency is then compared to reference exposure levels for TCDD expected to be without significant risk for producing health hazards.

PCDD/PCDFs may be formed during the chlorine bleaching process at pulp and paper mills. PCDD/PCDFs are also formed during chlorination by waste water treatment plants. They can occur as contaminants in the manufacture of certain organic chemicals. PCDD/PCDFs are released into the air in emissions from municipal solid waste and industrial incinerators and from any poorly controlled combustion process, such as backyard trash burning. Dioxin has often been identified as one of the most potent human carcinogens, which is supported by the fact that the most potent dioxin (2,3,7,8-TCDD) has a cancer slope factor higher than any other chemical on the list of approximately 770 chemicals in the EPA Regional Screening Level table.

When released into the air, some PCDD/PCDFs may be transported long distances, even around the globe. When released in waste waters, under certain conditions a small amount of the PCDD/PCDFs congeners may be broken down by sunlight, a fraction of some may evaporate to air, but most attach to

soil or attach to bottom sediment. Similar to the PCBs, PCDD/PCDF concentrations typically increase as they biomagnify up in the food chain, with higher trophic level organisms containing higher levels than present in lower level prey, and much higher levels than present in the water.

Penobscot River Point Source Discharges

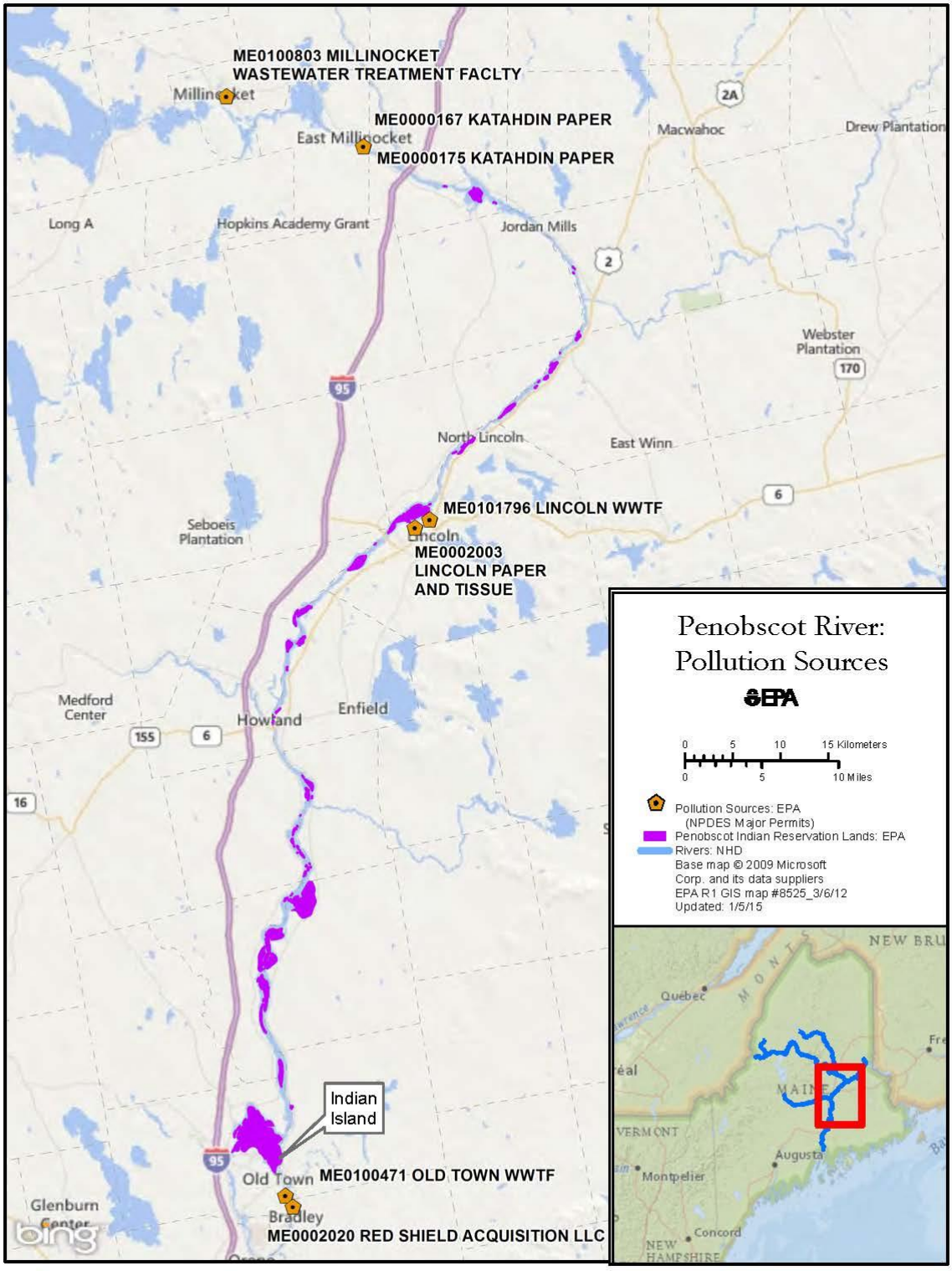


Figure 3: Point sources of pollution to the Penobscot River. Sources are labeled by orange pentagons. Inset shows location of this area in the Penobscot watershed.

Pulp mill, Lincoln, 1915 ***Contributed by Lincoln Historical Society,*** MMN Item 31548
http://www.mainememory.net

There are numerous point sources of pollution to the Penobscot River (Figure 3). The principal industries in the Penobscot River Basin are paper manufacturing, sawmills, lumber preservation, and other wood products manufacturing. Other industries in the basin include leather and allied product manufacturing and textile production (U.S. Bureau of the Census, 2000). The Lincoln Pulp & Paper Mill (LP&P; Figure 3, labeled as Lincoln Paper & Tissue) is of particular concern because pursuant to an analysis by the Department of the Interior (DOI), the Penobscot Indian Nation's Reservation abuts the facility along the bank of the Penobscot River, and one of the facility's wastewater discharge pipes, outfall number 1, discharges into the waters of the Penobscot Indian Nation's Reservation. On-site industrial operations for the Lincoln Pulp & Paper Mill began approximately in 1827. The 385-acre parcel is currently owned and operated by Lincoln Paper and Tissue (LP&T). This industrial site has been used as a grist mill, a saw mill, and wood pulp and paper manufacturing.

Between June 1983 and August 1998, LP&P was responsible for 276 releases of hazardous, nonhazardous, and unknown materials to either the ground surface, the Waste Water Treatment Facility (WWTF), or to containment structures. According to LP&P personnel, ME DEP personnel were notified of each release. Not all releases had adverse effects (LP&P, 2003).

In March of 1990, a Superior Court judge approved a settlement requiring Georgia-Pacific Corp. to pay a state record fine of $637,000 for alleged water and air pollution violations dating back to 1986. The civil fine against Georgia-Pacific, which became Maine's largest landowner when it recently assumed the property holdings of takeover target Great Northern Nekoosa Corp., is the largest ever

for violating Maine environmental laws, according to the Maine Department of Environmental Protection (ME DEP).

Previous Investigations

The Penobscot Indian Nation established a Department of Natural Resources (PIN-DNR) in 1980 to monitor and promulgate tribal ordinances to protect the Tribe's natural resources. Over the past three decades, the Department has established model air and water monitoring programs collaborating with local, state and federal partners to monitor the health of the ecosystem, develop toxicity studies assessing the level of toxins Penobscot tribal members are exposed to, and restoration initiatives to protect and restore the health of the ecosystem.

Monitoring of chemical contamination of the Penobscot River includes the State of Maine's Dioxin Monitoring Program, established in 1988, and the Surface Water Ambient Toxics Monitoring (SWAT) Program, established in 1993. The SWAT program includes monitoring for Dioxin, Mercury and PCBs. See http://www.maine.gov/dep/water/monitoring/toxics/. In addition, the Maine Department of Environmental Protection (ME DEP) maintains four sampling stations in the study area as part of a statewide Dioxin Monitoring Program. The State's Dioxin Monitoring Program involves regular sampling and reporting of concentrations of dioxins/furans in fish, wastewaters, sludges and effluents in the State of Maine (USEPA, 1989; Frakes, 1990; Opperhuizen, 1990; Mower, 1991-2002; ENSR Consulting and Engineering, 1995; USF&W, 1996; ME DEP, 1999-2000).

In 1998, the BIA approached EPA with their concern regarding the public health problems of the Penobscot tribal members. BIA was concerned that the pollution discharges into the Penobscot River were impacting the health of the Penobscot Nation. The BIA expressed concern with polychlorinated-*p*-dioxins (referred to as dioxin or PCDD in this document) and polychlorinated dibenzofurans (referred to as furan or PCDF in this document), and polychlorinated biphenyls (PCBs) in fish and sediment in the Penobscot River between the towns of Lincoln and Old Town, Maine. As a result of the BIA's concern, the BIA commenced an occurrence and distribution study of dioxin, PCBs and furans in the Penobscot River in collaboration with the PIN, EPA, USGS, ATSDR and USF&W in 1998. The purpose of this study was to characterize the riverbed sediments in an effort to complement the ME DEP data and more completely determine the ecological and human-health risks associated with dioxin, furans, and PCBs to the PIN tribal members. A Quality-Assurance Project Plan (QAPP) was developed by the cooperating agencies, authored by the USGS, and approved by EPA in 2001. Samples of riverbed sediment from nine river reaches and fish from two river reaches between Old Town and Grindstone, Maine were collected. The University of Maine Environmental Chemistry Laboratory (UMAECL) analyzed the samples for quantitative determination of dioxin, furan, and PCB congeners. However, due to a loss of funding and loss of staff, the lab equipment was not properly maintained and the integrity of the samples collected were impaired. USEPA conducted the data validation and determined that the data were not of the quality specified in the QAPP. On April 16, 2003 EPA issued a letter to UMAECL that it was unable to accept the dioxin, furan, and PCB analytical results. EPA concluded that the data were not of sufficient quality to be used to report with any degree of certainty concentrations of the compounds in the samples collected for the study.

In 1999, the U.S. Bureau of Indian Affairs submitted two requests to USEPA Region 1. The first letter was received on February 18, 1999 requesting that EPA conduct a comprehensive multimedia environmental compliance inspection of Lincoln Pulp & Paper Co., Inc. The second letter was received on April 22, 1999 from Franklin Keel, the Director of the Eastern Area Office of the BIA. Director Keel

requested that due to the numerous releases of hazardous substances in the Penobscot River, USEPA take the necessary action to compile the appropriate information in to the CERCLIS system.

In response to BIA's request, in May of 1999, EPA conducted a multi-media inspection of the facility and conducted a Preliminary Assessment/Site Investigation (PA/SI) of the Lincoln Pulp & Paper Company. According to the PA/SI some of the previous investigations included a solid waste disposal area investigation conducted by E.C. Jordan, Inc. in 1988 and Phase I and Phase II hydrogeological investigations conducted by Sevee and Maher Engineers, Inc. in 1991 and 1995, respectively (Final Preliminary Assessment/Site Inspection Report For Lincoln Pulp & Paper Co. Lincoln, Maine, May 30, 2003). Soil/source and sediment/source samples collected by EPA during this PA/SI indicated the presence of three volatile organic compounds (VOCs), ten semivolatile organic compounds (SVOCs), seven pesticides, three PCBs, 17 dioxins/furans congeners, 11 coplanar PCB congeners, and 14 priority pollutant metals. Beryllium was detected in one sample in excess of the Maine State Remediation Guidelines.

The PA/SI analytical results of the eight sediment samples collected from the Penobscot River indicated elevated concentrations of one SVOC (fluoranthene), one PCB (Aroclor 1254), two metals (copper and mercury), nine dioxin/furan congeners, and 11 coplanar PCB congeners. Analytical results of four sediment samples collected from Mattanawcook Stream indicated that one element (mercury), eight dioxin/furan congeners, and ten dioxin-like PCB congeners were detected above reference criteria in samples collected from areas downstream of the mill complex along Mattanawcook Stream. Five dioxin/furan congeners and nine coplanar PCB congeners were detected above reference criteria within the one unnamed stream sample (99-SD-03) (LP&P, 2003). Based on analytical results of the EPA sediment samples, release of hazardous substances to Mattanawcook Stream, the unnamed stream, and to the Penobscot River were documented.

On August 22, 2003, the EPA issued a letter stating that based on the available data and information concerning the site condition, that the appropriate designation for the site was a "No Further Federal Remedial Action Planned" (NFRAP) designation. EPA noted that its decision was based in part on knowledge that the, "… the ME DEP has been working with LP&P over a long period of time to address both solid waste & other issues at the property." EPA did state that its decision was subject to revision in consultation with the Penobscot Indian Nation or the State of Maine based upon new information or substantially altered site conditions. (Final Preliminary Assessment/Site Inspection Report For Lincoln Pulp & Paper Co. Lincoln, Maine, May 30, 2003).

Purpose and Objectives of Research

Due to the variety of pollutants that are discharged into the Penobscot River (See Figure 3.), the Penobscot Indian Nation (PIN) questions the ecological health and water quality of the river and how this may affect the practices that sustain their way of life. As a riverine tribe, the Penobscot culture and traditions are inextricably tied to the Penobscot River watershed. It is through hunting, fishing, trapping, gathering and making baskets, pottery, moccasins, birch-bark canoes and other traditional practices that the Penobscot culture and people are sustained.

Unfortunately, EPA lacked exposure information for assessing health risks for New England Tribal Nations that are sustaining a tribal subsistence way of life. The traditional methodology for health risk assessment used by the U. S. Environmental Protection Agency (EPA) is based on the use of exposure assumptions (e.g. exposure duration, food ingestion rate, body weight, etc.) that represent the entire American population, either as a central tendency exposure (e.g. average, median) or as a reasonable maximum exposure (e.g. 95% upper confidence limit). Therefore, EPA did not have means for assisting Federally Recognized Indian Tribes with developing Environmental and Health Protection Policies in Indian Country to protect tribal members who live according to their unique Native American traditions.

This study provides a scientific basis for the Penobscot Indian Nation for developing environmental and health protection policies that will protect tribal members who live according to their unique culture and tradition. This RARE study characterizes the potential health risks from cultural practices of Penobscot Indian Nation tribal members. This preliminary risk assessment evaluates the potential for exposure and risk to Penobscot Indian Nation tribal members from contaminants in sediment and biota when gathering, hunting or fishing according to the PIN's treaty protected rights afforded to them by the U.S. Congress.

Accordingly, the goal of this research was to assess potential exposures to dioxins, furans, PCBs, and mercury from ingestion of fish, duck, turtle, medicinal plants, and ingestion and dermal contact of sediments in the absence of any remedial action within the study area. This study was a preliminary risk assessment designed to determine if contaminant concentrations in fish, snapping turtle, wood ducks, and plants in Regions of the Penobscot River relevant to where PIN tribal members hunt, fish and gather plants are a health concern. This study was not designed to be a statistically validated assessment of contaminant differences among study sites or among species.

Objectives:

1. Develop culturally sensitive methodologies for assessing the potential level of exposure Penobscot Indian Nation tribal members may have from maintaining tribal sustenance practices.
2. Conduct field surveys and laboratory analysis on targeted flora and fauna for chemical exposure to dioxins/furans, PCBs, mercury and methyl-mercury.
3. Assist the ATSDR by providing the necessary data to conduct a Public Health Assessment.
4. Establish protocols for assessing the level of exposure to PCBs, dioxins/furans and mercury to tribal members as a consequence of gathering tribal plants for medicinal and nutritional purposes; as well as, consuming fish, eel, wood duck, and snapping turtle as a primary source of nutrition.
5. Survey surface water, sediment, and drinking water from the Penobscot River and Indian Island to assess the potential exposure of Penobscot Indian Nation tribal members to environmental genotoxicants that continue cultural sustenance practices.

Since an ecological risk assessment could not be conducted, the ecological samples collected by this study were archived for potential future analysis.

Research Responsibilities

The USEPA, USGS, ATSDR, and USF&W collaborated with the Penobscot Indian Nation to design a contaminant sampling and analysis program that would be usable for human health and ecological risk assessment. Various funding opportunities were pursued and in 2007, the team was awarded $100,000 through the Region 1 Regional Applied Research Effort (RARE) Competition. The purpose of RARE funding is to address priority research problems in EPA New England. The funds allowed the EPA to partner with the Penobscot Indian Nation and other Agencies to conduct a preliminary risk assessment of the Penobscot River Ecosystem.

An additional $30,000 in EPA RARE funds was acquired to conduct a supplemental study assessing the exposure of Penobscot Indian Nation tribal members to environmental genotoxicants. This supplemental study used the bacterial Ames test for mutagenic testing of the surface water, sediment, and drinking water from the Penobscot River near Indian Island, Maine. Mutagenicity is a feature of some cancer-causing (carcinogenic) chemicals.

Additional funds were also provided by Penobscot Indian Nation through EPA Indian Environmental General Assistance Program (GAP), CWA Section 104(b) 3, and CWA Section 106 grants to support sample collection and analyses.

Left to right: Jan Paul, Jason Mitchell, Robert Lent, Dan Kusnierz, Gary Perlman, Valerie Marshal, Janet Diliberto, Robert Hillger, Thomas Hughes, Robert Dudley, Carl Orazio, Jason Sockbeson

Research Team

PIN DNR staff and Federal Partners listening to Dan Kusnierz at boat launch on the Penobscot River

This project involved a significant collaboration among several Federal partners and the Penobscot Indian Nation. It involved the collaboration of approximately 50 scientists. See Appendix D: Personnel Associated with RARE Study.

Penobscot Indian Nation (PIN)

The Penobscot Indian Nation collaborated with USGS and USF&WS for logistical assistance with field collections of the flora, fauna, sediment, and water samples. USF&WS, USGS, and USEPA assisted the Penobscot Indian Nation with collecting the samples according to the approved QAPP. The Penobscot Natural Resource Department was the liaison to the tribal elders and facilitated consultations with the Penobscot Tribal Nation to assure that the tribe's unique traditional practices and lifestyle were accurately reflected and evaluated in this study.

United States Geological Survey (USGS)

USGS Columbia Environmental Research Center (CERC)

USGS was the lead agency for developing a Quality Assurance Project Plan (QAPP) for this study. The QAPP was developed in partnership with the Penobscot Indian Nation, USEPA, ATSDR, USF&WS, and the BIA. The USGS CERC lab conducted the Congener-Specific PCB Analytical Process for the study and the TOC, grain size, and mercury testing for sediment.

USGS Maine Water Science Center

The Field Sampling Leader, USGS, was the primary contact between the sampling team and the laboratories that conducted the processing and/or analysis. The USGS was the lead for the field sampling team (USGS, PIN-DNR, USF&WS, and EPA Region 1 and ORD) and was responsible for scheduling project fieldwork; establishing sampling site locations; organizing and coordinating shipping and handling with EPA NERL, USGS-CERC, Frontier Geoscience Lab, and EPA OPP laboratory managers; organizing and coordinating overall sampling schedule with EPA NERL and

PIN-DNR managers. Analytical chemistry data from each laboratory were reviewed by each laboratory's QA/QC program.

United States Environmental Protection Agency (EPA)

US EPA New England Region 1

EPA New England Indian Program supported the submission of this RARE proposal and approved Valerie Marshall to participate as a co-lead with Janet Diliberto of EPA ORD for this project. As a leader of this project, Valerie Marshall led all the conference calls and meetings for this study, assisted with the fish sample collection, participated in all the QA audits, and facilitated the successful development and completion of this research project. EPA New England Superfund Program assisted with the scoping of the current study and the review of the data generated. EPA GIS Department assisted with developing maps for this study.

US EPA New England Regional Laboratory at North Chelmsford, MA

EPA New England Regional Laboratory (NERL) at North Chelmsford, MA assisted with fish and turtle sample collection, development of the study and the QAPP, and conducted mercury sample analysis for the fish tissue. EPA New England's Quality Assurance Program approved the Quality Assurance Plan for this project. Analytical chemistry data from each laboratory were reviewed by each laboratory's QA/QC program and then reviewed by the RARE Project Data Validator at EPA's NERL.

US EPA Environmental Chemistry Laboratory at the Stennis Space Center, MS

The EPA Environmental Chemistry Laboratory (ECL), under the Office of Pesticide Programs (OPP) commonly referred to as the Stennis Lab conducted the analysis of PCBs, dioxin/furans and mercury of the sediment samples, and played an integral role in developing the parameters of this study and the QAPP and they also assisted with the review and validation of the sample analyses.

US EPA/ORD at Research Triangle Park, NC

Janet J. Diliberto was the co-lead for this project and assisted with the development of the QAPP, management of the Project, attended all site visits and participated in all the QA audits. Janet Diliberto retired from EPA on October 1, 2011.

US EPA/ORD/NHEERL/RCU

The Quality Assurance Manager was responsible for reviewing and approving the QAPP and served as the lead QA Auditor on the QA Audits. The Technical Systems Audit (TSA) of the Ames testing was conducted by EPA NHEERL QA Manager.

US EPA ORD/EERD: Ecological Exposure Research Department was responsible for processing all the fish tissue samples collected.

Agency for Toxic Substances and Disease Registry (ATSDR)

This study involved collaborating with the ATSDR to assure the scope and procedures identified in the QAPP met the objectives of the Penobscot Indian Nation to quantify the risk associated with Penobscot tribal members carrying out their traditional practices and ensuring that the methodologies employed are accepted within the scientific community. ATSDR participated in the scoping of this study and served as an integral research partner in performing and carrying out this research study. ATSDR attended all conference calls and meetings and assisted with the review and evaluation of the data generated from this study. ATSDR conducted a Public Health Assessment on behalf of the Penobscot Indian Nation based on past data acquired and the data generated from this study.

US Fish and Wildlife Service (USF&WS)

The USF&WS has been conducting investigations on the Penobscot River examining contaminant residues in Atlantic salmon, sturgeon, and bald eagles, and endocrine disruption in smallmouth bass. USF&WS' environmental contaminants biologist in the Maine Field Office – Ecological Services, assisted in field collections for the RARE project.

Bureau of Indian Affairs (BIA)

The Penobscot Indian Nation also collaborated with the Bureau of Indian Affairs on this project to assure that the data generated is usable to link science to policy and decision-making for the Penobscot Indian Nation. The Bureau of Indian Affairs participated in the scoping of this study.

Approach

Penobscot River

The study was designed as a preliminary risk assessment to determine if contaminant concentrations in sediment, fish, turtle, wood ducks and plants in regions of the Penobscot River relevant to where the PIN hunt, fish and gather plants were high enough to be a health concern. Several meetings at the Penobscot Nation Natural Resource Department office and numerous conference calls were held to develop a preliminary screening for assessing the level of exposure concentrations to PCBs, dioxins/furans, mercury, and methyl-mercury in sediment, plants, fish, duck and turtle from areas commonly used by Penobscot tribal members when gathering, hunting and fishing in the Penobscot River. Information was also gathered as to how the PIN tribal members consume the species collected and what portion is typically consumed or used. For example, most PIN tribal members prepare the sampled species by fileting and skinning them. Therefore, that is the sample portion we analyzed in this study. Details of the specific collection and preparation method for each species is contained in the Sample collection design section of this report.

The team selected specific geographical locations (reaches) along the Penobscot River for flora, fauna, and sediment collection. Six reaches deemed ecologically representative were selected along 87 miles of the Penobscot River between Old Town and Medway, Maine. The reaches were chosen based on the sediment mapping conducted by USGS in 1999 (selected reaches of the study area were mapped during a bed-sediment mapping effort in May of 1999 [Dudley and Giffen, 2001]). To ensure the highest quality and reliability, a process of internal and external peer review by both cultural and scientific experts was followed. The approach for this research project combined some of the elements of consumption surveys such as interviewing Tribal elders to determine recent natural

resource utilization patterns with careful identification of Tribal exposure factors (contaminant concentrations, pathways of exposure). Collaborating with numerous scientists assured the scope and procedures identified for this project met the objectives of the PIN and that the methodologies employed are accepted within the scientific community.

With the flora and fauna data collected from this study, ATSDR conducted a Public Health Assessment for the Penobscot Indian Nation that ATSDR will publish separately from this report. EPA conducted a preliminary risk assessment by comparing the concentrations in biota to risk-based concentrations to determine the level of risk to the Penobscot Indian Nation tribal members that maintain cultural practices and sustenance lifeways associated with the Penobscot River. ATSDR and EPA used Maine tribal ingestion and dermal contact rates that were developed in 2009. Through collaboration between EPA Region 1 and the federally recognized Maine Tribal Nations, exposure scenarios that reflect the Maine tribal traditional cultural uses of natural resources were developed, i.e. ***The Wabanaki Traditional Cultural Lifeways Exposure Scenario*** (Harper and Ranco, 2009).

The team also selected 4 sites for collecting surface water, sediment, and drinking water for the *Salmonella* mutagenicity assays. The *Salmonella* mutagenicity assay was used to assess complex, organic extracts of the river water, sediment from the river, and drinking water associated with the PIN. The data collected from the *Salmonella* mutagenicity assays provide an integrated measure of the mutagenic activity and, thus, potential carcinogenic activity, of the organics in the river water, sediment from the river, and drinking water associated with the PIN.

Research Study Location

River reaches in this study (Figures 4 - 8) are demarcated upon the basis of river-features that control or potentially impact fish passage or habitat (dam structures, impoundments, fish ladders, falls). USGS field sampling leader, Rob Dudley, and the Penobscot Indian Nation Water Resource Manager, Dan Kusnierz, divided the study area into six sampling reaches associated with the Penobscot Indian Nation Reservation distinguished by general hydrology and whether the area is located in impounded waters of a dam or free-flowing. Three of the reaches (reaches 1-3) were surveyed previously in 1995-96 and 1999 (Dudley and Giffen, 2001).

The reaches were chosen based on a sediment mapping study conducted by USGS in May 1999 in which bed sediments were mapped in selected reaches of the study area (Dudley and Giffen, 2001). The 1999 mapping effort involved the use of ground-penetrating radar data to characterize the bed-sediment composition in selected reaches of the Penobscot River. Sampling locations were chosen on the basis of the mapping information and other river characteristics including wading and swimming areas; depositional zones within the channel; and sites upstream and downstream of river features that control or potentially impact sediment transport (such as dam structures and impoundments). The control reach included both free flowing (East Branch Penobscot) and natural lake waters (Salmon Stream Lake) that were within the upper Penobscot Watershed and upstream of any discharge or known pollution sources.

Three types of samples were collected for the *Salmonella* mutagenicity assay: drinking (tap) water from Indian Island, surface water from the Penobscot River, and sediments from the Penobscot River. River water and sediments were collected at the following locations: (1) an upstream site (Salmon Stream Lake); (2) a site slightly downstream of an industrial-outfall (Lincoln Paper and Tissue Mill); and, (3) a publically owned treatment-works facility (Lincoln POTW), and a downstream site (West Enfield impoundment). A fourth sediment sample was obtained from a site adjacent to Indian Island. Drinking water samples were collected at the PIN DNR, Water Quality Monitoring Laboratory on

Indian Island, ME. Figure 8 and Table 2 provide details about the sites and the samples collected for the mutagenicity analysis.

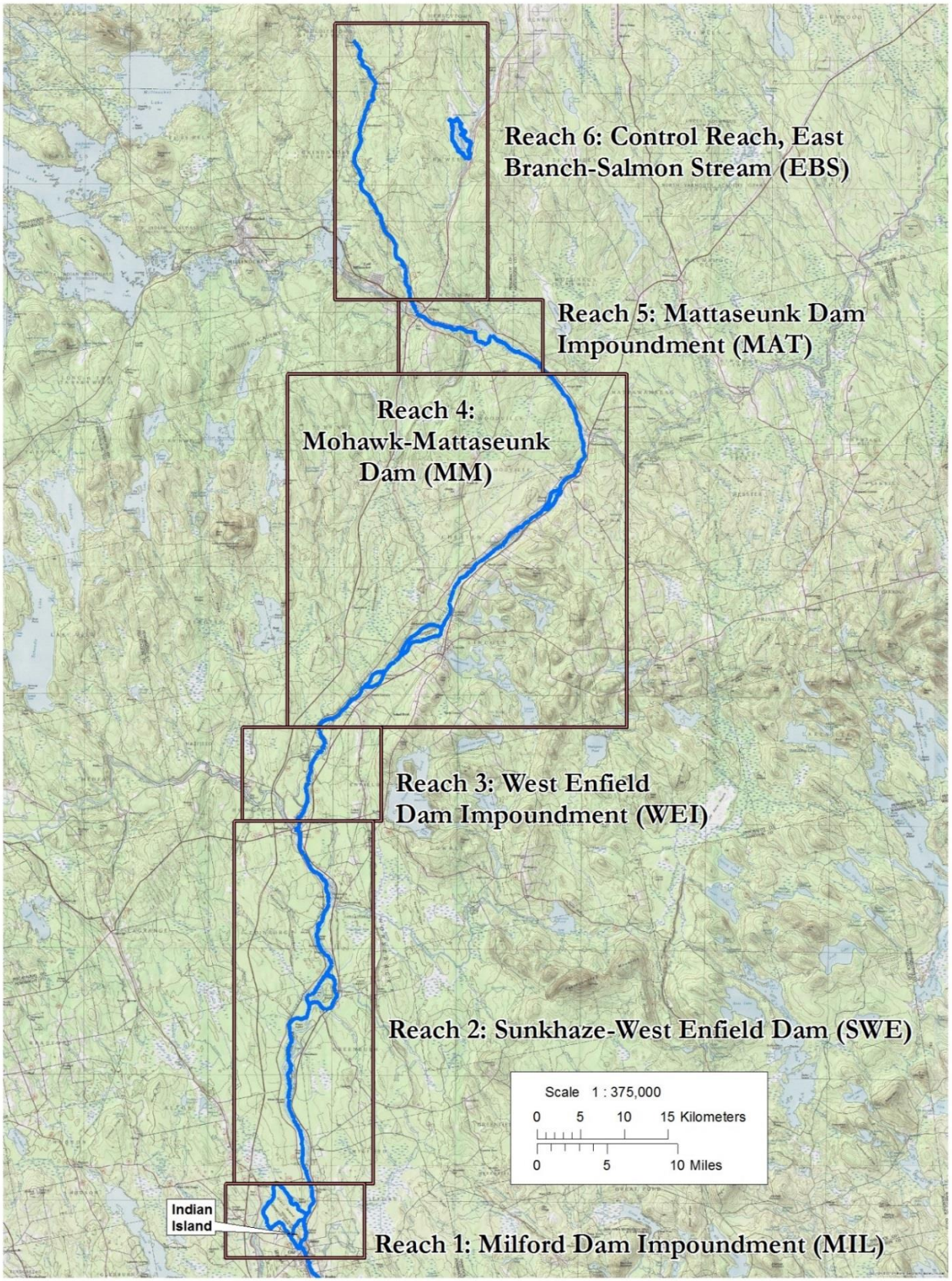
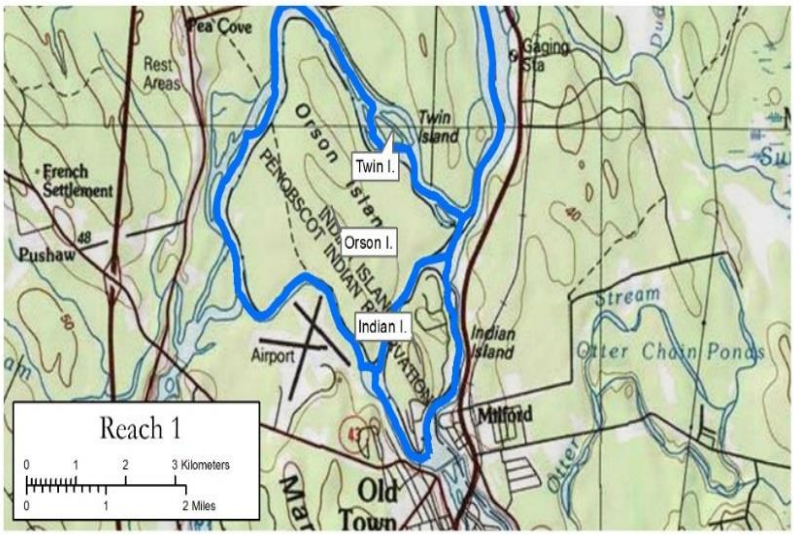


Figure 4: Penobscot River Study Six Reaches. The six reaches of the Penobscot River studied in this project.



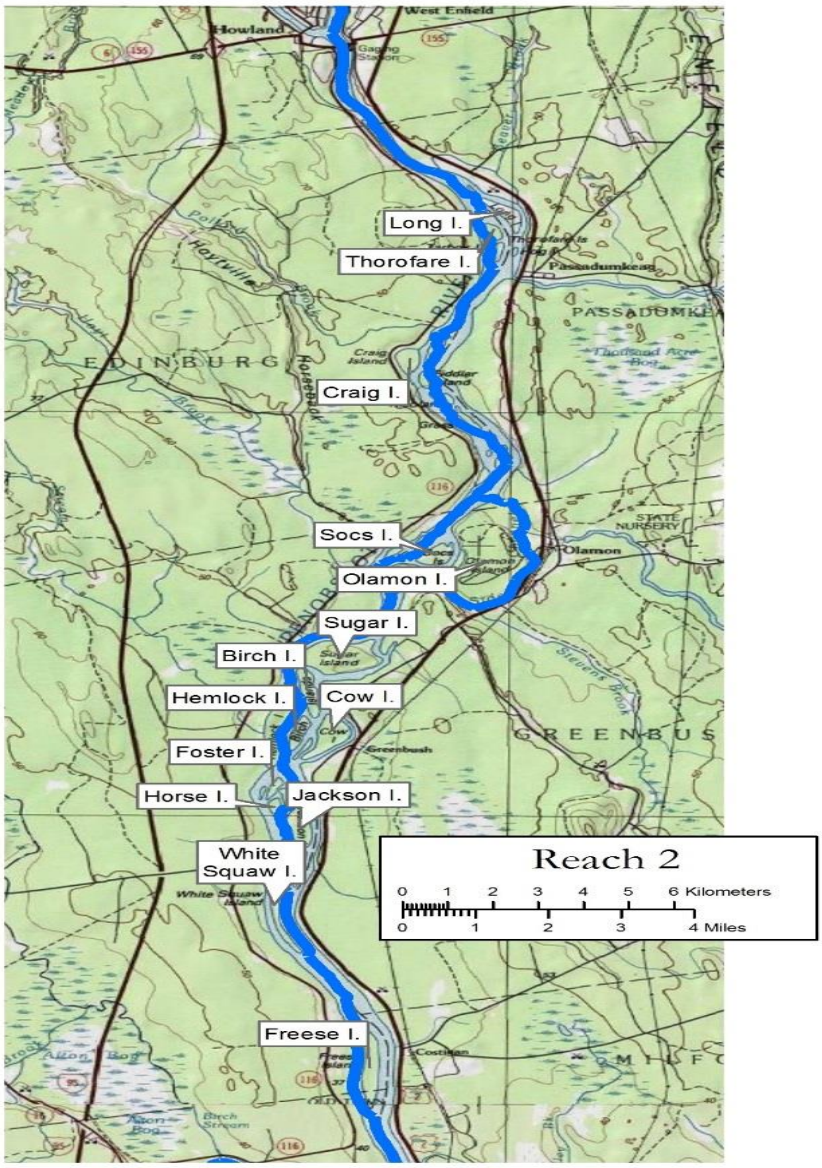


Figure 5: Penobscot River Study Reaches 1-2.

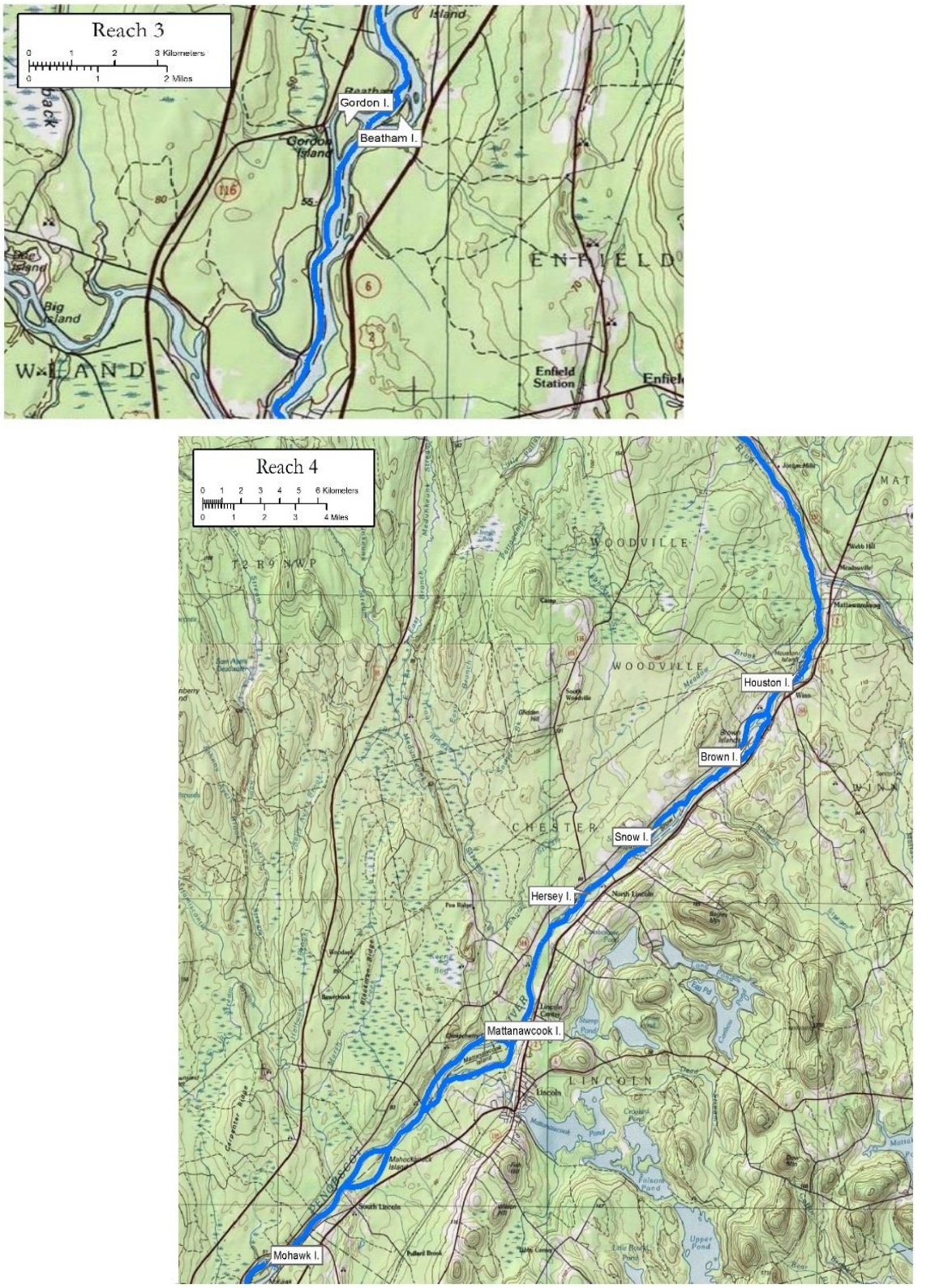


Figure 6: Penobscot River Study Reaches 3-4.

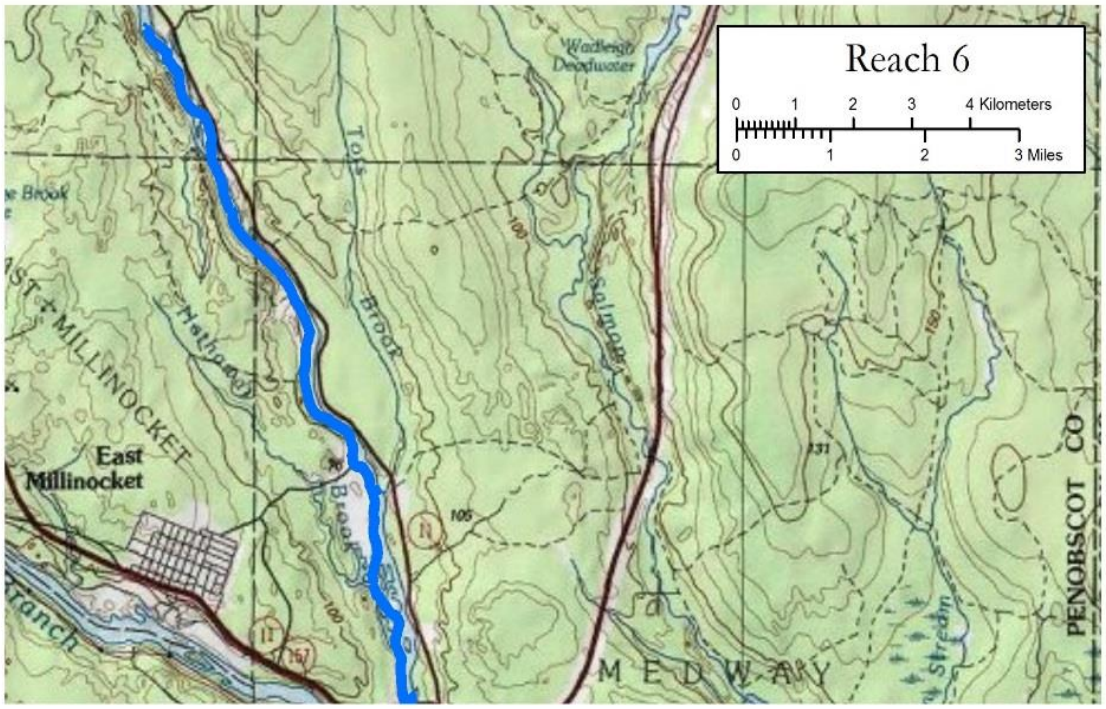


Figure 7: Penobscot River Study Reaches 5-6.

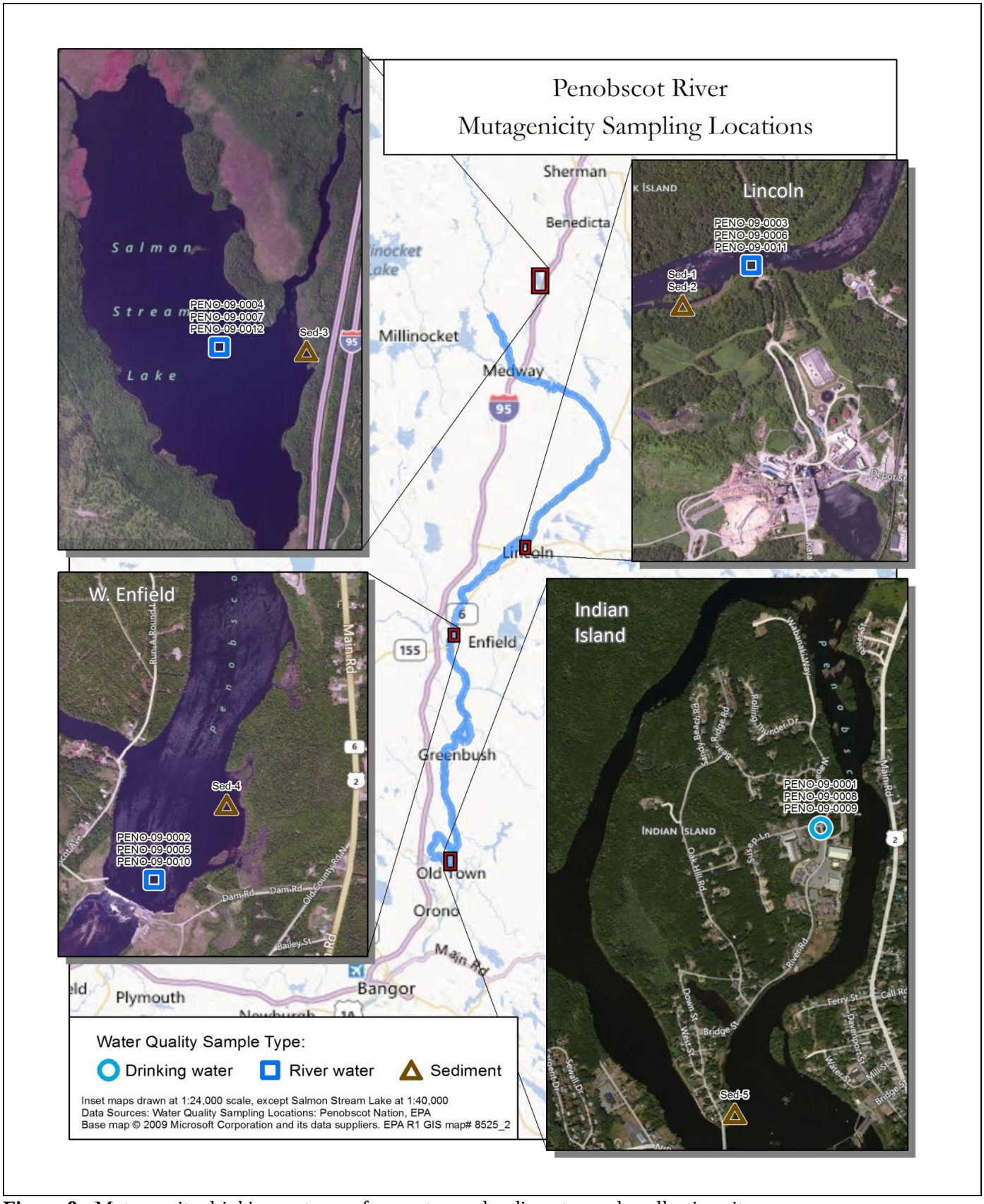


Figure 8: Mutagencity drinking water, surface water, and sediment sample collection sites.

Sample Collection Design and Analysis

From Left: Robert Lent, USGS; Robert Hillger, USEPA; Jason Sockbeson, PIN DNR; Gary Perlman, ATSDR; Valerie Marshall, USEPA.

Research Project Schedule

The funding for this research study was awarded in June 2007. Following the development of the QAPP and the completion of the design criteria for the study, samples were collected and analyzed from May 2008 until January 2011. Throughout the research period several audits were conducted to ensure the integrity of data collection and management. The consolidation and final analysis of data results were completed by September 2011. An overview of the project schedule can be found in Appendix C.

Sample Collection and Preparation

The study area was divided into six reaches, including a control reach. The reaches were identified by USGS in collaboration with the Penobscot Indian Nation, and are generally demarcated on the basis of river features that affect fish passage or habitat (dams, impoundments, free-flowing) (Figures 4 - 7). The control reach is upstream of any point source discharges and includes both free-flowing riverine habitat (East Branch Penobscot River) and natural lake habitat (Salmon Stream Lake). A variety of flora and fauna species, and sediment samples from each of the six reaches were collected. Some plants that were collected are used for medicinal purposes by the Penobscot Indian Nation and cannot be named in this report. To protect these resources from being exploited, these plants are referred to as "medicinal plants". The following section contains a description of the species collected and how they were sampled. An overview of the quantity, type, and species collected within each reach is provided in Table 1. All field sample collection and sample handling followed explicit protocols outlined in the QAPP.

Because the PIN has a concern about the possibility of environmentally induced cancers among their population caused by municipal and industrial waste discharges into the Penobscot River, the project team determined that an important aspect of this study should include evaluating if environmental mutagens occur in surface water, sediment and drinking water because mutagenicity could be indicative of the presence of potential carcinogens. To address these concerns, monitoring methods using the *Salmonella* mutagenicity assay (Ames test) were employed to test for mutagenic activity. Because there are many classes of carcinogens e.g., metals, fibers, dyes, and certain polycyclic aromatic hydrocarbons (PAHs), efforts to establish the presence or absence of mutagenicity in these samples serves to evaluate whether additional studies on potential carcinogens may be needed.

Samples Collected

Reaches were sampled from May 2008 to October 2009. Quality-control (QC) duplicate samples were obtained. Each sample location was recorded using a hand-held GPS unit. All sampling procedures followed USEPA-approved protocols as outlined in the QAPP for this project (Orazio, 2008). Daily field logs were maintained. The surface water, drinking water and sediment samples for the Mutagenicity assays were collected from July-October 2009. QAQC procedures were followed for collecting these Samples (See Claxton and DeMarinin EPA Intramural Research Protocol). Tables 1 and 2 below summarize the samples collected for this study.

Summary of Composite Samples Collected of Sediment, Flora, and Fauna										
Reach	**Sediment**	**Perch**	**SMB**	**Bullhead**	**Pickerel**	**Eel**	**OSF***	**Med. Plant ****	**Duck**	**Turtle**
	n ***(water depth)***	***n (spp.)*** ***#/Wt. (kg)*** ***Length (mm)***	***n*** ***#/Wt.(kg)*** ***Length(mm)***	***n*** ***#/Wt.(kg)*** ***Length(mm)***	***n*** ***#/Wt.(kg)*** ***Length(mm)***	***n*** ***#/Wt.(kg)*** ***Length(mm)***	***n*** ***#/Wt.(kg)***	***n*** ***#/Wt. (kg)***	***n*** ***#/Wt.(kg)***	***n*** ***#/Wt.(kg)***
1 **(MIL)**	3 shallow (0.6-0.9m)	1 (White) 7/2.26 245-300	1 4/2.40 320-405	1 11/2.39 220-284	1 8/2.15 335-410	1 4/2.07 555-721	1 3/2.67	0	1 4/0.79	1 1/2.76
	1 impoundment (1.8m)									
2 (SWE)	3 shallow (0.6 – 0.8m)	1 (Yellow) 13/1.76 204-270	1 5/3.5 347-464	1 10/2.89 248-328	1 7/2.27 350-431	1 5/1.75 481-684	2 3/1.87 3/1.87	0	1 3/0.58	0
3 (WEI)	3 shallow (0.8-1.1m)	1 (Yellow) 14/2.42 221-280	1 4/3.22 328-443	1 12/2.12 219-288	1 6/2.16 342-447	1 4/2.7 632-790	1 3/2.15	1 3/0.48	2 3/0.57 3/0.59	1 1/2.64
	1 impoundment (2.4m)									
4 (MM)	3 shallow (0.3– 0.6m)	1(White) 6/1.16 188-270	2 4/3.91 406-440	1 9/2.02 205-288	1 7/2.34 332-433	1 4/2.47 606-761	2 3/1.59 3/1.48	1 3/0.5	1 3/0.81	2 1/2.95 1/1.98
		1 (Yellow) 5/.37 151-208	4/3.74 387-423							
5 (MAT)	3 shallow (0.9m)	2 (White) 8/2.23 249-289	1 4/2.05 338-362	1 3/0.73 206-290	1 6/2.73 397-487	1 4/1.86 576-684	0	1 3/0.51	0	1 1/2.61
	1 impoundment (6.7m)	8/2.19 249-271								
6 **(EBS)**	3 shallow (0.5 – 0.6m)	1(White) 8/2.93 273-297	1 4/4.77 390-449	1 8/3.3 270-340	1 7/3.21 382-500	1 2/0.52 509-556	1 3/3.02	2 3/0.63 3/0.62	0	2 1/1.0 1/2.35
		1(Yellow) 14/2.51 208-265								

Table 1: Summary of composite samples collected and analyzed for the project. For non-sediment samples, n = number of composite samples, # = number of individuals or sites used in composite, wt. = total wet weight of tissue in composite. *****Ostrich Fern (OSF). ** Medicinal Plants (Med. Plant).

Summary of Samples collected for Mutagenicity Assays		
	# of samples	**Assay**
Drinking water	3 (composites)	Salmonella mutagenicity assay
River Water	9 (composites)	Salmonella mutagenicity assay
River Sediment	4 (composites of top sediment (<15 cm depth))	Salmonella mutagenicity assay

Table 2: Summary of samples collected for Mutagenicity Assays.

Sediment Collection and Preparation

Robert W. Dudley, USGS, collecting sediment sampling

Twenty one sediment samples were collected in July 2008. Three shallow water sediment composite samples, comprised of 2-5 grabs, were collected within each reach. Wading areas were chosen based upon the following criteria: Depositional zones of fine-grained material (both sand/silt and materials potentially rich in organic content) observed within the river channel via geophysical techniques; and, known or suspected littoral wading-contact areas along the mainland and island shorelines (associated with swimming, hunting, fishing, plant harvesting, boat launching, etc.).

Because the Penobscot River is a relatively high energy river system with frequent flushing of sediments, the team believed it was important to also analyze sediments behind some of the

impoundments (dams) where sediments have accumulated over time. One deep water composite sample was collected from each of the impoundments behind the Milford, West Enfield and Mattaseunk dams.

At each sampling location multiple grabs (2-5) of surface sediments (0-6" deep) were collected using a Ponar dredge sampler. After allowing excess water to drain, the sediment grabs were placed in a large metal pan until sufficient sample volume was collected. The sediment grabs were thoroughly mixed in a metal bowl using a spoon until homogenous and then transferred into labeled amber glass sample containers. Individual sample containers were placed in sealed Ziploc® bags and placed in coolers with double bagged water ice for transport to the PIN laboratory. Sediment samples were stored in a refrigerator near 4°C until they were shipped with ice to each laboratory for analyses.

Fish Collection and Preparation

Collection of fish at the Lincoln, Maine boat dock on the Penobscot River

US EPA Robert Hillger displaying eel trap used for this study at PIN DNR

Thirty-four composite fish samples, representing 228 individual fish from six species were collected from July - October 2008. The goal was to collect five species from each reach: Smallmouth bass (*Micropterus*

dolomieu), chain pickerel (*Esox niger*), white perch (*Morone americana*) or yellow perch (*Perca flavescens*) [depending on which perch species was present in the reach], brown bullhead (*Ameiurus nebulosus*) and American eel (*Anguilla rostrata*). Fish were collected by angling with line and tackle, trap nets, gill nets, or boat electro-shocking. Single species composite samples for each fish species of a reach was created by combining 3-5 individuals or as many as were needed to obtain a total mass of > 2 kg. White and yellow perch tissues were not composited together. The target size of fish was what is typically kept and consumed by Tribal members (See Table 1). The goal was to use fish of similar size so that the smallest individual in a species composite was no less than 70% of the largest individual (length). In the few instances in which the team was unable to meet this goal, the sample weight was recorded and the fish tissues were processed anyway. In these cases an attempt was made to analyze the samples for as many contaminants as possible with the limited sample amount.

Field duplicate pairs for fish consisted of two composite samples taken at a site containing fish of similar length. At two river reaches we produced paired composite samples of fish (of the same species) in which the fish sizes were as closely matched as possible. We chose white perch at Reach 5 (MAT) and bass at Reach 4 (MM) because those were the species and reaches for which we had an abundant supply of fish and from which we could make composites of similar size fish.

As fish of the appropriate species and approximate size range were collected, they were kept alive in coolers containing water until they were killed. Initial processing of fish was done in designated areas according to the approved QAPP. The field sampling team measured and recorded length and weight. Whole body fish were double wrapped in aluminum foil, labeled, placed in a Ziploc® bag and frozen in a secure location at the PIN laboratory. Fish were stored frozen until a sufficient number and size of fish were accumulated. Individual fish to be composited were organized into a plastic bag and labeled according to the Sample Labeling Protocol. Fish were shipped frozen in coolers containing dry ice to Dynamac, ORD's on site contractor, for filleting.

Because we were informed that most tribal members prepared the fish species used in the study by skinning and filleting, we used skinless fillets. Dynamac filleted and skinned each fish according to the approved research procedures with the following modification; fish were slightly thawed before removing skinned and boneless fillet with a sharp fillet knife or scalpel. The weight of the two removed fillets and the weight of the remaining offal (including skin and bones removed during filleting) from each fish were recorded separately. The fillets and offal from those samples collected at each reach were composited separately into two distinct samples. Skinned and boneless fillets were prepared for smallmouth bass, pickerel, perch, and bullhead. Sections of eel were taken after they were cleaned and skinned. At least 500g of skinless fillet tissue was needed to conduct the various chemical analyses.

The fillets of individuals of a species from a reach were wrapped in aluminum foil making sure that the dull side was in contact with the fillet and shiny side was on the outside, placed in a pre-labeled Ziploc® bag (following Sample Labeling Protocol), and placed in a -20°C freezer until they were shipped to the Region 1 laboratory. Once a cooler full of fillets had been accumulated, they were shipped on dry ice to the Region 1 laboratory contact, Dave McDonald, for homogenization. The remaining portion of the fish (referred to as offal or carcass) was wrapped in aluminum foil and shipped on dry ice to Joseph Ferrario/Stanley Mecomber at EPA Environmental Chemistry Laboratory and was stored in labeled bags and frozen for potential future analysis for ecological risk assessment.

Plant Collection and Preparation

Charles Culbertson, USGS
Washing ferns

Ostrich fern

Robert Dudley, USGS
collecting ferns

Fiddlehead fern (ostrich fern, *Matteuccia struthiopteris*) and a medicinal plant were analyzed due to the significance of these plants to the Penobscot Indian Nation culture and diet. Fiddleheads were collected as they emerged from the soil in May 2008, when and at locations harvested by tribal members. The medicinal plant was collected during early a by autumn (September and October 2009) when it is easiest to identify and harvest by tribal members. While the plant is also sometimes harvested in the spring, it is less abundant, more difficult to identify, and less accessible at that time. While carrying out other collection activities and with the assistance of a tribal botanist, the team located sites where the medicinal plant could be harvested. The sites were revisited during September and October for collecting, while taking care not to overharvest from any one area. Per the USEPA approved QAPP, the data is stored as a record from this study in Penobscot Indian Nation DNR files.

A total of seven composite fiddlehead samples were obtained, representing five of six reaches and one field duplicate sample. We were unable to find fiddleheads in the MAT Reach (Reach 2). In the MM reach (Reach 4) we collected two composite samples from the following sites; one downstream of the Lincoln Paper and Tissue mill and another upstream in an area heavily utilized by tribal harvesters.

Fiddlehead ferns were collected using similar methods to those used by tribal members when harvesting. We also analyzed that portion of the fern that is consumed by tribal members. Fiddlehead ferns were collected by breaking emerging fiddleheads from the stems and placing in a 1-gallon Ziploc® plastic bag labeled with reach and location. Approximately 500g of sample was collected at each site station location. Each reach composite sample was comprised of fiddleheads collected from two to three site station locations within the reach segment. The samples were transported in a cooler with double bagged water ice to the office/PIN lab. Soil and non-edible brown skins were removed from the fiddleheads by soaking and spraying the ferns with tap water through a screen. The ferns were then rinsed in deionized (DI) water. The cleaned fiddleheads from each location within a reach were combined and thoroughly mixed together. Approximately 500 grams of cleaned fiddleheads were weighed out with a balance or scale and placed in a new Ziploc® bag with a sample labeled according to the Field Sample Numbering protocol. Fiddlehead samples were frozen at -20°C.

A total of five composite medicinal plant samples were collected representing four reaches and one duplicate. The type of plant tissue (leaves, stems, roots) that was composited represents what is typically used by tribal members.

The medicinal plant collected for this study was collected using the same methods used by tribal members when gathering the plant. Root materials from the medicinal plants were extracted from where it grows by digging with gloved hands, or with the use of a trowel. The leaves were removed by cutting with a sharp knife and the root materials were placed in a Ziploc® bag labeled with reach and location. Depending upon abundance, each reach sample was comprised of root material from two locations within each reach segment. Samples were transported in a cooler with double bagged water ice to the office/PIN lab. At the PIN lab, the root materials were rinsed with tap water to remove soil, and then rinsed with DI water. Approximately equal amounts of plant material from each location within a reach were combined and thoroughly mixed together. For each reach approximately 500g of root materials were weighed out with a balance or scale and placed in a new Ziploc® bag with a sample label according to Field Sample Numbering protocol. The medicinal plant samples were frozen at -20°C.

Field duplicate pairs were collected for fiddlehead (1 duplicate) and medicinal plant (1 duplicate) samples from one of the six reaches. Both samples of a field duplicate pair were a composite of plant materials collected from the same locations within a reach and in accordance with the QAPP.

Plant samples were then shipped frozen from Maine on dry ice to CERC-USGS for analysis preparation. Upon delivery to laboratories, chain-of-custody forms were signed and the samples were stored in a secure location frozen at -20°C until processing.

Turtle Collection and Preparation

USF&W photo

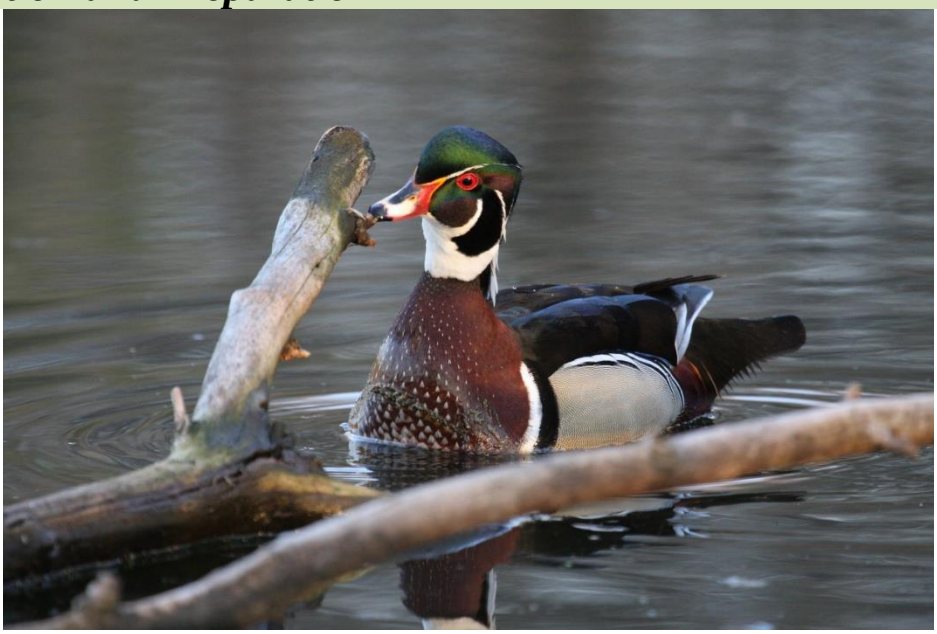
USF&WS Digital Library http://digitalmedia.fws.gov/cdm/

Snapping turtles (*Chelydra serpentine*) are an important tribal food. Initially the team had discussed collecting three snapping turtles per reach; however, due to the concern of negatively impacting the population, we reduced the targeted number of snapping turtle per reach. A total of seven snapping turtles were collected from five of the six reaches. No samples were obtained from Reach 2.
In September 2008, the team collected snapping turtles from two of the six reaches. In an attempt to collect snapping turtle from all the reaches, the team decided to try to collect snapping turtle again in 2009. During July – September 2009 we successfully collected snapping turtles from five of the six reaches. Snapping turtles were captured using baited hoop net traps. Snapping turtle traps were set up in slow moving water in suitable turtle habitat. Traps were staked, baited with fish from the local reach, and set out overnight. Snapping turtles larger than 5 lbs. were collected because this is the size used by tribal

members and the size the team estimated was needed to provide a sufficient amount of tissue (~500 g) for analyses. Upon collection, each turtle was tagged with its unique identification number and placed in a cooler of water ice and transported alive to the PIN office/lab. Each sampling location was identified in a field book and the sample coordinates using the GPS system were also recorded.

Each specimen was weighed to the nearest 0.5 lb with a hanging scale and measured (carapace length – to nearest 2 mm). Specimens were killed by decapitation after cooling them down in a freezer for several hours to slow reflexes and induce torpor. Specimens were held and processed within 48 hours of collection. Animals were rinsed with tap and DI water to dislodge sediment or other external material from their skin prior to making incisions. All equipment was pre-cleaned and managed following the QAPP guidance. We used muscle tissue portions that are typically consumed by tribal members. Using a pre-cleaned knife and scalpel, muscle tissue was removed from the hind limbs, fore limbs, tail, and neck. The muscle tissue was skinned and the bones removed. Adipose tissue deposits were not included with the muscle tissue sample. The mass of the meat was weighed and recorded to the nearest 1 g. The tissue was wrapped in an aluminum foil packet, placed in a pre-labeled Ziploc® bag (labeled following Sample Labeling Protocol), and frozen to -20°C. Observations of internal or external anomalies and sex of the specimen were recorded for each turtle. Turtle meat samples were shipped frozen from Maine on dry ice to CERC-USGS for grinding and sample preparation.

Duck Collection and Preparation



USF&WS Digital Library http://digitalmedia.fws.gov/cdm/

Although several species of duck have been historically important as food for tribal members, wood ducks (*Aix sponsa*) are currently the most utilized local duck species on the Penobscot River. Because wood ducks commonly breed on the Penobscot River, they are more likely to reflect local contaminant levels than other species that use the river more seasonally.

Wood ducks were collected mid-September to early October 2008, the time when tribal members typically hunt wood duck. Sixteen individual wood ducks were collected, representing five composite samples from four of the six river reaches. A duplicate sample was also collected from one reach. Ducks were collected by shooting with a shotgun with steel shot ammunition. The location of each collection

site was recorded on a map and GPS coordinates were recorded in a field notebook. Reach composite samples were created by combining muscle tissue from three to four wood ducks from each reach to provide a total weight $\geq$ 0.5kg. The collected birds were placed in labeled Ziploc® bags and transported on water ice back to the PIN laboratory for processing.

At the lab, weight, age, and sex of each wood duck were measured and recorded. Muscle tissue from the breast and legs (boneless, featherless and skin-on) was excised from each duck using a knife or scalpel. The muscle samples reflect the portions that are typically consumed by Tribal members. The excised tissue was weighed, wrapped in foil and Ziploc® bag, labeled and frozen. Tissue samples were shipped frozen with dry ice to CERC for compositing, grinding, and sample preparation. The remaining carcasses (including organs) were stored in labeled bags and frozen for potential future analysis for ecological risk assessment.

Collection and Preparation of Surface Water, Drinking Water, and Sediment for Mutagenicity Analysis

Water samples from the Penobscot River were obtained by collecting a composite of five sequentially filled 2.5-L bottles at each location for each sampling event. Samples were collected in amber bottles that were pre-cleaned and had a Teflon™ cap (Cat. No. #293680, Sci Spec, Hanover, MD) by submerging the capped bottle within 0.3 m of the river's surface, uncapping the bottle until it was filled, and recapping the bottle under the water. Care was taken to avoid disturbing bottom sediments to keep them from entering the sample bottle. Samples were placed in a cooler with water ice in the field and then stored in a refrigerator at 4°C in the dark until they were shipped. In order to keep samples cooled, they were shipped in coolers containing frozen Blue Ice®.

Drinking water samples were collected by compositing five sequentially filled 2.5-L bottles for each sampling event from a convenient tap on Indian Island at the PIN Water Quality Monitoring Laboratory. One composite was taken on the same days that river water was sampled. The water from a drinking water tap was allowed to flow for 10 min prior to collecting the samples. Samples were collected in amber bottles and stored in a cold room at 4°C. The drinking water samples were shipped in the same manner as the river water samples.

Sediment samples were collected at approximately the same sites as the river water was collected. Three river-sediment samples, were taken. At each location a composite of three to five grab samples of the top sediment (< 15cm) was taken using a Ponar dredge. The grab samples were placed in a stainless-steel container and mixed together until homogenous. The composite sample was then divided and transferred into 3 pre-cleaned amber glass jars with Teflon™ lined lids, each containing ~500g wet weight of sediment. The dredge and sampling equipment were cleaned with Alconox, deionized water, and methanol before and between sampling at each site. Each jar was placed in a plastic sealed bag and placed in a cooler with water ice for transport from the field until the bag was transferred to a dark 4°C refrigerator. Sediment samples were shipped in coolers with Blue Ice®.

Summary of Chemical Extraction Methods

Sediment/Vegetation

The sediment and vegetation samples collected from the Penobscot River watershed were extracted using a similar procedure. In addition, the plant material was prepared according to tribal cultural practice (washed, dried, stemmed, etc.) prior to compositing. A weighed quantity of dried sediment or vegetation was processed by means of Soxhlet extraction. The samples were weighed into a glass fiber thimble and then mixed with a quantity of anhydrous sodium sulfate. After the thimble was placed in the Soxhlet extraction column, the samples were spiked with a ^{13}C PCDD/PCDF/co-planar PCB compound mixture and extracted for a minimum of 12 hours. After extraction, the sample extracts were stirred with acidified silica gel and then decanted. The sample extracts were then further cleaned by means of acid/base chromatography. Following the acid/base chromatography, the PCDDs/PCDFs were separated from the co-planar PCBs using carbon column chromatography on ECL prepared columns using AX-21 (Winters et al., 1996; Ferrario et al., 1997). The PCBs were concentrated to 20 µl or less for HRGC/HRMS analysis. The PCDDs/PCDFs were further purified using alumina column chromatography, followed by concentration to 20 µl or less and analyzed by HRGC/HRMS analysis.

Tissue

Tissue samples collected from the Penobscot River watershed were weighed into a Nalgene® bottle, spiked with a ^{13}C PCDD/PCDF/co-planar PCB compound mixture, and extracted three times. Each extraction consisted of Polytron® grinding, centrifugation, and filtering through anhydrous sodium sulfate. After the final extraction, the sample extracts were stirred with acidified silica gel and then decanted. Additional fractionization, purification and analytical techniques were as described for sediments/vegetation or can be found in subsequent sections. ECL has worked extensively on the EPA Dioxin Reassessment Study and analyzed a number of food items including beef, pork, poultry, and milk (USEPA, 2004).

Water and Sediments for Mutagenicity Analyses

All extracts for use in mutagenicity analyses were prepared in dimethyl sulfoxide (DMSO) as well as the direct-acting controls 2-nitrofluorene and sodium azide (Sigma, St. Louis, MO, 3.0 µg/plate) and the indirect-acting control 2-anthramine (Sigma, 0.5 µg/plate). The river-water samples were extracted by open-column chromatography using a 50:50 layer of XAD-2/XAD-8 resin with the XAD-2 on the bottom; organics were eluted with ethyl acetate. The extracts were dried over sodium sulfate, concentrated, filtered across a 0.45-µm polytetrafluoroethylene (PTFE)-syringe filter, and solvent-exchanged into DMSO at 5,000X for the bioassay (unless this was too thick, at which point more DMSO was added to make the concentrate at 1,000X).

The drinking-water samples were processed as above except that the water was first acidified to pH 2 prior to extraction. Blanks prepared in the same way with XAD were also evaluated for mutagenicity. River-sediment samples were processed by taking 100 g dry-weight of each sample and extracting each by Accelerated Solvent Extraction (ASE) with a 50:50 mix of dichloromethane/methanol using an ASE 350 (Dionex Corp, Sunnyvale, CA). The extracts were filtered across 0.45-µm Teflon™ laminated-filter disks, concentrated, and solvent-exchanged into 1 ml of DMSO.

Sample Analysis

Contaminants of concern and the Data Quality Objectives (DQOs), Project Quantification Limits (PQLs) and Targeted Laboratory Quantification (TLQ) limits for fish, turtles, ducks, plants, and sediment collected from the Penobscot River can be found in the QAPP, dated May 13, 2008. The limits identified in the QAPP were agreed upon by the Project Team. The project team agreed to match the Project Quantification Limits (PQLs) and Targeted Laboratory Quantification (TLQ) limits for fish, turtles, ducks, plants, and sediment collected from the Penobscot River to the detection limits of the laboratory, e.g. based on the capabilities of the laboratory equipment. The detection limits were optimized by maximizing the amount of sample analyzed, reducing background, concentrating the extracts to low final volumes, and using highly sensitive instruments. For the high resolution gas chromatograph/high resolution mass spectrometer used in the analysis of samples for PCDDs/PCDFs/co-planar PCBs, the instrument operated at a resolution of 10,000 and a sensitivity of femtograms per gram (e.g. the resolution has no units. The formula for resolution has the same units [atomic mass units (m/z)] in the numerator and the denominator, so the units cancel.) The following table and text describe the types of analyses for the flora and fauna of this study.

Summary of Sample Types Collected for Chemical Analyses.

Sample Type	*PCBs*	*Dioxins/ Furans*	*Total Mercury*	*Methyl Mercury*	*TOC*	*Grain Size*	*Lipid*
Sediment	X	X	X	X	X	X	
Fish	X	X	X				X
Plants	X	X	X	X	X		
Turtle Meat	X	X	X	X			X
Duck Meat	X	X	X	X			X

Table 3: Summary of sample types collected for chemical analyses. This table includes the specific analyses performed on each sample type. Samples for mutagenicity analysis are not included in this table.

Sediment

Twenty-one sediment samples were collected and analyzed for the twelve WHO (World Health Organization) co-planar dioxin-like PCBs, dioxins/furans, total mercury, methyl-mercury, total organic carbon (TOC), and grain size. The analysis of these sediments revealed low levels of co-planar PCBs. To determine if the presence of the co-planar PCBs is directly related to the amount of total PCB congeners present, a subset of nine sediment samples was analyzed for total PCB congeners. The three deep water sediment samples collected were analyzed for grain-size distribution, TOC, and concentrations of dioxins, furans, co-planar PCBs, and total mercury.

Fish Tissue
Fish tissue samples were processed for percent lipid, total mercury, dioxins, furans, and PCB congeners. For PCB congener analysis in fish, six composite samples of smallmouth bass (SMB) were analyzed. The study team chose SMB composites for looking at patterns of PCBs in the fish as a means of potentially identifying source(s). The smaller subset of fish was tested for total PCBs congeners based on the reasoning stated above for sediments. The team agreed not to analyze the fish samples for methyl mercury.

In higher trophic level carnivorous fish, the ratio of methyl mercury to total mercury generally approaches unity, meaning that almost all of the mercury in the fish fillet is in the methyl mercury form. (See, Wiener et al., 2003) It is generally assumed that >90% of mercury in higher trophic level carnivorous fish is in the methyl mercury form, although site-specific variables and trophic level can influence the ratio of methyl mercury to total mercury in fish. The team agreed that analyzing the Penobscot fish fillet samples for total-mercury was a cost effective, accurate, and a slightly conservative way to estimate the level of methyl mercury.

Turtle and Duck Tissue
The composited snapping turtle and wood duck composite samples were analyzed for total lipid, total mercury, methyl mercury, dioxins/furans, and PCB congeners. Samples were stored in a secure location frozen at -20°C until processing began. Observations of internal or external anomalies were recorded for each snapping turtle.

Plants
Plant composite samples were analyzed for dioxins and furans, PCB congeners, methyl mercury and mercury. Ferns and medicinal plants are approximately 90% and 75% water, respectively. Therefore, each fern sample containing approximately 500 grams of fresh material produced ~50 grams of dried material; and, each medicinal plant sample produced ~ 125 grams of dried material. At CERC, samples were homogenized with a Tissuemizer, freeze-dried, and aliquots were sent to the OPP, NERL, and FGS for analysis. Freeze-dried samples were analyzed by 4 different labs as follows: 5 grams to NERL, 25 grams to EPA-OPP, 5 grams to FGS, and 10 grams retained at CERC.

Analytical Procedures

Total Mercury
Fiddlehead fern, medicinal plants, snapping turtle, and fish tissue samples were analyzed for the presence of total mercury (t Hg) by the Milestone DMA 80 laboratory at the EPA New England Regional Laboratory. All analyses were completed by the end of September 2010 and reported in October 2010. Freeze dried homogenized samples were analyzed using flash vaporization by a Milestone DMA80 Mercury Analyzer. Samples were heated to 850 degrees centigrade to release all mercury from tissue. Mercury vapor was then passed through a catalyst into an amalgamator for capture. After all the mercury was captured, the amalgamator was heated to 200+ degrees centigrade and the released mercury vapor was passed into a cuvette through which UV light was passed. A UV photodetector measures the difference in UV light (mercury vapor absorbs light at 254nm). The absorbance of UV is an indirect measure of mercury concentration in the tissue. All total mercury analyses were carried out using the EPA standard operating procedure (SOP) – "Milestone SOP2 (04/13/10) Standard Operating Procedure, Mercury Analysis by Milestone DMA-80". All results are reported as dry weight in ug/kg.

Methyl Mercury

Methyl mercury analyses were conducted by Frontier GeoSciences, Inc. (FGS) using FGS methods. Homogenized tissue samples were digested for approximately 2-4 hours at 70-80 °C with a potassium hydroxide and methanol solution. After cooling, samples were diluted with methanol according to the protocol - "Digestion of Tissue Samples for Methyl Mercury Determination - FGS-010". Sediment samples were extracted using the protocol "Extraction of Soil or Sediment Samples for Methyl Mercury Determination - FGS-045": Homogenized sediment samples were vigorously shaken for one hour with methylene chloride and acidic bromide and copper sulfate solutions. After centrifugation and removal of the aqueous layer, an aliquot of methylene chloride was added to water and purged with nitrogen for approximately thirty minutes to remove the methylene chloride. The sample, now in the aqueous phase, was brought to final volume with reagent water.

Methyl mercury samples were analyzed using Cold Vapor Gas Chromatography Atomic Fluorescence Spectrometry using protocol "Methyl Mercury Determination by Cold Vapor Gas Chromatography Atomic Fluorescence Spectrometry (CV-GC-AFS) - SOP FGS-070" Acetate buffer and ethylating agent were added to an aliquot of digested sample and the methyl mercury was purged onto carbotraps. The mercury species on the carbotrap column were volatilized and separated with a gas chromatography column, reduced on a pyrolytic column and then analyzed by thermal desorption into an atomic fluorescence detector using the dual amalgamation technique. A chart recorder was used to record the detector signal. Peak heights were measured by hand and entered manually into the Laboratory Information Management System (LIMS) for calibration and calculation of concentration.

Congener-Specific PCBs (USGS-CERC)

The following series of USGS-CERC SOPs were used for analysis of the sediment and fish samples for congener specific PCBs: SOP186, SOP187, SOP270, SOP271, SOP461, SOP464, SOP642, and SOP643. Several types of QC samples accompanied the analysis: field/procedural blanks, matrix blanks, matrix spikes, laboratory reference material, procedural recovery standards, and triplicate analyses. The biological tissue sample composite was dehydrated with sodium sulfate. Sediment homogenates were air dried and then were dehydrated with Na_2SO_4. The sample was spiked with procedural recovery compounds PCB 029 (2,4,5-trichlorobiphenyl), PCB 155 (2,2',4,4',6,6'-hexachlorobiphenyl), and PCB 204 (2,2',3,4,4',5,6,6'-octachlorobiphenyl). The dried tissue samples were column extracted and sediments were Soxhlet extracted, both with dichloromethane (DCM). Aliquots of extract were used for percent lipid measurement. Bulk lipids and co-extracted biogenic materials were removed from the extracts by low-pressure size exclusion chromatography 70-cm SX-3 BioBead column with DCM mobile phase, then by high-pressure size exclusion chromatography Phenomenex 300 X 21.2-mm Phenogel 10 100 Å column with DCM mobile phase. Elemental sulfur was removed from sediment using a combination of copper and HPSEC treatments. Extracts were cleaned up with reactive adsorbent silica gel columns, then fractionated using two layered octadecyl silica (ODS)/activated silica gel 60 (SG-60). PCB congeners were measured by dual-column GC-ECD according to CERC SOP P.195. Analyses were performed using cool on-column capillary injection onto retention gaps connected to 60 M DB-5 (5% phenyl-, 95% methylsilicone) and DB-17 (50% phenyl-, 50% methylsilicone) analytical columns, or equivalent. Potential peaks for PCB congeners were matched and identified on one or both GC capillary columns. The capillary GC-ECD data were collected, archived in digital form, and processed using chromatography data system software. Up to nine levels of calibration for each individual congener were used to quantify approximately 142 congeners. The calibration curve ranged from 10 to 8,000 ng/mL total PCB concentration.

Polychlorinated Dibenzo-p-dioxins (PCDDs), furans (PCDFs), and co-planar PCBs [dioxins/furans/cp-PCBs] (EPA/OPP/ECL)

The OPP Environmental Chemistry Laboratory tested the fish tissue samples for seven polychlorinated dibenzo-p-dioxins (PCDDs), ten polychlorinated dibenzofurans (PCDFs), and twelve co-planar PCBs. Twelve snapping turtle and five wood duck tissue samples were tested for seven polychlorinated dibenzo-p-dioxins (PCDDs), ten polychlorinated dibenzofurans (PCDFs), and twelve co-planar PCBs.

For analysis of the PCDDs, PCDFs, and co-planar PCBs, a Waters Autospec HRMS (High Resolution Mass Spectrometer) coupled to an Agilent 6890 gas chromatograph equipped with a split/splitters injector was used in lock mass correcting mode at 10,000 ppm resolution, using perfluorokerosene (PFK) as the reference for mass calibration. An Agilent DB5-MS capillary column (60 m, id 0.320 mm, 0.250 µm film thickness J&W, USA) was used at a constant flow rate of 1.5 ml/min helium, using a splitless injection of 275°C for the separation of both the PCDD/PCDF and PCB isomers. Two oven programs were used for two separate analyses: (1) PCBs: [Hold @ 130°C for 1 minute; then ramp to 235°C at 5°C /minute; hold for 15 minutes; then ramp to 290°C at 10°C /minute; hold for 5 minutes]; (2) PCDDs/PCDFs: [Hold @ 130°C for 1 minute; then ramp to 235°C at 5°C /minute; hold for 15minutes; ramp to 290°C at 6°C /minute; hold for 12 minutes]. The electron energy for the HRMS used was approximately 35 eV and the rest of the mass spectral lenses were tuned for maximum sensitivity. The HRMS was operated in SIM (single ion monitoring) mode with mass ions and windows monitored equivalent to a modified Method 1613 (Winters et al., 1996; Ferrario et al., 1997). Surrogate recovery standards, either a ^{13}C PCB or ^{13}C TCDD, were introduced in the initial extraction step in an amount, depending on sample amount, to equal a final injection volume concentration of between 5-20 pg/µL, depending on the target analyte. The ^{13}C labeled surrogate recovery standards were used to calculate the recovery of the ^{13}C labeled analogs, relative to a ^{13}C labeled injection standard (added to cleaned up sample extract prior to MS analyses) and, to quantify native analyte concentrations adjusted for recovery. A five or six point linear calibration curve was used for the analyses ranging from 100 fg/µL (2, 3, 7, 8-TCDD) to levels as high as 1000 pg/µL (PCB 118).

Mutagenicity Assays

For this study, the *Salmonella* mutagenicity assay was used to screen surface water, sediment, and drinking water for mutagenicity. The *Salmonella* mutagenicity assay has been used extensively to identify genotoxic substances in environmental samples (Claxton, 1985; Claxton et al., 1998, 2004; Claxton and George, 2002; Chen and White, 2004; Claxton and Woodall, 2007; Claxton et al., 2010; Maertens et al., 2004; Ohe et al., 2004; Richardson et al., 2007; Zwiener et al., 2007). The assay is useful in the present context because of its ability to identify mutagenic activity in surface waters (Ohe et al., 2003, 2004), sediments (Chen and White, 2004), and drinking waters (Richardson et al., 2007). The assay determines the mutagenicity, and potential carcinogenicity, of compounds and complex mixtures (Mortelmans and Zeiger, 2000). However, because many carcinogens act by mutagenic mechanisms, most organic carcinogens that are mutagens present a positive indication in the *Salmonella* assay. Conversely, the assay has identified some mutagens that have not been shown to be carcinogens. The *Salmonella* assay is the most widely used genotoxicity assay for identifying environmental carcinogens and for comparing locations, identifying sources, and identifying the likely carcinogens in complex environmental mixtures (Claxton, 1997; Claxton et al., 1998, 2010; MacGregor, 1994).

The *Salmonella* mutagenicity assays enabled the assessment of complex, organic mixtures of air, soil, and water by evaluation of organic extracts of these media. The results from such analyses provide an integrated measure of the mutagenic activity and, thus, potential carcinogenic activity, of the organics in

environmental media. In the present study we used the *Salmonella* mutagenicity assay to evaluate the mutagenicity of river water, sediment from the river, and drinking water associated with the PIN.

To assess mutagenicity of Penobscot River water, drinking water, and sediment the sample extracts in the *Salmonella* mutagenicity assay were tested with and without metabolic activation (Aroclor 1254-induced Sprague-Dawley rat-liver S9, Moltox Inc., Boone, NC) following the procedures of Maron and Ames (1983) with modifications from Claxton et al. (1987). The frameshift strain TA98 and the base-substitution strain TA100 were used, which were provided by Dr. B.N. Ames, Children's Hospital Oakland Research Institute, Oakland, CA. Strain YG1041 (derived from TA98) and strain YG1042 (derived from TA100) were also used, which over-express acetyltransferase and nitroreductase, enhancing the sensitivity of the strains to aromatic amines and nitroarenes (Hagiwara et al., 1993). These YG strains were kindly provided by Dr. T. Nohmi, National Institute of Health Sciences, Tokyo, Japan.

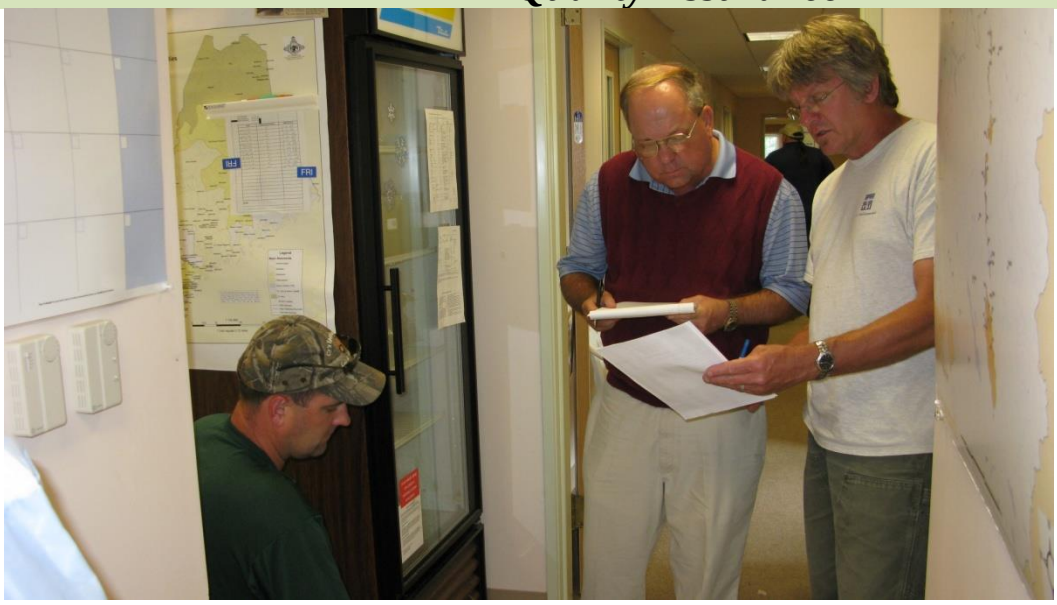
The strains and metabolic activation condition (with or without S9) used for screening the samples were chosen based on their particular sensitivities, their successful use in previous studies, and possible anthropogenic sources of contamination. Strain TA100 -S9, which detects direct-acting mutagens that induce base substitutions in deoxyribonucleic acid (DNA), has been used frequently when testing chlorinated drinking water. Strain TA98 detects agents that induce frameshift mutations and has been used with river water and sediments (Chen and White, 2004; Ohe et al., 2003, 2004). Surface water samples were tested with YG1041 and YG1042, which express elevated levels of both nitroreductase and acetyltransferase activity and are used for the detection of mutagenicity in environmental samples when nitroarenes and aromatic amines may be present.

Due to limited number of samples, each sample was first tested in the plate-incorporation assay at one plate per dose (5-7 doses) and then repeated if the volume of extract available permitted. The plates were incubated for 72 h at 37ºC and colonies counted with an AccuCount™ 1000 automatic colony counter (Biologics, Inc., Manassas, VA). The data were entered in the GeneTox Manager statistical analysis program (Claxton et al., 1995) for mutagenic potency determination using the Bernstein method (Bernstein et al., 1982). The mutagenic potencies were calculated as revertants (rev) per liter-equivalent (L-eq) for the river and drinking waters and as rev per gram-equivalent (g-eq) for the sediment samples. A positive result was defined as one in which the extract produced a dose-related increase of at least twofold over the DMSO control number of revertants/plate; the DMSO controls were used in the potency calculations from the dose-response curves.

River-water samples were tested for mutagenicity in strains YG1041 and YG1042 with and without S9 metabolic activation. The first experiments were performed with eight doses (10–500 ml-eq/plate) using YG1041. A repeat test was performed using a dose range of 100–500 ml-eq/plate with YG1041; a single experiment was performed with YG1042 with this dose range (with and without S9) due to limited sample.

The first experiment was performed with the drinking-water samples in strains TA98 and TA100 without S9 using the same doses used for the river-water samples; some of the lower doses for the repeat experiments were not used. A final experiment was performed in TA100 using a dose range of 300–1000 ml-eq/plate without S9. River-sediment samples were tested in strains TA98, TA100, YG1041, and YG1042 with and without S9. The first experiments were performed using a dose range of 0.2–10 g-eq/plate, and repeat experiments were performed using a dose range of 0.1–1 g-eq/plate.

Quality Assurance



US EPA Thomas Hughes conducting a TSA with USGS Charlie Culbertson and PIN DNR Dan Kusnierz at PIN DNR office.

The Research team that designed this study included an array of experts such as toxicologists, hydrologists, risk assessors, environmental health specialists and experts in Dioxin/Furan and PCB analysis and Mercury analysis. (See Appendix D for list of experts). Collaborating with numerous scientists and ATSDR assured the scope and procedures identified for this project met the objectives of the PIN and that the methodologies employed are accepted within the scientific community.

To ensure the highest quality and reliability, a process of internal and external peer review by both cultural and scientific experts was followed. The approach for this research project combined some of the elements of consumption surveys such as interviewing Tribal elders to determine recent natural resource utilization patterns with careful identification of Tribal exposure factors (contaminant concentrations, pathways of exposure). The process used was culturally sensitive, respectful, drew on traditional environmental knowledge (such as the observational expertise of elders), and was developed in partnership with tribal cultural and technical experts. The study was developed through a community-based participatory process, which provided an avenue to foster a strong, communicative relationship. The PIN Natural Resources Program's facilitation of this study with the PIN Tribal Community provided this assurance.

Thomas Hughes, EPA-ORD QA Manager, was the RARE Program QA Manager (PQAM). He assisted the team by ensuring that the study complied with the QAPP and EPA policies and procedures with the assistance of Steve DiMattei from the EPA Region1 Chelmsford Laboratory. The quality assurance (QA) activities on this project were extensive due to the importance of this research program to the EPA and the Penobscot Indian Nation (PIN).

A QA Statement, which is a listing of the five audits conducted during this RARE study, is in Appendix E. An initial site visit of the Penobscot River near Indian Island in October 2007 was followed by technical systems audits (TSA) in Old Town, ME and North Chelmsford, MA in 2008. A final data audit was conducted in Old Town, ME in October 2010. A TSA was conducted by Barbara Collins, a QA Manager at the EPA in RTP, in 2009 on the *Salmonella* (Ames) mutagenicity testing of the river and drinking water and the river sediments for potential carcinogenic potential. These audits demonstrated

that the procedures and data generated under this RARE program were scientifically acceptable. Accurate shipping records were kept on fish, water, and sediment samples. Information on exact sampling site positions was recorded.

The Co-PI on this RARE study at the EPA, Janet Diliberto, and the EPA PQAM, Thomas Hughes, were involved in the review and helped to generate the RARE QA Project Plan (QAPP) through monthly teleconferences with the Co-PI in Boston (Valerie Marshall), the Senior Regional Scientist for Region 1 (Robert Hillger), and the entire study research team of over 20 scientists. The generation and approval of this complex QAPP required an effort of the entire team and took a year to complete. After the generation of the QAPP, teleconferences were held consistently and on an as needed basis throughout the duration of this study. To ensure that the data from this study was of the highest quality, EPA QA Officers Tom Hughes and Steve DiMattei, EPA Region 1 laboratory, reviewed each of following procedures: sampling collection, sample handling, sample chemical analysis, and laboratory QA/QC procedures. The quality of the data from this study is considered exceptional, as verified by the review of the QAPP and SOPs, site visits, and five QA audits.

Peer Review

To ensure the reliability, credibility and integrity of this report, a formal EPA Peer Review of both the cultural and scientific aspects of this report was conducted. The data collected from this study was accepted by all the Agencies involved in this RARE Project, i.e. US EPA, USGS, ATSDR, and US F&WS. Collaborating with numerous scientists and ATSDR assured the scope and procedures identified for this project met the objectives of the PIN and that the methodologies employed are accepted within the scientific community. The methodology used to reach the conclusions of this study incorporated information from a variety of disciplines, including cultural and traditional environmental knowledge and ensured that the methodologies employed were accepted within the scientific community. A number of scientific peer reviewed publications have been developed based on the results of data collected from the study. An independent peer review of the papers to be published, including a Public Health Assessment by ATSDR was completed.

Tribal Risk Assessors were included as peer reviewers of this report, especially since the approach for this research project is culturally sensitive and drew on traditional environmental knowledge (such as the observational expertise of Tribal elders). The approach for this study was developed in partnership with the Penobscot Indian Nation. The PIN Natural Resource Department coordinated with the PIN Tribal Community and provided information pertaining to the sustenance practices of the Penobscot Indian Nation tribal members.

The report was peer reviewed by a panel of experts according to the US EPA's Peer Review protocols. A Confidential Draft Report was issued to a panel of 10 peer reviewers that consisted of the following areas of expertise:

- 2 Tribal Risk Assessors;
- State Health Assessor;
- Mutagenicity Expert;
- Green Chemist;
- State Toxicologist (Maine) ;
- Research Chemist;
- Research Hydrologist; and,
- 2 EPA Toxicologists.

General and specific charge questions were developed by the RARE Research Team. A list of objectives was used for focusing the peer review charge questions to obtain input from qualified colleagues ("the relevant scientific community"). The Research Team worked with the Region 1 Peer Review Coordinator to assure that the study was in compliance with the Agency's protocols.

All comments received from the peer reviewers were evaluated and addressed. All significant recommendations were incorporated into the report. Once all recommendations from the peer reviewers were incorporated into this report, the team provided an overview of the study to the PIN tribal council and community. The RARE team shared the draft confidential report and all other publications to gather input from the Tribal Leaders and the tribal community prior to finalizing the report. Any significant comments submitted by the Tribal Community are incorporated into the final report.

Data Validation

Data review, validation, and verification are the processes for documenting the degree to which the project objectives were met, individually and collectively, and to estimate the effect of any QA/QC procedural deviations on the ability to use the data.

EPA Region 1 (EPA-New England) has three tiers of data validation (DV):

- **Tier I** – The analytical laboratory data package is checked for completeness and any Performance Evaluation (PE) samples are checked for accuracy;
- **Tier II** – The quality control (QC) results are checked against acceptance criteria. Based on the QC results, reported laboratory data are qualified as either acceptable, estimated (J) or rejected (R);
- **Tier III** – An in-depth examination of instrument-generated analytical data is performed to ensure the accuracy of the results reported. The calculation of reported results is verified. Tier III is the preferred level of validation for human health and ecological risk assessments.

Tier I validation - determines whether or not the laboratory provided the contract or agreement required deliverables. This is called a completeness check. A Tier I validation includes the evaluation of Performance Evaluation (PE) sample results which demonstrate laboratory performance at the time of field sample analysis. Depending on the PE sample results, field sample data may or may not be qualified as acceptable, estimated (J) or rejected (R). A Tier I data validation report documents missing data/information that could not be retrieved from the laboratory, a discussion of the PE sample results, and a summary table of the laboratory results (unqualified).

Tier II validation - includes a Tier I review and the QC sample results are reviewed. Data qualifiers are applied to the laboratory results based on the PE and QC sample results and the project objectives. The results of a Tier II validation are documented on worksheets specific to parameters reviewed. The report includes a narrative discussion for each parameter reviewed and a data summary table which documents the qualified data.

Tier III data validation - includes Tier I and Tier II data validation procedures and a Tier III review, which includes in-depth qualitative and quantitative determination of accuracy. This requires re-calculating results for instrument generated reports and an examination of the various instrument outputs which document the results reported. During Tier III the gas chromatograms, the mass spectra and instrument out-put are examined to ensure the data corroborate the reported results. The data are checked for calculation, transcription and identification errors. Proper compound identifications are confirmed

and discrepancies resolved. The Tier III DV report is the same as the Tier II report however, there is potential for additional qualification of data as a more in-depth review is performed.

The validation for this project was 90% at Tier II level and 10% at Tier III (Table 4). The table below summarizes the data validation that was conducted for this study. EPA data validator, Steve Stodola reviewed and interpreted the data validation. Each laboratory that performed analysis for this project applied data validation flags in the form of Remark Codes to those sample results that fell outside of the QC acceptance criteria, for data under its purview.

RARE Penobscot Data Validation			
Analyte	**Media**	**No. of samples for Tier II**	**No. of Samples for Tier III**
D/F OPP ECL	Sediments	19	2
PCB WHO OPP ECL	Sediments	19	2
PCB Cong CERC USGS	Sediments	8	1
Total Hg ESS c/o CERC	Sediment	21	0
MeHg FGS	Sediment	21	0
D/F OPP ECL	Fish Fillet	30	4
WHO PCB OPP ECL	Fish Fillet	30	4
PCB Cong CERC USGS	6 Fish, 6 Ferns, 4 Ducks, 2 Turtles	6	1
Total Hg NERL EPA	27 Fish, 2008 7 Fish, 2009	NA	NA
MeHg	Fish Fillet	NA	NA
D/F OPP ECL	2 Turtles & 5 Ducks	6	1
WHO PCB OPP ECL	2 Turtles & 5 Ducks	6	1
Total Hg NERL EPA	2 Turtles, 5 Ducks, 7 Ferns	NA	NA
MeHg FGS	2 Turtle, 5 Duck, 7 Plants	14	0
TOC ESS c/o CERC	Sediment	21	0
Grain Size ESS c/o CERC	Sediment	0	0

Table 4: **Data validation for Penobscot data in the RARE study.**

Analytical Results from Reaches 1-6: Contaminants Concentrations

The objective of the preliminary risk assessment was to assess the level of contaminants that the Penobscot tribal members are potentially exposed to from partaking in their tribal cultural practices by comparing maximum concentrations of detected chemicals in a medium with conservative health risk-based concentrations. The intent of the preliminary risk assessment was to identify which Penobscot River reaches, and what types of exposures to which types of contaminants, are found to be above the Project Quantification Limits or risk-based concentrations identified for the chemicals analyzed in this study.

The targeted contaminants analyzed included PCDDs, PCDFs, WHO-coplanar PCBs, total-PCBs, total mercury, and methyl mercury. Concentrations of selected chemical contaminants were measured in samples of fish and streambed sediment collected from six reaches of the Penobscot River. Fish (including eel, pickerel, perch, smallmouth bass, and bullhead) and sediment (from wading areas) were collected. Skinless fillets were analyzed. The goal was to collect and analyze one composite sample of each species of fish from each reach. In addition, wood duck muscle, snapping turtle muscle, and plants were collected and analyzed. The contaminant concentrations for biota and sediment are provided in Tables 5 - 10. The maximum contaminant concentrations by sample type are presented in Table 11, and by reach in Table 12.

Contaminant concentrations in sediment and biota in Reach 1, Milford Dam Impoundment (MIL)

SAMPLES (A,B,C,D)		Dioxins/Furans (17 Congeners) Concentration TEQ pg/g	WHO-PCBs (12 Congeners) Concentration TEQ pg/g	Total TEQ (29 Congeners) Concentration TEQ pg/g	Total PCBs (142 Congeners) Concentration ng/g	Methyl Mercury Concentration ng/g	Mercury Concentration µg/g
Sediment (SED)	A	20.9[a]	0.285[a]	21.2[a]	34.2[a]	0.844[a]	0.12[a]
	B[Imp]	21.1[a]	0.219[a]	21.3[a]	45.5[a]	2.06[a]	0.13[a]
	C	11.4[a]	0.150[a]	11.6[a]		0.550[a]	0.09[a]
	D	10.0[a]	0.191[a]	10.2[a]		1.15[a]	0.10[a]
Average		15.9[a]	0.211[a]	16.1[a]	39.9[a]	1.15[a]	0.11[a]
Chain Pickerel (CP)	A	0.0217[b]	0.0207[b]	0.0424[b]			0.432[b]
Yellow Perch (YP)							
White Perch (WP)	A	0.177[b]	0.206[b]	0.383[b]			0.536[b]
Smallmouth Bass (SMB)	A	0.0423[b]	0.0576[b]	0.0999[b]	0.998[b]		0.803[b]
Brown Bullhead (BBH)	A	0.220 [b]	0.117[b]	0.337[b]			0.290[b]
American Eel (EEL)	A	1.34[b]	1.16[b]	2.50[b]			0.708[b]
Wood duck (WODU)		0.111[b]	0.176[b]	0.287[b]	0. 116[b]	47.90[b]	0.049[b]
Fiddlehead Ostrich Fern (OSF)	A	0.000321[b]	ND[b,e]	0.000321[b]	0.612[b]	1.3[a]	ND[a,e]
Medicinal Plant (MP)							
Snapping Turtle (SNTU)	A	3.51[b]	1.35[b]	4.86[b]		665[b]	0.963[b]

Table 5: Contaminant concentrations in sediment and biota in Reach 1, Milford Dam Impoundment (MIL)

[a] Dry Weight
[b] Wet Weight
[c] Total: Total concentration of congeners in this class of contaminants
[d] Duplicate Sample
[e] ND: Non-Detect
[Imp] Impoundment

Contaminant concentrations in sediment and biota in Reach 2, Sunkhaze-West Enfield Dam (SWE)

SAMPLES (A,B,C)		Dioxins/Furans (17 Congeners) Concentration TEQ pg/g	WHO-PCBs (12 Congeners) Concentration TEQ pg/g	Total TEQ (29 Congeners) Concentration TEQ pg/g	Total PCBs (142 Congeners) Concentration ng/g	Methyl Mercury Concentration ng/g	Mercury Concentration µg/g
Sediment (SED)	A	16.3[a]	0.373[a]	16.7[a]	6.88[a]	0.963[a]	0.15[a]
	B	13.8[a]	0.289[a]	14.1[a]		1.83[a]	0.083[a]
	C	4.33[a]	0.167[a]	4.50[a]		5.14[a]	0.073[a]
Average		11.5[a]	0.276[a]	11.8 [a]	6.88[a]	2.64[a]	0.102[a]
Chain Pickerel (CP)	A	0.0232[b]	0.0361[b]	0.0593 [b]			0.542[b]
	A [d]						0.428[b,d]
Yellow Perch (YP)	A	0.0206[b]	0.0151[b]	0.0357 [b]			0.377[b]
White Perch (WP)							
Smallmouth Bass (SMB)	A	0.0561[b]	0.111[b]	0.167 [b]	0.505[b]		0.945[b]
Brown Bullhead (BBH)	A	0.0872[b]	0.0631[b]	0.150[b]			0.423[b]
American Eel (EEL)	A	0.646[b]	0.533[b]	1.18[b]			0.666[b]
Wood duck (WODU)	A	0.171[b]	0.255[b]	0.426[b]	5.01[b]	26.5[b]	0.032[b]
Fiddlehead Ostrich Fern (OSF)	A	0.000179[b]	ND[b,e]	0.000179[b]	0.350[b]	0.8[a]	ND[a,e]
	A[d]	ND[b,d,e]	ND[b,d,e]	ND[b,d,e]	1.15[b,d]	0.8[a,d]	ND[a,d,e]
Medicinal Plant (MP)							
Snapping Turtle (SNTU)							

Table 6: Contaminant concentrations in sediment and biota in Reach 2, Sunkhaze-West Enfield Dam (SWE).

[a] Dry Weight

[b] Wet Weight

[c] Total: Total concentration of congeners in this class of contaminants

[d] Duplicate Sample

[e] ND: Non-Detect

[Imp] Impoundment

Contaminant concentrations in sediment and biota in Reach 3, West Enfield Dam Impoundment (WEI)

SAMPLES (A,B,C,D)		Dioxins/Furans (17 Congeners) Concentration TEQ pg/g	WHO-PCBs (12 Congeners) Concentration TEQ pg/g	Total TEQ (29 Congeners) Concentration TEQ pg/g	Total PCBs (142 Congeners) Concentration ng/g	Methyl Mercury Concentration ng/g	Mercury Concentration µg/g
Sediment (SED)	A	5.89[a]	0.239[a]	6.13[a]	5.18[a]	1.43[a]	0.091[a]
	B[Imp]	29.8[a]	0.612[a]	30.4[a]	44.1[a]	0.80[a]	0.22[a]
	C	26.6[a]	0.337[a]	26.9[a]		2.57[a]	0.20[a]
	D	20.5[a]	0.447[a]	20.9[a]		4.37[a]	0.20[a]
Average		20.7 [a]	0.409[a]	21.1[a]	21.6[a]	2.29[a]	0.178[a]
Chain Pickerel (CP)	A	0.0185[b]	0.0214[b]	0.0399[b]			0.867[b]
Yellow Perch (YP)	A	0.0372[b]	0.0269[b]	0.0641[b]			0.416[b]
White Perch (WP)							
Smallmouth Bass (SMB)	A	0.0443[b]	0.0877[b]	0.132[b]	0.686[b]		0.979[b]
Brown Bullhead (BBH)	A	0.189[b]	0.108[b]	0.297[b]			0.252[b]
American Eel (EEL)	A	1.18[b]	1.05[b]	2.23[b]			0.635[b]
Wood Duck (WODU)	A	0.137[b]	0.150[b]	0.287[b]	0.563[b]	24.1[b]	0.0203[b]
	A[d]	0.178[b,d]	0.276[b,d]	0.454[b,d]	2.44[b,d]	0.4[b,d]	0.0285[b,d]
Fiddlehead Ostrich Fern (OSF)	A	ND[b,e]	0.00442[b]	0.00442[b]	0.407[b]	0.9[a]	ND[a,e]
Medicinal Plant (MP)	A	0.064[b]	ND[b,e]	0.064[b]		ND[b]	0.00692[b]
Snapping Turtle (SNTU)	A	0.551[b]	0.198[b]	0.749[b]		532[b]	0.569[b]

Table 7: Contaminant concentrations in sediment and biota in Reach 3, West Enfield Dam Impoundment (WEI)

[a] Dry Weight
[b] Wet Weight
[c] Total: Total concentration of congeners in this class of contaminants
[d] Duplicate Sample
[e] ND: Non-Detect
[Imp] Impoundment

Contaminant concentrations in sediment and biota in Reach 4, Mohawk-Mattaseunk Dam (MM)

SAMPLES (A,B,C)		Dioxins/Furans (17 Congeners) Concentration TEQ pg/g	WHO-PCBs (12 Congeners) Concentration TEQ pg/g	Total TEQ (29 Congeners) Concentration TEQ pg/g	Total PCBs 142 Congeners) Concentration ng/g	Methyl Mercury Concentration ng/g	Mercury Concentration µg/g
Sediment (SED)	A	11. 5[a]	0.389[a]	11.9[a]	44.4[a]	1.43[a]	0.093[a]
	B	26.0[a]	1.19[a]	27.2[a]		0.798[a]	0.150[a]
	C	4.43[a]	0.188[a]	4.62[a]		2.63[a]	0.066[a]
Average		14.0[a]	0.589[a]	14.6 [a]	44.4[a]	1.62[a]	0.103[a]
Chain Pickerel (CP)	A	0.0151[b]	0.0227[b]	0.0378[b]			0.316[b]
Yellow Perch (YP)	A	0.0139[b]	0.0204[b]	0.0343[b]			0.146[b]
White Perch (WP)	A	0.156[b]	0.246[b]	0.402[b]			0.467[b]
Small-Mouth Bass (SMB)	A	0.0635[b]	0.157[b]	0.221 [b]	0.432[b]		0.965[b] 0.887[b]
	A[d]	0.0597[b,d]	0.184[b,d]	0.244[b,d]	1.25[b,d]		0.713[b,d]
Brown Bullheac (BBH)	A	0.136[b]	0.179[b]	0.315[b]			0.180[b]
American Eel (EEL)	A	0.447[b]	0.950 [b]	1.40[b]			0.337[b]
Wood duck (WODU)	A	0.426[b]	0.652[b]	1.08[b]	4.052[b]	16.8[b]	0.026[b]
Fiddlehead Ostrich Fern (OSF)	A	ND[b,e]	ND[b,e]	ND[b,e]	0.322[b]	6.3[a]	0.00744[a]
	A[e]	ND[b,d,e]	ND[b,d,e]	ND[b,d,e]	0.224[b]		ND [a,e]
	B					1.3[a]	
Medicinal Plant (MP)	A	0.050[b]	0.0402[b]	0.0902[b]		ND[b]	0.00861[b]
Snapping Turtle (SNTU)	A [g]	1.34[b,f]	0.699[b,f]	2.04[b,f]	21.4[b]	605[b]	0.577[b]
	B [h]	0.513[b,g]	1.18[b,g]	1.69[b,g]		202[b]	0.222[b]

Table 8: Contaminant concentrations in sediment and biota in Reach 4, Mohawk-Mattaseunk Dam (MM)

[a] Dry Weight
[b] Wet Weight
[c] Total: Total concentration of congeners in this class of contaminants
[d] Duplicate Sample
[e] ND: Non-Detect
[f] Year 2008
[g] Year 2009

Contaminant concentrations in sediment and biota in Reach 5, Mattaseunk Dam Impoundment (MAT)

SAMPLES (A,B,C,D)		Dioxins/Furans (17 Congeners) Concentration TEQ pg/g	WHO-PCBs (12 Congeners) Concentration TEQ pg/g	Total TEQ (29 Congeners) Concentration TEQ pg/g	Total PCBs (142 Congeners) Concentration ng/g	Methyl Mercury Concentration ng/g	Mercury Concentration µg/g
Sediment (SED)	A[Imp]	19.9[a]	0.407[a]	20.3[a]	76.7[a]	1.15[a]	0.24[a]
	B	54.8[a]	0.952[a]	55.8[a]	168[a]	5.28[a]	0.56[a]
	C	94.9[a]	1.23[a]	96.1[a]		3.65[a]	0.64[a]
	D	93.8[a]	4.41[a]	98.2 [a]		8.98[a]	3.48[a]
Average		65.9[a]	1.75[a]	67.8[a]	122[a]	4.77[a]	1.23[a]
Chain Pickerel (CP)	A	0.0579[b]	0.0677[b]	0.126[b]			0.588[b]
Yellow Perch (YP)							
White Perch (WP)	A	0.495[b]	0.311[b]	0.806[b]			0.627[b]
	A[d]	0.531[b,d]	0.281[b,d]	0.812[b,d]			0.545[b,d]
Smallmouth Bass (SMB)	A	0.0740[b]	0.109[b]	0.183[b,c]	1.10[b]		0.961[b]
Brown Bullhea (BBH)	A	0.534[b]	0.193[b]	0.727[b]			0.416[b]
American Eel (EEL)	A	4.02[b]	1.43[b]	5.45[b]			0.739[b]
Wood duck (WODU)							
Fiddlehead Ostrich Fern (OSF)							
Medicinal Plant (MP)	A	0.0240[b]	ND[b,e]	0.0240[b]		ND[b]	0.00853[b]
Snapping Turtle (SNTU)	A	2.26[b]	0.536[b]	2.80[b]		938[b]	1.046[b]

Table 9: Contaminant concentrations in sediment and biota in Reach 5, Mattaseunk Dam Impoundment (MAT)

[a] Dry Weight
[b] Wet Weight
[c] Total: Total concentration of congeners in this class of contaminants
[d] Duplicate Sample
[e] ND: Non-Detect
[Imp] Impoundment

Contaminant concentrations in sediment and biota in Reach 6, Control Reach- East Branch-Salmon Stream Lake (EBS)

SAMPLES (A,B,C)		Dioxins/Furans (17 Congeners) Concentration TEQ pg/g	WHO-PCBs (12 Congeners) Concentration TEQ pg/g	Total TEQ (29 Congeners) Concentration TEQ pg/g	Total PCBs (142 Congeners) Concentration ng/g	Methyl Mercury Concentration ng/g	Mercury Concentration µg/g
Sediment (SED)	A	0.651[a]	0.126[a]	0.777[a]	25.2[a]	1.65[a]	0.058[a]
	B	0.0760[a]	0.0650[a]	0.141[a]		0.197[a]	0.026[a]
	C	0.148[a]	0.0784[a]	0.226[a]		ND[a,f]	0.084[a]
Average		0.292[a]	0.0898[a]	0.381 [a]	25.2[a]	0.924[a]	0.056[a]
Chain Pickerel (CP)	A	0.0161[b]	0.0395[b]	0.0556[b]			0.544[b]
Yellow Perch (YP)	A	0.00370[b]	0.0117[b]	0.0154[b]			0.284[b]
White Perch (WP)	A	0.146[b]	0.173[b]	0.319[b]			0.477[b]
Smallmouth Bass (SMB)	A	0.0428[b]	0.168[b]	0.211 [b]	0.899[b]		0.809[b]
Brown Bullhead (BBH)	A	0.107[b]	0.102[b]	0.209[b]			0.135[b]
American Eel (EEL)	A	0.178[b]	0.283[b]	0.461[b]			0.209[b]
	A [d]						0.214[b,d]
Wood duck (WODU)							
Fiddlehead Ostrich Fern (OSF)	A	ND[b,e]	ND [b,e]	ND[b,e]	0.170[b]	0.8[a]	ND[a,e]
Medicinal Plant (MP)	A	ND[b,e]	0.0360[b]	0.0360[b]		ND[b]	0.00289[b]
	A [d]	ND[b,d,e]	ND[b,d,e]	ND[b,d,e]		ND[b]	0.00292[b,d]
Snapping Turtle (SNTU)	A [f]	0.0213[b,f]	0.0876[b,f]	0.109[b,f]	0.170[b]	277[b]	0.215[b,f]
	B [g]	0.0198[b,g]	0.124[b,g]	0.144[b,g]		166[b]	0.228[b,g]

Table 10: Contaminant concentrations in sediment and biota in Reach 6, Control Reach- East Branch-Salmon Stream Lake (EBS)

[a] Dry Weight
[b] Wet Weight
[c] Total: Total concentration of congeners in this class of contaminants
[d] Duplicate Sample
[e] ND: Non-Detect
[f] Year 2008
[g] Year 2009

Summary of Contaminant Concentration Data

Below is a summary of the contaminant concentration data for sediment and biota in the six study reaches, as presented in Tables 5 – 10:

Sediments

The concentrations of PCDD/PCDF and co-planar PCBs (pg/g, TEQ dry weight) were similar in sediments from Reaches 1-4, but differed markedly from those in sediments of Reach 5. Sediments from Reach 5 had the highest single and average concentrations of PCDDs/PCDFs and co-planar PCBs of sediments from any reach and were more than 200- and 15- fold higher for PCDD/PCDF and co-planar PCBs, respectively, than those in sediments from Reach 6, the control site. Sediment concentrations of these compounds in Reaches 1-5 all differed markedly from those in Reach 6.

Animals

With respect to the concentrations of PCDDs/PCDFs and co-planar PCBs in the tissue (pg/g, TEQ wet weight), there appear to be similarities and differences by species and locations.

1) For the chain pickerel (a water column predator at the top of the food web species) with respect to the concentrations of PCDDs/PCDFs in the fillet tissues, there appears to be a similarity between Reaches 1-4 and Reach 6, the control reach, but a marked difference between those five reaches and Reach 5 (Mattaseunk Dam/Impoundment). There was no difference among any of the reaches in the concentration of co-planar PCBs in chain pickerel.
2) For the yellow perch, a water column predator, with respect to the concentrations of PCDDs/PCDFs in the fillet tissues, there appears to be a difference between Reaches 1-4 and Reach 6, but no difference among any of the reaches in the concentration of the co-planar PCBs in yellow perch. No yellow perch were collected in Reach 5.
3) For the white perch, another water column predator, with respect to the concentrations of PCDDs/PCDFs in the fillet tissues, there appears to be a similarity between Reaches 1-4 and Reach 6 and a marked difference between those five reaches and Reach 5. There was no difference among any of the reaches in the concentration of co-planar PCBs in white perch.
4) For the small mouth bass, another water column predator, with respect to the concentrations of PCDDs/PCDFs and co-planar PCBs in the fillet tissues, there appear to be no differences among any reaches.
5) For the brown bullhead catfish, an opportunistic bottom feeder, with respect to the concentrations of PCDDs/PCDFs in the fillet tissues, there appears to be a similarity between Reaches 1-4 and Reach 6 and a marked difference between those five reaches and Reach 5. There was no difference among any of the reaches in the concentration of co-planar PCBs in brown bullhead catfish.
6) For the freshwater eels, a bottom dwelling predator, with respect to the concentrations of PCDDs/PCDFs in the fillet tissues, there appears to be a difference between Reaches 1-4 and Reach 6 and a marked difference between those five reaches and Reach 5. With respect to the concentrations of co-planar PCBs, there appear to be marked differences between Reaches 1-4 and Reach 6, and between Reach 5 and Reach 6.
7) For the snapping turtle, an opportunistic carnivore/scavenger, with respect to the concentrations of PCDDs/PCDFs and the co-planar PCBs in the fillet tissues, there appears to be a difference between Reaches 1-4 and Reach 6 and a marked difference between Reach 5 and Reach 6.

8) For the wood ducks, there were no differences in concentrations of PCDDs/PCDFs and co-planar PCBs among the four reaches. No wood ducks were collected in Reaches 5 and 6.

It appears that the concentrations of PCDDs/PCDFs and co-planar PCBs in some biota reflect their relative concentrations in the sediments, with the highest concentrations in biota from Reach 5. Those aquatic organisms that are in direct contact with the sediments appear to have the highest concentrations of PCDDs/PCDFs and co-planar PCBs (i.e., brown bullheads, eels, and snapping turtles).

Plants
The plants contained no appreciable concentrations of any of the pollutants.

Tables 11 to 12 provide a comprehensive overview of the highest measured contaminant concentration for all flora, fauna and sediments sampled per reach. An analysis of the risk associated with these contaminant concentrations can be found in the **Exposure Assessment Section** of this report.

Highest Contaminant Concentrations in Sediment and Biota by Reach					
	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
Total Dioxin/Furan (17 Congeners)	**Turtle** (3.51 pg/g)		**Plants** (0.064 pg/g)	**Duck** (0.426 pg/g)	**Sediment** (65.9 avg. pg/g) **Eel** (4.02 pg/g) **Brown Bullhead** (0.534 pg/g)
Total WHO-PCB (12 Congeners)	**Turtle** (1.35 pg/g)				**Sediment** (1.75 avg. pg/g) **Eel** (1.43 pg/g) **White Perch** (0.311 pg/g)
Total TEQs (29 Congeners)	**Turtle** (4.86 pg/g)				**Sediment** (67.8 avg. pg/g) **Eel** (5.45 pg/g) **White Perch** (0.812 pg/g)
Total (142) PCB Congeners				**Smallmouth Bass** (1.25 ng/g), **Turtle** (21.4 ng/g)	
Methyl Mercury					**Sediment** (4.77 avg. ng/g) **Turtle** (938 ng/g),
Mercury			**Smallmouth Bass** (0.979 µg/g)		**Sediment** (1.23 avg. µg/g) **Eel** (0.739 µg/g) **Turtle** 1.046 µg/g)

Table 11. Highest contaminant concentrations in sediment (dry weight) and biota (wet weight) by study Reach.

Highest Contaminant Concentrations found in Sediment and Biota by Sample Type						
Sample Type	**Total Dioxin/Furans (17 Congeners) Concentration, Dioxin Toxic Equivalent (TEQ pg/g)**	**Total WHO-PCB Congeners (Dioxin-like PCBs; 12 congeners) Concentration, (TEQ pg/g)**	**Total TEQs (29 Congeners) Concentration TEQ Pg/g**	**Total PCB (142 Congeners) Concentration (ng/g)**	**Methyl Mercury Concentration (ng/g)**	**Mercury Concentration (µg/g)**
Sediment (Avg.)	65.9	1.75	67.8	122	4.77	1.23
Eel	4.02	1.43	5.45		No samples tested for Methyl Mercury	0.739
Fish (other than Eel)	0.534 (Brown Bullhead)	0.311 (White Perch)	0.812 (White Perch)	1.25 (Smallmouth Bass)	No samples tested for Methyl Mercury	0.979 (Smallmouth Bass)
Duck	0.426	0.652	1.08	5.01	47.9	0.049
Turtle	3.51	1.35	4.86	21.4	938	1.046
Plants	0.064	0.0402	0.0902	1.15	6.3	0.00861 µg/kg

Table 12. Highest contaminant concentrations found in sediment (dry weight) and biota (wet weight) by sample type.

Exposure Assessment of Penobscot Indian Nation tribal members

Risk Assessment vs. Risk Management

Risk assessment is the process of calculating the exposure dose for particular exposure pathways and then calculating the risk of cancer and non-cancer health effects. Risk assessment is the use of a factual base to define the health effects of exposure to individuals or population to hazardous materials or situations. Selection of maximum acceptable risk is a policy or risk management decision, rather than a risk assessment calculation. The risk assessment calculations provide an estimate of the likely quantitative level of risk using the best available exposure and toxicity information.

Risk management is the process of deciding what to do about the risks that were calculated in a risk assessment. For most Federal Agencies, risk management is the process of weighing policy alternatives and selecting the most appropriate regulatory action, integrating the results with engineering data and with social, economic, and political concerns to reach a decision. For stakeholders, risk management is a decision of how much risk is acceptable. For this RARE study, EPA selected risk management criteria consistent with EPA criteria for water quality standards and other EPA environmental programs. (See Table 17)

EPA Exposure Assessment

An exposure assessment is the determination or estimation (quantitative or qualitative) of the magnitude, frequency, duration and route of exposure. The exposure assessment is a three step process consisting of characterizing the exposure setting, identifying the exposure pathways and quantifying the exposure.

EPA uses the following equation for estimating the exposure to contaminants:

$$\text{Site Dose} = \frac{\text{Ingestion Rate} \times \text{Exposure Frequency} \times \text{Exposure Duration}}{\text{Body Weight} \times \text{Averaging Time}}$$

For this RARE study, the team was able to use tribal ingestion rates. In 2009, the USEPA and the federally recognized Maine Tribal Nations worked in a collaborative effort to develop exposure scenarios that reflect the Maine tribal traditional cultural uses of natural resources, i.e. ***The Wabanaki Traditional Cultural Lifeways Exposure Scenario*****.** The Wabanaki Traditional Cultural Lifeways Exposure Scenario was developed by gathering information from several types of literature (ethnohistorical, ecological, nutritional, archaeological, and biomedical) to develop a description of Wabanaki traditional subsistence lifestyles and diets through the lens of natural resource use and activities necessary to survive and thrive in Maine environments. Although the information used to develop a nutritionally complete diet is taken from literature that describes diets from the 16th, 17th, 18th, and 19th centuries, this information is still relevant today even if that diet is eaten by fewer people at present.

The Wabanaki Traditional Cultural Lifeways Exposure Scenario (Wabanaki Exposure Scenario) describes the lifestyle that was universal when resources were in better condition and that some Tribal Members still practice today. The Wabanaki Exposure Scenario reflects full traditional resource uses. Therefore, rather than using nationwide conservative default consumption rates to assess potential exposure, realistic tribal consumption rates combined with data collected for contaminants in water, soil/sediment, flora or fauna were used to determine realistic potential exposures to Tribal Members of the Penobscot Indian Nation. By coupling contamination information gathered through the RARE study with the ingestion factors developed in the Wabanaki Exposure Scenario, the RARE team was able to assess the level of exposure to Penobscot Indian Nation Tribal Members that occurs when they sustain their traditional life ways. Accordingly, this

study reflects EPA's National Tribal Science Council's Tribal Health and Well Being paradigm by incorporating tribal culture to assess exposure risks to tribal health and the ecosystem.

The exposure assessment for the Penobscot River study assumed that the diet was the "Inland Non-Anadromous" diet presented in the Wabanaki Exposure Scenario. Below is a table that shows the tribal consumption/ingestion rates for the flora and fauna analyzed in this RARE study based on the Wabanaki Exposure Scenario. The team chose to use the inland non-anadromous diet described in the Wabanaki Exposure Scenario because it appeared to be the diet most closely aligned with the Penobscot Indian Nation's cultural lifestyles.

Food Categories and Consumption Rates for Wabanaki Tribal Populations					
Tested Biota	**Symbol**	**Food Category**	**Consumption Rates (g/day)**		
			Inland Anadromous	**Inland Non-Anadromous**	**Coastal**
Chain Pickerel	CP	Resident fish and other aquatic resources	114	286	57
Yellow Perch	YP	Resident fish and other aquatic resources	114	286	57
White Perch	WP	Resident fish and other aquatic resources	114	286	57
Smallmouth Bass	SB	Resident fish and other aquatic resources	114	286	57
Brown Bullhead	BB	Resident fish and other aquatic resources	114	286	57
American Eel	AE	Anadromous and marine fish and shellfish	400	0 (286)[1]	457
Wood duck	WD	Fowl and Eggs	70	70	120
Fiddlehead Fern	FF	Greens, Tea (includes leaves, stems medicinal plants)	133	133	133
Medicinal Plant	MP	Greens, Tea (includes leaves, stems medicinal plants)	133	133	133
Snapping Turtle	ST	Resident fish and other aquatic resources	114	286	57

Table 13- Food Categories and Consumption Rates for Wabanaki Tribal Populations Source: Section 7.2 *Wabanaki Traditional Cultural Lifeways Exposure Scenario*

[1] Eel are catadromous rather than anadromous and are considered to be resident fish for much of their life cycle

The Definition for the diets can be found in the *Wabanaki Traditional Cultural Lifeways Exposure Scenario* and are defined as follows:

- **Inland Anadromous** = inland communities living on rivers with anadromous fish runs.
- **Inland Non-Anadromous** = inland communities without access to anadromous fish runs.
- **Coastal** = communities living where coastal resources are available.

As shown in Table 13 above, the inland non-anadromous diet consumption rates are 286 g/day for each freshwater fish species (including eel) and snapping turtle, 70 g/day for wood duck, and 133 g/day for both

Fiddlehead Ostrich fern and medicinal plant. Although the American eel is catadromous (marine spawning) rather than anadromous (freshwater spawning), it is appropriate to include eel in the Inland Non-Anadromous diet at the same ingestion rate as resident fish because eel are available for long periods of time in the river where PIN members fish.

The contaminant concentrations in each type of biota from the various river reaches are shown in Tables 5-10 under the **Analytical Results: Contaminant Concentrations** section of this report. These data were produced by the Office of Research and Development and the US EPA Environmental Chemistry Laboratory, under the Office of Pesticide Programs (OPP). Tables 5-10 summarize the results of the analysis of dioxins/furans, dioxin-like PCBs, total PCBs (as the sum of 142 PCB congeners), methyl mercury, and total mercury. Although this table includes data for sediment, this exposure assessment only evaluated ingestion of biota. The concentrations of dioxins/furans and PCBs in biota were reported as the contaminant concentration per gram of wet weight tissue (i.e. on a wet weight basis). The concentrations of methyl mercury and total mercury were also reported as the concentration per gram of wet weight tissue, but also on a dry weight basis for fiddlehead ostrich fern. Dry weight concentrations in fern were not adjusted to wet weight because percent moisture data were not readily available for the biota samples. Since dry weight contaminant concentrations are always higher than wet weight contaminant concentrations in the same sample, and ingestion rates are based on wet weight, the mercury risks of fern ingestion are overestimated by an unknown amount (for example, the wet weight concentration would be about five times lower than the dry weight concentration if the tissue is 80% moisture). This overestimation is insignificant because, as shown later, the overestimated non-cancer hazard quotients of mercury in fern were between 0.1 and 0.02.

Mercury was reported as total mercury for all the fish species. Both methyl mercury and total mercury for all fern and duck samples, and for two of four turtle samples was reported. Methyl mercury is an organic form of mercury that is much more toxic than inorganic mercury. Therefore, for risk assessment purposes, it is important to know how much of the mercury in food is in the form of the more toxic methyl mercury. The percent methyl mercury in a sample is calculated as the concentration of methyl mercury divided by the concentration of total mercury (in the same concentration units), multiplied by 100. In higher trophic level carnivorous fish, the ratio of methyl mercury to total mercury generally approaches unity, meaning that almost all of the mercury in the fish fillet is in the methyl mercury form. (See, Wiener et al., 2003) It is generally assumed that >90% of mercury in higher trophic level carnivorous fish is in the methyl mercury form, although site-specific variables and trophic level can influence the ratio of methyl mercury to total mercury in fish. The team agreed that analyzing the Penobscot fish fillet samples for total-mercury was a cost effective, accurate, and a slightly conservative way to estimate the level of methyl mercury.

The percent methyl mercury in one fern sample (Reach 4) was 85%, but could not be calculated in four other samples because methyl mercury was measurable but total mercury was lower than the detection limit. The percent methyl mercury in wood duck from five paired samples (i.e. both methyl mercury and total mercury detected in the same sample) was 98%, 83%, >100%, 14 %, and 65% (average = 72%). The percent methyl mercury in turtle from two paired samples was greater than 100% in each sample. This impossible result is an artifact of variability in the analytical methods, but indicates that, as in fish, almost all of the mercury in snapping turtle is in the form of methyl mercury. Since it can be assumed that 100% of the mercury in fish is methyl mercury, and most of the mercury in duck, turtle, and fern is shown to be in the form of methyl mercury, it was assumed that all mercury concentrations used in the risk screening were in the form of the more toxic methyl mercury.

Although there was often more than one sample result for a particular species/analyte/reach combination, the maximum concentration was selected for preliminary risk assessment, rather than calculating average concentrations. In almost all cases there were no more than two samples of the same species/analyte/reach combination. EPA risk assessment guidance indicates that the use of the maximum concentration is appropriate when there are too few samples to calculate the 95% upper confidence limit of the mean, which requires three or more samples, and preferably more.

Toxicity Assessment

In order to determine the adverse health risks to the Penobscot tribal members of the chemicals tested, a toxicity assessment of the contaminants was conducted. A toxicity assessment is the characterization of the toxicological properties and effects of a substance, specifically the dose response relationship associated with a particular route of exposure. The basic objective of a toxicity assessment is to identify what adverse health effects a chemical causes and how the appearance of these adverse effects depends on exposure level (dose). The toxic effects of a chemical frequently depend on the route of exposure (oral, inhalation, dermal) and the duration of exposure (subchronic, chronic, or lifetime). Thus, a full description of the toxic effects of a chemical includes a listing of what adverse health effects the chemical may cause and how the occurrence of these effects depends upon dose, route, and duration of exposure.

The toxicity assessment process is usually divided into two parts: the first characterizes and quantifies the non-cancer effects of the chemical, while the second addresses the cancer effects of the chemical. This two-part approach is employed because there are typically major differences in the time-course of action and the shape of the dose-response curve for cancer and non-cancer effects. http://www2.epa.gov/region8/human-health-toxicity-assessment. For example, toxicity of non-carcinogens is expressed as Reference Dose, the dose (e.g. mg contaminant/kg body weight per day) considered by EPA to have no adverse effects; while the toxicity of carcinogens is expressed as Cancer Slope Factor, the cancer risk probability/unit dose (e.g. risk probability per mg contaminant/kg body weight per day). Cancer risk (CR) of carcinogens is expressed as a probability of getting cancer due only to the exposure at the area of interest, rather than from all causes. It is calculated by multiplying the calculated lifetime average daily dose of the chemical at the area of interest by the chemical's cancer potency, which is also called the Slope Factor. The Slope Factor is derived by EPA, preferably, or by other agencies based on data from the scientific literature. Cancer risks are expressed as an incremental lifetime cancer risk (ILCR) as a probability such as 1-in-1 million. This probability can also be expressed as 1E-06 or $1x10^{-6}$. ILCR values of 1-in-1 million and less are generally considered to be of "no concern". For this report ILCR was simplified to CR (cancer risk). The exposure assumptions and toxicity values used for the risk assessment are provided below.

Exposure Assumptions		Toxicity Factors				
Exposure Duration	**30 years**	**Chemical**	**RfDo**		**CSF**	
Exposure Frequency	350 days/year		(mg/kg-day)	Source	(mg/kg-day)$^{-1}$	Source
Lifetime	70 years	TCDD-TEQ	7.0E-10	IRIS	1.3E+05	CALEPA
Body Weight	70 kg	meHg	1.0E-04	IRIS	NA	
Ingestion Rates	70 g/day (wood duck) 133 g/day (plants) 286 g/day (fish)	PCB	2.0E-05	IRIS	2.0E+00	IRIS

Table 14: Exposure assumptions and Toxicity factors

RfDo = oral Reference Dose **CALEPA** = California Environmental Protection Agency
CSF = oral Cancer Slope Factor **NA** = Not Available
IRIS = EPA Integrated Risk Information System

(Note: toxicity values for PCB are those for Aroclor 1254; the three ingestion rates are for various food items as identified in text.)

Twelve of the 209 possible forms (congeners) of PCBs have dioxin-like activity. Of the 209 possible PCBs, 142 were measured by the analytical method used in this study. The cancer and non-cancer risks of the twelve dioxin-like PCB congeners are evaluated separately from the other PCBs using the Reference Dose and Slope Factor for dioxins/furans and a Toxic Equivalents Scheme described below:

Toxic Equivalents Scheme (TEFs & TEQs)

The chlorinated chemicals known as polychlorinated dibenzo-para-dioxins (PCDDs or dioxins), polychlorinated dibenzofurans (PCDFs or furans) and PCBs occur as mixtures of congeners. There are 75 dioxin congeners, 135 furan congeners, and 209 PCB congeners, each with its own toxic potency. To express the overall toxicity of a given mixture of these chemicals as a single number, the concept of Toxic Equivalence is used (World Health Organization, 2011a, b). The toxicities of dioxin, furan and PCB congeners are expressed relative to the most toxic dioxin congener (2, 3, 7, 8- tetrachlorodibenzo-p-dioxin, TCDD), which has a reference toxicity of 1. Under this scheme, each congener is attributed a specific **"Toxic Equivalency Factor" (TEF),** indicating the degree of its toxicity compared to 2, 3, 7, 8-TCDD. To calculate the total TCDD toxic equivalent (TEQ) of a dioxin/furan, PCB mixture, the concentration of each toxic compound is multiplied by its Toxic Equivalency Factor (TEF) and then added together.

For this study we analyzed 17 congeners of dioxins/furans and 12 congeners of PCBs [the World Health Organization (WHO-PCBs)], for a total of 29 congeners that contribute to the TEQ.

The TEQ scheme refers **only** to adverse effects (e.g. cancer, non-cancer) associated with the interactions of these chemicals with cellular aryl hydrocarbon (Ah) receptors. Other toxic effects of dioxins and dioxin-like compounds are not quantified by this method. TEF values vary for different animal species.

The following table contains the various dioxin-like toxicity equivalency factors for Dioxins, Furans and PCBs (Van den Berg et al. 2006), which are the World Health Organization 2005 values.

Dioxin Toxicity Equivalence Factors			
Chlorinated dibenzo-p-dioxins	**Dioxins and Furans**		**TEF**
	2,3,7,8-TCDD		1
	1,2,3,7,8-PeCDD		1
	1,2,3,4,7,8-HxCDD		0.1
	1,2,3,6,7,8-HxCDD		0.1
	1,2,3,7,8,9-HxCDD		0.1
	1,2,3,4,6,7,8-HpCDD		0.01
	OCDD		0.0003
Chlorinated dibenzofurans			
	2,3,7,8-TCDF		0.1
	1,2,3,7,8-PeCDF		0.03
	2,3,4,7,8-PeCDF		0.3
	1,2,3,4,7,8-HxCDF		0.1
	1,2,3,6,7,8-HxCDF		0.1
	1,2,3,7,8,9-HxCDF		0.1
	2,3,4,6,7,8-HxCDF		0.1
	1,2,3,4,6,7,8-HpCDF		0.01
	1,2,3,4,7,8,9-HpCDF		0.01
	OCDF		0.0003
PCBs			
	IUPAC No.	**Structure**	
Non-*ortho*	77	3,3',4,4'-TetraCB	0.0001
	81	3,4,4',5-TetraCB	0.0003
	126	3,3',4,4',5-PeCB	0.1
	169	3,3',4,4',5,5'-HxCB	0.03
Mono-*ortho*	105	2,3,3',4,4'-PeCB	0.00003
	114	2,3,4,4',5-PeCB	0.00003
	118	2,3',4,4',5-PeCB	0.00003
	123	2',3,4,4',5-PeCB	0.00003
	156	2,3,3',4,4',5-HxCB	0.00003
	157	2,3,3',4,4',5'-HxCB	0.00003
	167	2,3',4,4',5,5'-HxCB	0.00003
	189	2,3,3',4,4',5,5'-HpCB	0.00003
Di-*ortho**	170	2,2',3,3',4,4',5-HpCB	0.0001
	180	2,2',3,4,4',5,5'-HpCB	0.00001

Table 15: Dioxin Toxicity Equivalence Factors.

* Di-ortho values come from Ahlborg, U.G., et al. (1994), which are the WHO 1994 values from Toxic equivalency factors for dioxin-like PCBs: Report on WHO-ECEH and IPCS consultation, December 1993 Chemosphere, Volume 28, Issue 6, March 1994, Pages 1049-1067.

Risk Characterization

Using the toxicity factors and the exposure assumptions described previously, the cancer and non-cancer risks were calculated for each food item consumed at the inland non-anadromous diet rate in each reach. The risks are summarized in Table 18. The results from each combination of species and reach are tabulated in Appendix F. The risk of chemicals with health effects other than cancer, so called non-carcinogens, is expressed as a Hazard Quotient (HQ), which is the value produced by dividing the average daily dose at the area of interest by the Reference Dose, which is considered to be the "safe" dose. The Reference Dose is derived by EPA, preferably, or other agencies from the scientific literature. When the average daily dose from the area of interest is less than the Reference Dose, then the HQ will be less than 1. HQ values of 1 or less are generally considered to be insignificant. A preliminary risk assessment was conducted as detailed below using the EPA calculator for fish consumption risk-based concentrations on the EPA Regional Screening Level website (http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search .)This computer program calculates the concentration of a contaminant in food associated with a given risk level (i.e. a risk-based concentration), using chemicals and exposure assumptions that can be entered into the calculator.

Summarized below are the risk-based concentrations (RBCs) for the three ingestion rates and three chemicals.

Risk Based Concentrations			
Ingestion Rate (g/day)	**Chemical**	**Risk Based Concentration (mg/kg)**	
		Cancer (for Cancer Risk = 1E-06)	**Non-Cancer (for Hazard Quotient = 1)**
70 (wood duck)	TEQ meHG PCB	1.87E-08 NA, 1.22E-03	7.30E-07, 1.04E-01, 2.09E-02
133 (plants)	TEQ meHG PCB	9.85E-09 NA 6.40E-04	3.80E-07 5.49E-02 1.10E-02
286 (fish/turtle)	TEQ meHG PCB	4.58E-09 NA 2.98E-04	1.79E-07 2.55E-02 5.10E-03

Table 16: Risk Based Concentrations.

TEQ = dioxin Toxic Equivalents **PCB** = Polychlorinated Biphenyls
meHg = methyl mercury **NA** = Not Applicable

For the current preliminary risk assessment, the risk based concentration (RBCs) were calculated for risks of HQ =1 and CR =1E-06. The contaminants selected from the drop down list on the calculator were 2, 3, 7, 8-TCDD (for total TEQ based on dioxins/furans and dioxin-like PCBs), methyl mercury (for total and methyl mercury levels), and Aroclor 1254 (as representative of cancer and non-cancer risk of total PCBs by congener analysis). The biota consumption rates were set at one of the three different tribal ingestion rates (70 g/day for wood duck, 133 g/day for plants, and 286 g/day for fish, eel, and turtle). The other exposure assumptions include an exposure frequency of 350 days/yr, an exposure duration of 30 years, adult body weight of 70 kg, lifetime of 70 yr, non-cancer averaging time of 10950 days (i.e. 30 years x 365 days/year) and cancer averaging time of 25550 days (i.e. 70 years x 365 days/year).

The equations used in the calculator to calculate RBCs for HQ =1 and cancer risk (CR) = 1E-06 are provided below:

The equation for calculating the non-carcinogenic screening level is provided below:

$$RBC\text{-}nc = \frac{THQ * AT\text{-}nc * BW}{EF * ED * 1/RfDo * IR\text{-}F * CF}$$

The equation for calculating the carcinogenic screening level is provided below:

$$RBC\text{-}c = \frac{TR * AT\text{-}c * BW}{EF * ED * CSF * IRF * CF}$$

RBC-nc =Risk Based Concentration, non-carcinogen (mg/kg)-chemical specific
THQ = Target Hazard Quotient (unitless) (set at HQ=1 for this assessment)
AT-nc = Averaging Time-non-cancer = 10950 days (365 days/year x 30 years)
RBC-c = Risk Based Concentration, carcinogen (mg/kg)-chemical specific
TR = Target Risk (unitless), set at cancer risk = 1E-06 for this assessment
AT-c = Averaging Time, cancer =25550 days (365 days/year x 70 years)
BW = Body Weight = 70 kg
ED = Exposure Duration = 30 years
EF = Exposure Frequency =350 days/year
RfDo = oral Reference Dose (mg/kg-day)-chemical specific
CSF = Cancer Slope Factor (per mg/kg-day)-chemical specific
IR-F = Ingestion rate-Fish (mg/day)-food item specific
CF = Conversion Factor = 1E-06 kg/mg
*=symbol for multiplication

The risks were calculated differently for cancer and non-cancer risk as described below. For non-cancer risk, the Hazard Quotient (HQ) was calculated by dividing the concentration of a chemical in biota by the non-cancer RBC for HQ=1 for that chemical. As an example, if the concentration in biota is 8 mg/kg, and the RBC representing HQ =1 is 4 mg/kg, then the HQ would be 2 (i.e. 8/4=2).

The Cancer Risk (CR) was calculated by dividing the concentration of a chemical in biota by the cancer RBC for CR=1E-06 for that chemical, and then multiplying by 1E-06. As an example, if the concentration in biota is 4 mg/kg, and the RBC representing CR=1E-06 is 2 mg/kg, then CR would be 2E-06 (i.e. 4/2 x 1E-06 = 2E-06).

Since cancer risks of different chemicals can be added together, the CR of each carcinogenic chemical was added to calculate a total CR. Some chemicals such as dioxins/furans and PCBs have both cancer and non-cancer effects. Non-cancer risks for different chemicals can be added together only if the chemicals have the same target tissue (e.g. liver damage, central nervous system effects). Therefore, the HQ of each non-carcinogenic chemical was not added to the HQ of other non-carcinogenic chemicals.

The non-cancer Reference Doses and cancer Slope Factors for the contaminants as used in the calculator were obtained from the latest version of EPA's Regional Screening Level website, which obtain most of the toxicity values from the Integrated Risk Information System (IRIS) available at http://epa.gov/iris/. Although IRIS does not have a Slope Factor for dioxins/furans, this calculator used EPA's currently

recommended value from the California Environmental Protection Agency (CalEPA). Based on the conclusion that most of the mercury detected in biota is methyl mercury, the Reference Dose in the calculator for methyl mercury was used rather than the Reference Dose for inorganic mercury. According to the EPA Integrated Risk Information System (IRIS), the primary toxic effects of mercury are non-cancer effects on the neurological system. Mercuric chloride and methyl mercury are classified as possible human carcinogens but the cancer risk is not quantifiable due to no or inadequate data in humans and limited evidence of carcinogenic effects in animals. As a result, mercury has a Reference Dose (from IRIS) but no Slope Factor for cancer risk. Dioxins/furans have both cancer and non-cancer effects and, therefore, the screening level risk assessment used a Reference Dose (from IRIS) and a Slope Factor (from CalEPA). PCBs have both cancer and non-cancer effects, and, therefore, the preliminary risk assessment used a Reference Dose and Slope Factor for Aroclor 1254, a mixture of PCB congeners. Toxicity factors for Aroclor 1254 were selected because it is the only PCB on the IRIS database that has both a Reference Dose and a Slope Factor, and it is adequately and conservatively representative of the mixture of highly chlorinated PCBs likely to occur in fish populations.

Risk management Criteria

The preliminary risk assessment estimates the quantitative level of risk; however, the process of risk assessment does not itself identify the maximum acceptable level of risk. Identifying acceptable risk levels is a risk management process that is based on the goals of the stakeholders as well as any regulatory requirements. Therefore, it is beyond the scope of this report to specify which, if any, state or federal regulatory program(s) applies to the issue of contaminants in biota in or near the Penobscot River. Nevertheless, the risks identified in this report can be placed in context by identifying the maximum permitted risks under some of EPA environmental regulatory programs as shown in table 17 below.

EPA Acceptable Cancer Risk Management Criteria			
EPA	Maximally exposed member of the general public	Hazardous air pollution	1×10^{-6} to 1×10^{-4} [a]
EPA	General public	Drinking water	Goal of zero[b]
EPA	General public	Abandoned hazardous waste sites	1×10^{-6} to 1×10^{-4}
EPA	General public	Operating hazardous waste sites	1×10^{-6} to 1×10^{-4} [c]
EPA	General population	Surface Water Quality Criteria	1×10^{-6} to 1×10^{-5}
EPA	Sensitive subpopulation	Surface Water Quality Criteria	1×10^{-6} to 1×10^{-4}

Table 17: Maximum Lifetime Cancer Risks Permitted by EPA Environmental Regulations

a. If the risk to the maximally exposed individual (MEI) is no more than 1×10^{-6}, then no further action is required. If not, the MEI risk must be reduced to no more than 1×10^{-4}, regardless of feasibility and cost, while protecting as many individuals as possible in the general population against risks exceeding 1×10^{-6}.

b. EPA sets a goal of zero risk for carcinogens in drinking water. The enforced limit is then set as close as possible to this goal given what is feasible using the best available control technology.

c. Chemicals are listed as hazardous if they pose a risk of $\geq 1 \times 10^{-5}$. They are de-listed only if their risk is determined to be $\leq 1 \times 10^{-6}$. Corrective action must reduce risks to 1×10^{-4} to 1×10^{-6}. For

incinerators, risks associated with Group A and Group B carcinogens (substances likely to cause cancer in humans or animals) can be no more than 10^{-6}. Risks associated with Group C carcinogens cannot exceed 10^{-5}.

This table identifies the maximum lifetime cancer risk under EPA regulations for hazardous air pollution, surface water quality criteria, drinking water, and operating or abandoned hazardous waste sites. Cancer risk is expressed as a probability of getting cancer from the particular type of exposure, for instance a probability of 1 in 1 million, also expressed mathematically as either 1×10^{-6} or 1E-06 Table 17 indicates that a cancer risk level of 1×10^{-6} (1 in 1 million) or less is generally considered to be below regulatory concern.

Therefore, for this report, the cancer risks of 1×10^{-6} or less are considered to be of "no concern". The cancer risk is different from the risk based concentration because the CR is a multiple of the RBC. Cancer risks of 1×10^{-6} or less, or non-cancer risks of HQ of 1 or less, are designated as being of "no concern". All cancer risks greater than 1×10^{-6}, or non-cancer risks of HQ greater than 1, are designated as being of "potential concern".

This risk management approach using just two criteria of "no concern" or "potential concern" is similar to the risk management criteria used by ATSDR and is considered to be appropriate given the high uncertainties associated with the contaminant data in this study. Such uncertainties include the use of only one or two composite samples per reach for each species, the use of maximum contaminant concentrations rather than average concentrations, the collection of larger (and therefore probably more contaminated) fish, and the collection of biota during only one season. Since it is known that contaminants in river fish vary greatly with species, age, river location/habitat, and season, the actual representative concentrations in biota of the Penobscot River may be higher or lower than those measured in this study. Additional collection and contaminant analysis of biota would be necessary to develop statistically based representative contaminant concentrations.

The risk of chemicals that have effects other than cancer, such as kidney damage or birth defects, is also regulated by various environmental regulatory programs. The non-cancer risk of these chemicals is expressed as a hazard quotient (HQ), which is simply the number obtained when the estimated exposure dose of the chemical is divided by the no-effect dose, the so-called Reference Dose (RfD). The Reference Dose is derived from the scientific literature and published by EPA or other agencies. If the estimated exposure dose is higher than the no-effect dose, then the HQ will be greater than 1. Therefore, most regulatory programs consider a HQ greater than 1 to be of potential concern. For instance, an HQ of 1 is used for EPA drinking water health advisories and national recommended water quality criteria for protection of human health for non-carcinogens and as the level above which remedial actions are considered at operating or abandoned hazardous waste sites.

Based on this analysis of multiple regulatory programs, and without specifying which, if any, regulatory program applies to contaminants in biota in or near the Penobscot River, risks of 1×10^{-6} or less, or an HQ of 1 or less, are identified in this report to be of "no concern". Conversely, risks of 1×10^{-6} or greater, or an HQ greater than 1, are identified in this report to be of "potential concern".

Preliminary Risk Results

Using the toxicity factors and the exposure assumptions described previously, the cancer and non-cancer risks were calculated for each food item consumed at the Inland Non-Anadromous diet rate in each reach. The risks are summarized in Table 18. The results from each combination of species and reach are tabulated in Appendix F.

EPA used the data from this study to conduct a screening level risk assessment which compared the concentrations in biota to risk-based concentrations representing a Hazard Quotient of 1 and a cancer risk of 1 in 1 million. These risk levels are considered to be insignificant or of "no concern". The results suggest that that ingestion of each animal species at the Wabanaki Exposure Scenario consumption rates is associated with a risk higher than the level of "no concern" i.e., HQ=1 and CR=1E-06.

Among the animal biota, the lowest risks were for wood duck, with a maximum HQ of 1 and a maximum CR of 6E-05. All other animal species had HQ values greater than 1 and CR values greater than 1E-06. Among fish, eel, and turtle, the HQ values ranged from a low of 5 for brown bullhead in the control reach 6 to a high of 40 in smallmouth bass in four reaches and snapping turtle in two reaches (including control reach 6). EPA's preliminary risk assessment indicates that the species of highest concern are small mouth bass, American eel and snapping turtle. These HQ values above one were due primarily to mercury, but also dioxin TEQ in snapping turtle and eel. The CR values were due primarily to dioxin TEQ and secondarily to PCBs. Based on EPA's designation of cancer risks greater than 1E-06 as being of potential concern in this report, ATSDR's recommendations that PIN members should limit the consumption of eel and snapping turtles from the reaches identified in this study are not inconsistent with EPA's preliminary risk assessment. PIN members should be aware that reach 5 is an area where there are especially high cancer risks in eel, snapping turtle, white perch and brown bullhead (See Figures 9 -14). PIN members can use the information in Table 18 and Figures 9 to14 to tailor their fishing, hunting and gathering practices to reduce their health risks.

The data from this study also showed that consumption of plant materials at the Inland Non-Anadromous tribal consumption rate had a maximum HQ that was less than 1 and a maximum CR of 9E-06. Since the CR for plant materials is greater than 1E-06, consumption of plants is of "potential concern". EPA's screening level risk assessment also indicates that mercury was not found in duck, fiddlehead fern, or medicinal roots at levels of health concern. Table 18 and Figures 9-14 illustrate which species are of potential concern for each reach.

Adult Risks at Inland-Non-Anadromous Tribal Ingestion Rate for Penobscot River Reaches																		
Tested Food Item	**Tribal Ingestion Rate**	**Risk for Adults**																
		Reach 1			**Reach 2**			**Reach 3**			**Reach 4**			**Reach 5**			**Reach 6**		
	(g/day)	**HQ**	**CR**	**Driver**	**HQ**	**CR**	**Driver**	**HQ**	**CR**	**Driver**	**HQ**	**CR**	**Driver**	**HQ**	**CR**	**Driver**	**HQ**	**CR**	**Driver**
Chain Pickerel	286	**20**	**9E-06**	TEQ Hg	**30**	**1E-05**	Hg TEQ	**30**	**9E-06**	Hg TEQ	**10**	**8E-06**	TEQ Hg	**20**	**3E-05**	TEQ Hg	**20**	**1E-05**	Hg TEQ
Yellow Perch	286				**20**	**8E-05**	Hg TEQ	**20**	**1E-05**	TEQ Hg	**6**	**7E-06**	Hg TEQ				**10**	**3E-06**	Hg TEQ
White Perch	286	**20**	**8E-05**	Hg TEQ							**20**	**9E-05**	Hg TEQ	**20**	**2E-04**	Hg, TEQ	**20**	**7E-05**	Hg TEQ
Smallmouth Bass	286	**30**	**3E-05**	TEQ PCB Hg	**40**	**4E-05**	TEQ PCB Hg	**40**	**3E-05**	TEQ PCB Hg	**40**	**6E-05**	TEQ PCB Hg	**40**	**4E-05**	TEQ PCB Hg	**30**	**5E-05**	TEQ PCB Hg
Brown Bullhead	286	**10**	**7E-05**	TEQ Hg	**20**	**3E-05**	TEQ Hg	**10**	**6E-05**	TEQ Hg	**7**	**7E-05**	TEQ Hg	**20**	**2E-04**	Hg, TEQ	**5**	**5E-05**	TEQ Hg
American Eel	286	**30**	**5E-04**	Hg, TEQ	**30**	**3E-04**	Hg, TEQ	**20**	**5E-04**	Hg, TEQ	**10**	**3E-04**	Hg, TEQ	**30**	**1E-03**	Hg, TEQ	**8**	**1E-04**	Hg, TEQ
Wood duck	70	0.5	**2E-05**	TEQ	0.6	**3E-05**	TEQ	0.6	**3E-05**	TEQ	1	**6E-05**	TEQ						
Fiddlehead Fern	133	<1	1E-06		<1	**2E-06**	PCB	<1	4E-07		<1	5E-07					<1	3E-07	
Medicinal Plant	133							<1	**6E-06**		<1	**9E-06**		<1	**2E-06**		<1	**4E-06**	
Snapping Turtle	286	**40**	**1E-03**	Hg TEQ				**20**	**2E-04**	TEQ Hg	**20**	**5E-04**	PCB TEQ Hg	**40**	**6E-04**	Hg, TEQ	**10**	**3E-05**	TEQ Hg

Table 18: Adult Risks at Inland-Non-Anadromous Tribal Ingestion Rate for Penobscot River Reaches
TEQ = Dioxin Toxic Equivalents **HQ** = Hazard Quotient
Hg = Mercury **CR** = Cancer Risk

Numbers that are bolded and shaded in the column under HQ indicate that there is a non-cancer risk of potential concern because the risk value exceeds HQ=1 and numbers in the column titled CR indicate that there is a cancer risk of potential concern because the risk value exceeds CR = 1E-06. Numbers that are not bolded or shaded indicate that the health risk is of no concern because the HQ is 1 or less or the CR is 1E-06 or less.

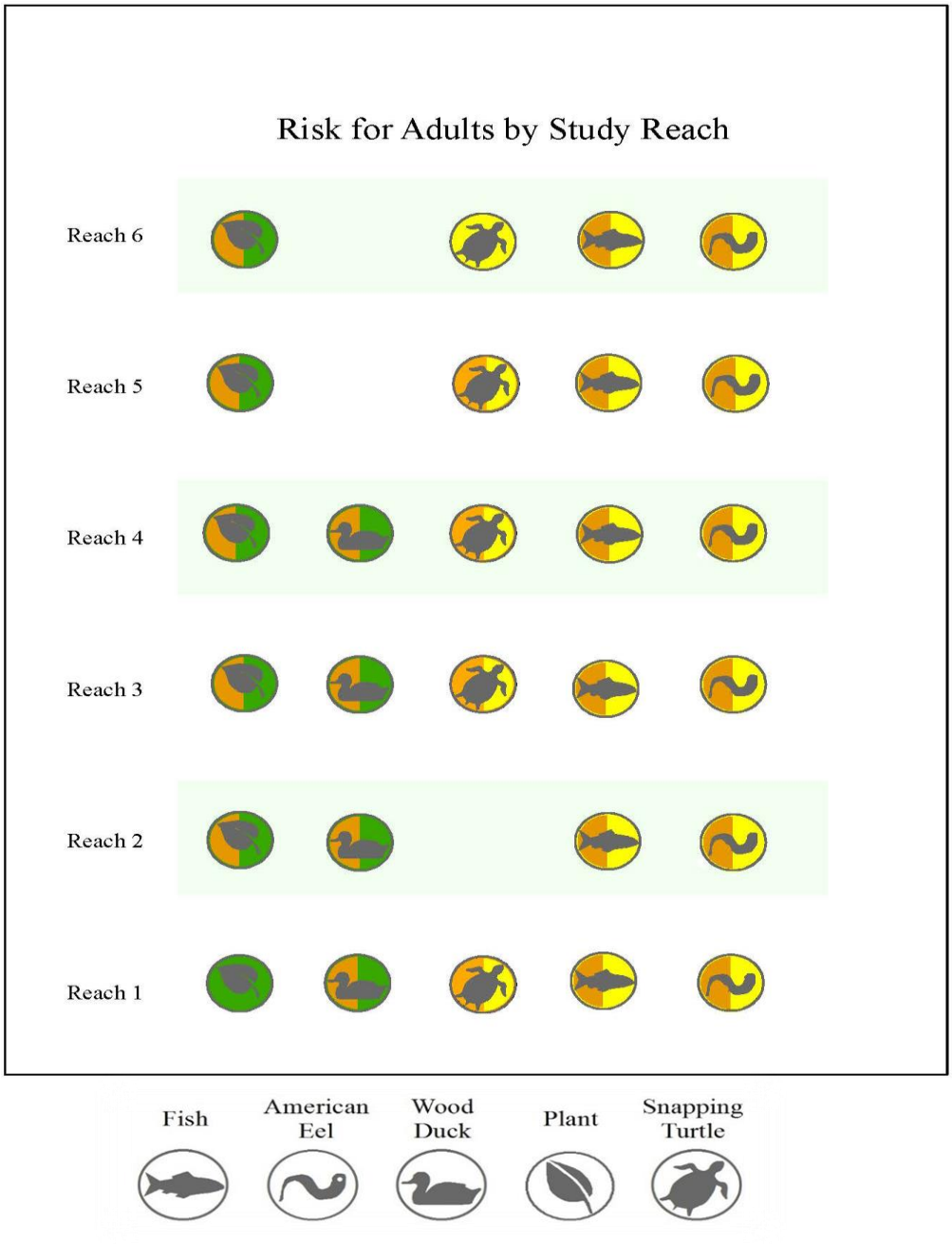


Figure 9: Chart of Adult Risk by Reach

Green Shading Concentrations in green shading indicate the risk is of no concern.
Yellow Shading Concentrations in yellow shading indicate there is a non-cancer health risk of concern (HQ>1).
Orange Shading Concentrations in orange shading indicate there is a cancer health risk of potential concern (CR>1E-06).

(Note: Half orange and half yellow indicates there is both a non-cancer health risk and a potential cancer risk of concern.)

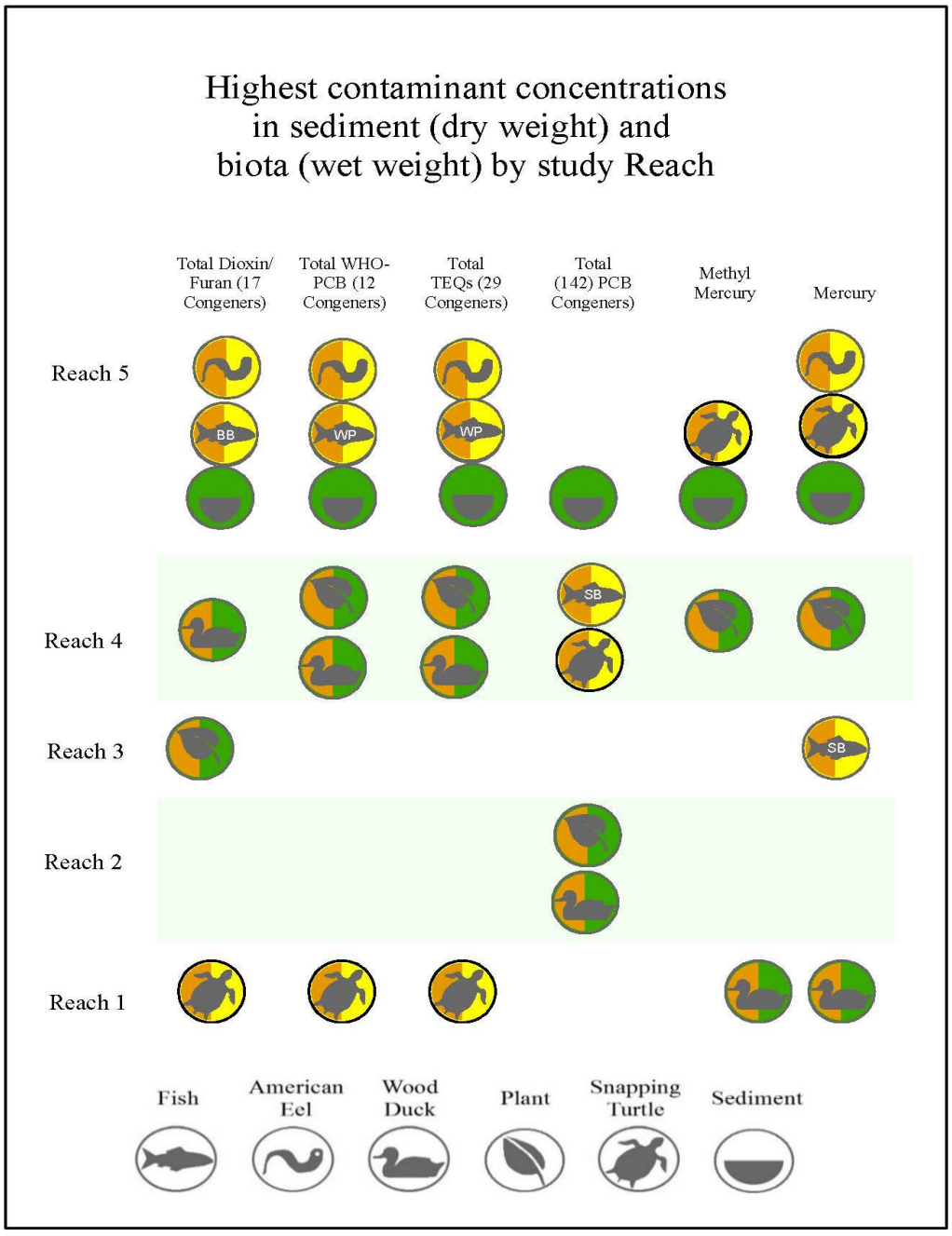


Figure 10: Chart of highest contamination concentrations in sediment and biota by Reach.
Green Shading Concentrations in green shading indicate there is no health concern.
Yellow Shading Concentrations in yellow shading indicate there is a non-cancer health risk of concern (HQ>1).
Orange Shading Concentrations in orange shading indicate there is a cancer health risk of concern (CR>1E-06).
(Note: Half orange and half yellow indicates there is both a non-cancer and a cancer risk of concern. BB=Brown Bullhead;WP=White Perch)

Hazard Quotients

Figures 11 to 12 illustrate the Hazard Quotient for each animal species that exceed a HQ =1 in each reach. A hazard quotient of 1 or less is considered to represent a non-cancer risk of "no concern". The hazard quotient is the value of the estimated dose of contaminants in flora and fauna divided by the safe ingestion dose for adverse health effects other than cancer.

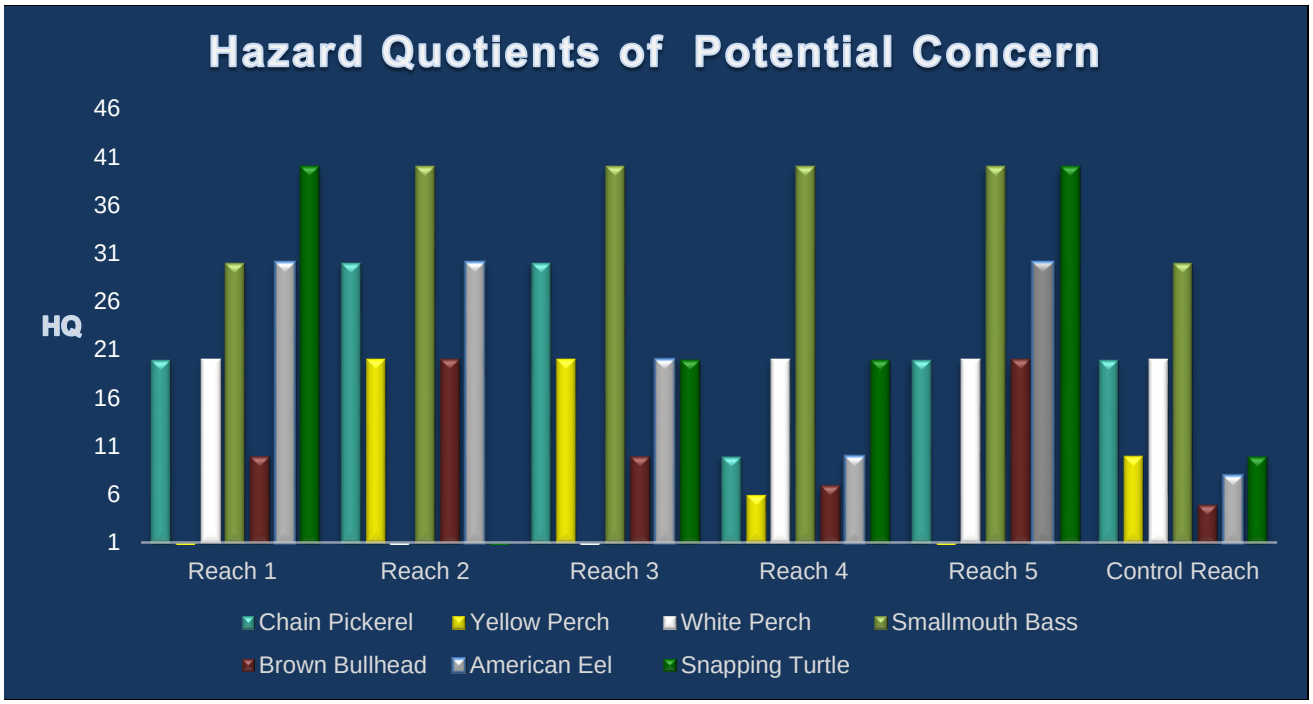


Figure 11: Hazard Quotient (HQ) for fauna that exceed a HQ =1.

Reach 1 = Milford Dam Impoundment (MIL)
Reach 2 = Sunkhaze-West Enfield Dam (SWE)
Reach 3 = West Enfield Dam Impoundment (WEI)
Reach 4 = Mohawk-Mattaseunk Dam (MM)
Reach 5 = Mattaseunk Dam Impoundment (MAT)
Reach 6 = Control Reach, East Branch-Salmon Stream Lake (EBS)

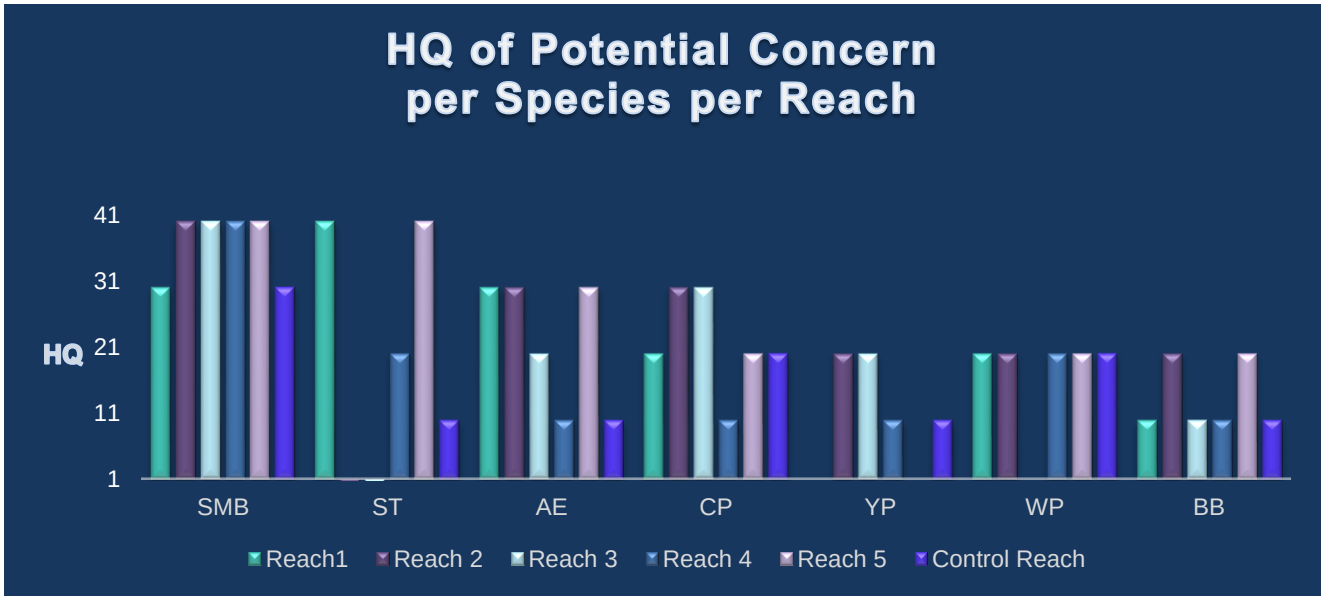


Figure 12: Hazard Quotient (HQ) for fauna that exceed a HQ =1.

SMB- Smallmouth bass	AE- American Eel	YP- Yellow perch	BB- Brown bullhead
ST- Snapping turtle	CP- Chain pickerel	WP- White perch	

Cancer Risk

Figure 13 illustrates the Cancer Risk (CR) for fish, eel, and snapping turtle that exceed a CR= 1E-06 for each reach. The CR is expressed as a lifetime probability of getting cancer due to exposure at the area of interest, over and above the normal probability of getting cancer from all causes.

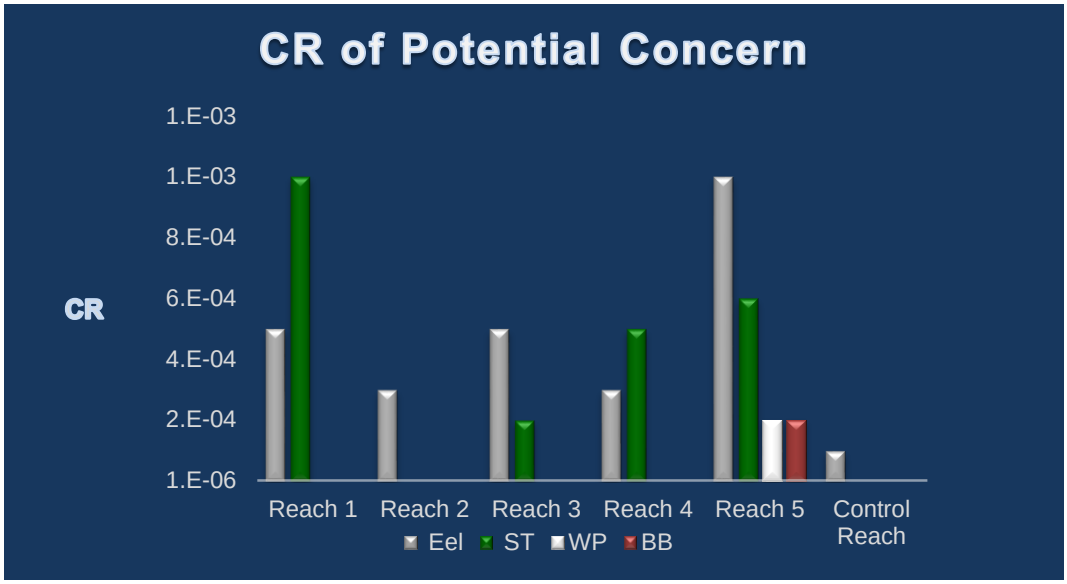


Figure 13: Cancer Risk (CR) for fauna that exceed a CR= 1E-06.
ST- Snapping turtle AE- American Eel
WP-White perch BB- Brown bullhead

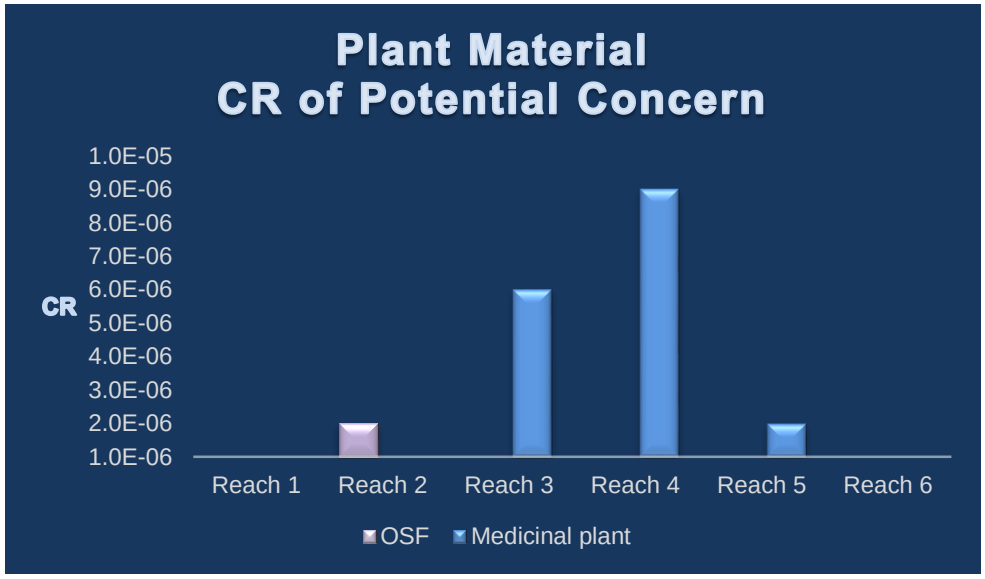


Figure 14: Cancer Risk (CR) for flora that exceed a CR= 1E-06.
Reach 1 = Milford Dam Impoundment (MIL)
Reach 2 = Sunkhaze-West Enfield Dam (SWE)
Reach 3 = West Enfield Dam Impoundment (WEI)
Reach 4 = Mohawk-Mattaseunk Dam (MM)
Reach 5 = Mattaseunk Dam Impoundment (MAT)
Reach 6 = Control Reach, East Branch-Salmon Stream Lake (EBS)

Uncertainty Analysis

There are many sources of variability and uncertainty in conducting any risk assessment. The variability in concentrations among individual fish is unknown because only composites were analyzed. There is uncertainty about the concentrations of the individual dioxin/furan/PCB congeners because of analytical detection limits. The analyses were conducted using the best available practicable methods; therefore the total concentrations of the congeners and TEQs may be somewhat under- or over-estimated, but the data are usable for a preliminary risk assessment. The use of maximum concentrations for preliminary risk assessment suggests that the risks are somewhat over-estimated. Since the maximum concentration of the composite sample was used, there were individual fish in the sample that had lower and higher concentrations. It is likely that some individual fish in the river have even higher concentrations than the maximum composite concentration, particularly the larger and older fish that may be caught in the river.

There is uncertainty about the exposure assumptions in that some people may eat more or less than the amount used in the preliminary risk calculation. It is assumed that an adult tribal member weighs 70 kg and would ingest the individual food items for 30 years in the study area over a lifetime of 70 years. It is probable that some tribal members would not move from the area and therefore would have 70 years of exposure over a lifetime of 70 years. Use of the latter assumption would approximately double the risks (i.e. 70/30= 2.3). It should also be noted that this preliminary risk assessment was for adults exposed from childhood through 30 years of age, rather than for children exposed only during childhood. Tribal consumption rates for children were not available. Assuming that a 6-year old child (weighing 15 kg) would consume about half of the adult consumption rate for 6 years, the non-cancer risks for a child would be about twice as high as those for a 70 kg adult consuming at the adult consumption rate for 30 years.

It should be emphasized that the preliminary risk assessment is based on the specified tribal consumption rate of individual food items, rather than the combined consumption of different kinds of food items. Since there is an almost infinite number of combinations possible for consumption of the seven animal species and plant species, estimation of combined risks was beyond the scope of this preliminary risk assessment. Rather, the risks of each food item at the tribal consumption rate were estimated in this study to help enable individual tribal members to evaluate the risks for the particular combinations of food items that they consume.

There is also uncertainty about whether the non-cancer risks of dioxins/furans, PCBs, and mercury should be added together. All three chemicals have neurological effects but there are many other toxic effects that these chemicals do not have in common. It would be conservative to add the hazard quotients together but this was not done; however, inspection of the HQ values in the risk table in Appendix F indicates that adding the HQ values would not change the conclusion about whether the separate HQ values exceed 1 or not.

Health and Exposure Assessment Conclusions and Recommendations

ATSDR Health Assessment

ATSDR used the data generated from the RARE report to conduct a health assessment for the Penobscot Indian Nation. A Health Assessment is a way for ATSDR to respond to a need for health information on toxic substances and to make recommendations for actions to protect the public's health.

ATSDR staff evaluated information available about toxic material at the site, determined whether people might be exposed to it, and reported what harm exposure might cause.

Health Assessments typically consider the following:

- what the levels (or "concentrations") of hazardous substances are;
- whether people might be exposed to contamination and how (through "exposure pathways" such as breathing air, drinking or contacting water, contacting or eating soil, or eating food);
- what harm the substances might cause to people (or the contaminants' "toxicity");
- whether working or living nearby might affect people's health; and,
- other dangers to people, such as unsafe buildings, abandoned mine shafts, or other physical hazards.

Based on the results of the samples collected, the ATSDR came to the following conclusions concerning the health hazards:

- Penobscot Indian Nation (PIN) members who eat fish and turtle at the ingestion levels suggested in the Wabanaki Traditional Cultural Lifeways Exposure Scenario report (Scenario) may be exposed to harmful levels of mercury, dioxins/furans and dioxin-like PCBs.

- ATSDR is most concerned about mercury in fish and turtle taken from the Penobscot River. Mercury is most harmful to children and developing fetuses, therefore it is especially important for pregnant and breastfeeding women, women who may become pregnant, and children to limit their consumption of fish and turtle in order to decrease their risk of neurological damage due to mercury exposure.

- PIN members who eat duck, fiddlehead fern, or medicinal plants at the Scenario- suggested ingestion rates will not be exposed to harmful levels of mercury, PCBs, dioxins/furans or dioxin-like PCBs.

- Incidental ingestion of, and dermal exposure to, Penobscot River sediment does not pose a human health hazard. All sediment contaminants analyzed in this report were found in concentrations below initial screening values with the exception of dioxins/furans in three samples. Dioxin/furan concentrations in those three sediments were below human health exposure guidelines and therefore pose no health threat to the Penobscot Indian Nation tribal members that may be exposed to sediments in the Penobscot River.

ATSDR's Health Assessment Recommendations

ATSDR is most concerned about mercury in fish and snapping turtle taken from the Penobscot River. Mercury is most harmful to children and developing fetuses, therefore it is especially important for pregnant and breastfeeding women, women who may become pregnant, and children to limit their consumption of fish and snapping turtle in order to decrease their risk of neurological damage due to mercury exposure. PIN members should follow the existing PIN DNR fish advisory and the State of Maine Safe Eating Guidelines for all fish caught in the Penobscot River.

ATSDR recommends that Penobscot Indian Nation members should reduce their consumption of fish and snapping turtle in order to decrease their exposure to potentially harmful methyl mercury, as well as dioxins/furans and dioxin-like PCBs based on the following recommendations:

- PIN members limit their consumption of fish to 1-2 fish meals per month in order to minimize their risk of harmful health effects due to methyl mercury; and their lifetime risk of cancer due to dioxin/furans and dioxin -like PCBs.

- PIN members limit their snapping turtle consumption to 2-3 servings per month.

- If PIN members eat both fish and turtle, limit their consumption to no more than some combination of 1-2 (10 oz.) servings of fish, OR 2-3 (8 oz.) servings of turtle per month.

- Incidental ingestion of, and dermal exposure to, sediment in the Penobscot River is not expected to cause a health hazard.

- It is safe to eat wood duck, fiddlehead ferns and medicinal roots at the rates suggested in the Wabanaki Traditional Cultural Lifeways Exposure Scenario.

US EPA Exposure Assessment Recommendations

The data from this study were used by EPA in a preliminary risk assessment which compared the concentrations in biota to risk-based concentrations representing a Hazard Quotient of 1 and a cancer risk of 1 in 1 million. The risks are summarized in Table 18 and Figures 9 to 14.

The results indicate that consumption of plant materials at the Inland Non-Anadromous tribal consumption rate had a maximum HQ that was less than 1 and a maximum CR of 9E-06. Among the animal biota, the lowest risks were for wood duck, with a maximum HQ of 1 and a maximum CR of 6E-05. All other animal species had HQ values greater than 1. Among fish, eel, and turtle, the HQ values ranged from a low of 5 for brown bullhead in the control reach 6 to a high of 40 in smallmouth bass in four reaches and snapping turtle in two reaches (Reaches 1 and 5). These HQ values above one were due primarily to mercury, but also dioxin TEQ in snapping turtle and eel.

All the fish, eel and turtle analyzed for this study exceeded the CR of $1x\ 10^{-6}$ and have a cancer risk of potential concern. The CR values for these animal species were due primarily to dioxin TEQ and secondarily to PCBs. Based on EPA's preliminary risk assessment, the species of highest concern are Smallmouth Bass, White Perch, Brown Bullhead, American Eel and Snapping Turtle. Table 18 and Figures 9 to 14 illustrate which species are of most concern for HQ and CR per reach.

Based on EPA's assessment of cancer risks, EPA concurs with ATSDR that PIN members should limit the consumption of eel and snapping turtles from the reaches identified in this study and that the consumption of plant material sampled in this study may pose a risk of potential concern.

However, the risk from consuming the plant material is less than ten times the level considered to be of "no concern". Since EPA's screening level risk assessment is based on a maximum acceptable risks as defined by various EPA regulatory programs and not based on health based standards as is ATSDR's Public Health Assessment, some of the conclusions between ATSDR and EPA differ. For example, EPA's screening level risk assessment did show that there is a cancer risk of "potential concern" in wood duck and plants at certain reaches in the Penobscot River, particularly reach 4, which do not mirror the conclusions of ATSDR's. This is due to the different methodologies used by the different agencies and the designation of risk management criteria of "no concern" defined as HQ=1 and CR= 1E-06. Nonetheless, EPA does concur with ATSDR's recommendations that the consumption of plants and wood duck do not pose a significant health risk while the consumption of fish, especially eel, and snapping turtle should be limited per ATSDR's recommendations PIN members should be aware that reach 5 is an area where there are especially high screening cancer risks in eel, snapping turtle, white perch and brown bullhead (See Figure 13)**.** If PIN members use the information in Table 18 and Figures 9-14 to tailor their fishing, hunting and gathering practices this will help to reduce the risk of cancer and non-cancer health effects for PIN members.

Recommendation for further Investigation

Because this study was a preliminary assessment, it was understood from the beginning that only a limited number of samples could be collected and analyzed. Samples of edible muscle and plant issue were analyzed for a screening level human health risk assessment. The remaining tissue (offal) was frozen so that the "whole body" contaminant concentrations could be mathematically reconstructed for evaluation of ecological risk through food chain transfer (e.g. fish to fish-eating bird). The data from the preliminary study supports a conclusion that contamination levels are high enough in specific fauna in certain reaches to warrant further investigation of both human health and ecological risk.

Due to the culturally significant use of, and subsistence on, these resources, and the potential for adverse ecological effects due to food chain bioaccumulation, EPA recommends that a more thorough research study be conducted. Such a study should include collecting and analyzing sufficient individual fish to statistically characterize how contaminant concentrations are related to species, individual length/weight, and with river location. These relationships can be used to provide risk-based recommendations to PIN members concerning consumption of fish from different river locations. The frozen "offal" samples should also be analyzed to estimate the contaminant concentrations in the whole fish that are consumed by fish-eating wildlife (e.g. eagles, mink, snapping turtles) so that the ecological risk to such higher trophic level predators can be evaluated.

The resulting data could be used to inform food chain ecological risk assessment on the river, as well as risk management concerning risk-based size limits, advisories concerning fishing in specific river locations, and serve as a baseline for tracking changes in contaminant concentrations over time. Further studies should be coordinated with the PIN Health Department in their effort to correlate the health results with fish consumption and track changes in fish consumption behavior through education and issuance of health advisories to PIN members.

Conclusions and Recommendations of Mutagenicity Study

Analytical Results of Salmonella Mutagenicity Study

As discussed in the Introduction, the *Salmonella* mutagenicity assay is the bioassay of choice for determining the mutagenicity of organic compounds present in environmental media (Claxton et al. 2010). A positive result suggests the possibility that the water or sediment may contain some potential carcinogens. A negative result has less meaning than a positive result but would suggest that the mixture or compound has a lower probability of containing carcinogens than would those that produce a positive response.

A positive mutagenic response is defined as one in which the extract produces a dose-related increase of at least twofold over the DMSO control number of revertants/plate. Revertants are colonies of bacteria on the Petri plate; they are mutant bacteria formed from exposure of the bacterial cells to the extract. The extracts are tested in the presence and in the absence of a homogenate of rat liver called S9, which provides some aspects of mammalian metabolism. Bacteria do not have as much of the enzymatic activities as those found in humans, so S9 provides some of this activity. Some environmental mutagens/carcinogens require metabolism in order to be mutagenic/carcinogenic; thus, S9 is added to the Petri dish to provide this activity. When extracts are mutagenic in the absence of S9, this indicates that the mutagens in the extract do not require metabolism and are directly acting on the DNA in the bacteria. Various strains of bacteria are used in the mutagenicity assay because each strain detects only a limited set of chemical classes of mutagens. Because no single strain detects all classes of mutagens, a variety of strains are used to capture mutagenic activity over a range of classes of chemical mutagens that might be in the extracts.

The drinking water samples from all three sampling days were mutagenic in TA98 –S9, with an average mutagenic potency in TA98 –S9 of 198 rev/L-eq (Table 19). Samples from day 8/03 were positive in TA100 –S9. The average mutagenic potency for TA100 -S9 was 476 rev/L-eq. Blank XAD samples were not mutagenic (data not shown).

Mutagenic activity was not detected in the majority of the river water samples tested in YG1041 and YG1042 with or without S9 (Table 20). The sample "At," which was derived by pooling 5, 2.37-L samples taken at the outfall from the Lincoln Paper and Tissue Mill, was mutagenic in both YG1041 +/-S9 and YG1042 –S9 only on the third day of sampling. The resulting average mutagenic potencies for YG1041 were 144 rev/L-eq -S9 and 210 rev/L-eq +S9. The same "At" sample was mutagenic in strain YG1042. The other two sampling days from the outfall ("At") and the other sampling sites (labeled "Above" and "Below") were negative in both strains and S9 conditions. Blank XAD samples were not mutagenic (data not shown).

Our results show that the Penobscot River water samples have no or low mutagenic activity for the classes of compounds that this assay detects relative to that of other river waters (Ohe et al., 2004). We compared our river water results to the rankings identified in a compilation of surface water quality monitoring (Umbuzeiro et al., 2001), a review of surface water mutagenicity studies (Ohe et al., 2004), and the mutagenic-potency classification of industrial wastes and effluents by Houk (1992). The average mutagenic potency of the PIN river water samples (177 rev/L-eq) was <500 rev/L-eq, categorizing the Penobscot River as has having low mutagenic potency. For comparison, high would be >5,000 rev/L-eq (Ohe et al. 2004).

The drinking-water samples from all 3 sampling days were mutagenic in TA98 –S9, with an average mutagenic potency in TA98 –S9 of 198 rev/L-eq (Table 19). Samples from day 8/03 were positive in TA100 –S9. The average mutagenic potency for TA100 -S9 was 476 rev/L-eq. Blank XAD samples were not mutagenic (data not shown).

The drinking water samples exhibited negative or low mutagenic potencies for the classes of compounds that this assay detects relative to other drinking water samples (DeMarini et al., 1995; Schenck et al., 1998; Takanashi et al., 2009). The average mutagenic potency for the positive drinking water samples in this study was 337 rev/L-eq; most samples had negative results. For comparison, Takanashi et al. (2009) found an average mutagenicity of 1,100 rev/L-eq among 179 water samples from 17 sampling sites located from Hokkaido to Kagoshima Prefecture, Japan. Compared to the potencies reported in other studies (DeMarini et al., 1995; Schenck et al., 1998; Takanashi et al., 2009), the average mutagenic potency of the drinking water samples (337 rev/L-eq) was lower than typical drinking waters described in the papers above, which are ~1000 rev/L-eq.

Results from sediment samples tested in TA98, TA100, YG1041, and YG1042 with and without S9 were mostly negative (Table 21). Positive results for this group of samples were found in the "Above" location in YG1041 +S9 and YG1042 -S9, which gave values of 276 and 333 rev/g-eq, respectively. The "Island" sample was mutagenic in YG1041 -S9 (150 rev/g-eq) and YG1042 -S9 (314 rev/g-eq). Mutagenic potencies for the sediment samples in all strains ranged from 96 to 333 rev/g-eq (Table 21).

As stated above, the mutagenic potencies for the sediment samples tested were also negative or low relative to other sediments (Chen and White, 2004) for the classes of compounds that this assay detects. As noted in Table 21, the positive samples were from the "Island" and two from the "Above" location. The average mutagenic potencies of the sediment extracts (244 rev/g-eq) were typical of sediments from urban/industrial areas, which average ~150 rev/g-eq (Chen and White, 2004). For comparison, sediments from remote regions or heavily contaminated regions have potency values of 10 or >10,000 rev/g-eq, respectively (Chen and White, 2004). Thus, the river sediment from the PIN was generally not mutagenic, but when positive, samples had mutagenic potencies typical of that from urban/industrial areas as described in the literature.

A second set of samples (data not shown) were captured when river water levels were lower than the initial sampling period in order to see if the river volume was affecting the results. The sample set consisted of surface water from the "Below" and "At" locations and were tested with YG1041 and YG1042 with and without S9; all were negative.

Summary of Mutagenicity Drinking Water Samples (rev/L-eq)				
		Sampling date		
Strain	**Exp. date**	7/30/09	8/03/09	8/05/09
TA98	10/23/09	217	195	182
TA100	10/14/09	N[a]	425	N[a]
	10/23/09	IS[b]	793	N[a]
	12/01/09	IS[b]	211	IS[b]

Table 19: Summary of mutagenicity (rev/L-eq) –S9 of 3 samples of drinking water.
aN = Negative (not mutagenic).
[b]IS – insufficient sample to test.

Summary of Mutagenicity of Surface Water Samples (rev/L-eq)											
			Sampling Date and Site								
		S9[a]	Above			At			Below		
Strain	**Exp. date**		7/30/09	8/03/09	8/05/09	7/30/09	8/03/09	8/05/09	7/30/09	8/03/09	8/05/09
YG1041	08/25/09	-	N[b]	N[b]	N[b]	N[b]	N[b]	180	N[b]	N[b]	N[b]
	08/25/09	+	N[b]	N[b]	N[b]	N[b]	N[b]	227	N[b]	N[b]	N[b]
	09/01/09	-	N[b]	N[b]	N[b]	N[b]	N[b]	108	N[b]	N[b]	N[b]
	09/01/09	+	N[b]	N[b]	N[b]	N[b]	N[b]	192	N[b]	N[b]	N[b]
YG1042	09/10/09	-	N[b]	N[b]	N[b]	N[b]	N[b]	179	N[b]	N[b]	N[b]
	09/10/09	+	N[b]	N[b]	N[b]	N[b]	N[b]	N[b]	N\ b	N[b]	N[b]

Table 20: Summary of mutagenicity (rev/L-eq) of 3 samples of surface water from each of 3 sites.
[a]S9 = A homogenate of rat liver added to provide mammalian metabolism to the bacteria.
[a]N = Negative (not mutagenic). Values are given only for positive mutagenic results.

Summary of Mutagenicity of River Sediment Samples (rev/g-eq)						
Strain	**Exp date**	**S9[a]**	**Site**			
			Above	**At**	**Below**	**Island**
TA98	10/23/09	-	N[b]	N[b]	N[b]	N[b]
	10/14/09 10/23/09	+	N[b]	N[b]	N[b]	N[b]
TA100	10/23/09	-	N[b]	N[b]	N[b]	N[b]
	10/14/09 10/23/09	+	N[b]	N[b]	N[b]	N[b]
YG1041	11/06/09	-	N[b]	N[b]	N[b]	96
	11/06/09	+	276	N[b]	N[b]	N[b]
	11/19/09	-	N[b]	N[b]	N[b]	203
YG1042	11/06/09	-	N[b]	N[b]	N[b]	N[b]
	11/06/09	+	N[b]	N[b]	N[b]	N[b]
	11/19/09	-	333	N[b]	N[b]	314

Table 21: Summary of mutagenicity (rev/g-eq) of composite river sediments from 4 sites.
[a]S9 = A homogenate of rat liver added to provide mammalian metabolism to the bacterial cells.
[b]N = Negative (not mutagenic).

Conclusions of Salmonella Mutagenicity Study

The Penobscot River is a valuable resource to the Penobscot Indian Nation and has played a major role in their cultural traditions of hunting and fishing. Any threat of contamination to the river will be a concern for tribal members. There have been improvements to the water quality as shown in an Agency for Toxic Substances and Disease Registry's (ATSDR) review (Williams and Cseh, 2007) of tissue samples from fish caught in the Penobscot River near the town of Lincoln, Maine (upstream from Indian Island) spanning 1988 to 2003. These samples showed a slight decrease in the toxic equivalency quotient concentrations of dioxins/furans, but a slight increase in the levels of methyl mercury. This may be due in part to some changes in the processes of the Pulp and Paper Mills (U.S. EPA, 2007). However, there are fish advisories in place for the Penobscot River near Lincoln for dioxins and PCBs and throughout the river for mercury regarding fish consumption limits based on findings by the Maine Bureau of Health and the PIN. The ATSDR review was in agreement with these advisories.

Our findings in this survey study do not address these issues because of the limitations of the assay, but they do show that the surface water, sediment, and drinking water samples evaluated here are either not mutagenic or have low mutagenic potencies. The results indicate that there is little risk to human health due to the presence of typical organic mutagens or genotoxic carcinogens, such as PAHs, aromatic amines, heterocyclic amines, or nitroarenes, which are readily detectable by the *Salmonella* mutagenicity assay.

Determining the actual source(s) and compound(s) responsible for the low levels of mutagenicity detected would require a more rigorous and much larger study than the present one. Surface water is a complex mixture, and assessing the risk is a complicated puzzle to solve. Donnelly et al. (2004) discussed the challenges in estimating potential health effects associated with complex mixture exposures and concluded that extensive information is needed regarding mixture interactions and the effects of unidentified chemicals in the mixture in order to properly assess the risks.

Salmonella Mutagenicity Recommendations

The results indicate that there is little risk to human health due to the presence of typical organic mutagens or genotoxic carcinogens, such as PAHs, aromatic amines, heterocyclic amines, or nitroarenes, which are readily detectable by the *Salmonella* mutagenicity assay.

However, the assay does not detect non-genotoxic carcinogens or certain other types of toxicants such as PCBs, dioxins, most metals, neurotoxins, or developmental toxins, which might be present in the water or sediment. In addition, our study did not evaluate any airborne toxicants or toxicant exposure associated with lifestyle exposures. Given the limits of the assay and of our study, there appears to be either no or low levels of mutagenic activity in the river and drinking water due to typical genotoxic, organic compounds. Other types of assays and analyses are required to identify the presence of dioxins, PCBs, and metals that might contaminate the water or air.

APPENDIX A
ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
BEAD	Biological and Economic Analysis Division, Environmental Chemistry, Office of Pesticide Programs, US EPA
BIA	Bureau of Indian Affairs
CalEPA	California Environmental Protection Agency
CAFRL	S.O. Conte Anadromous Fish Research Laboratory
CERC	Columbia Environmental Research Center
CD	Compact Disk
COPC	Chemical of Potential Concern
CR	Cancer Risk
CV	Health-based comparison value
CWA	Clean Water Act
DI	Deionized
Dioxin	Polychlorinated dibenzo(*p*)dioxin
DMSO	Dimethylsulfoxide
DNA	Deoxyribonucleic acid
DOI	Department of the Interior
DQO	Data Quality Objective
ECL	Environmental Chemistry Laboratory
EPA	U.S. Environmental Protection Agency
EPA NE	Environmental Protection Agency New England
ESAT	Environmental Services Assistance Team
FGS	Frontier Geosciences Inc.
Furan	Polychlorinated dibenzofuran
FTP	File Transfer Protocol
Hg	Mercury
HQ	Hazard Quotient
HRGC/HRMS	High Resolution Gas Chromatography/High Resolution Mass Spectrometry
IRIS	Integrated Risk Information System
IUPAC	International Union of Pure and Applied Chemistry
LP&P	Lincoln Pulp and Paper
LSC	Leetown Science Center
ME DEP	Maine Department of Environmental Protection
NCEA	National Center for Environmental Assessment
NERL	National Environmental Research Laboratory, US EPA
NFRAP	No Further Federal Remedial Action Planned
NWS	National Weather Service
OP	Operating Procedures
OPP	Office of Pesticide Programs
ORD	Office of Research and Development
PA/SI	Preliminary Assessment/Site Investigation
PAHs	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyl

PCDD	Polychlorinated dibenzo(*p*)dioxin (dioxin)
PCDF	Polychlorinated dibenzofuran (furan)
PFK	Perfluorokerosene
PIN	Penobscot Indian Nation
PIN-DNR	Penobscot Indian Nation-Department of Natural Resources
POTW	Publically owned treatment works
PQAM	Program QA Manager
PQL	Project Quantification Limits
PTFE	Polytetrafluoroethylene
QAPP	Quality Assurance Project Plan
QA	Quality Assurance
QC	Quality Control
RARE	Regional Applied Research Effort
SIM	Selective ion monitoring
SOP	Standard Operating Procedure
START	Superfund Technical Assessment and Response Team
SVOC	Semi-volatile organic compounds
SWAT	Surface Water Ambient Toxics Monitoring Program
TEF	Toxic Equivalency Factor
TEQ	Dioxin Toxic Equivalent
TQL	Targeted Laboratory Quantification
TSA	Technical System Audit
TOC	Total Organic Carbon
UMAECL	University of Maine Environmental Chemistry Laboratory
US EPA	United States Environmental Protection Agency
USF&WS	United States Fish and Wildlife Service
USGS	United States Geological Survey
OPP	Office of Pesticide Programs,
VOC	Volatile organic compounds
WHO	World Health Organization
WQS	Water Quality Standards

Measurement Abbreviations

$^{\circ}$C	degrees Centigrade
$^{\circ}$F	degrees Fahrenheit
ft^3	cubic feet
km	kilometers
km^2	square kilometers
MW	megawatt
mi	miles
mi^2	square miles
µg/g	micrograms per gram (parts-per-million)
mg/kg	milligrams per kilogram (parts-per-million)
mm	millimeters
ng/g	nanograms per gram (parts-per-billion)
ng/kg	nanograms per kilogram (parts-per-trillion)
pg/g	picograms per gram (parts-per-trillion)

APPENDIX B
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APPENDIX C

Penobscot RARE Project Schedule

August 30, 2007
- Conference call to review project schedule
- Identify persons responsible for action items for QAPP
- Data Quality Objectives
- Data Usability
- Project Action limits
- Set up a standard time for conference calls for QAPP development.
- Identify next steps with time frames and responsible parties

September 2007
- Finalize Data Quality Objectives
- Finalize Data Usability Objectives
- Finalize Project Action Limits

October 2007
- Finalize Sampling SOP for fish and sediment
- Review all SOPs for analysis against Project Action Limits and identify lab concerns regarding any detection limit issues
- Develop flow charts for data analysis, i.e. what each lab needs in order to conduct analysis to meet data quality objectives
- Develop flow chart for chain–of-custody of samples
- Develop flow chart of responsibilities of project team members
- Initial QA site visit

November 2007
- Develop Sampling SOP for plant, wood duck and snapping turtle
- Review all SOPs for analysis against Project Action Limits and identify lab concerns regarding any detection limit issues
- Develop flow charts for data analysis, i.e. what each lab needs in order to conduct analysis to meet data quality objectives
- Develop flow chart for chain-of-custody of samples
- Develop flow chart of responsibilities of project team members

December 2007
- Review QAPP for other areas that need to be revised to ensure consistency with data quality objectives.
- Develop and send out draft QAPP for review by December 15th, 2007

January 2008
- Review and comment on draft QAPP

April 2008
- Final comments due on QAPP

May 2008
- Send out final QAPP for approval
- Collect plants (Ostrich Fern at fiddlehead stage)
- Fern samples shipped from PIN to USGS

July 2008
- Collection of sediment samples for contaminant analysis
- RARE QA Officers review and conduct technical systems audit (TSA) of field sample collection, handling, and shipment in Maine

July-October 2008
- Collection of fish, ducks, turtles (only able to collect 2 turtle samples)
- Sediment samples shipped from PIN to laboratories
- Sediment and fern samples received by OPP/ECL

August 2008
- RARE QA Officer at Chelmsford, MA Lab, (August 4-6, 2008)
- Methyl mercury results received from Frontier GeoSciences (FGS) lab for sediment

September 2008
- Methyl mercury results received from FGS lab for fiddlehead ferns

October 2008
- Sediment samples analyzed by OPP/ECL

October 2008-January 2009
- Fish fillets received by EPA-NERL, homogenized, and shipped to other labs
- Turtle meat, duck meat, and ferns received by USGS, homogenized, and shipped to labs.

March 2009
- Fish fillet samples received by OPP/ECL

April 2009
- Turtle samples (collected in 2008) received by OPP/ECL
- Duck samples received by OPP/ECL
- Fish fillet samples analyzed by OPP/ECL

May 2009
- Methyl mercury results received from FGS lab for turtle and duck

July – October 2009
- Collect additional snapping turtles from all reaches
- Collect and ship water and sediment samples for AMES study

- Conduct TSA by QA Manager at the US EPA in RTP on the *Salmonella* (Ames) mutagenicity testing of the river and drinking waters.

September – October 2009
- Collect Medicinal Plants
- Attempt to collect wood ducks from EBS reach or adjacent area.

October 2009
- Fern samples were analyzed by OPP/ECL
- Duck samples were analyzed by OPP/ECL
- Turtle samples (collected in 2008) were analyzed by OPP/ECL

November 2009
- Analytical Data Reports from Laboratories sent to US EPA data validator
- Data validation conducted by US EPA

December 2009
- Validated data sent from data validator to EPA-ORD.

February 2010
- Medicinal Plants and Turtle samples (collected in 2009) shipped from PIN to USGS

March 2010
- Data Validation memos issued

July 2010
- Turtle meat (collected in 2009) and medicinal plants received by USGS, homogenized, and shipped to lab
- Turtle samples collected from 2009 received by OPP/ECL
- Medicinal plant samples received by OPP/ECL

August 2010
- Turtle samples collected from 2009 analyzed by OPP/ECL

September 2010
- Medicinal plant samples analyzed by OPP/ECL

October 2010
- Analysis completed October 2010
- Final data audit was conducted in Maine
- Project team met at PIN to evaluate available data

February 2011
- ORD Draft Report issued (ORD lead retired)

2011-2013
- Region 1 co-lead development of Draft Report

- Development of Peer Review Charge questions with team

April
2013– May 2013
- Peer Review

May 2013 – January 2014
- Peer Review edits incorporated and responses to comments developed.

January 2014
- Draft Report presented to Penobscot Tribal Council for review and comments

October 2014
- Internal EPA Region 1 (R1) review.
- Coordination with R1 IT to develop final report with a CD for distribution

October 2014 - April 2015
- Incorporation of all comments
- Development of table of contents for CD

May – August 2015
- Coordination with R1 and ORD for approval and presentation of final RARE report
- Obtained EPA publication number for final RARE report
- Incorporated final changes requested by ORD

APPENDIX D

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RARE Quality Assurance Statement

U.S. EPA ORD, RTP, NC
"Developing Exposure Concentrations for Regional Cultural Tribal Exposure Assessment, Penobscot River, Maine"

Page 1 of 2

The study "Developing Exposure Concentrations for Regional Cultural Tribal Exposure Assessment, Penobscot River, Maine" was conducted by the National Health and Environmental Effects Research Laboratory (NHEERL), Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC, in compliance with NHEERL and ORD QA Guidelines. These audits were conducted by Tom Hughes, US EPA QA and Records Manager and Program QAM (PQAM) for this ORD RARE, and Janet Diliberto, Co-Principle Investigator. This RARE study was conducted in collaboration with Region 1 of the US EPA. Old Town, Maine is near Indian Island, the home of the Penobscot Indian Nation. Critical phases in the study were audited.

Date of Inspection	Type	Items Inspected
October 15-17, 2007	Site Visit, Old Town, ME	Inspect reaches of the Penobscot River; Meet research team; Have discussions on QAPP
July 21-24, 2008	TSA, Old Town, ME	Observe sampling of fish from the Penobscot River; Observe shipping of fish; Audit records; Meet with team members
October 6-9, 2008	TSA, North Chelmsford, MA	Audit Mercury Lab for RARE project; Meet with team members
Nov 2-3, 2009	TSA, RTP, NC	Audit of Ames/Salmonella Mutagenicity results from samples of river water, drinking water and sediment from the Penobscot River Conducted by Barbara Collins, QAM, ISTD, US EPA, RTP, NC
October 12-14, 2010	Surveillance Old Town, ME	Inspect records of Penobscot Indian Laboratory for RARE project.

TSA = technical systems audit

RARE Quality Assurance Statement

U.S. EPA ORD, RTP, NC
"Developing Exposure Concentrations for Regional Cultural Tribal Exposure Assessment, Penobscot River, Maine"

The Program Quality Assurance Manager (PQAM) of this ORD RARE program and the Co-PI of this RARE Program have determined by the above review process that the conduct of this program was in compliance with US EPA quality requirements and the operating procedures and study Quality Assurance Project Plan (No.: ORD RARE- Region 1- Diliberto.Bataille/2008-01-r00). Furthermore, the results accurately reflect the raw data obtained during the course of the study.

Thomas J. Hughes
Thomas J. Hughes, USEPA RARE QA and Records Manager

12-20-2013
Date

Valerie Marshall
Valerie Marshall, USEPA RARE Co-Principle Investigator

6-11-2014
Date

Appendix F

Risk of Each Biota Type in Each Reach at the Inland Non-Anadromous Tribal Ingestion Rate

Reach	Biota Type	Chemical	Conc. in Biota (mg/kg)	Tribal Ingestion Rate (g/day)	Risk Based Concentration		Risk in Biota	
					HQ=1 (mg/kg)	CR=1E-06 (mg/kg)	HQ	CR
1	CP	PCB	ND	286	5.10E-03	2.98E-04		
1	CP	TEQ	4.24E-08	286	1.79E-07	4.58E-09	2E-01	9E-06
1	CP	Hg	4.32E-01	286	2.55E-02	NA	2E+01	
2	CP	PCB	ND	286	5.10E-03	2.98E-04		
2	CP	TEQ	5.93E-08	286	1.79E-07	4.58E-09	3E-01	1E-05
2	CP	Hg	8.09E-01	286	2.55E-02	NA	3E+01	
3	CP	PCB	ND	286	5.10E-03	2.98E-04		
3	CP	TEQ	3.99E-08	286	1.79E-07	4.58E-09	2E-01	9E-06
3	CP	Hg	8.67E-01	286	2.55E-02	NA	3E+01	
4	CP	PCB	ND	286	5.10E-03	2.98E-04		
4	CP	TEQ	3.78E-08	286	1.79E-07	4.58E-09	2E-01	8E-06
4	CP	Hg	3.16E-01	286	2.55E-02	NA	1E+01	
5	CP	PCB	ND	286	5.10E-03	2.98E-04		
5	CP	TEQ	1.26E-07	286	1.79E-07	4.58E-09	7E-01	3E-05
5	CP	Hg	5.88E-01	286	2.55E-02	NA	2E+01	
6	CP	PCB	ND	286	5.10E-03	2.98E-04		
6	CP	TEQ	5.56E-08	286	1.79E-07	4.58E-09	3E-01	1E-05
6	CP	Hg	5.44E-01	286	2.55E-02	NA	2E+01	
2	YP	PCB	ND	286	5.10E-03	2.98E-04		
2	YP	TEQ	3.83E-07	286	1.79E-07	4.58E-09	2E+00	8E-05
2	YP	Hg	5.36E-01	286	2.55E-02	NA	2E+01	
3	YP	PCB	ND	286	5.10E-03	2.98E-04		
3	YP	TEQ	6.41E-08	286	1.79E-07	4.58E-09	4E-01	1E-05
3	YP	Hg	4.16E-01	286	2.55E-02	NA	2E+01	
4	YP	PCB	ND	286	5.10E-03	2.98E-04		
4	YP	TEQ	3.43E-08	286	1.79E-07	4.58E-09	2E-01	7E-06
4	YP	Hg	1.46E-01	286	2.55E-02	NA	6E+00	
6	YP	PCB	ND	286	5.10E-03	2.98E-04		
6	YP	TEQ	1.54E-08	286	1.79E-07	4.58E-09	9E-02	3E-06
6	YP	Hg	2.84E-01	286	2.55E-02	NA	1E+01	
1	WP	PCB	ND	286	5.10E-03	2.98E-04		
1	WP	TEQ	3.83E-07	286	1.79E-07	4.58E-09	2E+00	8E-05
1	WP	Hg	5.36E-01	286	2.55E-02	NA	2E+01	
4	WP	PCB	ND	286	5.10E-03	2.98E-04		
4	WP	TEQ	4.02E-07	286	1.79E-07	4.58E-09	2E+00	9E-05

Reach	Biota Type	Chemical	Conc. in Biota (mg/kg) `	Tribal Ingestion Rate (g/day)	Risk Based Concentration		Risk in Biota	
					HQ=1 (mg/kg)	CR=1E-06 (mg/kg)	HQ	CR
4	WP	Hg	4.67E-01	286	2.55E-02	NA	2E+01	
5	WP	PCB	ND	286	5.10E-03	2.98E-04		
5	WP	TEQ	8.12E-07	286	1.79E-07	4.58E-09	5E+00	2E-04
5	WP	Hg	6.27E-01	286	2.55E-02	NA	2E+01	
6	WP	PCB	ND	286	5.10E-03	2.98E-04		
1	SMB	Hg	8.03E-01	286	2.55E-02	NA	3E+01	0E+00
2	SMB	PCB	5.05E-04	286	5.10E-03	2.98E-04	1E-01	2E-06
2	SMB	TEQ	1.67E-07	286	1.79E-07	4.58E-09	9E-01	4E-05
2	SMB	Hg	9.45E-01	286	2.55E-02	NA	4E+01	4E-05
3	SMB	PCB	6.86E-04	286	5.10E-03	2.98E-04	1E-01	2E-06
3	SMB	TEQ	1.32E-07	286	1.79E-07	4.58E-09	7E-01	3E-05
3	SMB	Hg	9.79E-01	286	2.55E-02	NA	4E+01	3E-05
4	SMB	PCB	1.25E-03	286	5.10E-03	2.98E-04	2E-01	4E-06
4	SMB	TEQ	2.44E-07	286	1.79E-07	4.58E-09	1E+00	5E-05
4	SMB	Hg	9.65E-01	286	2.55E-02	NA	4E+01	6E-05
5	SMB	PCB	1.10E-03	286	5.10E-03	2.98E-04	2E-01	4E-06
5	SMB	TEQ	1.83E-07	286	1.79E-07	4.58E-09	1E+00	4E-05
5	SMB	Hg	9.61E-01	286	2.55E-02	NA	4E+01	4E-05
6	SMB	PCB	8.99E-04	286	5.10E-03	2.98E-04	2E-01	3E-06
6	SMB	TEQ	2.11E-07	286	1.79E-07	4.58E-09	1E+00	5E-05
6	SMB	Hg	8.09E-01	286	2.55E-02	NA	3E+01	5E-05
1	BB	PCB	ND	286	5.10E-03	2.98E-04		
1	BB	TEQ	3.37E-07	286	1.79E-07	4.58E-09	2E+00	7E-05
1	BB	Hg	2.90E-01	286	2.55E-02	NA	1E+01	
2	BB	PCB	ND	286	5.10E-03	2.98E-04		
2	BB	TEQ	1.50E-07	286	1.79E-07	4.58E-09	8E-01	3E-05
2	BB	Hg	4.23E-01	286	2.55E-02	NA	2E+01	
3	BB	PCB	ND	286	5.10E-03	2.98E-04		
3	BB	TEQ	2.97E-07	286	1.79E-07	4.58E-09	2E+00	6E-05
3	BB	Hg	2.52E-01	286	2.55E-02	NA	1E+01	
4	BB	PCB	ND	286	5.10E-03	2.98E-04		
4	BB	TEQ	3.15E-07	286	1.79E-07	4.58E-09	2E+00	7E-05
4	BB	Hg	1.80E-01	286	2.55E-02	NA	7E+00	
5	BB	PCB	ND	286	5.10E-03	2.98E-04		
5	BB	TEQ	7.27E-07	286	1.79E-07	4.58E-09	4E+00	2E-04
5	BB	Hg	4.16E-01	286	2.55E-02	NA	2E+01	
6	BB	PCB	ND	286	5.10E-03	2.98E-04		
6	BB	TEQ	2.09E-07	286	1.79E-07	4.58E-09	1E+00	5E-05
6	BB	Hg	1.35E-01	286	2.55E-02	NA	5E+00	

Reach	Biota Type	Chemical	Conc. in Biota (mg/kg) `	Tribal Ingestion Rate (g/day)	Risk Based Concentration		Risk in Biota	
					HQ=1 (mg/kg)	CR=1E-06 (mg/kg)	HQ	CR
2	AE	PCB	ND	286	5.10E-03	2.98E-04		
2	AE	TEQ	1.18E-06	286	1.79E-07	4.58E-09	7E+00	3E-04
2	AE	Hg	6.66E-01	286	2.55E-02	NA	3E+01	
3	AE	Hg	6.35E-01	286	2.55E-02	NA	2E+01	
4	AE	PCB	ND	286	5.10E-03	2.98E-04		
4	AE	TEQ	1.40E-06	286	1.79E-07	4.58E-09	8E+00	3E-04
4	AE	Hg	3.37E-01	286	2.55E-02	NA	1E+01	
5	AE	PCB	ND	286	5.10E-03	2.98E-04		
5	AE	TEQ	5.45E-06	286	1.79E-07	4.58E-09	3E+01	1E-03
5	AE	Hg	7.39E-01	286	2.55E-02	NA	3E+01	
6	AE	PCB	ND	286	5.10E-03	2.98E-04		
6	AE	TEQ	4.61E-07	286	1.79E-07	4.58E-09	3E+00	1E-04
6	AE	Hg	2.14E-01	286	2.55E-02	NA	8E+00	
1	WD	PCB	1.16E-04	70	2.09E-02	1.22E-03	6E-03	1E-07
1	WD	TEQ	2.87E-07	70	7.30E-07	1.87E-08	4E-01	2E-05
1	WD	Hg	4.79E-02	70	1.04E-01	NA	5E-01	2E-05
2	WD	PCB	5.01E-03	70	2.09E-02	1.22E-03	2E-01	4E-06
2	WD	TEQ	4.26E-07	70	7.30E-07	1.87E-08	6E-01	2E-05
2	WD	Hg	2.65E-02	70	1.04E-01	NA	3E-01	3E-05
3	WD	PCB	2.44E-03	70	2.09E-02	1.22E-03	1E-01	2E-06
3	WD	TEQ	4.54E-07	70	7.30E-07	1.87E-08	6E-01	2E-05
3	WD	Hg	2.41E-02	70	1.04E-01	NA	2E-01	3E-05
4	WD	PCB	4.05E-03	70	2.09E-02	1.22E-03	2E-01	3E-06
4	WD	TEQ	1.08E-06	70	7.30E-07	1.87E-08	1E+00	6E-05
4	WD	Hg	1.68E-02	70	1.04E-01	NA	2E-01	6E-05
1	FOF	PCB	6.12E-04	133	1.10E-02	6.40E-04	6E-02	1E-06
1	FOF	TEQ	3.21E-10	133	3.84E-07	9.85E-09	8E-04	3E-08
1	FOF	Hg	1.30E-03	133	5.49E-02	NA	2E-02	1E-06
2	FOF	PCB	1.15E-03	133	1.10E-02	6.40E-04	1E-01	2E-06
2	FOF	TEQ	1.79E-10	133	3.84E-06	9.85E-08	5E-04	2E-08
2	FOF	Hg	8.00E-04	133	5.49E-02	NA	1E-02	2E-06
3	FOF	PCB	ND	133	1.10E-02	6.40E-04		
3	FOF	TEQ	4.42E-09	133	3.84E-07	9.85E-09	1E-02	4E-07
3	FOF	Hg	8.00E-04	133	5.49E-02	NA	1E-02	
4	FOF	PCB	3.22E-04	133	1.10E-02	6.40E-04	3E-02	5E-07
4	FOF	TEQ	ND	133	3.84E-07	9.85E-09		

Reach	Biota Type	Chemical	Conc. in Biota	Tribal Ingestion	Risk Based Concentration	Risk in Biota	1E-01	
			(mg/kg)	Rate	HQ=1	CR=1E-06	HQ	CR
			`	(g/day)	(mg/kg)	(mg/kg)		
6	FOF	Hg	8.00E-04	133	5.49E-02	NA	1E-02	
3	MP	PCB	ND	133	1.10E-02	6.40E-04		
3	MP	TEQ	6.40E-08	133	3.84E-07	9.85E-09	2E-01	6E-06
3	MP	Hg	6.92E-03	133	5.49E-02	NA	1E-01	
4	MP	PCB	ND	133	1.10E-02	6.40E-04		
4	MP	TEQ	9.02E-08	133	3.84E-07	9.85E-09	2E-01	9E-06
4	MP	Hg	8.61E-03	133	5.49E-02	NA	2E-01	
5	MP	PCB	ND	133	1.10E-02	6.40E-04		
5	MP	TEQ	2.40E-08	133	3.84E-07	9.85E-09	6E-02	2E-06
6	MP	TEQ	3.60E-08	133	3.84E-06	9.85E-08	9E-02	4E-06
6	MP	Hg	2.92E-03	133	5.49E-02	NA	5E-02	
1	ST	PCB	ND	286	5.10E-03	2.98E-04		
1	ST	TEQ	4.86E-06	286	1.79E-07	4.58E-09	3E+01	1E-03
1	ST	Hg	9.63E-01	286	2.55E-02	NA	4E+01	
3	ST	PCB	ND	286	5.10E-03	2.98E-04		
3	ST	TEQ	7.49E-07	286	1.79E-07	4.58E-09	4E+00	2E-04
3	ST	Hg	5.69E-01	286	2.55E-02	NA	2E+01	
4	ST	PCB	2.14E-02	286	5.10E-03	2.98E-04	4E+00	7E-05
4	ST	TEQ	2.04E-06	286	1.79E-07	4.58E-09	1E+01	4E-04
4	ST	Hg	6.05E-01	286	2.55E-02	NA	2E+01	5E-04
5	ST	PCB	ND	286	5.10E-03	2.98E-04		
5	ST	TEQ	2.80E-06	286	1.79E-07	4.58E-09	2E+01	6E-04
5	ST	Hg	1.046E+00	286	2.55E-02	NA	4E+01	
6	ST	PCB	1.70E-04	286	5.10E-03	2.98E-04	3E-02	6E-07
6	ST	TEQ	1.44E-07	286	1.79E-07	4.58E-09	8E-01	3E-05
6	ST	Hg	2.77E-01	286	2.55E-02	NA	1E+01	3E-05

CP = Chain Pickerel
YP = Yellow Perch
WP = White Perch
SMB= Smallmouth Bass
BB = Brown Bullhead
AE = American Eel
WD = Wood duck
FOF = Fiddlehead Ostrich Fern
MP = Medicinal Plant
ST = Snapping Turtle
CR = Cancer Risk
HQ = Hazard Quotient
HQ = RBC for HQ=1/Concentration in Biota
CR = BC for CR= 1E-06/Concentration in Biota x 1E-06
ND = Non-Detect Risk values are rounded to the nearest whole number.
PCB = Polychlorinated Biphenyls
TEQ = dioxin Toxic Equivalents
Hg = Mercury

Number in gray is sum of cancer risks for PCB and TEQ

Computer Printout from EPA Regional Screening Level Calculator
(http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search)

Note: This printout documents the chemicals, exposure parameters and toxicity factors that were entered into the calculator to calculate risk-based concentrations for Hazard Index =1 and cancer risk of 1E-06 for ingestion of food.

Site-specific

Fish Equation Inputs for Fish

1

Variable	Value
TR (target cancer risk) unitless	1.0E-6
AT (averaging time)	365
EF_a (exposure frequency) days/yr	350
ED_a (exposure duration) yr	30
LT (lifetime) yr	70
BW_a (body weight) kg	70
IRF_a (fish consumption rate) mg/day	133000

Output generated 05NOV2012:13:33:44

Site-specific

Fish Risk-Based Screening Levels (RSL) for Fish

ca=Cancer, nc=Noncancer, ca* (Where nc SL < 100 x ca SL),
ca** (Where nc SL < 10 x ca SL),
max=SL exceeds ceiling limit (see User's Guide), sat=SL exceeds csat

2

Chemical	CAS Number	Ingestion SF $(mg/kg\text{-}day)^{-1}$	SFO Ref	Chronic RfD (mg/kg-day)	RfD Ref	Ingestion of Fish SL - TR=1.0E-6 (mg/kg)	Carcinogenic SL - TR=1.0E-6 (mg/kg)	Ingestion of Fish SL - HQ=1 (mg/kg)	Noncarcinogenic SL - HI=1 (mg/kg)	Screening Level (mg/kg)
TCDD, 2,3,7,8-	1746-01-6	1.30E+05	C	7.00E-10	I	9.85E-09	9.85E-09	3.84E-07	3.84E-07	9.85E-09 ca*
Methyl Mercury	22967-92-6	-		1.00E-04	I	-	-	5.49E-02	5.49E-02	5.49E-02 nc
Aroclor 1254	11097-69-1	2.00E+00	S	2.00E-05	I	6.40E-04	6.40E-04	1.10E-02	1.10E-02	6.40E-04 ca*

Output generated 05NOV2012:13:33:44

Site-specific

Fish Equation Inputs for Fish

1

Variable	Value
TR (target cancer risk) unitless	1.0E-6
AT (averaging time)	365
EF_r (exposure frequency) days/yr	350
ED_r (exposure duration) yr	30
LT (lifetime) yr	70
BW_a (body weight) kg	70
IRF_a (fish consumption rate) mg/day	70000

Output generated 05NOV2012:13:28:02

Site-specific

Fish Risk-Based Screening Levels (RSL) for Fish

ca=Cancer, nc=Noncancer, ca* (Where nc SL < 100 x ca SL),
ca** (Where nc SL < 10 x ca SL),
max=SL exceeds ceiling limit (see User's Guide), sat=SL exceeds csat

2

Chemical	CAS Number	Ingestion SF $(mg/kg\text{-}day)^{-1}$	SFO Ref	Chronic RfD (mg/kg-day)	RfD Ref	Ingestion of Fish SL - TR=1.0E-6 (mg/kg)	Carcinogenic SL - TR=1.0E-6 (mg/kg)	Ingestion of Fish SL - HQ=1 (mg/kg)	Noncarcinogenic SL - HI=1 (mg/kg)	Screening Level (mg/kg)
TCDD, 2,3,7,8-	1746-01-6	1.30E+05	C	7.00E-10	I	1.87E-08	1.87E-08	7.30E-07	7.30E-07	1.87E-08 ca*
Methyl Mercury	22967-92-6	-		1.00E-04	I	-	-	1.04E-01	1.04E-01	1.04E-01 nc
Aroclor 1254	11097-69-1	2.00E+00	S	2.00E-05	I	1.22E-03	1.22E-03	2.09E-02	2.09E-02	1.22E-03 ca*

Output generated 05NOV2012:13:28:02

Site-specific

Fish Equation Inputs for Fish

1

Variable	Value
TR (target cancer risk) unitless	1.0E-6
AT (averaging time)	365
EF_r (exposure frequency) days/yr	350
ED_r (exposure duration) yr	30
LT (lifetime) yr	70
BW_a (body weight) kg	70
IRF_a (fish consumption rate) mg/day	286000

Output generated 05NOV2012:13:36:35

Site-specific

Fish Risk-Based Screening Levels (RSL) for Fish

ca=Cancer, nc=Noncancer, ca* (Where nc SL < 100 x ca SL),
ca** (Where nc SL < 10 x ca SL),
max=SL exceeds ceiling limit (see User's Guide), sat=SL exceeds csat

2

Chemical	CAS Number	Ingestion SF $(mg/kg\text{-}day)^{-1}$	SFO Ref	Chronic RfD (mg/kg-day)	RfD Ref	Ingestion of Fish SL - TR=1.0E-6 (mg/kg)	Carcinogenic SL - TR=1.0E-6 (mg/kg)	Ingestion of Fish SL - HQ=1 (mg/kg)	Noncarcinogenic SL - HI=1 (mg/kg)	Screening Level (mg/kg)
TCDD, 2,3,7,8-	1746-01-6	1.30E+05	C	7.00E-10	I	4.58E-09	4.58E-09	1.79E-07	1.79E-07	4.58E-09 ca*
Methyl Mercury	22967-92-6	-		1.00E-04	I	-	-	2.55E-02	2.55E-02	2.55E-02 nc
Aroclor 1254	11097-69-1	2.00E+00	S	2.00E-05	I	2.98E-04	2.98E-04	5.10E-03	5.10E-03	2.98E-04 ca*

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APPENDIX G

Penobscot RARE Peer Review Panel	
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Penobscot RARE Peer Review Panel	
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