Ausable River Watershed Management Plan

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Acknowledgments

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Over a period of five years, many people in the Ausable watershed and beyond came together through a variety of workshops and conversations. Their goal was to protect and restore the health and resiliency of the Ausable River as a vital resource to the region by creating a framework for action and good management. These conversations created a snapshot of ecological and community challenges in the Ausable River watershed and a vision for planning with a broad understanding of community interests and needs.

The scope of the report relied on the input of the Ausable River Watershed Management Advisory Committee, made up of representatives from numerous agencies and organizations:

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Larry Master: pp. 2, 6, 14
Kelley Tucker/AsRA: p. 95
Brendan Wiltse: cover page, pp. 3, 7, 17

Executive Summary

The Ausable River is one of 14 major rivers that have their sources in the Adirondack Mountains of upstate New York, and the longest of the three that drain into Lake Champlain. Its watershed covers 512 square miles and includes 94 miles of river channel, fed by more than 70 streams. Seven towns, eight hamlets, and one incorporated village lie within the watershed, which covers portions of two counties.

The watershed contains many ecologically rich environments with vibrant human histories. Home to over 20,000 people, it is largely rural in character with its population concentrated in small hamlets that hug the river. Upstream, the Ausable's two branches flow through protected forest lands that are part of the New York State Forest Preserve, but protections diminish downstream as land ownership shifts from public to private. For over 200 years people have relied on the river as an economic resource, even as they have valued its wild beauty and recreational value. But our reliance on the river has taken its toll.

A history of logging for much of the 19th and 20th centuries had profound effects on the river, which was used as a highway to convey logs to mills downstream. At first logging served the iron industry, which needed charcoal for its furnaces and cut the hardwoods, deforesting thousands of acres in the Ausable valley each year. With the decline of Adirondack iron mining in the late 19th century, the conversion of several mills to pulp paper production—a new technology at the time—cut the softwoods found at higher elevations along the river's tributaries. Both industries were focused at the confluence of the Ausable's two forks, in Au Sable Forks, home to the J. & J. Rogers Co. Through several reorganizations, it spanned the iron- and paper-making eras and employed the community from the 1830s until the early 1970s. The company had vast land holdings throughout the watershed; over the years, it cleared river banks of trees, built dams to control water flow, and straightened sections of the river and removed boulders to facilitate annual spring log drives. Its paper mills also used the river for waste disposal.

For several decades in the mid-20th century, once heavy machinery made it possible, many Ausable River towns used the riverbed as a source of gravel for road maintenance. This practice was halted by the Army Corps of Engineers in the 1970s. Because the 1950 and 60s, and most of the 70s, were a period with no major floods (though there were many minor ones), some local residents still believe the practice of regular dredging helped to prevent flooding, by allowing more room in the river bed for water (Longmire, 2012). We now know the practice had the opposite effect, collapsing banks and widening the stream channel.

These management decisions have taken their toll on the river's structure and sustainability. What may seem to casual viewers a pristine river without industry is still shaped by the legacy of past industrial activity. Local infrastructure is also a legacy of prior economies. Settlements hug the river and often sit in or block its access to the floodplain, as do many roads. As a consequence, the management tools used to maintain roads, and to deal with stormwater and wastewater, all have direct impacts on the river.

While water quality in the Ausable and its tributaries remains good enough to support the human and aquatic populations that rely on it, the river is stressed by many factors. Water quality tests show increasing levels of chloride from winter road deicing, phosphorus from septic system discharges, and other pollutants. Miles of river channel are incised with deeply eroded banks, leading to increased sediment pollution, which can smother delicate aquatic ecosystems and damage transportation infrastructure. Rivers move sediment as well as water—different sizes of sediment at different flows—but, once impaired, they cannot do this efficiently. Heavy rain events along the Ausable quickly overwhelm roadways, bridges and culverts, leading to flooding, and the existing infrastructure—bridges, culverts, and reinforced riverbanks—often exacerbates these problems, trapping sediment the river can no longer move.

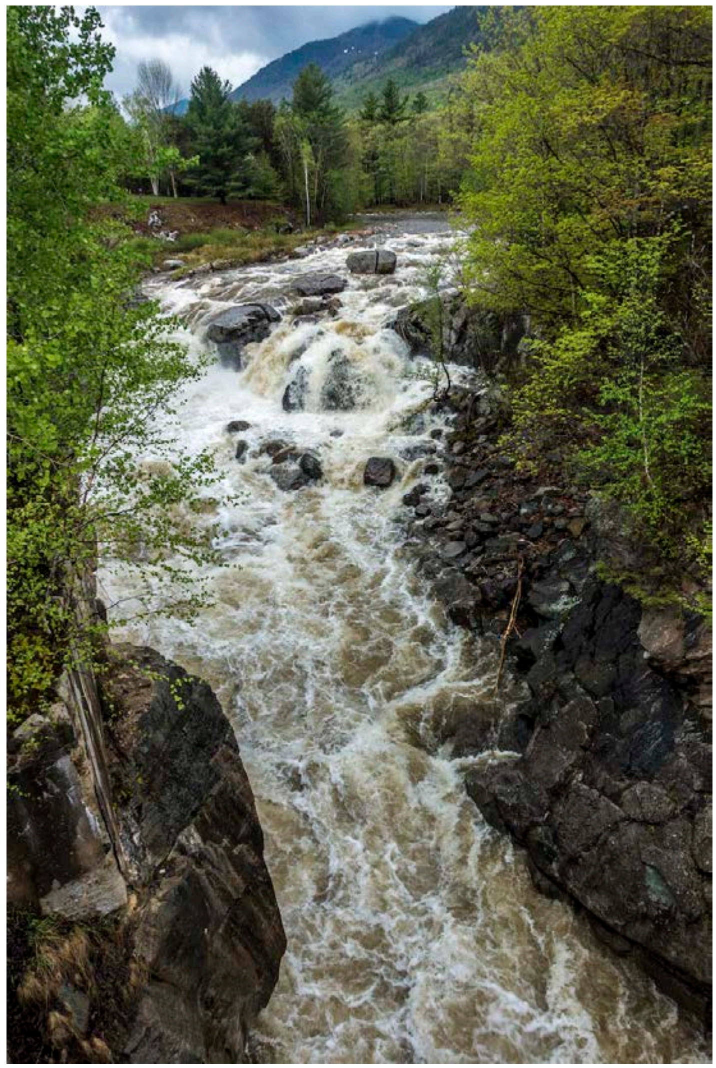
Cataloging and understanding these challenges to the river's ecological health and its ability to maintain itself and support healthy human communities are key goals of this watershed management plan. Spearheaded by the staff of the Ausable River Association (AsRA) and funded by the NY State Department of State (NYS DOS), the plan is the result of many years work by local officials, state and county agencies, AsRA staff and volunteers, scientists, and members of the community. All these participants are working to protect the river for its own sake and as an essential resource to the human communities it has gathered in this special place.

Ausable watershed residents know that a healthy, resilient river is essential to water quality and to the region's economic vibrancy. To achieve this goal the plan lays out several key recommendations, which will guide watershed conservation and planning efforts for years to come.

I: Introduction

1.1 Watershed Value & Challenges

The magnificent scenery, ecological diversity, and clean waters of the Ausable River make it a jewel of the Adirondack region of New York State. Coursing down from the state's highest mountain peaks, plunging over waterfalls and through steep bedrock gorges and then meandering through valley lowlands, the river creates extensive wildlife habitat, hardy forests, fertile valleys, and stunning landscapes before it empties into Lake Champlain. Diverse human communities scattered throughout the 512-square-mile watershed owe their economic vitality, past and present, to the river's health and resilience. Today, the watershed is a destination for world-class trout fishing, wilderness hiking, rock climbing, paddling, and many winter sports, including downhill, backcountry, and cross-county skiing.



Even so, the Ausable River and its watershed face numerous challenges. In a 2009 inventory of waterbody health, the New York State Department of Environmental Conservation (NYS DEC) rated the Ausable's entire Main Stem as "threatened" and its East and West Branches as "stressed." Both designations recognize that many important ecological functions, public uses, and recreational services remain intact, but suggest the Ausable is a river struggling to retain its ecological balance.

Stressors include elevated chloride concentration from road salt runoff, phosphorus loading from septic discharge and runoff from forest, agricultural and developed lands, a growing number and distribution of invasive species, widespread sedimentation, significant streambank erosion, and undersized culverts that impair brook trout habitat. People suffer too, since riverside communities are hit hardest by flooding—as Tropical Storm Irene, the worst flood on record since the mid-19th century, showed in 2011.

The river's steep gradient, its high narrow valleys and sandy soils, make it particularly sensitive to disturbance. An inventory conducted in the preparation of this management plan documented miles of deeply eroded banks along the Ausable that limit the river's access to its floodplain. Restoring this access would slow flood waters when they come, as they will. Floods are a fact of life in river valleys, and they come up quickly in such a "flashy" river, the second steepest in New York State (second only to its shorter neighbor to the southeast, the Boquet River, which also drains the Adirondack High Peaks into Lake Champlain). Flood damage is largely a function of infrastructure placement and planning, not river health—so preparation, not prevention, must be the long-term goal.

Essential practices such as the maintenance of roadways for public safety in winter, and critical infrastructure such as bridges and culverts, have impacts on water quality, fisheries, and stream flow. Increased residential development, reliance on in-ground septic systems, clearance of streamside trees to enhance views, and direct alteration of stream flows—all affect water quality and the river's ability to self-regulate, and pass their effects downstream.

We know that our use of the river has costs, but what can we do to reverse these troubling trends? How do we protect the health of this magnificent river, the resources it provides, and our communities? How do we strike a balance?

This report provides a comprehensive view of the Ausable River and its watershed. It is written for a broad audience and covers a variety of topics—including geologic and cultural history, demographics, land use, and maintenance of infrastructure, current measures of water quality and measures of stream condition, municipal regulatory frameworks, and more—in an effort to protect the river and its watershed effectively and efficiently while enjoying its exceptional resources. The report proposes priorities and projects that will help to restore and sustain a healthy river ecosystem so that it can continue to nourish vibrant human communities.

1.2 Watershed Management Planning

Throughout the United States and on every continent, rivers struggle to remain healthy in the face of intensified human development and increasingly extreme weather events. A river's health is the net result of historical and current resource policy and management, decision-making, and individual actions along its path and throughout its entire watershed. While the responsibility for protecting and managing the Ausable River benefits from the work of many government agencies and private organizations, local communities play a critical role in defining, implementing, and monitoring day-to-day and long-term management efforts. But without broad-based community understanding and agreement on methods, efforts to protect the river and improve its infrastructure are too often piecemeal and can be ineffective or even redundant. Increasingly, planning and revitalization efforts work hard to engage citizens and their elected municipal leaders in all phases of river restoration, giving them access to the many new tools and processes available, and helping them aim for long-term resiliency over short-term fixes. Protecting river health and our communities is complex, but it is achievable.

The process of organizing efforts to protect the Ausable River watershed and developing mechanisms for sharing essential knowledge and resources began in 1988. Municipal officials from throughout the watershed and from the Essex County planning office (a sub-division, since 2010, of the County's Department of Community Resources), working with Congressional support, requested assistance from the National Park Service to conduct a planning study. The resulting Ausable River Study of 1994 was the first survey of the watershed to compile comprehensive information for residents, scientists, municipal managers, and state and local leaders (National Park Service et al., 1994). It led to the formation of the Ausable River Association in 1998. AsRA works cooperatively with landowners, municipalities, and government agencies to conserve and restore the valued resources of the Ausable watershed.

Its staff provides scientific and technical expertise, engages stakeholders in responsible stewardship, and fosters collaboration and information sharing across the watershed and beyond.

Ausable watershed residents know that a healthy, resilient river is essential to the region's economic and ecological health. The challenge lies in synchronizing planning among diverse stakeholders; making the best science available; coordinating action by individuals, businesses, non-profits and governments; providing ongoing education; implementing projects with the entire watershed in mind; and monitoring results. In pursuit of these goals, and as an outgrowth of the Town of Wilmington's Local Waterfront Revitalization Program, AsRA began work on a comprehensive Watershed Management Plan in 2005, with technical support and funding from New York's Department of State (NYS DOS) through the Environmental Protection Fund Local Waterfront Revitalization Program. The Department's Office of Planning and Development works to increase the resilience and sustainable growth of New York communities by advancing progressive land use solutions, community-based development and building standards and codes, through partnerships with local governments, community-based organizations, academia, and other stakeholders.

NYS DOS oversees the Intermunicipal Watershed Management Program; it provides municipalities with professional expertise and funding to develop and implement watershed management plans to protect and restore water quality and related resources. The program focuses on identifying connections between land use and water quality to help stakeholders reach consensus on actions that protect water resources, while facilitating economic development and guiding growth. It enables communities to establish mechanisms for long-term watershed management by describing and seeking to understand existing water quality and watershed conditions, current impairments, and anticipated threats to water quality, and by recognizing key problems and opportunities in the watershed. The program helps communities prioritize actions that address water quality impairments or threats and strategies that address them, identifying stakeholder roles, financial and institutional resources, and methods for measuring success, tracking implementation, and monitoring performance. It also helps them communicate with other communities, agencies, and organizations with experience in the successful preparation and implementation of watershed management plans.

From the beginning, AsRA worked with an advisory committee with representatives from each of the seven watershed towns, two incorporated villages (including the former village of Keeseville, dissolved at the end of 2014), Essex and Clinton County Soil and Water Conservation Districts (SWCD), NYS Department of Environmental Conservation (NYS DEC), NYS Department of Transportation (NYS DOT), and with NYS DOS assisting in the planning process. Citizens provided input at several meetings and via written surveys. Several other organizations provided input, including the Adirondack Park Agency, Lake Placid Shore Owners Association, Mirror Lake Watershed Association, Whiteface Mountain Ski Center, Adirondack Mountain Reserve/Ausable Club, Trout Unlimited Adirondack Chapter, and the Olympic Regional Development Authority. The support and input of these partners has been invaluable throughout the planning, data collection, and drafting process.

This watershed management plan should serve as a living document, laying the groundwork for cooperation and action. It is designed to inform and inspire active protection of the Ausable River and its tributaries by individuals, municipalities, businesses, landowners, visitors and more. By building long-term resiliency, the partnership of organizations and individuals that joined with AsRA strives to ensure that the river will regain its ecological health and continue to define and benefit the communities that rely on it to live, work, and play—for those who live here, for visitors who return year after year to enjoy it, and for generations to come. The challenge is a puzzle with many pieces, all of them integral to the venture's success.

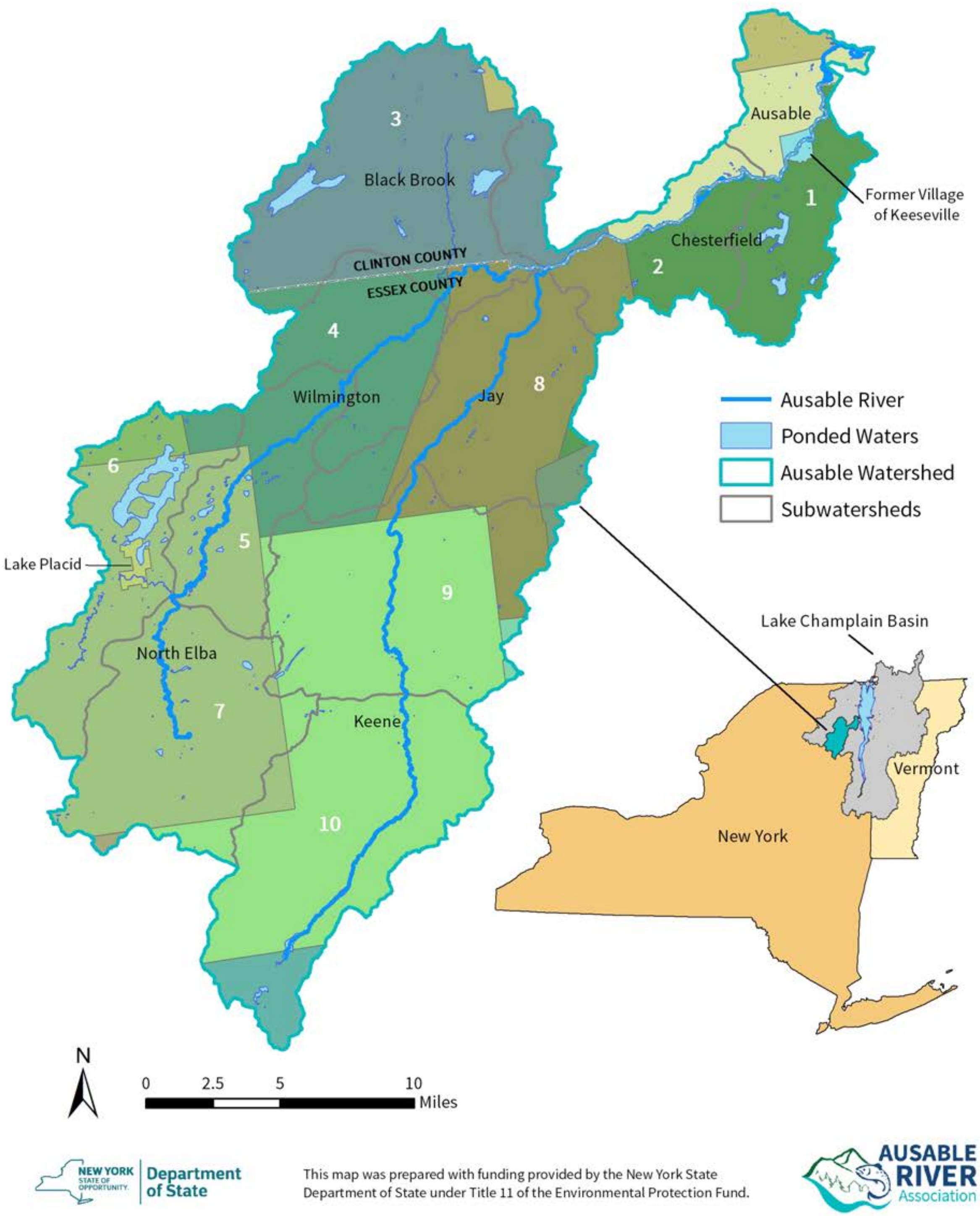
II: The Ausable River Watershed

Situated in northeastern New York State, the Ausable River watershed covers 512 square miles and includes 94 miles of river channel, fed by more than 70 streams—including its two major tributaries, the Chubb River and Black Brook. Seven towns, eight hamlets, and one incorporated village are located in the watershed, which covers portions of two counties. Except for a small area at the river's mouth on Lake Champlain, the entire watershed is located within the boundaries of the six-million-acre Adirondack Park.

For the purposes of this report, the watershed is further divided into ten subwatersheds, delineated on all its maps. These subwatersheds are defined by geomorphic and ecological characteristics laid out by the NYS Waterbody Inventory/Priority Waterbody List maintained by NYS DEC:

1. Lower Main Stem
2. Upper Main Stem
3. Black Brook and Tributaries
4. Lower West Branch and Tributaries
5. Middle West Branch and Tributaries
6. Chubb River and Tributaries
7. Upper West Branch
8. Lower East Branch
9. Middle East Branch
10. Upper East Branch

Ausable River Watershed, Subwatersheds, Municipalities, and Counties



MAP 1. Seven towns, eight hamlets, and one incorporated village are located in the watershed, which covers portions of two counties. Ten distinct subwatersheds comprise the watershed.

2.1 Watershed Geography

In common parlance, the river is divided into three major sections: the East Branch, the West Branch, and the Main Stem. The headwaters of the East and West Branches lie more than 5,000 feet above sea level in the High Peaks of the Adirondack Mountains, on the shoulders of Mount Marcy and Algonquin, New York's highest peaks. The East and West Branches are effectively two separate rivers until they merge at Au Sable Forks. Like their source tributaries, both branches traverse mountainous terrain to meet in this hamlet, the focus of local industry for a century and a half, but the East Branch drops quickly from its headwaters and, for much of its length, flows at a lower elevation and gentler grade than the West Branch. The confluence resembles a river mouth, with considerable sediment deposition, an ongoing challenge for the community of Au Sable Forks. From there, the Main Stem meanders 20 miles through gently sloping lowlands before tumbling through the spectacular gorge of Ausable Chasm, finally entering Lake Champlain just 100 feet above sea level. This rapid descent from its headwaters to the lake makes the Ausable the second steepest river in New York State. At its mouth, it forms a sandy delta that led early French explorers to call it the "sandy river," or "river of sand." From Lake Champlain, its waters drain into the Richelieu River, joining the Saint Lawrence as it flows northeast into the Atlantic Ocean.

The region in and around the Ausable watershed is dominated by the Adirondack Mountains, some of the tallest and oldest mountains in eastern North America. Geologically, the Adirondack region is a dome-shaped uplift that includes high shallow valleys and hundreds of peaks, nearly fifty of which rise over 4,000 feet, and two, Mt. Marcy and Algonquin, over 5,000. The Ausable and 13 other major rivers flow off this dome, feeding the Mohawk and Hudson Rivers to the south, Lake Ontario to the west, the St. Lawrence River to the north, and Lake Champlain to the east.

2.2 Geology and Physiography

The Adirondack dome is an unusual formation composed of crystalline bedrock created 1.1 billion years ago when the North American plate collided with another large land mass to create the continent-long Grenville Mountains. These mountains had at their core crystalline igneous rocks, notably anorthosite, and metamorphic rocks—assorted gneisses and some marble. The Grenvilles were worn down by a billion years of erosion and continental-scale tumult. They now form the basement, or deeply buried, bedrock of a wide swath of the eastern United States and Canada. To make the Adirondack Mountains, a subsequent uplift that began 65 million years ago raised this bedrock to the surface in a dome that today fills much of northern New York State. Over the past million years, vast glaciers emanating from northern Canada flowed southward over and around the Adirondacks. The glaciers did not erode the hard igneous composition of the Adirondack dome, but left huge deposits of glacial outwash, sand, and gravel throughout the central part the Adirondack range. As the glaciers melted, sandy beaches and deltas left their dry remains along upper valley walls, and clay deposits were left where lakes once filled the mountain valleys.

This episode of snow and ice came to an end some 12,000 years ago. Since then, long before human settlement, rivers such as the Ausable became the dominant land-shaping force in the region, determining, by the sheer force of water, the hills and valleys of the region. This deep geological history defined the nature of the Adirondack region and the Ausable River watershed. Glacial sand and gravels predominate in the high valleys, while hard anorthosite lies at the base of the Ausable's tributaries. The Ausable, its tributaries, and other rivers in the region are subject to flooding and ice—processes that have been ongoing for thousands of years and are part of the river's natural maintenance cycle.

Rainfall varies from 50 inches annually in the western Adirondacks to 30 inches in the vicinity of Lake Champlain. Maximum seasonal snowfall is more than 175 inches on the western and southwestern slopes of the Adirondack Mountains. Average snowfall is around 90 inches, with amounts decreasing to 60 or 70 inches in the lowlands of the St. Lawrence and Champlain Valleys. Temperatures in the Adirondack region are cool compared with the rest of the state. The annual mean temperature is 40°F; in winter it is 16°F.

These geological and physiographic facts have consequences for the Ausable watershed. The steep gradients, high valleys, and sandy soils of the Ausable River make it especially sensitive to man-made changes. Cool summers, long winters, and deep snow pack—aided by the prevalence of anorthosite and granite, glacial sand and gravel—align the area with the northern forests, blending conifers and hardwoods, and a host of plants and animals otherwise rare in New York State. These features made for marginal farming, historically—though small-scale farming is experiencing a significant revival in and around the watershed today—but provide a mineral and timber-rich environment, the primary attractions for early white settlers (Jenkins, 2004).

2.3 Cultural History

Prior to becoming a hub for world-class trout fishing, wilderness hiking, white-water recreation and skiing, the Ausable watershed supported very different industries that revolved around water power and the extraction of natural resources—iron ore, hardwood for charcoal production, timber for sawmills, and later, pulp wood for paper.

Not long after the Revolutionary War, settlers began to carve out homesteads and livelihoods in the Ausable valley—some on land they were given in return for military service. Settlement was possible because of the fast-flowing river and the abundance of timber and game. Settlers discovered iron ore deposits quite early, most notably with the 1806 discovery of a substantial vein on Arnold's Hill, in Clintonville, between Au Sable Forks and Keeseville. By the 1820s the valley hummed with activity: sawmills, grist mills, carding and cloth making mills, and open-hearth furnaces for iron making dotted the landscape along the river from Keene to Keeseville. The opening of the Champlain Canal in 1832, connecting Lake Champlain to the Hudson River and New York harbor, enlarged the market for Adirondack iron. By 1873, Keeseville's horse nail factory was selling 2,000 tons of nails a year, and the village was substantial (Engelhart, 1991). Au Sable Forks thrived under the monopoly of the J. & J. Rogers Company's iron mills—later converted to pulp paper production, keeping them busy through the first two-thirds of the 20th century.

At the core of all this industry was the cutting and moving of the wealth of timber in the watershed. Through much of the 19th century iron ore smelting was prevalent throughout the valley—indeed, the northeastern Adirondacks was one of the major iron producing regions of the country—and required massive cutting of hardwood to make charcoal to fire the furnaces scattered along the river. A large ironworks might cut and burn all the hardwood in 1,000 acres each year (Engelhart, 1991). As vast forest tracts near iron furnaces were exhausted, businesses moved on. Ausable valley iron ceased to be profitable by 1890, given the discovery of cheaper iron production processes elsewhere in the country, but in its place came a building boom spurred by railroads that brought leisure travelers to Lake Placid, Keene Valley, St. Huberts, and many locations outside the watershed. Saw logs came down mountainsides via the many tributaries of the Ausable to feed local sawmills, and the river was managed to transport logs to mills and markets downstream as of the 1850s. As iron manufacturing became obsolete, paper mills took their place, requiring pulpwood (mostly spruce) to be driven downriver to the J. & J Rogers pulp mill at Au Sable Forks and its subsidiary, the Alice Falls paper mill below Keeseville. The last of these annual log drives, which carried the results of each winter's logging downstream on the Ausable's spring flood of snow melt, occurred in 1923. By the 1920s, many of the surrounding valleys were cut over, and wood came to the paper mills by truck, often from considerable distances. The Au Sable Forks mill remained in business until 1971, when dwindling pulp wood supplies and paper orders, and the high cost of a wastewater treatment facility required by New York State to address pollution, forced its closure.

The river was essential to each phase of this economy, but the industries of the 19th and early 20th centuries altered the structure of the river and its ability to maintain itself. Logging deforested streambanks and hillsides, creating erosion and bank collapse along tributaries and the river itself; fewer trees meant less shade and increased water temperatures that dramatically altered the aquatic ecosystem; practices such as dynamiting the granite and anorthosite boulders that blocked the flow of logs downstream to market and mills made the river flow faster during floods and removed aquatic habitat; wood pulp waste and paper dyes made the river run red and black with contamination below the mills; and the levees and dams that raised water levels to move logs altered the river's natural flow, established over millennia, trapping and periodically releasing vast quantities of sediment. The worst flood on the Ausable, prior to Tropical Storm Irene in 2011 (which it resembled in many ways), was the "freshet of 1856," a massive rainstorm that overwhelmed the new dam holding back the man-made Lower Ausable Lake and washed out every bridge on the East Branch and Main Stem down to Keeseville, taking many lives and structures with it (Longmire, 2012). The dam had been built a year before by New York State to facilitate controlled floods for log drives. Local residents sued the state for damages, claiming the dam was poorly built, but the court ruled heavy rain was at fault. The dam was rebuilt, and it was recently rebuilt again by the Ausable Club, a summer resort spanning the headwaters of the East Branch, which values Lower Ausable Lake for swimming and boating. (Upper Ausable Lake, near the headwaters of the East Branch, is a natural phenomenon.)

By the late 1800s, the impact of unchecked timber cutting in the Adirondacks, in the Ausable watershed and beyond, was evident to many New Yorkers who valued the wild nature of the region—and its links to sustainable sources of timber and water for New York City and the Erie Canal. The destructive cycle of clear-cutting was finally halted around the highest peaks in the region in 1892 with the creation of the Adirondack Park, and in 1894 with the constitutional protection of Article 14, vowing to keep the region "forever wild." The upper reaches of the Ausable watershed were included in this designation, but the Ausable valley, from the towns of Keene and Jay northward, largely cut over, were, with few exceptions, not added to the Park until 1931.

Today, logging remains part of the Ausable watershed economy, but on a much smaller scale. In its place a mix of retail trade, tourist accommodation and food service, education, health and other social services, along with construction and a smaller forest products industry, employs both multi-generational local families and the many newcomers of recent decades who call the Ausable valley home.

2.4 Demographics and Infrastructure

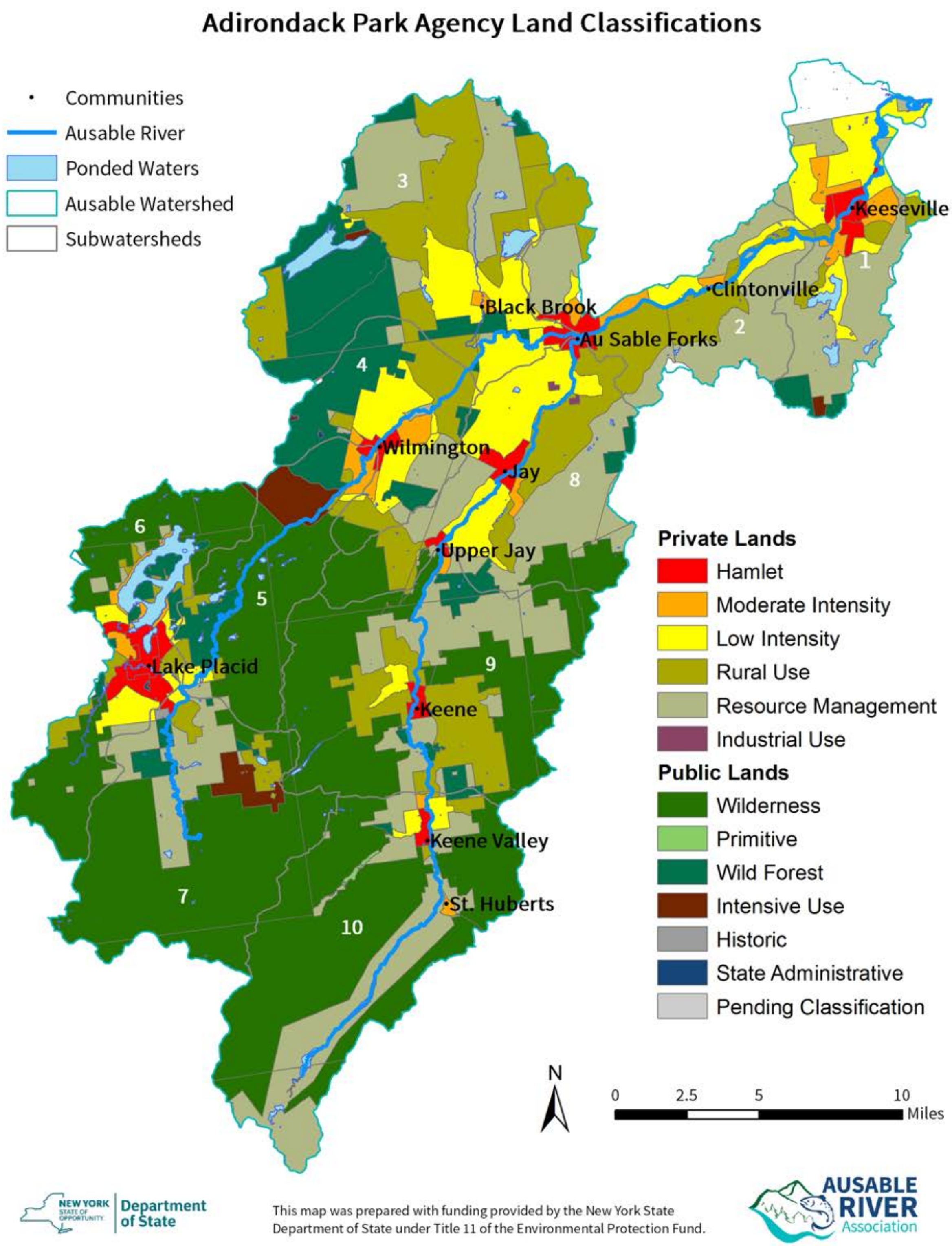
As of the 2010 census, approximately 20,000 permanent residents live in the Ausable watershed. One third of the population is concentrated in its several hamlets and its one incorporated village, Lake Placid. There are nine schools with roughly 2,360 students in all. Income levels vary little across the watershed, with median household incomes slightly below the national average. As in other Adirondack communities, residents and leaders seek to balance the year-round and seasonal economies, protecting the wilderness and wildlife that will lead to sustainable regional prosperity in this special place.

Most of the Ausable valley's population lives downstream of the headwaters region of the Adirondack High Peaks. The bulk of lands in the upstream portion of both the East and West Branches is public, held in the Forest Preserve and protected from logging, allowing a wide variety of recreational uses. Moving downstream along both branches, private ownership is the rule in the lower two thirds of the watershed.

As part of the Adirondack Park's protections, public and private lands are categorized for specific use and development potential (Map 2 and Table 1). All but 7% of the Ausable River watershed lies inside the park boundary. State-owned, public lands are managed according to the *Adirondack Park State Land Master Plan.* Close to 40% of the watershed is public land, held in the Forest Preserve as "forever wild," and designated as "wilderness," "wild forest," or "primitive" land, each classification allowing for a different intensity of development. An additional 22% of the watershed is designated "resource management" land—privately held land with development caps, scattered throughout the watershed. Traditionally resource management lands have been open space or timberland, but some have recently been approved for residential development (Map 2).

The private lands that dominate the valley landscape have varying density caps imposed by the Adirondack Park Agency's *Land Use and Development Plan* (Table 1). These density caps are far from realized, and allow for considerable development. Private lands—designated as "hamlet," "moderate" or "low intensity," or "rural use"—make up approximately 30% of the watershed. The balance tilts to more heavily urban and agricultural percentages along the Ausable's Main Stem.

To date, the entire region, with its relatively small population, has remained largely forested—86.3% of the watershed's land cover is forest, of greatly varying quality and density. Few concentrated residential developments exist, leaving the watershed largely rural in character. But the potential for considerable development exists under current zoning.



MAP 2. The APA categorizes public and private lands for specific use and development potential.

Table 1: APA Development Intensity Guidelines		
Land Use Area	**Average number of buildings/ square mile**	**Average lot size in acres**
Hamlet	No limit	none
Moderate Intensity	500	1.3
Low Intensity	200	3.2
Rural Use	75	8.5
Resource Management	15	42.7
Industrial Use	No limit	none

Table 1: Intensity Guidelines, from APA Citizen's Guide to APA Land Use Regulations, p. 2

Historically, residential settlement and industry clustered along the banks of the river, and today's communities remain close to it, with portions situated in floodplains. While the floodplains of the Ausable are narrow in the upper elevations, a quarter to a third of a mile wide, at lower elevations its floodplains are up to two miles wide (National Park Service, et al., 1994). Most primary state roads connect settlements by running alongside the river's two branches and its Main Stem. Many smaller county or municipal roads serving Ausable watershed communities also follow the valleys of Ausable River tributaries. All roadways rely on networks of bridges and culverts to navigate this intimate relationship with the river, but these structures often end up complicating the passage of water during high flow events. Built to ensure road safety and protect communities, this infrastructure can disrupt the river's natural flows, limiting its ability to provide habitat for fish and other wildlife and to manage increased flows—endangering the very communities they were designed to serve.

In the wake of Tropical Storm Irene in 2011, residents, government agencies, local non-profits, and others who care about the ecological and economic prosperity of the river began to assess how best to manage, rebuild, and reimagine roadways, hamlets, and communities throughout the watershed. Planning a future where communities can grow alongside a healthy Ausable River will lead to economic and ecological resiliency for the watershed.

III—The State of the Watershed

3.1 Introduction

We value the river for its own sake, but also as a tremendous resource. To build a resilient river ecosystem that supports and enriches a vital, economically resilient community, we must first understand the many factors at play. Having described the river and its watershed—their cultural and physical geographies, their history and demographics—we turn now to their present condition, providing a snapshot of the state of the watershed, highlighting its current resources and ecological health. This information gives us the tools to facilitate informed public discussions; it provides a baseline to monitor changes and trends; it helps us plan effectively and manage the river wisely—for those who live, work, and play here, and those who will in the future.

Assessing the state of any watershed involves many factors—scientific measures of water quality, inventories of native plant and animal populations, recreational opportunities, and much more. Over the past several years, AsRA and its partners have assembled information from diverse sources and conducted scientific studies to inform decision-making and planning. Each group of users has relevant concerns. What quickly becomes evident is how critical the clear, clean waters of the Ausable are to all who live in and rely on the watershed for sustenance of one sort or another.

Although water quality monitoring conducted for this plan indicates that water quality remains good for much of the Ausable River, analysis of water chemistry suggests emerging threats to community and ecosystem health. Identifying these threats, understanding their sources and dynamics, will allow the community to manage them and protect our watershed. Fortunately, many of the recreational activities most highly valued in the watershed are compatible with the continuing health of the river and its waters.

3.2 Historic Value

Water power, human ingenuity, and the availability of raw materials, principally iron ore and timber, fueled the settlement and development of the Ausable valley in the 19th century. Evidence of this busy period is visible in numerous historic structures in the watershed.

The Keeseville Historic District contains 142 structures built between 1820 and 1936, showing much of the infrastructure of an early industrial community embracing the river, including well-preserved houses and businesses, large and small, and gathering places, from churches to the Grange Hall. The recently restored 1847 headquarters of the Ausable Horse Nail Company, now home to Adirondack Architectural Heritage, a non-profit historic preservation advocacy organization, sits beside the river which once powered this busy factory.

The centrality of the river to Ausable valley communities has also left us a great number and variety of historic bridges, many of them listed on the National Register of Historic Places. “There are few watercourses in America, comparable in length to the Ausable, over which so many early bridge types remain,” according to the historian Richard Sanders Allen. “Crossing the Ausable are bridges that represent one hundred and forty-nine years of engineering history” (quoted in Engelhart, 1991). Keeseville’s 1843 stone arch bridge is the only bridge in the valley that predates, and survived, the “freshet of 1856”—and every flood since. Just upstream, the deep river gorge is spanned by two iron bridges, the Swing Bridge (1888), a suspension bridge strictly for pedestrians, and the wrought iron Pratt truss Upper Bridge (1878); together, these three Keeseville bridges have been designated a Historic Civil Engineering Landmark by the American Society of Civil Engineers. Jay's iconic wooden Howe truss Covered Bridge, recently rebuilt, was built in 1857, a year after the 1856 flood swept an earlier bridge away.

In Upper Jay, the Arts and Crafts-era Wellscroft mansion (1903) and Wells Memorial Library (1906), and a former Ford assembly plant and showroom (1920), now home to the Upper Jay Art Center, are all listed on the National Register of Historic Places. Upstream, near the headwaters of the East Branch, so are the Ausable Club, originally the St. Hubert's Inn (1890), and the nearby, more rustic Putnam Camp, founded by the philosopher William James and friends—links to the early years of Adirondack summer tourism.

The watershed also boasts a National Historic Landmark, the highest level of landmark protection in the country: John Brown's farm and gravesite (1849/59) in Lake Placid, commemorating the home and burial site of the abolitionist whose activism helped precipitate the Civil War. The Adirondack Forest Preserve (est. 1885), the state-owned lands that make up the original core of the Adirondack Park, was itself designated a National Historic Landmark in 1963 to commemorate this remarkable conservation measure. Today, the park—some six million acres in all, including both public and private lands—is the largest protected area in the contiguous United States.

Lake Placid and Wilmington boast numerous sites rich with the history of the Winter Olympics, held there in 1932 and 1980, including the Mount Van Hoevenberg Olympic Bobsled Run, used at both games and listed on the National Register. Equally famous locally is the rink at Lake Placid's Olympic Center that was the site of the "Miracle on Ice," the upset victory of the US men's hockey team in 1980 over the favored Soviet Union team, which many Americans considered a symbolic victory in the Cold War.

3.3 Recreation and Scenery

Recreation lies at the heart of the Ausable valley economy throughout the year. The wild mountainous forests and clear rushing streams of the Ausable River, particularly in its upper reaches, and the surrounding Adirondack Park, have few parallels in the eastern United States. The region boasts some of the best trout fishing and hiking in the northeast, along with Olympic-level skiing resources that make tourism a year-round industry. Both road and mountain biking also bring many tourists to the region in summer, as do many other forms of outdoor recreation.

The full length of the Ausable River is included on the National Park Service's Nationwide Rivers Inventory, which identifies rivers of statewide or national significance. The Nationwide Rivers Inventory recognizes the Ausable River as having "outstanding, remarkable free-flowing, undeveloped and scenic values," also citing the outstanding fisheries of the East and West Branches. The State of New York identifies the entire length of the Ausable as part of the State Wild and Scenic River System, which affords additional protections to public stretches of high-value rivers. The East Branch, from its headwaters at Marcy Swamp to St. Huberts, is listed among the 38 Scenic Rivers in the state. The remainder of the East Branch, the majority of the West Branch, and the Main Stem, below their confluence at Ausable Forks, are designated Recreational Rivers by New York State.

Numerous rapids, waterfalls, and scenic vistas occur along both branches of the Ausable and on the Main Stem. Along the West Branch, Wilmington Notch with its high cliff walls affords fine views, fishing, and occasional glimpses of osprey and peregrine falcons. High Falls Gorge, a popular tourist attraction, and the flume near Wilmington both afford exciting views of the river as it tumbles through tight rocky crevices. On the East Branch, Roaring Brook Falls is visible from Route 73; short hikes bring visitors to the top and bottom of this 350-foot plume of water. Further down the East Branch, the falls at the Covered Bridge in Jay is a popular destination. On the Main Stem, Ausable Chasm is the most dramatic of the Ausable River falls. With its 175-foot walls of Potsdam sandstone—a departure from the granite and bedrock walls of upstream falls and gorges—the chasm is the deepest gorge on the Ausable and one of the oldest tourist destinations in the Adirondacks, often represented by the 19th century painters and photographers whose images helped to popularize the region.

Along both branches of the river, especially the West Branch, tumbling, cool water alternates with deep pools, riffles, and long reaches with freestone bottoms, making for excellent trout fishing. The Ausable's West Branch is ranked among the top 100 trout streams in America, and is one of 17 Blue Ribbon Trout Streams designated by New York State (Ross, 1999).

The Ausable River is also noted for its fine whitewater paddling opportunities. Upper segments of the West Branch and one segment of the Main Stem offer excellent whitewater paddling, when water levels are sufficiently high. The River Road section of the West Branch and portions of the East Branch offer flat-water cruising opportunities; both branches also have rapids from class II to class V for those with appropriate skills.

An extensive system of trails, managed by the NYS DEC on Forest Preserve lands, provides hiking, camping and cross-country skiing opportunities. The watershed is also known for its combination of easy scenic and challenging competitive bicycling routes along the Ausable River and its tributaries. Each year, Lake Placid hosts the Ironman triathlon competition, using roads and waters in the Ausable watershed as its racecourse and backdrop, and an increasing number of non-competitive, long-distance bike rides pass through the region each summer. Whiteface Mountain Ski Center, one of the finest downhill skiing areas in the eastern US, is located on the banks of the West Branch. The Keene/Keene Valley region and Wilmington Notch are home to a variety of rock and ice climbing opportunities. The Adirondack International Mountainfest, held each January in Keene Valley, attracts internationally known climbers.

3.4 Biodiversity
The Ausable watershed hosts a broad array of species as it traverses a variety of ecosystems, from the boreal wilderness of Mt. Marcy and the High Peaks, along the Sentinel and Giant Mountain Wildernesses, down to the lowland valley of Lake Champlain.

Scientists from the New York State Natural Heritage Program have identified 36 rare plants within the watershed, six of them globally rare: Alpine Sweetgrass, Boott's Rattlesnake Root, Diapensia, Fernald's Bluegrass, Lancelear Arnica, and Ram's-head Ladyslipper. Change and stress in the ecosystem have caused the disappearance of others, including Clustered Sedge, and Pickering's Reedgrass.

Tree cover, especially along the banks of the Ausable and its tributaries, is essential to the cool waters needed to support the watershed's trout fisheries. Balsam, quaking aspen, black spruce, hemlock, and other trees of the northern boreal forest are found along the higher elevations of the East and West Branches, and an incredible diversity of hardwoods, pine, and spruce flourish in the valley. Beech and elm diseases have greatly reduced the populations of these tree species, and others are threatened by invasive boring pests. The many ash species integral to regional forests are threatened by the emerald ash borer beetle, which has yet to enter the watershed, but is in nearby regions adjacent to the Adirondack Park.

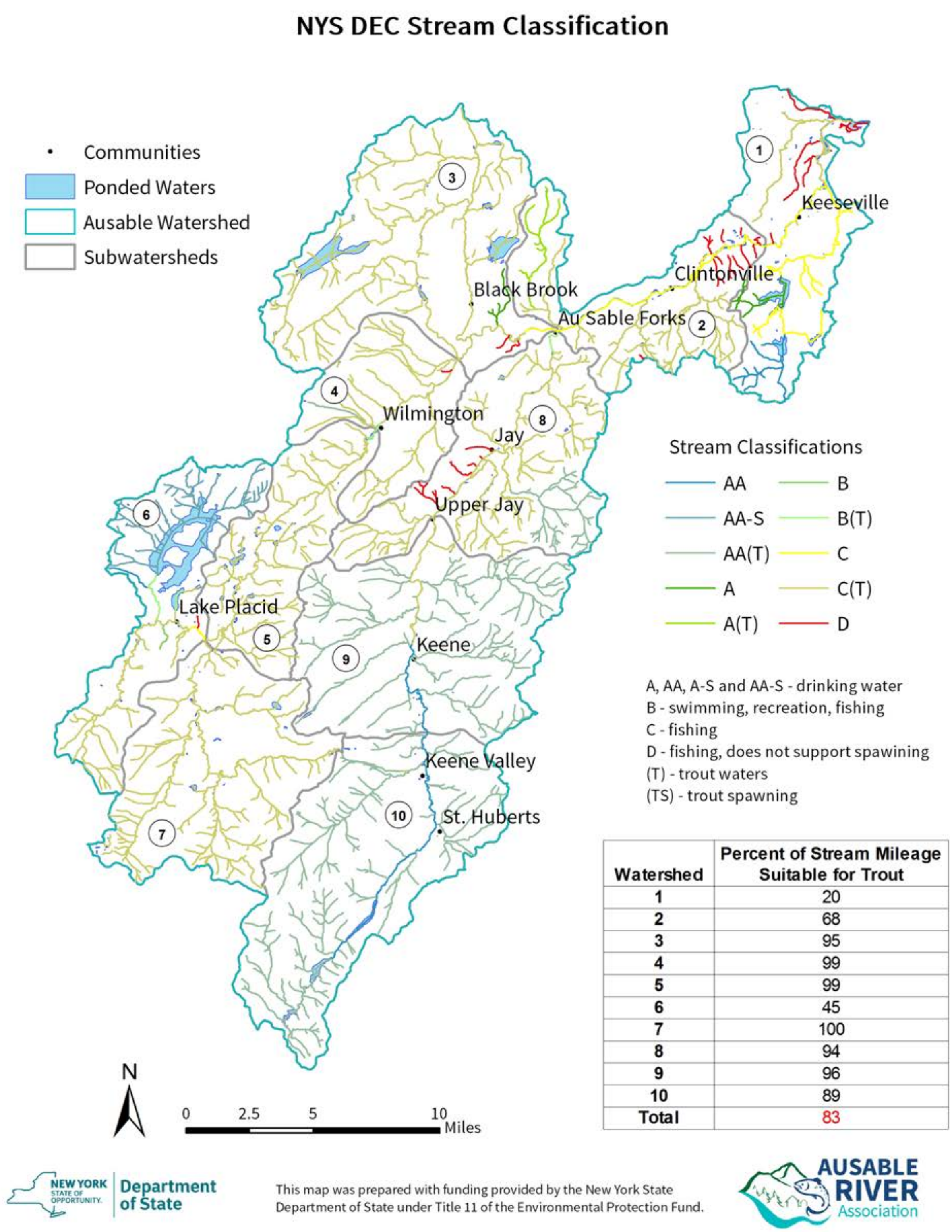
The New York State Natural Heritage Program recognized the Ausable River watershed as providing one of the few habitats in New York State for the peregrine falcon and the round whitefish, the latter found in the Cascade Lakes. Both species are known to have five or fewer habitats in New York State. Boreal bird species including the blackpoll warbler and Bicknell's thrush depend on high altitude areas such as those found at the Ausable's headwaters. Moose and beaver, once extirpated from the Adirondack region, are back in the park and in the watershed; black bears are frequent in the forested areas of both the Ausable's branches. Carnivores including eastern coyote, bobcat, marten, fisher, long-tailed weasel, ermine, and red and gray fox seem to have stable populations throughout the valley and the wider region, but little research has been done to establish their numbers. Cougar and wolves are potential visitors to the watershed and the greater Adirondack region, but no recent reliable report has yet established their residence.

All these species rely on high water quality and benefit from the watershed's extensive protected forests. But the watershed's aquatic residents are its sentinel species, most notably its native brook trout. Most of the Ausable River offers viable trout habitat (Map 3). Brook trout are native to the cooler waters of the East and West Branches. Brown and rainbow trout were first introduced in the 1800s and continue to be stocked regularly. Smallmouth bass are found in watershed lakes, the lower West Branch, and the river's Main Stem. Landlocked salmon can be found in the lower five miles of the Main Stem, below Ausable Chasm, and are stocked in Taylor Pond (Roden-Tice, 2000). Although brook trout reproduce naturally in the river, Essex County and NYS DEC stock hatchery-raised strains throughout the Ausable River. Brown trout make up most of the stocking population, with lower numbers of brook and rainbow trout. Brown trout and other non-native fish species are listed as the highest biological threat to native brook trout by the Eastern Brook Trout Joint Venture (EBTJV)—a partnership between state and federal agencies, regional and local governments, businesses, conservation organizations, academics, scientific societies, and private citizens working toward protecting, restoring, and enhancing brook trout populations and their habitats across their native range (Trout Unlimited, 2006).

The West Branch is one of the most heavily fished streams in the state, and fishing on the Ausable generates an estimated $2.3 million in local expenditures annually (Levine, 2013). The 2006 Angler's Diary's from the West Branch reported a catch rate of 0.8 trout per hour and reasonable numbers of brown trout 14-16" in size (NYS DEC, 2007). Despite heavy fishing, a 2003 electrofishing study recorded significant increases in average brown trout length and in the abundance of wild trout fingerlings on the West Branch over a 1992 study (Schoch, 1994). Wild trout made up 23 percent of the yearling and older brown trout population, up 1% from 1992. In contrast to this good news for brown trout, the 2006 study by EBTJV, mentioned above, reports reduced numbers of brook trout in the West Branch and Main Stem, but intact brook trout populations in the East Branch. The report suggests the population decline on the Main Stem may result from high water temperatures.

Trout and other fish rely on healthy invertebrate populations, a building block of the river's food chain. Invertebrate populations in the Ausable are sampled on a five-year cycle as part of the NYS DEC "Rotating Intensive Basin Study" (RIBS). RIBS data (NYS DEC, 2009) over three decades of sampling indicates "excellent" to "good" species richness and "excellent" to "good" biotic indices for the length of the West Branch from Lake Placid to Ausable Forks. Clean-water mayflies and caddis flies dominate the invertebrate species assemblage in most parts of the river. The invertebrates observed in the East and West Branches and the Main Stem face minor but increasing impacts in specific sections of the river, its tributaries and lakes because of wastewater and, more often, sand and sediment deposition from streambank erosion and roadway runoff. Sand and sediment can decrease spawning success and limit macroinvertebrate production.

Because of the biodiversity found in the Adirondacks, in 1989 the Educational, Scientific, and Cultural Organization of the United Nations (UNESCO) designated the Champlain-Adirondack Biosphere Reserve. It includes the entirety of the Ausable watershed, the Adirondack mountain region and the Lake Champlain watershed in both New York and Vermont. The Biosphere Reserve designation recognizes ecologically notable areas where sustainable approaches to conservation are being developed through local and regional efforts using sound science. The hope is that these special places can serve as models for other communities seeking to reconcile ecosystem conservation with economic development.



Watershed	Percent of Stream Mileage Suitable for Trout
1	20
2	68
3	95
4	99
5	99
6	45
7	100
8	94
9	96
10	89
Total	83

MAP 3. Brook trout spawning is known to occur throughout the watershed. DEC designates special protections for trout spawning waters in specific geographies as needed for resource protection. No TS waters are designated in the Ausable.

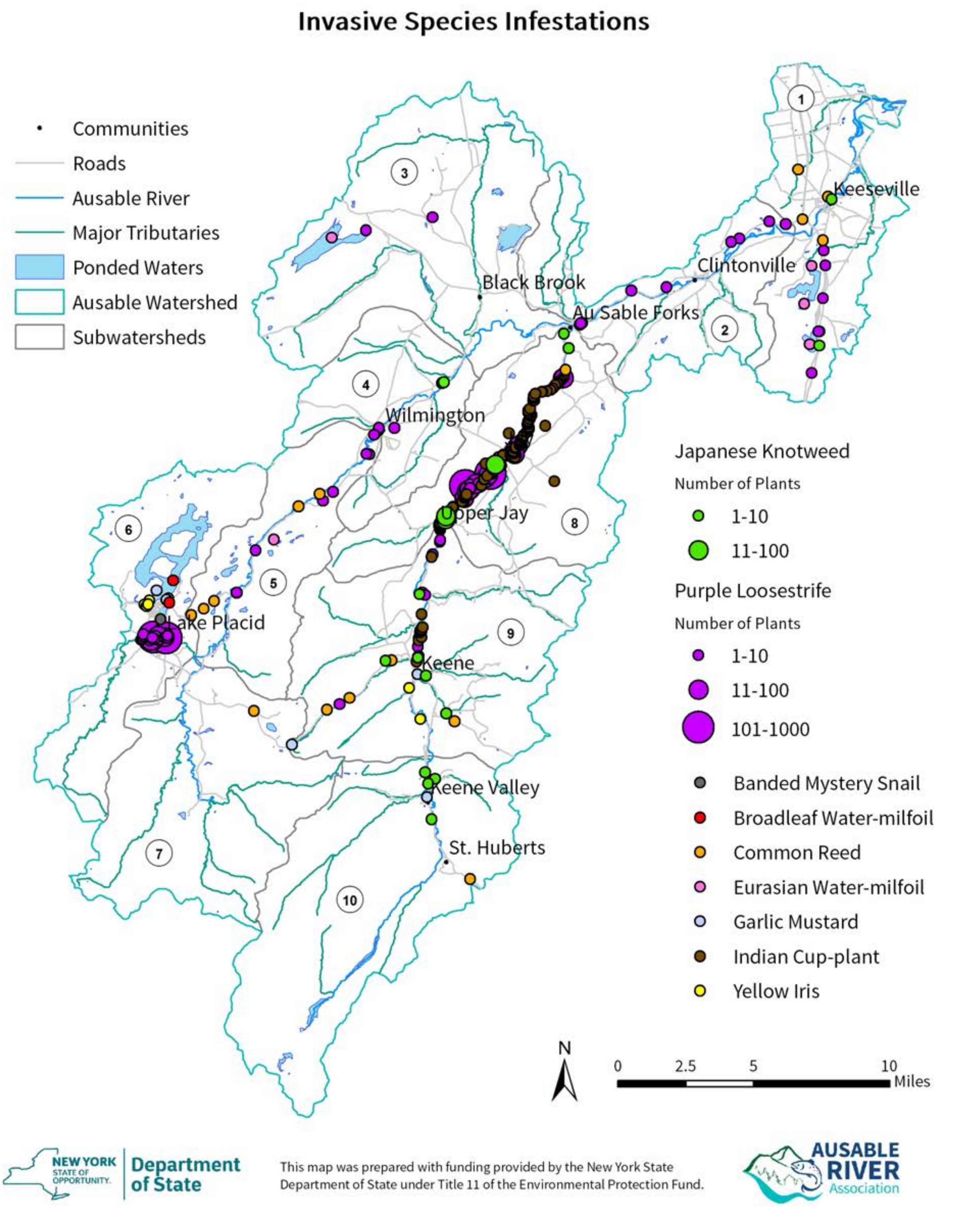
3.5 Invasive Species

Didymo, known as “rock snot” for its slimy brown appearance, is a nuisance algae that has infested waters internationally and in the western United States. It can form thick mats on river bottoms; whether these block invertebrate production, thereby affecting fish, or are simply unattractive remains a subject of research. To date, didymo blooms are not found in the Ausable or other Adirondack waterways, but they have been found in many Vermont and Quebec waterways, as close as Kayaderosseras Creek, near Saratoga Springs. It is up to the many users of the Ausable River to protect it from aquatic invasive species by properly cleaning gear, including waders, fishing equipment, and boats after any outing, since didymo and other microscopic organisms, such as New Zealand mud snail, are easily spread. Educated users taking proper precautions are the best defense for the watershed.

In the late 20th and early 21st centuries the introduction of invasive zebra mussels into the Lake Champlain basin highlighted the need to assess populations of native mussels and verify any incursions of zebra mussels into the Ausable River. In 2001-2002, AsRA’s staff examined existing populations of mussels in the river and watershed lakes (AsRA, 2001). Historical data suggest that the Ausable River never supported large native populations of mussel species. The AsRA study found small numbers of two native mussel species, *Elliptio complanata* and *Lampsilis radiate*, at the river’s mouth. Lakes within the watershed that feed the river also support mussels. *Elliptio complanata* was found in large numbers (50–500) in Augur Lake, Upper Ausable Lake, and Mirror Lake. A third species, *Pyganodon cataracta*, was found in small numbers in Upper Ausable and Mirror Lakes. Zebra mussels were found on the Ausable delta by Vermont DEC in 1994 (Fiske & Levey, 1994), but the AsRA study found no zebra mussels at the river mouth or in watershed lakes. The Ausable River likely lacks mussel habitat because of its cobble-boulder substrate, steep gradient, and low calcium levels (Fichtel & Smith, 1995).

Several terrestrial invasive plant populations have made inroads into the watershed. Invasive plants can quickly displace native plant populations, particularly on eroded streambanks; they form monocultures, disturb natural soil structure, weaken streambanks, and threaten water quality as a result. In a 2002 survey of both Ausable River branches, 32 small invasive plant sites covering less than 0.5 acre each were recorded. The majority were located in private yards or on farm field edges—one site containing approximately half the invasive plant population in the watershed. Purple loosestrife was the most abundant documented, covering 1,721 square yards; Japanese knotweed the second most abundant at 297 square yards; phragmites the least abundant at 218 square yards. Seeds are spread downstream by the river, so upstream infestations spread rapidly. Public education is the best defense.

By 2006, a resurvey of the East Branch noted significant increases in invasive plant species. A total of 214 sites containing purple loosestrife, Japanese knotweed, Japanese barberry, and Indian cup plant were discovered. Indian cup plant increased significantly and appears to have spread 30 miles downstream from its original sighting near Keene all the way to Keeseville (AsRA, 2007). A compilation of the most recent data is detailed in Map 4. Invasive plant species currently found in the Ausable watershed include Japanese knotweed, purple loosestrife, Japanese barberry, phragmites, garlic mustard, Indian cup plant, broadleaf and Eurasian water milfoil, yellow iris, bush honeysuckle, Canada thistle, wild parsnip, and balsam wooly adelgid. A total of 22,646 invasive plants were recorded for the entire watershed via multiple survey methods.



MAP 4. Data gathered by AsRA during walking and canoeing surveys conducted in 2002 and from 2005-2010. Additional data points were added by AsRA river stewards in 2014-2015. iMap invasives data for this period is partial but adds 5 incidences each of wild parsnip and European spindle tree.

3.6 River Temperature

AsRA's staff monitors water temperature in order to determine the degree to which this limits fish and invertebrate survival in the Ausable River. It is widely accepted that brook trout prefer temperatures below 20°C (68°F). In Southern Ontario, streams with weekly maximum temperatures exceeding 22°C (72°F) have marginal or no brook trout populations (Barton et al., 1985). Other published studies report temperatures between 19-26°C (68-79°F) as the upper limits tolerable to all trout species (Eaton et al., 1995).

Data loggers were placed in the Ausable River at seven locations in 2008 and 2009. The loggers recorded water temperature from May through October. Several locations on all three sections of the river were found to be above 20°C for more than 20 days. It is the Ausable River's tributaries, however, that provide key habitat for native brook trout. Having their sources at higher mountain altitudes, these tributaries are generally much cooler than the river itself, though little comparative data exists to establish their precise temperature profiles. In 2015, AsRA re-established a network of data loggers in key tributaries and river segments throughout the watershed. It will share this data continuously with the public through its website.

3.7 Water Quality

Access to adequate clean water is essential to life, and clean, clear water is at the heart of every community in the Ausable watershed. Its many streams, brooks, and aquifers, like the river, depend upon floodplains, riparian corridors, and wetlands to maintain water quality. These natural systems filter nutrients, trap sediment, reduce flooding, and stabilize soils. Together, these functions help to sustain healthy human communities, wildlife populations, and fisheries, and timber, agriculture, and tourism industries.

Water monitoring conducted in the preparation of this plan indicates that water quality remains good to excellent for much of the Ausable River. However, water chemical trends indicate several emerging threats that need correction in order to maintain community and ecosystem health.

Clean, clear water has not always been the prevailing condition of the Ausable River. In 1899, the New York Board of Health declared the river contaminated with high levels of pollution and undrinkable at Keeseville. Starting in 1893, the Ausable ran alternately red and black from Au Sable Forks to its mouth because of the high volumes of pulp waste discharged at the J. & J. Rogers Co. paper mill in Au Sable Forks, forcing Keeseville to find an alternate source of drinking water (Harris & Wilson, 1993).

In 1996 and 2003 the river was again exposed to contaminant sources that compromised safe drinking and recreation (BRASS, 1995; Murphy, 2002; Dunlap, 2007). These episodes on the Main Stem and West Branch were the result of aging or inadequate septic systems and wastewater treatment plants. As a result, wastewater treatment plants were retrofitted or replaced in Au Sable Forks and Lake Placid, removing the sources of pollution. The costs of reacting to such events are typically much greater than the costs of proactive management. An important result of watershed management planning is the information that will allow municipalities to address potential threats to water quality before a contamination occurs.

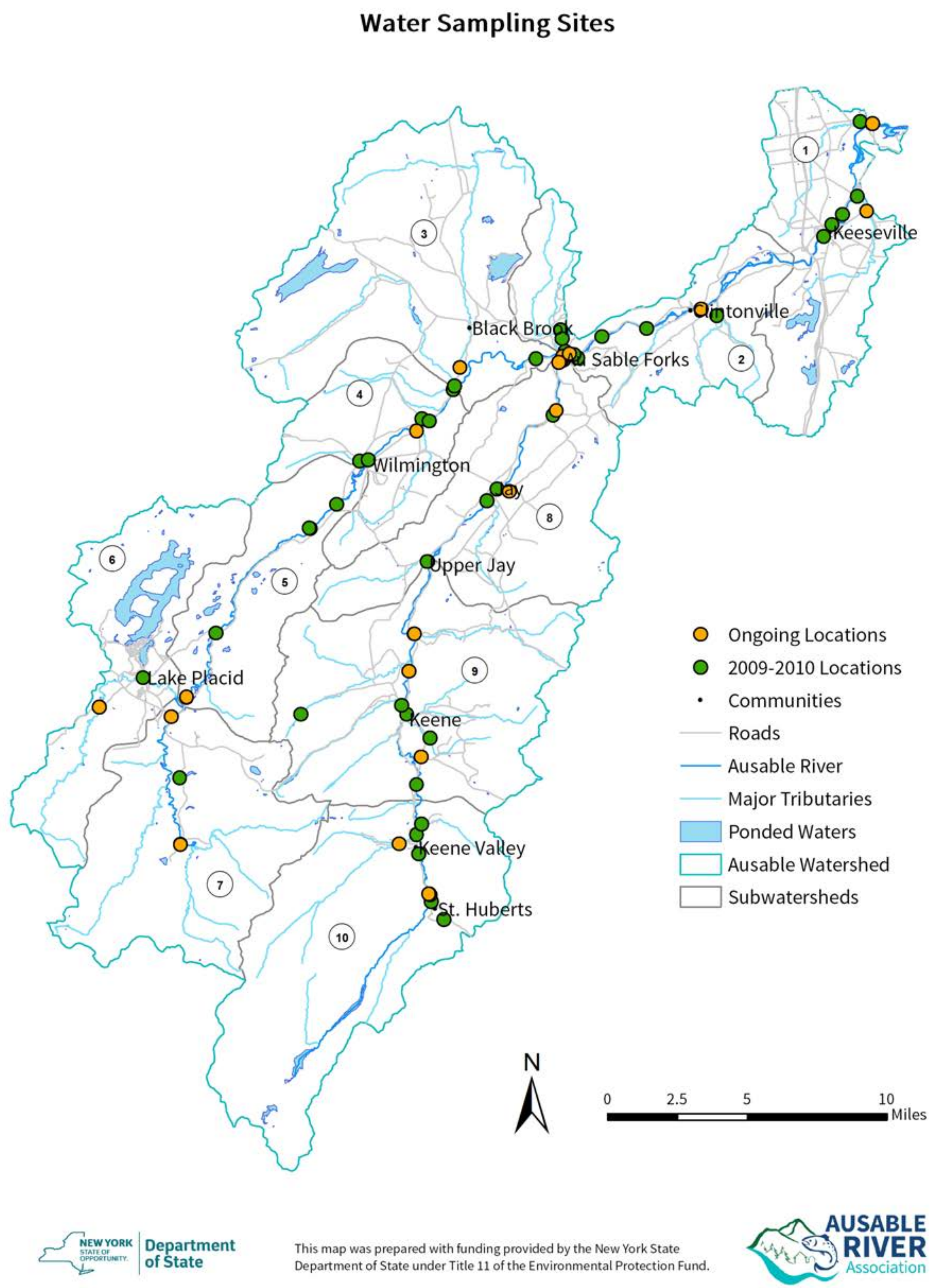
Water Sampling and Analysis

Water quality along the entire length of the Ausable River was tested in two phases over a two-year period in 2009 and 2010. During Phase I (2009) conductivity, temperature, and turbidity were measured using field probes. During Phase II (2010) water samples were collected and analyzed at the Lake Champlain Research Institute for pH, total suspended solids, organic compounds, phosphorus, nitrates, chloride and cations. A detailed report of this study, “Water Quality in the Ausable River” (2012/15), can be found on AsRA’s website.

Water samples were taken from the river at every bridge crossing and from the mouth of every major tributary. This includes 21 sites on the East Branch, 20 on the West Branch, and 13 on the Main Stem. Samples were retrieved from the thalweg (the area of swiftest, deepest flow) using a perforated one-gallon sample bottle suspended from a rope. Weather and discharge (the volume of water moving down a stream per unit of time) have measurable effects on water concentration and chemistry; to explore these influences in the Ausable watershed, sampling was done during different weather and flow events.

During Phase I (2009), samples were collected monthly between May and October. Water sampling teams tested conductivity at sites along the full length of the river. During Phase II the river was sampled on four dates (March 15, May 19, July 12, and September 10, 2010) to capture different runoff, flow, and temperature conditions. Three sampling teams worked simultaneously; the West and East Branch teams started at the headwaters and worked downstream to the confluence at Au Sable Forks, while a Main Stem team started at the river’s mouth and worked upstream to Au Sable Forks.

Bedrock geology has a significant influence on natural water chemistry. Most of the Ausable watershed is underlain by metamorphic rock: meta-anorthosite, both mafic and felsic gneisses, and some marble. The river does not encounter sedimentary rock until the Main Stem reaches Keeseville. Potsdam sandstone makes up the riverbed for a significant portion of its journey through Keeseville and Ausable Chasm. All these rocks have very low solubility; consequently, the river and tributaries of the Ausable have very low dissolved loads.



MAP 5. AsRA sampling locations past and present.

The data collected shows downstream changes in concentration from sampling point to sampling point, highlighting any large inputs from tributaries or point sources. It also captures seasonal changes in temperature, discharge, and environmental variables such as biomass production and other land/water inputs. A typical method for displaying water data from rivers is to calculate the discharge-weighted average of the measured concentration (load). It is not possible to calculate load for the Ausable because USGS streamgages are not present at most water sampling points, and the distance between gages makes extrapolation impossible. This tends to emphasize water composition during high flows.

Specific conductance

Conductivity—the ability of water to pass an electrical current because of the presence of dissolved ions—is often called the "watchdog" environmental test since it is informative and easy to perform. Calculations of specific conductance standardize conductivity measurements to the temperature of 25^{o}C for the purposes of comparison. Rain, streambank erosion, snowmelt, runoff carrying livestock waste, failing septic systems, and road salt raise conductivity because of the presence of ions such as chloride, phosphate, nitrite etc. Oil spills lower water conductivity. Temperature influences conductivity, therefore colder tributaries, shade, sunlight, stream depth, and sampling depth all affect conductivity. A conductivity probe does not identify the specific ions in a water sample—it simply measures the level of total dissolved solids (TDS) in the stream.

Conductivities measured during Phase I (2009) were, for the most part, very low. The range of specific conductance in the Ausable is between 10 microsiemens/cm (µs/cm) at the headwaters to 120-150 µs/cm at the mouth. Typical conductivity of rivers in the United States is between 50 and 1500 µs/cm. Specific conductance reported by the US Geological Survey for five other rivers in the eastern Adirondacks is between 49 to 1169 µs/cm (Butch et al., 2005). The relatively low conductivity of the Ausable River is an indication of good water quality, but it is also a reflection of the type of rock found in the watershed. Bedrock in most of the Ausable watershed has very low solubility and contributes few ions to runoff.

Conductivity rises gradually heading downstream. This is typical of river chemistry: as the area drained increases, TDS increase as contributions from tributaries and streambanks do too. The downstream changes in conductivity are most drastic during low flow months. In these months, the greatest changes in conductivity occur downstream of Keene, Lake Placid, and Keeseville. Conversely, downstream of Au Sable Forks, an increase in conductivity is observed during high flow months. Closer examination of specific analytes helps to explain these trends.

Analytes – Acidity (pH)

Acidity in Adirondack surface waters has two sources: acid deposition (rain, snow, and dry deposition) and organic acids from evergreen needles and other plant matter. Long-term monitoring by the Adirondack Lakes Survey Corporation shows that 25% of lakes in the Adirondacks have a pH of 5.0 or lower and another 25% are vulnerable to springtime acidification (ALSC, 1990). A comprehensive study of acidification of Adirondack rivers has not been done, but in the Black and Oswegatchie Rivers, 58% of reaches are prone to acidification (Lawrence, et. al, 2008). These rivers are most acidic in March and least acidic in August. During spring snowmelt, the largest acid contribution comes from acid deposition. In other months, dissolved organic carbon (DOC) contributes a large portion of the acid content and the contribution from acid deposition decreases.

Water in the Ausable River, by contrast, has a near neutral pH (7) for much of the year and showed high pH variability from stream to stream in July (2010). The upland river and tributaries are more acidic, but water is neutralized as it flows downstream.

The cause of this downstream neutralization can only be inferred because acid neutralizing capacity and dissolved organic carbon were not measured for this study. Alkalinity is another way to express a water's ability to neutralize acid. It may be in the form of hydroxyl (OH^-), carbonate (CO_3^-), or bicarbonate (HCO_3^-) ions. In this study, TDS as approximated from conductivity were measured and used as an approximation of alkalinity.

There are few natural sources of acid neutralizing compounds in the Ausable watershed. Bedrock contains few carbonate minerals—except in the region of Lake Placid and the Cascade Lakes, where calc-silicates in the form of limestone and dolomitic marbles are found. Anthropogenic inputs are a more likely cause for increasing pH. TDS increases in the downstream direction, suggesting some source of runoff that may act as an acid neutralizer. Further water analysis is needed to clarify the acid neutralizing capacity of the water.

Water in snow acts as stored acid in solution (Lawrence et al., 2008). When snow melts, it releases acid into the river. In early spring, the river's discharge is much greater (6,580 cfs in March vs. 400 cfs in July). This added water volume dilutes TDS and reduces the water's ability to neutralize acid, thus increasing the temporary acidification. Prolonged exposure to low pH levels has been studied extensively in lakes, and lake pH levels of 5 to 5.5 found to be toxic to mayflies and near-toxic to trout. The effects of short pulses of acid runoff and subsequent swings in pH are not well documented, however. It is unknown to what extent pH drops during the spring runoff period and whether that has any effect on aquatic organisms.

In July, pH in the river is at its highest (least acid). During this month the concentrations of dissolved solids are also high because the amount of water in the channel is low, providing less dilution. This creates greater acid neutralizing capacity. The low volume of precipitation in July contributes to lowering acid inputs from precipitation.

Summary: While acid deposition and acidification of surface waters are more serious in the western Adirondacks, more study is needed to define the impacts of springtime acidity on the Ausable's aquatic ecosystem. The sources of the acid neutralizing capacity (ANC) in the watershed also need closer examination and identification.

<u>Analytes – Chloride (Map 6)</u>
The element chlorine can occur in various forms or states of oxidation, but the chloride form (Cl^-) is most common in surface waters. There are a number of natural sources of chloride, including various rocks that contain chlorine-bearing minerals. The most abundant natural mineral form of chloride is NaCl or Halite, also known as rock salt. Large halite deposits form when ocean water evaporates and mineral deposits are buried, eventually becoming rock.

Chloride is present in most natural waters at very low concentrations, except where surface or groundwater mixes with ocean water. Adirondack lakes and river have average chloride concentrations of 0.24 ppm (Kelting et al., 2012). Another source of chloride is road runoff, in regions where rock salt is used as a road deicing agent in winter. New York has the highest rock salt application rates per lane mile in the United States (Kelting & Laxson, 2010). These application rates are mandated on state roads across the state, regardless of proximity to surface waters.

There is increasing evidence of groundwater contamination from road salt in the Ausable watershed. This issue is most pronounced around salt storage areas, but is also a concern in areas adjacent to roads. Elevated sodium and chloride levels also have the potential to negatively impact human health by tainting well water, among other risks. The EPA drinking water guideline for sodium is 20 ppm and 250 ppm for chloride.

Chloride toxicity to organisms is complex and not well understood. Wildlife can be exposed in a wide variety of ways: birds ingest salt pellets mistaking it for grit, while fish and aquatic organisms are exposed to chloride concentrations throughout the year via dermal exposure and ingestion. Toxicity standards (based on LD50 or LC50 values, the dosage or concentration lethal to 50% of the tested population) are set by state and federal agencies as the result of laboratory studies. They do not take into consideration the complex interactions that occur in natural ecosystems—effects of chronic exposure, or regional differences in sensitivity that may result from adaptions to local conditions.

EPA chloride guidelines for aquatic life are 230 mg/L for chronic exposure (four-day average) and 860 mg/L for acute exposure (one-hour average) (EPA 1998). The NYS DEC Water Quality Regulation for chloride in surface waters is 250 ppm for class A, AS, and AA-S waterbodies. Most Ausable waterbodies are class AA, A, B, or C (Map 3).

Some researchers have observed negative effects from chloride levels much lower than the EPA and NYS DEC guidelines. Certain zooplankton species may be affected at concentrations as low as 5 to 30 ppm (Dalinsky et al., 2014; Palmer and Yan, 2013), and a study by the US Geological Survey showed very low tolerances (3.1 ppm) to chloride for brook trout (Meador and Carlisle, 2007). Chloride toxicity may also depend upon a variety of biotic and abiotic factors. Eurasian water milfoil, an invasive aquatic plant, has been shown to have higher tolerances to chloride than native milfoil species (Dalinsky et al., 2014). A study of chloride toxicity to zooplankton found that decreases in the quantity of food increase chloride toxicity (Brown & Yan, 2015). This means zooplankton in Adirondack lakes, which are generally low in nutrients (oligotrophic) may experience toxic effects at lower chloride concentrations than lakes with greater nutrient productivity. Elevated chloride levels have also been implicated in the ability of lakes to recover from acidification (Jensen et al., 2014).

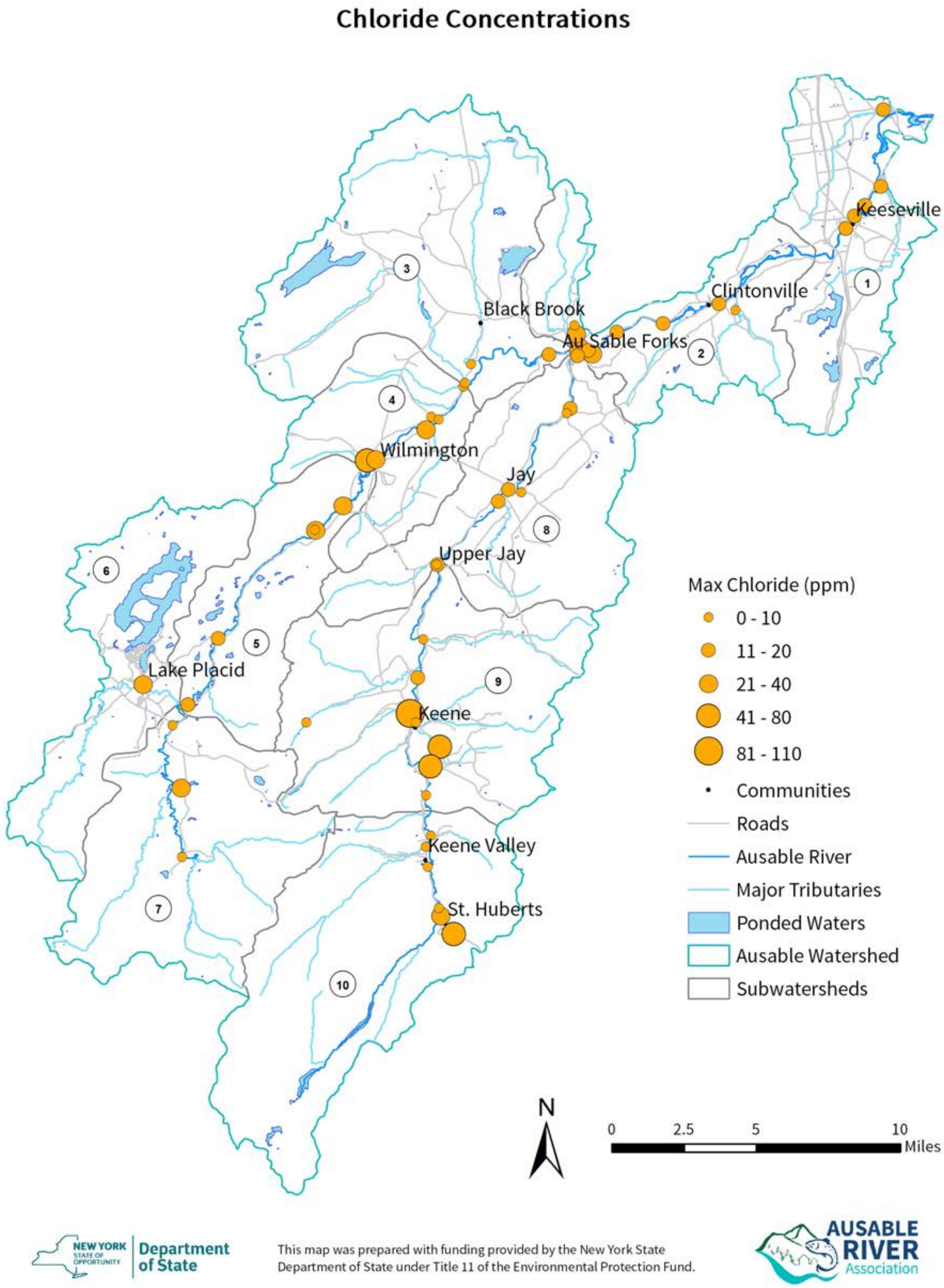
Chloride concentrations were measured from Ausable water samples taken at approximately five-mile intervals and at the mouth of every major tributary. Chloride concentrations in the Ausable River measured between 0 and 120 ppm (Map 6). The West Branch and Main Stem have chloride concentrations that fall within the standards set by New York State. In the East Branch, however, chloride levels approach 50 to 115 ppm. Concentrations are highest in the river between Marcy Field and Lacy Bridge in the Town of Keene, and in Norton, Dart, and Cascade Brooks, all nearby. Studies show that Chapel Pond and Upper and Lower Cascade Lakes have chloride concentrations up to 100 times greater than expected for Adirondack lakes (Langen, et. al., 2006).

Long-term sampling at the river's mouth shows chloride concentrations in the Ausable increased between 1990 and 2010 (VT DEC, 2011). Current chloride concentrations are troublingly high, particularly in the East Branch, the Cascade Lakes, and Mirror Lake (ALAP, 2014), but have not yet exceeded EPA or NYS DEC guidelines. Documented steady increases in chloride concentrations are a cause for serious concern. To adequately protect native fish and other aquatic organisms the source of chloride must be determined and action taken to stop its introduction to the river.

In Ausable River samples, sodium and chloride levels increase and decrease in tandem. With no natural sources of chloride in the watershed, the source of chloride must be NaCl (a 1:1 ratio of sodium to chlorine) or halite, the mineral in road salt. Exceptionally high concentrations of chloride in the East Branch are likely a result of the river's proximity to state roads and urban areas, and the legacy of uncovered salt storage facilities (no longer in use).

Given the harshness of Adirondack winters and the perceived demand for high salt application rates, it is not surprising to find elevated levels of chloride in surface waters during winter and spring runoff. Its persistence in the river during the summer months is alarming, however, and suggests that groundwater is contaminated with chloride. If chloride were entering the river from groundwater, it would be most apparent in summer when most of the water in the river is from base flow.

Magnesium and chloride also trend in tandem, suggesting that some of the chloride could come from magnesium chloride salt applications. In the Ausable Valley, NYS DOT trucks maintaining Routes 73 and 9N apply coated salt, NaCl salt crystals coated with $MgCl_2$. Norton, Dart, and Cascade Brooks are also adjacent to roadways that receive coated salt and all have higher than background levels of magnesium, with Dart Brook showing the highest. The NYS DOT salt shed and road salt mixing area are in the Dart Brook watershed. The facility is covered (and shared in recent years by the Town of Keene), but this is unlikely to be a coincidence.



MAP 6. Results of 2009–2010 water quality analysis.

Summary: High chloride concentrations in the Ausable River are a top water quality concern. The East Branch of the Ausable, Mirror Lake, and both Upper and Lower Cascade Lakes have chloride concentrations up to 100 times greater than expected for Adirondack surface waters. This is especially alarming for a river where rapid flushing rates should cleanse the stream in summer months.

Evidence of negative chloride impacts on the ecosystem have been documented in the Cascade Lakes, where round whitefish (*Prosopium cylindraceum*), an endangered species, exhibits growth patterns indicative of environmental stress (Langen, et. al., 2006). A similar examination of wild trout would provide useful data.

Examining water tests of the Cascade Lakes by NYS DEC for trends would help to assess the cumulative value of alternative salt applications in the Ausable valley and Cascade Lakes. Alternatives being promoted by the New York State Task Force to reduce road salt should be pursued for the Ausable valley. These chemical or abrasive alternatives should be properly managed and evaluated for other negative ecological impacts (Lindberg, 2009; Kelting, 2010).

<u>Nutrients – Phosphorus (Map 7)</u>

Phosphorus is relatively common in igneous rocks such as those found in the Adirondacks and is also fairly abundant in sediments. The concentration of phosphorus in natural waters is low however, because of the low solubility of these inorganic forms. Phosphorus is also a component of wastewater and this is a primary source of phosphorus in many waters. Typical concentrations of phosphorus in surface water are a few tenths of a part per billion. Additions of phosphorus to the aquatic environment enhance algal growth and accelerate eutrophication of waterbodies that leads to depletion of dissolved oxygen, limiting aquatic plant life.

Phosphorus is also added to surface waters from non-point sources such as eroding soils, stormwater runoff, runoff from fertilized fields, lawns, and gardens, and runoff from livestock areas or poorly managed manure pits. Poorly maintained or sited septic systems can also add phosphorus to surface waters. In addition, analyses of water chemistry in Adirondack upland streams shows that streams coming off old growth forest have higher phosphorus concentrations than those flowing off managed forests (Meyers et. al, 2007).

Maybeck (1982) estimates that naturally occurring dissolved inorganic phosphate in river water should average about 10 ppb and total dissolved phosphorus about 25 ppb. In addition, particulate forms of phosphorus make up about 95% of total phosphorus carried in river water. For rivers influenced by human activities it is not unusual for phosphorus concentrations to be 10 to 100 times greater than normal background measures.

Concentrations of soluble reactive phosphorus (SRP) and total phosphorus (TP) in the Ausable River are within the expected range for natural surface waters. Several prominent exceptions include measurements taken at the Iron Bridge near Lake Placid, Big Brown Brook, Palmer Brook, and points downstream of Keeseville. Spring (March) and fall (September) SRP levels are higher than summer levels (Map 7).

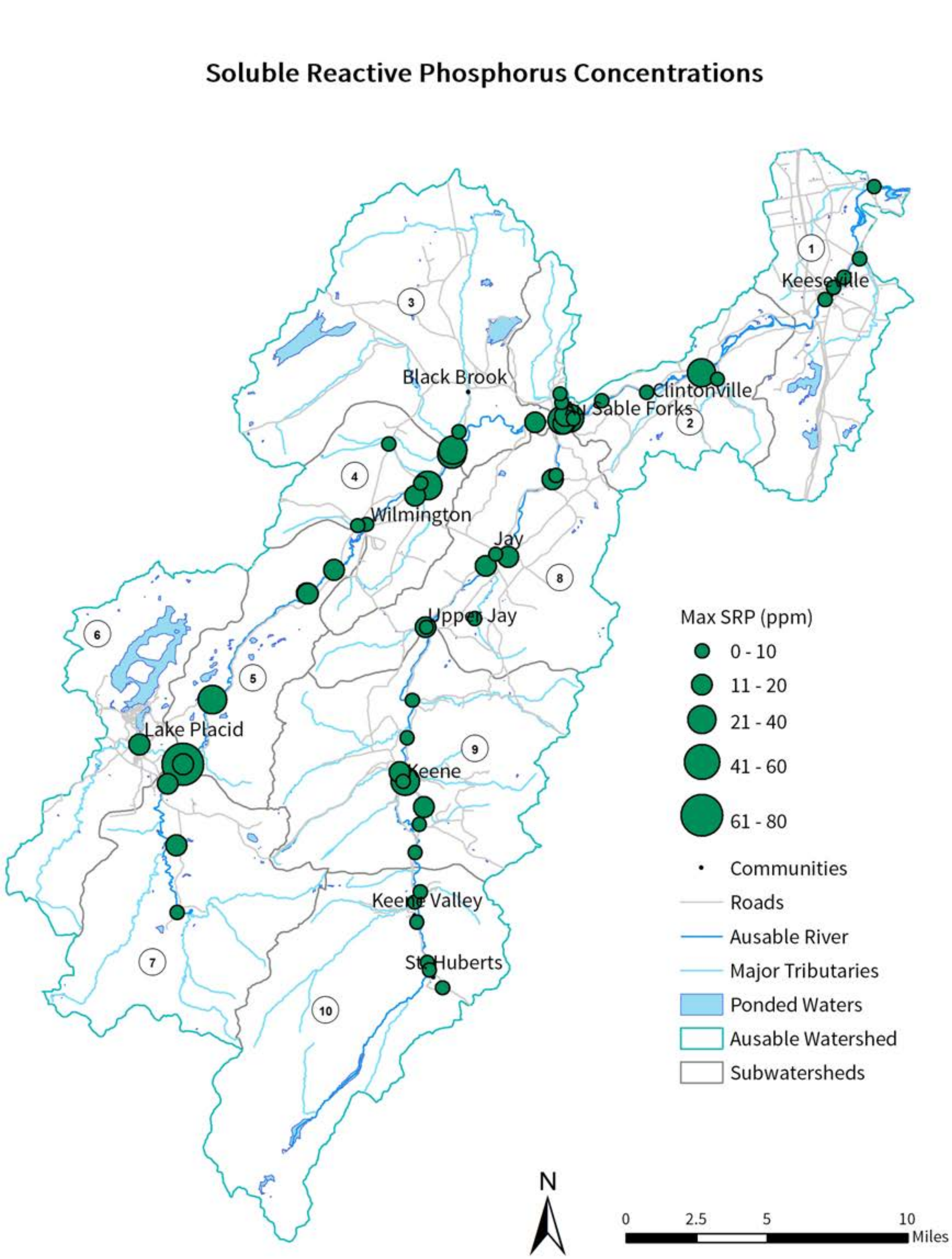
Phosphorus concentrations appear to vary seasonally in the Ausable. March and September SRP levels are higher than late spring and summer concentrations. Spring and fall are typically rainy, so this trend may reflect phosphorus introduced from stormwater runoff. Another explanation may be nutrient uptake during the growing season. Biologic uptake is minimal in March and Septemberm, and SRP levels are highest in these months. In late spring and summer the water warms and photosynthetic uptake by algae increases; concentrations of SRP in the Ausable decrease in May and July. Field notes taken by water sampling teams in May record bright green algal blooms in the river.

SRP and TP concentrations also appear to increase downstream of developed areas. Samples showed increases of phosphorus downstream of the village of Lake Placid, Keene, Au Sable Forks, Clintonville, and Keeseville. Possible sources for these higher levels of phosphorus include urban runoff, storm drains, wastewater treatment plants, inadequate septic treatment, and fertilizers from lawn and golf course maintenance. Each village and hamlet needs to be carefully assessed to determine phosphorus sources; some have municipal wastewater treatment plants (Lake Placid, Au Sable Forks, Keeseville), but most hamlets rely on septic systems (Upper Jay, Jay, Keene, Clintonville, Wilmington). A few communities have golf courses that may influence river water (Lake Placid, Au Sable Forks). The Lake Placid Club receives treated effluent from the village's wastewater treatment plant to augment the irrigation of its golf courses.

A surprisingly large increase in total phosphorus (TP) is recorded in March in tributaries downstream of Wilmington (New Bridge Brook, Pettigrew Brook, and Big Brown Brook). This spike coincides with higher total suspended solids (TSS) and suggests that sediment in the water could account for elevated TP. Smaller increases in TSS and TP are recorded in other tributaries in March, i.e. North Meadow in the Upper West Branch watershed and Upper Otis Brook, North Jay Brook, and Palmer Brook in the East Branch. All of these streams have large wetlands that shed large amounts of suspended organic matter and may account for elevated TP and SRP during high runoff events. Within the Ausable watershed, spring runoff and other times of increased suspended sediment loads may account for higher concentrations of phosphorus.

Summary: Urban areas and spring runoff appear to be the two largest sources of phosphorus in the Ausable watershed. Each urban area within the Ausable watershed needs to be carefully assessed to determine possible phosphorus sources. Samples taken at the mouth of the river show that the Ausable has one of the lowest phosphorus discharges to Lake Champlain (Vermont DEC, 2011). Clearly, the river is not overloaded with phosphorus, though further reductions would help Lake Champlain meet its total maximum daily load (TDML) goals for reducing phosphorus loads under Section 303 of the Clean Water Act. The seasonality of phosphorus in the river emphasizes its role as a limiting nutrient. Phosphorus levels decline downstream from the point of introduction, suggesting that it is rapidly consumed within the Ausable's aquatic environment. Algae blooms within the river are not prominent, but some isolated occurrences of Cladophora could be examined as indicators of phosphorus sources.

Soluble Reactive Phosphorus Concentrations



This map was prepared with funding provided by the New York State Department of State under Title 11 of the Environmental Protection Fund.

MAP 7. Results of 2009-2010 water quality analysis.

Nutrients – Nitrogen

Nitrogen is present in many forms in the atmosphere, hydrosphere, and biosphere. It is the most common gas in the earth's atmosphere. The behavior of nitrogen in surface waters is strongly influenced by its vital importance to plant and animal nutrition.

Nitrogen occurs in water as nitrite (NO_2^-) or nitrate (NO_3^-) anions, or ammonium (NH_4^+) cations. Nitrite is an indicator of organic waste or sewage. Nitrate or ammonium may also be from a pollutant source but generally are introduced at a site far removed from the sample point. This is because nitrate is stable over a range of conditions but nitrite rapidly volatilizes in oxygenated water. Ammonium is a dangerous pollutant in rivers, because the bacterial conversion of NH_4 to NO_3 robs the river of oxygen.

Nitrate is the only reported form of nitrogen for this study. Nitrite does not withstand long storage times and is difficult to process for large sample sets such as in this study; nitrite is therefore not included here.

Nitrate concentrations are very low (less than one ppm) for most of the Ausable. Two exceptions are samples from Whiteface Brook at Whiteface Mountain Ski Center and Palmer Brook in the hamlet of Au Sable Forks, Town of Black Brook.

The data at Whiteface Brook does not indicate an organic source such as fertilizer (a combination of phosphorus, nitrate, and potassium). Other possible sources of nitrate are chemical additives introduced in ski area operations. Whiteface Mountain Ski Center does not use chemical additives in its snow making operations, but the New York Ski Education Foundation (NYSEF) did utilize nitrogen in the form of urea for hardening snow on race courses during some alpine race events prior to 2011. The practice has since been halted. Urea, CH_4N_2O, is highly soluble in water and when dissolved becomes ammonium (which oxidizes to nitrate) and carbon dioxide. Levels of 5 ppm nitrate are not harmful to the ecosystem, but urea is a concern and the source of nitrate in Whiteface Brook may need further consideration. AsRA staff will resurvey Whiteface Brook in 2016 to ascertain current nitrate levels.

Concentrations of nitrate and phosphorus in Palmer Brook are also elevated in several months. The combination of these two anions suggests nutrient loading from an organic source, or from fertilizer usage in the Palmer Brook subwatershed. Levels of 5 ppm Nitrate are probably not harmful to the local aquatic ecosystem; however, providing education on non-point source pollution prevention and septic maintenance to Black Brook residents will help them better protect local waterways.

Summary: Water quality remains good in the Ausable watershed, but the presence of several pollutants raises concerns which, if not addressed, could become larger problems. These include spring pH levels, chloride levels in the East Branch, phosphorus from urban areas and sediment runoff, and nitrate from winter snow sports and organic sources.

Ongoing Monitoring

AsRA is involved in several monitoring programs to understand issues facing the river and associated streams and lakes. Water temperature, dissolved oxygen, conductivity, and pH are measured at 21 locations on a bi-weekly basis to identify challenges to water quality as they occur (Map 5). Measures of temperature and dissolved oxygen provide a basic understanding of the river's ability to support fish and show when thermal conditions negatively impact specific species, such as brook trout. Conductivity measurements help to track chloride and phosphorus concentrations in the river. Elevated phosphorus levels often indicate faulty septic or sewage systems. Elevated chloride levels, a likely result of winter road maintenance practices, negatively impact the aquatic food web (Meador & Carlisle, 2007; Kelting et al. 2012; Palmer & Yan, 2012; Dalinsky et al., 2014).

AsRA has also partnered with the Adirondack Watershed Institute (AWI) to install two long-term monitoring stations on the Chubb River. One is located near Averyville Rd., the other just below the Village of Lake Placid's wastewater treatment facility. These stations continuously monitor the river's height, temperature, and specific conductance. Water samples collected from these locations are processed at the AWI lab on a bi-weekly basis, for two years starting in the fall of 2015, so that chloride concentrations and other pollutants can be tracked hour by hour.

As part of the collaborative Adirondack Lake Assessment Program—an effort supported by the Mirror Lake Watershed Association, the Town of Wilmington, NYS DOS, and private donors—AsRA is also monitoring water quality in Mirror Lake, Lake Everest, Taylor Pond, and Butternut Pond. Water samples from each lake are collected during the summer months, along with vertical profiles of temperature, dissolved oxygen, specific conductance, and pH. These data help chart the impact of phosphorus, road salt, and climate change on watershed lakes.

AsRA has placed 13 temperature data loggers in the Ausable River to provide a continuous measure of water temperature. Warm water seriously threatens the survival of many native Adirondack species, notably brook trout. Given the challenges posed by global climate change, the goal is to understand where waters are warming, whether stream restoration efforts have a cooling effect, and the long-term suitability of the Ausable and its tributaries as habitat for brook trout. Partnership efforts coordinated by AsRA to increase connectivity in small streams, by replacing undersized culverts that block fish passage to cooler upstream waters, also rely on this data.

Summaries of this ongoing data collection are available on AsRA's website: www.ausableriver.org.

3.8 Flooding

In terms of geology and hydrology, periodic flooding is a maintenance system for rivers such as the Ausable. All rivers move, up and down and side to side. They shift their flow and form, sometimes spreading out, altering their meander bends, and sometimes returning to old channels. Rivers routinely do all this within their floodplains, those flat areas to either side of the channel, when they are not blocked from accessing them. Using current technology, floodplains are relatively easy to calculate or map from the air—and just as important to maintain, restore, and plan for, as river channels.

Floodplains are also enticing places to build and fertile areas to farm—and this was especially true when the Ausable valley was settled over 200 years ago. As a result, a preponderance of watershed communities, roadways, and critical infrastructure—including homes, businesses, emergency services, and wastewater treatment facilities—lie in the Ausable River's floodplains. New development in these floodplains adds to the challenge of flood preparedness and response and emphasizes the need for local communities to adopt and enforce strong floodplain development regulations.

The combination of floodplains and development can be devastating for communities, individuals, businesses, and for the ecology of the river and its ability to support trout and other species. Until recently, responses to flooding tried to control the flow of water by armoring and straightening channels, digging out sediment, and building protective berms—doing little to reduce the negative impacts of the next flood (in some cases, even worsening them), and creating further disequilibrium in the river.

Instead, we can use our knowledge of hydrology, geology, and engineering to look closely at our infrastructure and how we manage or hem in the river, finding ways to give it room to slow down and spill flood waters, using its floodplain fully, identifying and alleviating pinch points—places where road infrastructure cuts the river off from its floodplain, forcing water to speed up and carve new channels. Pinch points can be caused by bridges and culverts, raised roads that block access to floodplains, or other infrastructure that cannot manage storm-level flows. Many climate models predict more frequent severe storm events, increases in annual precipitation, and mean lake levels rising by up to two feet by the end of this century, so what we regard as record floods could be the new norm in the future.

A partnership coordinated by AsRA including The Nature Conservancy, the US Fish & Wildlife Service, NYS DOS, Essex County Soil and Water Conservation District, and several towns along the East and West Branches, has begun replacing undersized culverts along tributaries to the river. Appropriately situated and sized to a stream's morphology (its pattern, dimension, and profile), culverts protect property, infrastructure, and ensure passage for fish. Studying recurrent pinch points where state roads cut off some or all floodplain access (e.g. alongside Marcy Field in Keene Valley, or just south of the Upper Jay bridge), and places where undersized bridges are frequently the source of debris jams (e.g. Stickney Bridge in the Town of Jay) is critical. New York Rising, an effort spearheaded by the Governor and NYS Department of State in 2013-2014 brought additional planning resources to the East Branch Towns of Jay and Keene, worst hit by Tropical Storm Irene, to explore and undertake projects that build resilience to future floods.

Floods arising from a variety of causes have been recorded in all seasons throughout the Ausable watershed. Floods frequently occur in the early spring, when substantial rains combine with rapid snowmelt to produce heavy runoff. Major floods from significant rainfall in short periods, such as occurred in late August of 2011, when Tropical Storm Irene dumped seven or more inches of rain throughout the watershed in less than 24 hours, are relatively infrequent. Seasonal flooding in the region is often caused by spring ice jams.

Ice jams can happen anywhere along the Ausable, as is the case on many north-running rivers, where southerly upstream flows often melt before areas downstream. But they occur with greatest frequency in three areas, all heavily modified, widened, and deforested over the course of human settlement—from the straightening of channels for log drives in the 19^{th} century to the annual dredging of the mid-20^{th} century: upstream of the Route 9N bridge in Upper Jay and of Stickney bridge in Jay, along the East Branch, and downstream of the confluence in Au Sable Forks, where considerable sediment is inevitably deposited. Where the river is cut off from its floodplain by road infrastructure, or pinned in place and deprived of its ability to move and bend, such conditions are difficult to resolve.

Flooding will always be a fact a life in the Ausable watershed. That said, its impacts can be minimized considerably by hydrologically informed re-engineering of select infrastructure, together with planning initiatives that keep future development out of the floodplains, and efforts that allow the river to move naturally through populated areas and around roadways, slowing and storing flood waters.

IV—Land Use & Stream Management

4.1 Introduction

Human and geological history, current water quality, species populations, and the total mileage of paved roads in the watershed are, for the most part, givens. They help us understand the condition of the watershed and why we find it in its present configuration. We can't change the history of the Ausable watershed, but we can make wise decisions about how to move forward. How can we use land prudently and effectively with minimal negative impact on the river we rely upon? How can we ensure our waters remain safe; that fish, wildlife, and forests flourish; and that the beauty of the watershed remains for generations to come? Can thoughtful assessment of current management strategies increase their effectiveness? Where is there room for improvement?

This review of land uses, development patterns, and management practices now in place in the watershed attempts to answer these questions. Far from being a wilderness sealed off from humans, the Ausable valley is defined by and relies upon a balance between human activities and ecological health—between our use of land and water and the integrity of the river and its watershed. This section reviews the current composition of land uses and management practices, and the role of soil in determining water quality. Over the course of several years, AsRA's staff, with the help of many volunteers and partners, has walked streams, forests, and roads, collected information on stormwater runoff, eroded banks, winter road maintenance practices, culverts, wastewater management, and more. Each of these challenges to water quality and balanced management is discussed in detail and forms the basis for the recommendations presented in Chapter VIII of this report.

4.2 Land Use and Development

Land use and development have a tremendous influence on water quality. How fast snow melts and rain runs off the surfaces it lands on, how much water runs off, what soils or chemicals it takes with it, and the patterns in which it moves—all these factors affect water quality and public safety. Forests, wetlands, and grasslands soak up and filter water, while pavement, roads, roofs, parking lots, and other impervious surfaces repel it. A one-acre paved parking lot generates 16 times more runoff than a meadow of the same size (Schueler, 1995). The resulting runoff pools and leaves the parking lot in a concentrated stream, often carrying automotive oil and sediment.

How land is used also affects the flow and quality of water and its power in a storm event. As hamlets expand and new homes and businesses are built, it is important to minimize impervious surfaces, maximize native plantings and tree cover—especially streamside, in riparian buffer zones—and to install catchment basins to slow flows and allow water to soak into the ground. Planning for both residential and commercial development should take into account water flow off impervious surfaces, movement and filtration of wastewater, increased road traffic and the need for new roads, to ensure clean water and responsible growth. Current land use/land cover in the Ausable watershed, drawn from 2011 data, is detailed in Map 8.

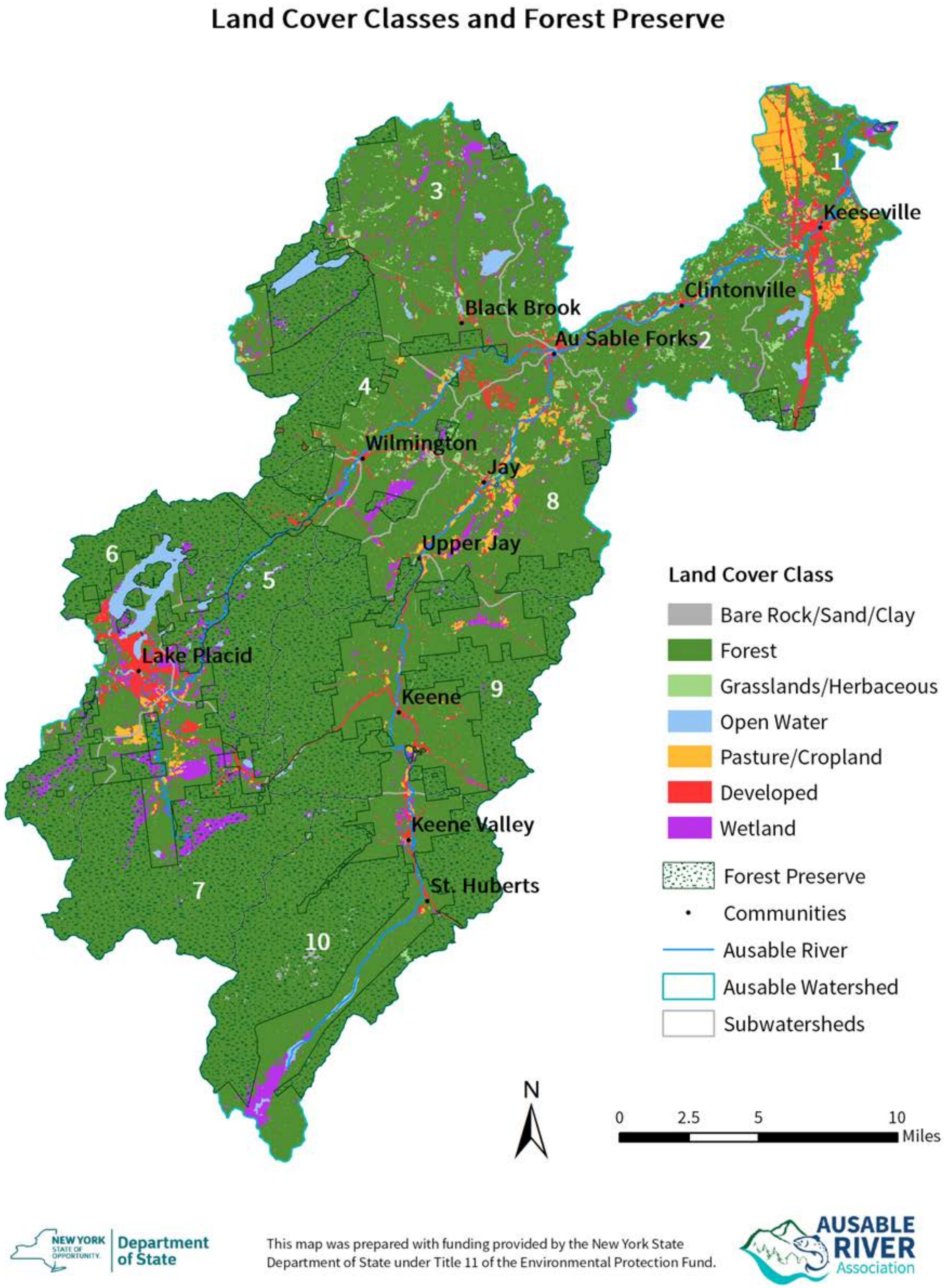
The 512-square-mile Ausable watershed is predominantly forested: 86.3%. Roughly half these forested lands are within the NY State Forest Preserve (Map 8) and are thus kept "forever wild," and protected from development by New York State's Constitution. River health benefits from these large areas of protected dense forest, especially along the steeper headwaters.

Established healthy forests experience low rates of runoff so soil erosion is minimal, with very little nutrient runoff. They also provide cooling shade, a critical element for high quality trout waters.

The remainder of this forested area (just under half) is on private lands. Varying degrees of development or land management practices that change the composition of the forest (timber extraction, thinning along streamsides, residential development) can occur within these forested areas. As a result, the chances of erosion, nutrient runoff, and bank instability can increase. On private forestry lands, adopting current best practices for forest stewardship help working forests maintain many of their ecological functions. On other private lands, efforts to increase public awareness about the impacts of land management decisions for water quality can help to protect the watershed.

Wetlands cover 4.3% of the watershed, while open waters cover 3.8% (41 sq. mi. combined). This includes Lake Placid, Mirror Lake, Upper and Lower Ausable and Cascade Lakes, Taylor Pond, and Fern Lake, and many other lakes, as well as all associated streams and dammed portions of the river. Even the smallest ephemeral wetlands are important for filtering water and absorbing floodwaters. The amount of land covered by open water and wetlands is greatest along the West Branch; this may contribute to reduced impacts from flooding there.

Urban areas currently cover 3.5% of the watershed (18 sq. mi.). This includes one incorporated village, ten hamlets, roadways, and large developed areas such as the state-owned Whiteface Mountain Ski Center and Mt. Van Hoevenburg cross-country skiing facilities. In terms of urban development potential, 13.3% of the watershed is classified as either hamlet (2.1%, with no limit on density), moderate intensity (2.1%, 500 buildings per sq. mi. with average lot size of 1.3 acres), or low intensity (9.1%, 200 buildings per sq. mi. with average lot size of 3.2 acres), according to the Adirondack Park Agency (APA) Land Use and Development plan (Map 2). The APA plan also designates state intensive use lands of 1.2% in the watershed and less than 1% of lands for private industrial use. Private land ownership dominates the lower portions of both branches of the Ausable and its Main Stem (Map 2).



MAP 8. An overlay of NYS designated Forest Preserve and USGS (2011 NLCD) determined land cover classes.

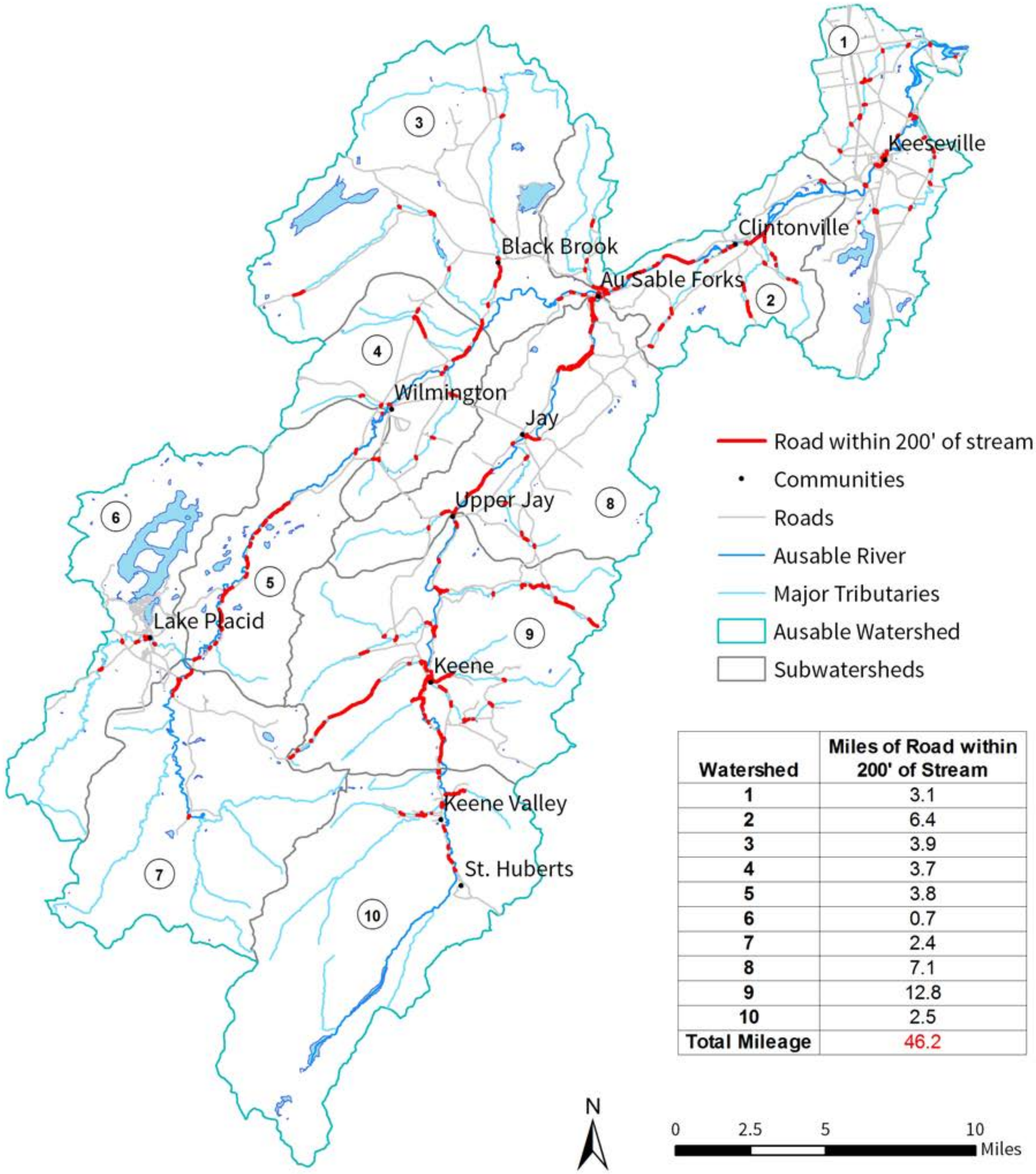
Cropland and pasture currently cover 2.1% of the watershed (10 sq. mi.). The APA plan allocates 16.5% of the watershed to its Rural Use category, which includes cropland, livestock, other agricultural, and compatible residential use (no more that 75 buildings per square mile, with an average lot size of 8.5 acres). Agriculture can have a significant impact on water quality. Nutrient runoff from cropland and livestock areas contributes to phosphate loading, eutrophication of surface waters, and other unintended impacts. Runoff impacts don't stop with the Ausable watershed, but go on to affect water quality in Lake Champlain.

While the total acreage of agricultural land uses in the watershed may be small, it has been increasing in recent years—a result of the success of community-supported agriculture and the expansion of larger farms based outside the watershed purchasing and converting available land in the Keeseville area. The potential impacts of these larger operations (land clearing, installation of subsurface drainage) merit further attention. Otherwise, farms are generally small, as are livestock operations (cattle, elk, horses, and alpacas). Both the Essex and Clinton County SWCD offer guidance and assistance to local farmers to ensure sound management practices are in place. Best management practices for agricultural land include livestock exclusions, manure management, and no till cropping.

It is an artifact of the region's history that the areas of most intensive development in the watershed are located alongside the river. Main arterial roads also hug the river (Map 9), meaning road design and management practices often have direct and immediate impacts on water flow and quality. Once the river descends from its mountain headwaters and leaves the protection of the Forest Preserve, streamside or riparian forest cover is patchy. This is especially true on the entire Main Stem, on the West Branch in the Town of North Elba surrounding Lake Placid, and throughout the Town of Jay along the East Branch (Map 10). The only segment of the Ausable River surrounded on both sides by state forest is the West Branch between Lake Placid and Wilmington. But this same segment is paralleled closely by State Highway 86, which minimizes the protection forestland affords.

Development presents challenges to water quality and the broader Ausable River ecosystem. But residents, municipal leaders, and those who care for the natural beauty of the watershed know that a balance between a healthy river system and thriving communities can be struck. Every watershed citizen, every municipality and government agency, can contribute towards good stewardship of the land. Thoughtful land management involves maintaining septic systems, protecting against erosion by reducing bare sediment, collecting and filtering runoff from roads, parking lots, and roofs—all help to maintain clean water for the health of watershed citizens and the river on which they rely.

Roads Alongside Streams



Watershed	Miles of Road within 200' of Stream
1	3.1
2	6.4
3	3.9
4	3.7
5	3.8
6	0.7
7	2.4
8	7.1
9	12.8
10	2.5
Total Mileage	46.2

NEW YORK STATE OF OPPORTUNITY. | Department of State

This map was prepared with funding provided by the New York State Department of State under Title 11 of the Environmental Protection Fund.

AUSABLE RIVER Association

MAP 9. Where roads run within 200' of streams, road maintenance practices directly affect water quality and stream structure. These practices include winter deicing, roadside mowing, stormwater management, such as ditching, and attempts to protect roads by hardening shorelines or building berms to block water from floodplains.

4.3 Soils and Water Quality
Mountainous terrain with deep valleys contributes to a diversity of soil types within the Ausable watershed. Understanding these soil types and how they interact with water is critical to assessing land management practices and development impacts. Soils are also critical to understanding erosion and stormwater flows. Understanding soils, in short, is essential to managing water quality.

The effect of soils on water quality is most strongly influenced by permeability—the ability of a soil to transmit water. Given the diversity of soil types, most analyses rely on a common classification system maintained by the Natural Resources Conservation Service of the US Department of Agriculture. These Hydrologic Soil Groups divide soils with similar porosity and runoff potential into four categories. Sandy soils, classified as "A" type soils, have high permeability, meaning water soaks through quickly. Sandy soils are easily eroded, and when left bare, through natural processes or human activities, are susceptible to high erosion rates that generate large volumes of sediment pollution. At the other end of the spectrum, clay soils have very low permeability, and water pools on top or soaks through very slowly ("D" type soils).

Soil permeability influences water quality. In areas of "A" type soils, septic systems and leach fields can cause groundwater pollution if not maintained. Leachate from septic systems may also find its way to a stream or river. Low permeability "D" type soils generate large volumes of surface runoff and may contribute to contaminants reaching surface waters.

Within the Ausable watershed, type "A" soils cover much of the valley bottom (Map 10). These occur in the East Branch valley from St. Huberts to the hamlet of Keene, in the Norton Brook stream valley, and between Upper Jay and Ausable Forks. Type "A" soils cover the West Branch valley from Marcy Pond to Basset Flats. The Main Stem valley is completely filled with sandy soils except for a lenticular occurrence of type "D" soils south of the river, downstream of Clintonville. The valleys of Black Brook and Big Brown Brook are also filled with type "A" soils. Within areas with type "A" and "D" soils, septic systems, roads, and ditches, should be maintained with special care, and ecologically sound development practices followed closely, in order to minimize impacts to the river and groundwater.

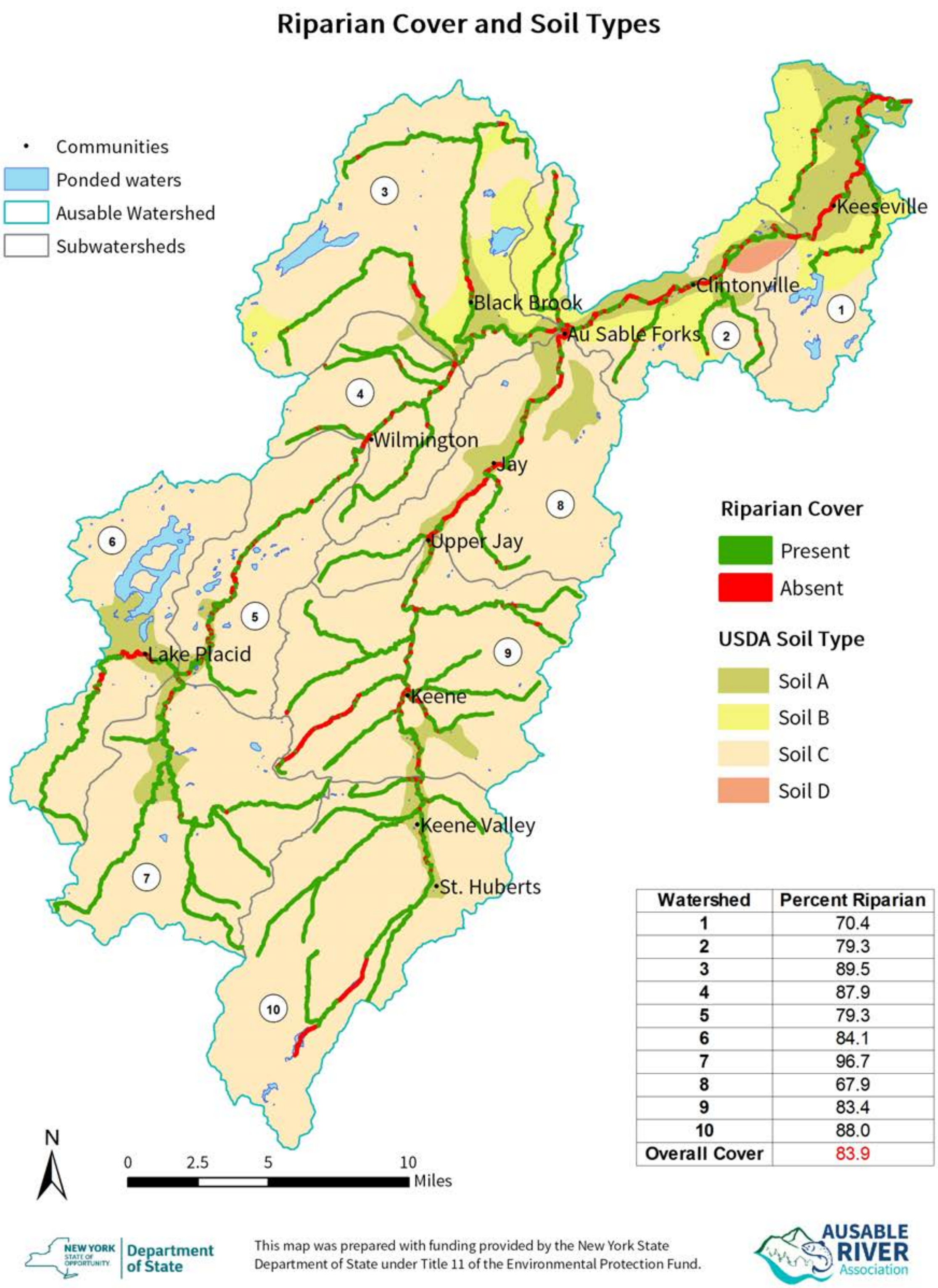
Type "C" soils (sandy clay loam), dominate the higher elevations of the Ausable watershed. For the most part, type "C" soils present fewer wastewater disposal and development challenges, but erosion and both water and sediment runoff can be high in these soils once they are saturated with water—as in a storm event. Thus, in a region prone to concentrated rainfall, deep snow, and flooding, even with "C" type soils, development can cause soil loss and generate sediment pollution to streams. Careful planning can go a long way to minimize erosion, preserving water quality and habitat.

4.4 Stormwater Runoff
Stormwater runoff from roads, driveways, parking lots, rooftops, and other impervious surfaces collects and moves quickly, often with greater force than the precipitation it collects, eroding soils and picking up sediment, debris and pollutants as it makes its way to local streams, wetlands, lakes, and finally to the river. When drainage is poorly planned or impaired, sediment, nitrogen, phosphorus, bacteria, pesticides, oil, and trash flow into local waters without the benefit of natural filtration.

The EPA ranks urban runoff and storm-sewer discharges as the second most prevalent source of water quality impairment in our nation's estuaries, and the fourth most prevalent source of impairment in lakes in the United States (US EPA, 1998). In other parts of New York State, stormwater runoff from developed areas is the leading cause of beach closures, primarily because of bacteria. In the Adirondacks and the Ausable watershed, where dense snowpack develops at higher elevations, snowmelt plays a similar role in the transfer of pollutants to local waters each spring. Stormwater runoff compromises fish and wildlife populations, kills native vegetation, degrades water quality, and reduces the recreational value of rivers, lakes and streams. Stormwater can be managed to reduce these threats, but this requires thoughtful planning, implementation, and management by municipalities and watershed citizens.

In response to 2003 revisions to the Federal Clean Water Act, NYS DEC regulations address stormwater threats in new development, but no state or federal laws regulate runoff from existing roads, subdivisions, or communities in the Ausable watershed. Construction activity can dramatically increase sediment and pollutant delivery to streams, degrading fish habitat, compromising the clarity and recreational use of waterways, and increasing the costs of maintaining drinkable water. Such activity is regulated when it disturbs more than one acre of land. To reduce stormwater pollution from existing roads, the first step is to identify locations where overland flow, ditches, culverts, and bridges discharge runoff into surface waters—"outfalls"—then develop and implement sustainable solutions that protect the river and adjacent communities.

Reducing the amount of stormwater that reaches the Ausable River is one of the highest priorities of the Ausable River Watershed Management Plan. In order to locate and assess stormwater entry points along the river, AsRA and Essex County SWCD conducted an inventory of stormwater outfalls on roadways adjacent to the river. Clinton and Essex Counties also participated in a project to identify erosion areas along roadways that generate large amounts of sediment pollution. The results are summarized below.



Watershed	Percent Riparian
1	70.4
2	79.3
3	89.5
4	87.9
5	79.3
6	84.1
7	96.7
8	67.9
9	83.4
10	88.0
Overall Cover	83.9

MAP 10. Ample riparian cover is critical to absorbing flood flows and protecting streambank stability, community infrastructure, and wildlife habitat. Tree cover also reduces water temperatures through shading, and cooler waters are essential to cold-water fish, such as brook trout.

Stormwater Outfall Inventory

Town, county, and state roadways parallel much of the Ausable River and many of its larger tributaries. And most of the settled areas—including nine hamlets and one incorporated village—are located along the banks of the river. Most county and town roads lack stormwater infrastructure or sediment and erosion controls and rely on ditches and gutters to carry stormwater off the roads. Improving stormwater infrastructure, monitoring the effectiveness of current systems and any changes in water flow, as well as consistent maintenance of existing systems, are all critical to the effective management of stormwater. The development of stormwater management regulations falls primarily to towns and villages in New York State; as detailed in Chapter VI, with few exceptions, most Ausable watershed towns lack rigorous regulatory frameworks that effectively protect and enforce runoff and water quality.

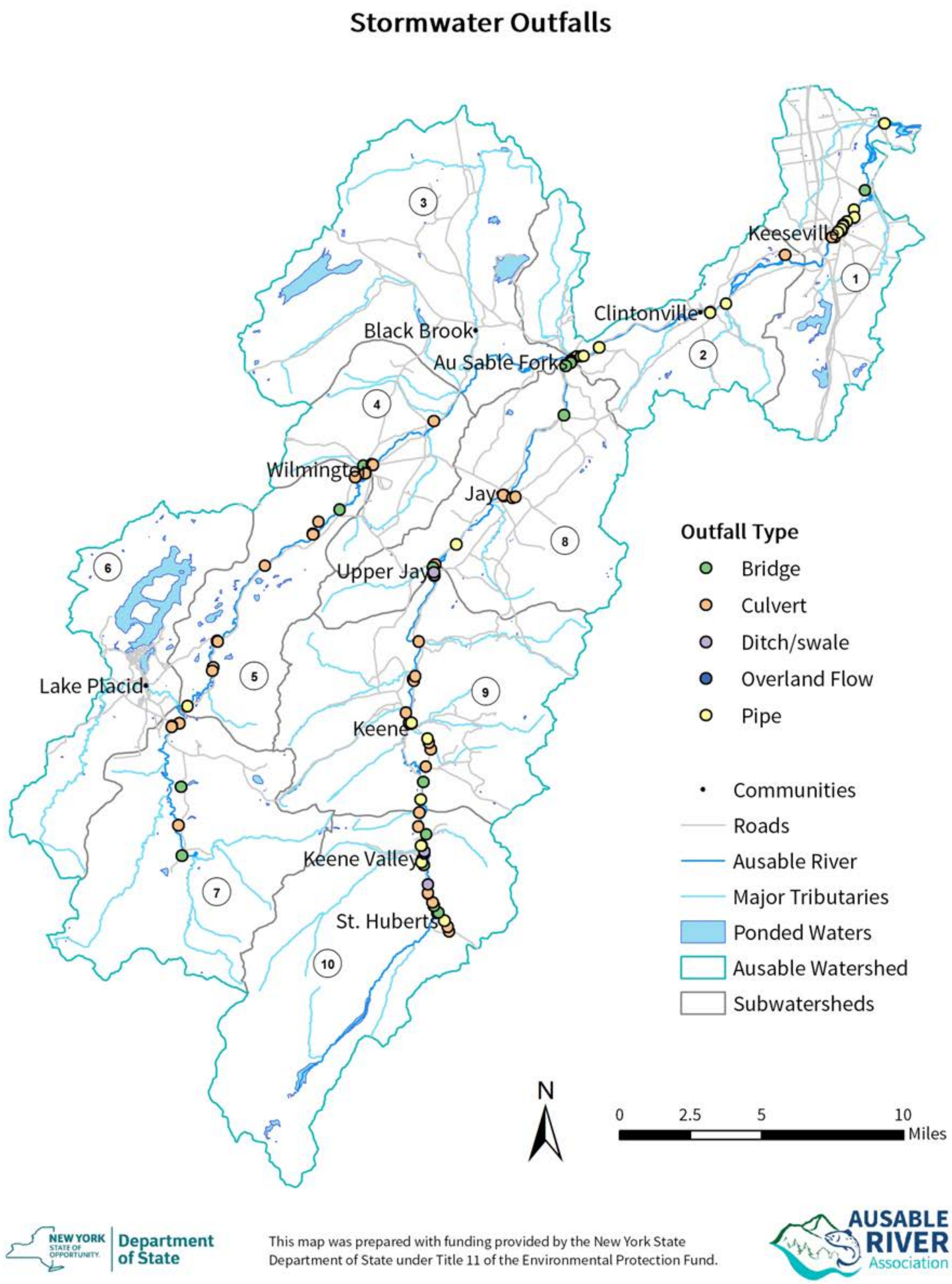
On the West Branch, roads closely parallel 47% of the 35 river miles, and there are 29 outfalls that enter the river (0.83 per mile). River Road (Essex County Road 23), State Route 86, and Hazelton Road in Wilmington make up 16.4 miles of roadway adjacent to the river. Adirondack Loj Road passes over the river and its tributaries at three locations. Specialized sediment separating systems, or hydrodynamic separator units, have been installed in four locations along the West Branch to capture stormwater runoff before it is discharged into the river. These large, underground concrete structures are designed so stormwater swirls inside them, releasing sediment from suspension to collect in the bottom of the system. Floatables and trash are also separated and remain in the concrete box. The filtered water is then discharged back into the stormwater conveyance system. Two hydrodynamic separator units are operating at the Whiteface Mountain Ski Center bridge. Installation of these units resulted from a watershed planning effort guided by AsRA and funded through a Local Watershed Revitalization Program grant (LWRP) with funds from the NYS Environmental Protection Fund (EPF). Two more are located at the Route 86 bridge in Wilmington (rebuilt in 2015).

Of the 32 miles of the East Branch, 21 miles (60%) have roadways adjacent—predominately state highways (Routes 73 and 9N). Of the 49 roadway outfalls along the East Branch (1.5 per mile), none is fitted with a catchment or filtering unit.

The Main Stem has a state road (Route 9N) alongside 21 miles of river (40% of its length). Twenty-three outfalls occur within this 21 miles (1.09 per mile). The highest concentration of outfalls is in Au Sable Forks, on the Clinton County side, and in Keeseville. None is fitted with a functioning catch basin or filtering unit.

Stormwater sewer systems are installed in the Village of Lake Placid and the former village of Keeseville (dissolved at the end of 2014) and along state roads where they pass through these communities. Storm drains that discharge directly into the river without filtering sediment capture stormwater from these roads.

Table 2: Road Proximity and Outfalls by Branch			
	West Branch	**East Branch**	**Main Stem**
Length of river adjacent to roadway	47%	60%	40%
Roadway, river length, and number of outfalls	Loj Road, 7 miles, 3 outfalls River Road, 4 miles, 5 outfalls Route 86, 9.3 miles, 18 outfalls Hazelton Road, 3 miles, 2 outfall Route 9N, Bridge in Au Sable Forks	Route 73, 7 miles, 27 outfalls Route 9N, 14 miles, 22 outfalls	Route 9N, 9 miles, 27 outfalls
Total number of outfalls/river mile	29/35	49/32	23/21
Density of outfalls	0.83/mile	1.5/mile	1.09/mile



MAP 11. AsRA completed a stormwater inventory of the Ausable River corridor in 2010.

The outfall inventory identified six areas where runoff from stormwater outfalls have the greatest impact on the river: in the hamlets of Keene Valley, Upper Jay, Wilmington, Au Sable Forks, and Keeseville, and the Village of Lake Placid.

Hamlet of Keene Valley

Town roads within Keene Valley lack stormwater infrastructure but, with a few exceptions, most of the outfalls do not present issues of current concern. One exception occurs where State Route 73 passes through the hamlet, where state road drop structures capture stormwater. The outfalls to these are into John's Brook near the Ausable River. Stormwater from Route 73 from the site of the Valley Grocery north to John's Brook is conveyed through pipes and discharges at John's Brook, drops and sumps catch sediment at the intersection. A hydrodynamic separator unit was installed here in 2016.

Stormwater-related flooding creates problems where town and state roads intersect in the center of the hamlet. Town road runoff can overwhelm drop structures on the state road meant to convey only highway runoff. This happens most frequently at the intersection of Adirondack Street and Route 73. The outfall from this section empties onto private property. The combination of collected stormwater and flow off Adirondack Street inundates portions of private roads. This flow reaches the river untreated, as is the case with many outfalls in the watershed.

Hamlet of Upper Jay

State Route 9N in the hamlet of Upper Jay has poor drainage, which results in localized flooding and unfiltered stormwater entering the East Branch. Problems arise where uncontrolled runoff from Springfield Road (Essex County Road 83) collects in a paved ditch at its intersection with Route 9N. An inlet here is frequently overwhelmed by sediment from winter road maintenance and from a steep, unpaved driveway uphill. This debris is conveyed through a pipe under Route 9N, where it drops into the river shortly downstream of the highway bridge on private property. Higher up Springfield Road, sediment-laden runoff is directed by a galvanized gutter into a wetland on private land some 200 feet from Lewis Brook, a tributary to the Ausable River with a native book trout population. A remedy to these stormwater drainage issues was proposed in the 2014 New York Rising Community Reconstruction (NYRCR) plan, led by the Governor and NYS DOS. It included installation of stormwater infrastructure along 2400 feet of Springfield Road and across the intersection of Route 9N that would reduce icing and flooding on the road and mitigate sediment, nutrients, yard and road pollutants entering the river. AsRA was represented on the NYRCR Planning Committee and shared key findings, such as the Springfield Road stormwater issue, from an earlier draft of this watershed management plan. The estimated cost of installing stormwater infrastructure along this section of Springfield Road was just under $1 million.

Hamlet of Au Sable Forks

In the hamlet of Au Sable Forks, inlets from State Route 9N are piped to the East Branch and outfall downstream of the Grove Street bridge. Town of Jay roads in some parts of the hamlet are higher than the adjacent house foundations and yards. Runoff from streets quickly floods these yards and basements because of the lack of stormwater controls or absorption fields. The Town of Jay is working with consultants, members of the public, and AsRA to address these issues and others via a NYS DOS-supported Long-Term Community Recovery planning effort focused on the hamlet.

Village of Lake Placid

The Village of Lake Placid, with the encouragement of the Mirror Lake Watershed Association, has been proactive in installing hydrodynamic separator units for stormwater from the streets around Mirror Lake. The village and the Town of North Elba have retrofitted some of the stormwater inlets around Mirror Lake to flow through these units. Significant portions of the roadway along Mirror Lake still lacks infiltration or filtering structures, and plans to install them remain unfunded.

Mill Pond in the lower Village of Lake Placid has several unprotected outfalls with large sediment deltas at their end points. A hydrodynamic separator unit was installed on private property just upstream of one of these outfalls, but it is regularly overwhelmed and a sediment delta at the end of this pipe grows annually.

Sand from winter road maintenance washes uncontrolled off Mill Pond Drive into Outlet Brook, the eastern outlet of Lake Placid. Once a much loved brook trout stream, it is now choked with sediment. In the past it was deep enough to canoe, but now the channel is ankle deep for most of the year and a sandy island extends into Mill Pond from the mouth of the brook. A similar sediment delta spills into Mill Pond from an unnamed brook that flows under Station Street at the village pumping station and the railroad crossing. The marshy environment created by this deposit hosts a large infestation of invasive purple loosestrife.

In 2009, sediment deltas from village street outfalls were evident at Power Pond, downstream of Mill Pond on the Chubb River. Draining of Power Pond in the summer of 2010 revealed a large sediment delta extending from an outfall on the southern shore, near the intersection of Route 73 and Power House Drive. In 2012, the village received over $1 million from the State of New York to remove the dam below Power Pond and restore the Chubb River. This work, completed in 2014, also facilitated installation of a new sewer line and restoration of about 1,200 feet of natural streambed and riparian buffers, as well as the construction of nearly an acre of new wetlands.

Hamlet of Wilmington

Stormwater flow is one source of the sediment filling Lake Everest, an impoundment on the West Branch. Tributaries of the lake have marshy deltas formed by sediment deposits. Stormwater from State Route 86 and paved and unpaved town roads alongside the river and its tributaries are one source of this fill (Treadwell, 2008).

Recent retrofits using filtration units have alleviated some of the sediment loading. In 2010, a hydrodynamic separator unit was installed by NYS DOT at the inlet on the west side of the Wilmington bridge. Funds were not available at that time for a second unit to filter stormwater coming off Route 86 on the east side of the bridge. Instead, a settling pond was constructed at the outfall, but could not contain the large volume of sediment coming off Route 86 as a result of flooding in early 2011. In response, in 2012, using funds provided by the Champlain Watershed Improvement Coalition of NY (CWICNY) through a US EPA Targeted Watershed Grant, a second unit was installed on the east side of the Wilmington bridge.

Whatever the source of the sediment in Lake Everest, the dam stops it from moving downstream. Sedimentation of the lake is an increasing challenge for the Town of Wilmington. Sediment loads are increasing upstream, forcing the river to form multiple braided channels. Changes to the dam that would allow sediment to flow downstream would minimize deposition, but may be costly. The Town of Wilmington will explore dam modifications with the help of a 2015 grant through an EPF LWRP. Watershed-wide stormwater, sediment, and erosion controls could also alleviate threats to the lake from sediment buildup.

Management practices at the Whiteface Mountain Ski Center parking lots and roads has been a source of ongoing concern. Two hydrodynamic separator units were placed near the western end of the ski area bridge—part of a larger project resulting from the watershed planning effort guided by AsRA and funded through an EPF LWRP—but these capture only a small portion of the parking lot runoff. Dirt surfaced ski area parking lots on the eastern side of the bridge have minimal stormwater controls, requiring annual maintenance. Better diversions and structural controls could help release the pressure on the small catch basins that capture these flows. An existing stormwater management plan may need updating to be more effective.

Hamlet of Keeseville

The hamlet of Keeseville has several stormwater conveyances that empty directly into the Main Stem of the Ausable River. These are on the river's north and south banks, at the bridges on Front Street and Route 9.

4.5 Critical Roadway Erosion Areas

Erosion of soils along roadways can quickly complicate stormwater management, blocking inlets and undermining road infrastructure. From 2010 to 2011, CWICNY conducted an inventory of critical erosion areas along roadways on the New York side of the Lake Champlain watershed. A protocol was established to assess roadside erosion sites based on multiple criteria. Each individual site was ranked as a high, medium, or low remediation priority based on five factors: bank slope, extent of erosion, direct connection to a waterbody or proximity to a stream, percentage covered by vegetation, and site size (LCLGRPB, 2012). Remediation recommendations and their costs were estimated for each site.

The Ausable is one of the largest watersheds in the New York Champlain basin and contains the majority of the roadside areas that need repair. The CWICNY inventory recorded 62 critical erosion areas within the Ausable watershed, with remediation costs totaling approximately $150,000. Several sites require major structural corrective actions, in addition to traditional remediation techniques such as hydroseeding and installation of sediment controls. Ongoing and widespread roadside erosion will require a number of infrastructure and road repairs throughout the watershed.

Ten of the Ausable River critical erosion sites are within Clinton County. Recommendations include a number of fixes including hydroseeding, regrading slopes, large vegetative plantings, check dams, and catch basins. Locations and details on these critical erosion areas are detailed in the CWICNY Report (LCLGRPB, 2012).

Fifty-two (52) of the 62 critical erosion sites lie within Essex County. Recommendations include those listed for Clinton County and also sediment catchment and infiltration basins, stabilizing ditches with stone and gravel, cleaning ditches, repairing roadways, and repaving undermined road edges. Locations and details on these critical erosion areas can be found in the Champlain CWICNY Report.

4.6 Road Maintenance Practices

Discussions of land use often focus on residential development, industry, and agriculture, and less on the arteries that connect them. Roads are essential infrastructure in any community. This network that integrates our communities and supports our economy has a clear impact on water quality. Sand and salt spread on roads for winter maintenance, motor oils, carbon and metal from tires, all wash from roadways into streams, threatening critical habitat and degrading water quality for humans and wildlife. The Ausable watershed includes 140 miles of state, 115 miles of county, and 222 miles of town roads (APA, 2001).

Each town and the two counties in the watershed has a department of public works (DPW) or highway department to maintain the infrastructure and safety of the roadways under its jurisdiction. A local unit of the NY State Department of Transportation (NYS DOT), Region 1, located in Elizabethtown, is responsible for routine maintenance and safety of state roads. The Region 1 office in Albany subcontracts major construction and emergency repairs on state roads to this facility.

<u>Winter Road Maintenance</u>

Adirondack winters are known for their snow, wind, ice, and length; no wonder Lake Placid has hosted two winter Olympics. Due to the severity of winter weather, and perhaps amplified by the value of winter tourism to the local economy, winter road maintenance is an important concern to town, county, and state officials. New York State applies more salt per lane mile than any other state in the country, and uses very little of the alternative de-icing agents now available (Kelting & Laxson, 2010). Salt from winter road maintenance has long been a concern to watershed managers because of its damaging effects on roadside flora, fauna, and local water quality. Nevertheless, the traveling public has come—perhaps unrealistically—to expect clear roads in all weather.

Impacts from winter deicing compounds have been noted throughout the Ausable watershed. The most prevalent effects are seen in Cascade Lakes and Mirror Lake, where chloride concentrations are up to 220 times higher than in lakes with no adjacent paved roads in the watershed (Langen, 2014 Mirror Lake ALAP Report). The Ausable River has elevated levels of chloride; the East Branch tributaries Cascade Brook, Dart Brook, and Norton Brook show the highest levels. Town-owned water wells in Keene were contaminated with chloride. In response, the Town of Keene relocated its public water system and its salt storage facility. In the end, managers must consider whether the long-term ecosystem, scenic, and water quality costs of large-scale salt applications outweigh the short-term costs of effective, higher cost alternatives. Policy options, such as reduced winter speed limits on select roadways, should also be considered.

State roads are treated with 100 percent salt. In most cases this is rock salt, or sodium chloride. Some roadways in the watershed receive applications of coated salt. Sodium chloride coated with magnesium chloride melts ice at a lower temperature, reducing application rates—but adding magnesium to the runoff profile. The state-owned salt shed on Route 73 in the Town of Keene supplies coated salt. The trucks leaving this station treat Route 73 from its southern end north to Bobsled Road in North Elba and Route 9N from the hamlet of Keene north to Au Sable Forks.

NYS DOT tracks the amount of salt delivered to sheds and the amount trucks apply on each route. On-board computerized systems adjust application rates based on weather variables. Checks are in place to ensure spreading rates are within established guidelines.

The towns and counties employ a wide range of winter road maintenance practices from simply plowing, applying a sand/salt mixture, to using pure salt. Winter maintenance on some Essex County roads is subcontracted to the towns and receives the same applications. Clinton County maintains all county roads on its side of the Ausable and uses more salt than the towns.

Each spring, town road crews clean up what remains of the winter sand in order to keep it from choking ditches, to avoid creating safety hazards, and to minimize dust pollution. The sequence of road sweeping is determined by economics and perceived public need, and is completed at the discretion of each town highway superintendent. A more systematic approach geared to protecting water resources might prioritize roads closest to water bodies to minimize the entry of salt, sand and other road waste into the river ecosystem. But cleaning roads by sweeping them can, without care and additional time and expense, lead to a significant amount of sand being pushed and swept directly into adjacent stream systems. Vacuum units exist that would help municipalities capture road sand before the heavy rains of spring, ensuring that it does not enter adjacent waterways.

<u>Ditching</u>

Because of the rural nature of the Ausable watershed, roadside ditches provide the primary means of conveying stormwater, even in hamlets. County and town public works departments maintain ditches alongside roads under their jurisdiction.

County engineers determine ditching and sediment retention practices for county roads. Drainage ditches are cleaned, or scraped as needed. Hydroseeding is sometimes employed as a sediment retention measure. Essex County DPW installs cement check dams in some ditches to slow water during extreme events and also maintains equipment to make sediment logs. Sediment logs are geofabric tubes filled with mulch that are laid across ditches to slow flow and retain sediment. The fabric and mulch encourage vegetative growth, but may require maintenance to avoid new channels forming around them.

Town road crews maintain ditches along town streets and roads as needed. Ditches are routinely scraped to maintain volume and remove sediment buildup. The most common practice is complete cleaning using a toothless grading bucket. Hydroseeding with tackifier and bonded fiber, or stabilizing with rock and gravel, are commonly employed erosion control measures in drainage ditches. Hydroseeding helps reintroduce vegetation for the purpose of slowing flow and capturing sediment. A hydroseeder, purchased by the Essex County SWCD in 2010, is available to towns in the county free of charge; in some cases, supplies and materials are funded by grants. The Towns of Chesterfield and Wilmington have used the hydroseeder for work along their roads. Other town road managers feel this practice decreases the lifespan of a ditch and increases the rate at which cleaning must take place. For this reason, and because budgets and work crews are stretched thin, some towns decline the use of the hydroseeder. The Essex County SWCD staff continues to provide education on its benefits.

In 2014—with assistance from the Lake Champlain Basin Program (LCBP)—CWICNY, local SWCDs, and municipal highway departments throughout the watershed launched a new roadside protection program to provide guidance and assistance to municipalities with issues critical to secondary roads, including ditches. The Rural Roads Active Management Program encourages the use of best management practices to increase the resiliency of infrastructure, reduce erosion, protect natural resources, and save both time and money. Best management practices include lining ditches with rock, installing check dams and cross culverts to reduce water velocity, hydroseeding, and utilizing ditch slurry. Such methods will reduce sediment transport into local waterbodies, while reducing the need for ongoing repair and the associated maintenance costs. Two manuals are available free of charge to local municipalities. Additional LCBP funding has been made available to extend this program and to evaluate the feasibility of establishing a permanent, statewide rural roads program.

Culverts & Bridges

The impact of transportation infrastructure on species and ecosystems is well documented (Forman et al., 2003). Within aquatic systems, roads can significantly alter habitat structure, hydrology, chemical inputs, connectivity for species movement, and ecosystem processes (Jones et al., 2000; Spellerberg, 1998; Trombulak & Frissell, 2000). Where roads and streams meet, culverts and bridges are unavoidable. Undersized, collapsed, or improperly engineered culverts fragment natural stream pattern and ecosystems, contribute to erosion, and exacerbate flooding. They block native fish and other aquatic organisms from moving upstream to the cooler waters and habitat they need to reproduce. High flows forced through undersized pipes scour away soil at the downstream ends of culverts, creating large dropoffs to the streams below. Debris builds up at the upstream ends of such culverts, flooding roads, threatening adjacent property, and requiring costly ongoing maintenance by local road crews. Streambanks at either end are often eroded. Stripped of plants and the root systems that stabilize them, banks collapse, increasing sediment pollution and compromising the habitat of fish and other wildlife essential to a healthy stream.

In response to this nationwide problem—made plain in the Ausable watershed by Tropical Storm Irene in 2011, and exacerbated throughout the country by climate change—a public-private partnership has formed to address the issue in the Ausable watershed. Its goals are to evaluate, prioritize, fund, and retrofit or replace culverts that are high priorities, based on ecological assessment and community needs; and to use the watershed as a model for other such efforts nationwide. Partners include The Nature Conservancy—Adirondack Chapter, the US Fish and Wildlife Service (US FWS), AsRA, county SWCDs, municipal highway departments, town and county leaders, state agencies including the NYS DOS, and landowners.

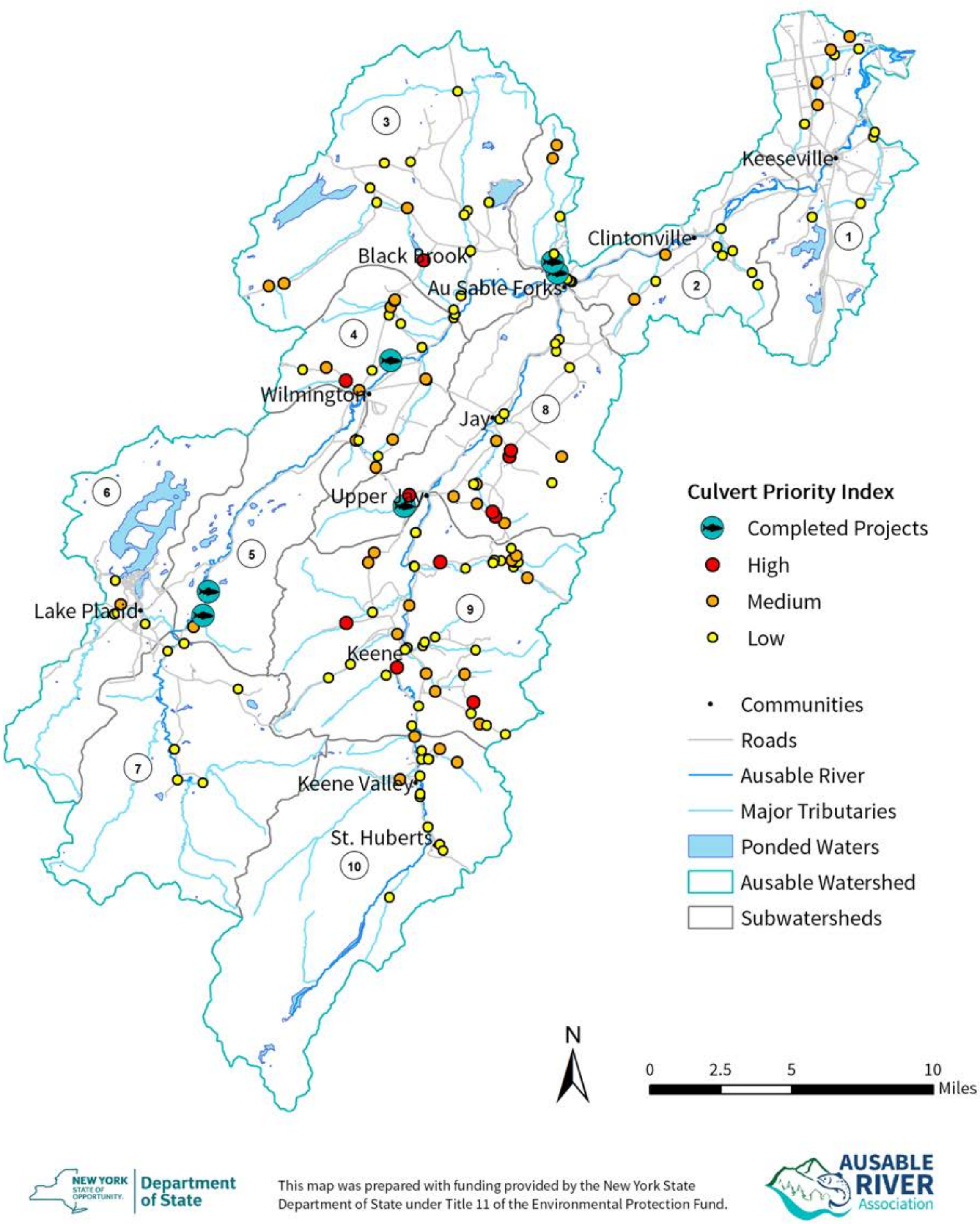
GIS tools developed by The Conservancy in 2010 identified road crossings that might serve as barriers for trout and other aquatic Species of Greatest Conservation Need (as defined by the NYS DEC). Field crews from the State University of New York at Plattsburgh measured stream and culvert dimensions to prioritize those that posed the greatest barrier to aquatic organism passage. Culverts with large outlet drops, shallow water depth, high velocity flows, and those narrower than their associated streams were ranked as low, medium, or high priorities for replacement or retrofitting. Local community leaders then identified culverts that were priorities for replacement, based on their historical flood frequency and potential for damaging public and private infrastructure. These two classifications were combined to create an index of priority culverts for replacement (Map 12).

In the Ausable watershed, 533 stream crossings were identified by GIS as potential barriers to aquatic habitat; of these, 165 were assessed in the field. Sixteen proved to be major fish barriers and community priorities, 43 moderate to high fish barriers but not community priorities, and 106 are not fish barriers or community priorities, or moderate fish barriers but not community priorities.

Between 2012 and 2015, with a combination of private, state, and federal funds, and in-kind donations of time, materials, and machinery by partner organizations, including local towns and counties, this partnership replaced and retrofitted six of the highest priority culverts. Replacement and retrofitting of the remaining culverts that block fish passage is a priority for ecosystem health and public safety and makes good economic sense. Culverts that block fish passage and high stream flows undermine the very roads they are meant to protect. Replacing them with culverts sized at 125% of a stream's width, measured when full to the banks during a periodic flood—known as "bankfull"—will help to eliminate costly road repairs and ensure the safety of the travelling public and travelling aquatic organisms.

State bridge repair and management falls to NYS DOT; any road-stream crossing over 20 feet wide falls under state regulations and requires regular inspection. Since Tropical Storm Irene in 2011, the department has identified many bridges for upgrade or replacement. The goal is to allow for more efficient flow of sediment and debris in the river, especially during flood conditions. There are opportunities for collaboration between NYS DOT engineers and work crews with experienced organizations working on similar issues in the Ausable watershed. Joint efforts may allow for repairs of adjacent bank and stream areas at reduced cost, to protect and improve new or repaired structures.

Priority Culverts for Replacement



MAP 12. Culverts were identified and categorized by The Nature Conservancy, AsRA, and SUNY Plattsburgh starting in 2010.

4.7 Wastewater Management

Each time someone in the watershed washes laundry, uses a dishwasher, flushes a toilet, or takes a shower, s/he relies on a wastewater system to treat the water, chemicals, and waste. It may be a simple septic system behind a home or a municipal treatment plant, but in either case the efficiency and effectiveness of these wastewater systems are essential to public safety and river health.

A patchwork of agencies regulates the treatment and management of wastewater in New York State. Regulatory enforcement is overseen by a series of state, county, and local government offices. Municipal wastewater treatment plants are required to have a State Pollutant Discharge Elimination System (SPDES) permit from NYS DEC. This sets limits for the amount of pollutant that can be discharged directly into surface waters. Plant discharges are tracked daily and reports sent monthly to NYS DEC.

Regulation of onsite wastewater treatment or septic systems (OSWT) falls under several jurisdictions. Any surface water sanitary discharge, regardless of source and flow, requires a SPDES permit. Any groundwater discharge of greater than 1,000 gallons per day, regardless of source, requires a SPDES permit. Any industrial groundwater discharge, regardless of flow, requires a SPDES permit. Private, commercial, or institutional systems (P/C/I) with a volume of less than 10,000 gallons per day (such as hotels, restaurants, schools, and summer camps) may receive P/C/I SPDES general permits.

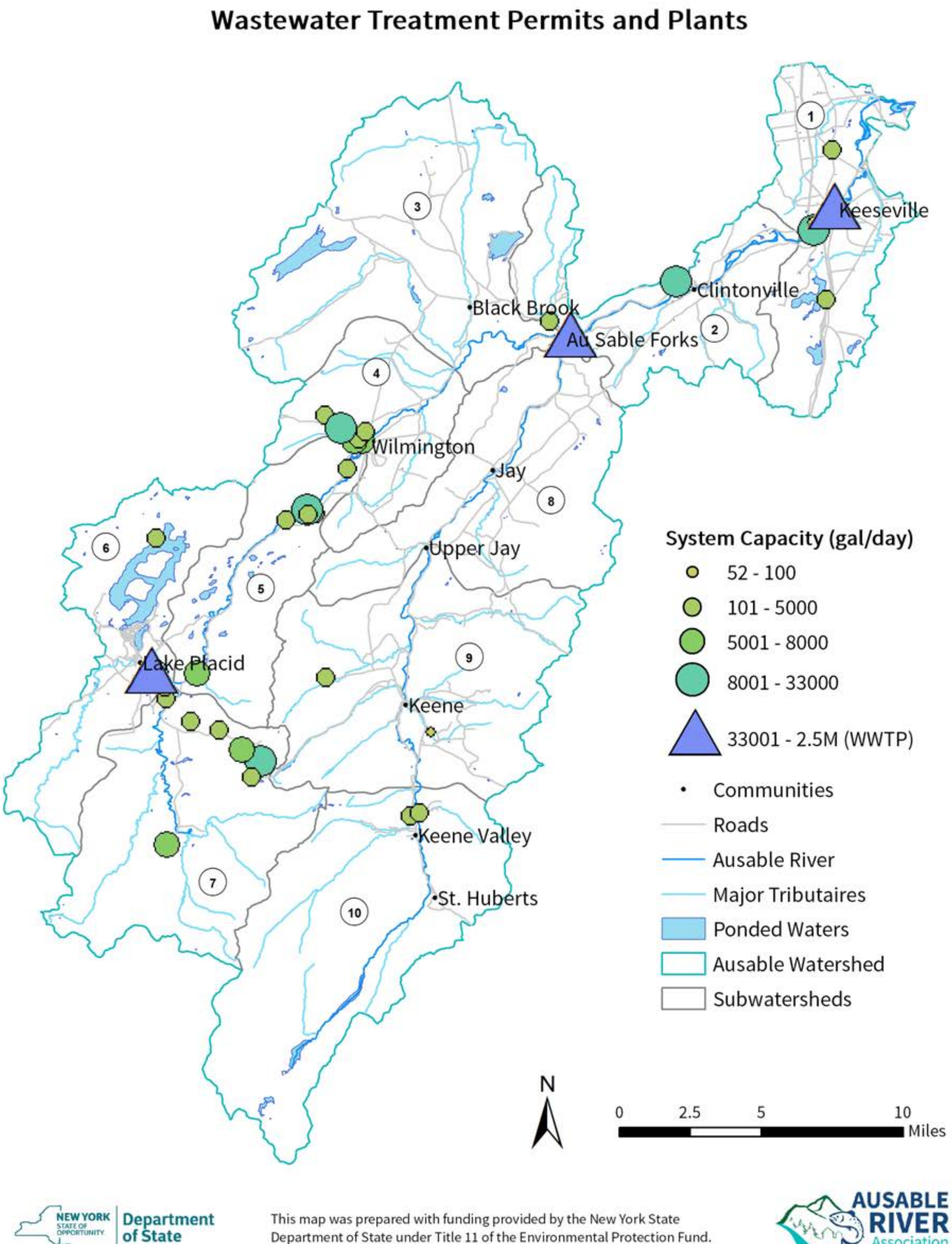
The smallest OSWTs are residential and treat waste from homes not connected to municipal wastewater treatment networks. The NY State Department of Health (NYS DOH) regulates the design and installation of these septic systems, and plans are approved by either a regional NYS DOH office or the appropriate county health department. County health department staff or town code enforcement officers are responsible for inspection of new systems to ensure they are built to plan. The maintenance and upkeep of these systems receives no regulatory oversight, unless a local municipality requires routine inspection and pumping.

<u>Wastewater Treatment Plants</u>

Within the Ausable watershed there are three municipal wastewater treatment plants (WWTP) serving the communities of Lake Placid, Au Sable Forks, and Keeseville (Map 13).

The Lake Placid WWTP was upgraded in 2005, having exceeded its life expectancy. Inflows during the 2002 Ironman event overwhelmed the system, highlighting the need for upgrading the conventional facility—a secondary activated sludge plant with effluent disinfection and phosphorus removal. The new plant is a tertiary system; three steps—settling, digestion, and UV neutralization treat the water before it is discharged into the Chubb River below Power Pond Dam. Since the 2005 makeover, the plant operator has kept discharges within limits defined by the plant's SPDES permit. The WWTP also discharges some water to the Lake Placid Club, where it is used to irrigate the club's golf courses, directly across the river.

In addition to WWTP upgrades, the Village of Lake Placid replaced the combined stormwater and sewer pipes that serve Mill Pond Drive and other neighborhoods. As noted above, the Village received state funding in 2012 to install a new sewer line below Power Pond as part of a wider project restoring this area of the Chubb River, completed in 2014.



MAP 13. Data based on a Freedom of Information Law request in 2015.

A wastewater treatment plant serves residents of Au Sable Forks on both sides of the river and the Clinton/Essex County line in the Towns of Black Brook and Jay. It is located on the south (Town of Jay) side of the river, downstream of the hamlet. The Au Sable WWTP was constructed in 1990, after high levels of e. coli bacteria were discovered in surface waters around the Forks (BRASS, 1996). The plant serves 353 households and businesses in the Towns of Black Brook and Jay and relies on a lagoon system that treats only wastewater. Solid waste is collected in tanks at each residence. Regulations require these systems to be pumped every three years. Each municipality enforces this pumping regulation. Pumping records are available but were not examined for this report. Elevated levels of phosphorus found in water samples taken from Palmer Brook suggest an organic source in this subwatershed that flows through Au Sable Forks in the Town of Black Brook. In addition, in recent years the plant has had difficulty meeting its SPDES discharge limits. The two towns employed AES Engineering to assess the plant and make recommendations for its maintenance, upgrade, or replacement.

The Keeseville WWTP is located on the north bank of the Ausable, downstream of the Route 9 bridge. It serves residents and businesses from both sides of the river in the Towns of AuSable and Chesterfield (the former Village of Keeseville), spanning the Clinton/Essex County line. The plant employs primary and secondary settling and digestion to treat wastewater. AsRA's staff toured the facility in 2010 and was told the plant routinely met its SPDES limits at that time. During heavy rainfall operators note larger receiving flows, but have been able to return the treatment cells to the required limits. An apparent change in river chemistry occurs when the river contains very low flows during dry summer months: the plant discharge/river discharge ratio increases. During these times, elevated conductivity is measured in river water just below the WWTP in Keeseville.

Onsite Wastewater Treatment Systems (P/C/I systems)

Properties with onsite wastewater treatment systems larger than 1000 gallons also require SPDES permits. The locations and size of the 32 systems currently permitted in the watershed are shown on Map 13).

Onsite Wastewater Treatment Systems (Domestic Septic Systems)

Onsite domestic septic systems, properly designed, installed, and maintained, do a good job of maintaining water quality. Improperly maintained or aging septic systems, however, contribute to water quality impairments through surface introduction of nitrogen, phosphorus, pathogens, and pharmaceuticals. The majority of residences in the Ausable River watershed (with the exception of those in Lake Placid, Au Sable Forks, and Keeseville) rely on septic systems.

NYS DOH standards require septic systems be separated by 100 feet from the nearest waterway. To protect water quality in Placid Lake, the Village of Lake Placid and Town of North Elba passed an ordinance requiring the placement of any septic system at least 300 feet from the Lake Placid shoreline.

Two different agencies regulate septic systems within the watershed. In Essex County, the approval of new system installation designs falls to the regional NYS DOH office, located in Saranac Lake. Town code enforcement officers conduct site visits and oversee the installation of new systems. In Clinton County, the county Health Department approves plans and new installations. Centralized record keeping in Clinton County facilitates good septic housekeeping.

Recordkeeping in Essex County is decentralized, making the tracking of water quality protection more challenging.

The knowledge and attitudes of waterfront property owners are important for maintaining or improving the water quality of lakes and rivers. To succeed at minimizing pollution from septic systems, nothing is more critical than property owner maintenance. In 2006, the College of Engineering at St. Cloud State conducted an online surveyed of property owners within the Ausable watershed, gathering data on waterfront properties, including the presence and age of septic systems and owners' perceptions of environmental regulations. Findings from this study include:

- 56% of respondents' properties are served by septic systems.
- 23% of septic systems in use are at least 30 years old.
- 11% of respondents did not know when the last service had been performed on their septic system. A single respondent indicated that his system had not been serviced in over 20 years.

Important gaps in information include the number, location, size, and age of septic systems within the Ausable watershed. Data on septic system impacts in waterbodies is also limited. Paul Smith's College conducted dye tests on septic systems along Lake Everest in the Town of Wilmington. No irregularities in local septic impacts were noted by the study.

AsRA conducted a septic maintenance program in 2009-2010, sharing costs with homeowners. Seventy residents with property adjacent to the river and Lake Everest were offered free inspections of their septic systems and half-price pump-outs. Forty-two septic systems in North Elba, Wilmington, and Jay were pumped. Two failed systems were identified and remediated by their owners.

Of the property owners who qualified for the cost share program, only half participated. A distrust of the regulatory environment and a fear that they might incur further repair costs may have kept others from participating. But the overall success of this outreach effort suggests that a revolving fund dedicated to septic system maintenance and/or replacement could radically upgrade the quality of onsite domestic wastewater treatment and water quality in the Ausable watershed. (Support for septic maintenance is available to low income households through the Housing Assistance Program of Essex County, but it is not focused on the river corridor.)

AsRA's 2009-2010 septic program also funded the placement of portable toilets seasonally along the West Branch. The stretch of river between Lake Placid and Wilmington is one of the most heavily visited in the Adirondacks. Between May and September thousands of anglers, hikers, bicycle and motorcycle riders, and windshield tourists use this stretch of river and the pull-outs along Route 86. There are no public restrooms between Lake Placid and Wilmington, and in the past the streambanks were littered with human waste. Since 2009, AsRA has continued to facilitate a donation-based program to support portable toilets at high use areas on the East and West Branches of the river.

Summary: A large number of OWTS in the Ausable watershed are aging and approaching the limits of their serviceability. Environmental constraints, such as inadequate soils, and the need to service higher density development in areas such as hamlets, highlight the need for some type of centralized wastewater treatment system. Traditional centralized wastewater collection and treatment systems are extremely costly to build and operate and are typically beyond the financial resources of hamlets with limited tax bases.

Small communities within New York State, including Wilmington, are beginning to consider alternative decentralized wastewater treatment systems that do not require large plants with full-time operators. Solids are collected in tanks and low cost, low maintenance treatment cells treat wastewater. A number of companies provide decentralized alternative systems and the Rural Community Development Corporation provides assistance to communities with wastewater problems. A feasibility study for decentralized systems was conducted in Wilmington in 2014 using EPF LWRP funds. Nevertheless, Ausable watershed communities, with their small tax bases and stressed budgets, have not yet chosen to pursue such alternatives.

4.8 Salvage Yards and Junk Storage

Motor oil and other toxic fluids were listed as a suspected pollutant on the Main Stem in the *2000 Champlain Basin Priority Water Body List* and salvage yards listed as a suspected source. The 2007 report delisted this segment of the river, but pollutant threats from salvage yards remain a concern voiced by citizens during the public input portion of this watershed management planning process and in the Town of AuSable's comprehensive plan.

A related concern to citizens is the number of discarded tires in the Main Stem of the river. The Town of AuSable has several commercial salvage yards. One is located on the riverbank in the hamlet of Clintonville. Groundwater pollution has been detected at other uphill yards. The AuSable Junk Storage Ordinance was passed in order to prevent further water quality threats, but in towns where salvage yards are present and where private landowners may keep junk on private lands, rethinking where such storage occurs in relation to flood prone areas is critical.

4.9 Natural Stream Function, Erosion & Restoration

Almost 90% of the Ausable River watershed is forested, but this measure is deceptive as an indicator of wild nature or river health. Historic land clearing, logging operations, and roadway development in the valley altered the physical characteristics of the river, leaving it in what hydrologists consider a state of disequilibrium.

Healthy Streams

In a stable, self-regulating stream or river, the gradual erosion of channels is a natural process that benefits the stream and its riparian ecosystem. Erosion, in this case, is a dynamic process that is critical to the creation of diverse habitats in one stream. To river scientists, this is known as a graded stream in equilibrium (Mackin, 1948; Leopold & Maddock, 1953). Erosion in a stable stream is evenly distributed and therefore minimized; the stream transports the flows and sediment coming from its watershed while maintaining channel dimension, pattern, and profile (Rosgen, 1996). When channel shaping variables change—whether it is an increase in water velocity, channel slope, width, depth, discharge, the size or amount of sediment—a stable river will adjust its form and structure (Leopold et al., 1964). Stable streams in equilibrium minimize flood damage, maintain water quality, and provide habitat critical for diverse healthy ecosystems. Of course it is easiest to find such conditions on rivers that flow wild, with minimal human intervention, but streams flowing through populated landscapes can be managed, and if necessary, restored in ways that keeps them stable and in equilibrium.

Two of the most commonly cited causes for stream instability are land use changes (land clearing or urbanization of the riparian corridor and floodplain) or human alterations to the channel (bridges, rip-rap, dredging, dams etc.). Multiple alterations of a channel over time, combined with significant fragmentation of a stream's valley—reducing access to floodplains, for example—can destabilize a stream, resulting in disequilibrium. When streams are in disequilibrium, excessive erosion occurs in some channel locations, while excessive sediment deposition occurs at others. Some reaches are scoured of beneficial woody debris and sediment, while others may become smothered in sediment, destroying habitat and degrading water quality. Subsequent changes in slope or water depth can lead to damaging erosion of banks and beds. Where stream disequilibrium is prevalent in a watershed, analytes and nutrients (e.g. sodium, phosphorus) found in eroding sediments are released in large amounts, leading to increased pollution of surface waters.

The challenge of maintaining roadways in floodplains highlights the problems caused by disequilibrium. The historic pattern of settlement in the Ausable valley led to the adoption of a roadway system that parallels the river for most of its length and occupies a significant portion of the riparian and flood zones. This contributes to several disequilibrium conditions. Out of necessity, many riverside roadways are protected from erosion with riprap. This hard armoring effectively straightens the channel and passes energy and erosion problems downstream. When meandering rivers are straightened, stream length becomes shorter and slope increases, thus increasing stream power, erosion, and flood potential. Roadways elevated above the river for protection or ease of construction prevent floodwaters from spreading out onto the floodplain, where energy and erosive power are reduced. Confined floodwaters pass downstream more quickly, increasing flood levels downstream and interrupting the river's relationship with its floodplain. Bridges and culverts can also impede full access to floodplains and straighten channels. Bridge spans that are not wide enough limit sediment transport, causing cobbles and debris to build up in the stream, and can be undermined or blocked and bypassed in a major storm. Where erosion or flooding continuously threaten existing communities, recreating stable channels in disturbed streams underpins many other management strategies (e.g. floodplain and stormwater management, riparian revegetation, and replacement of undersized culverts) and is essential to building community flood resilience.

Restoring the Ausable to its presettlement condition is untenable. Local roads and communities are where they are, and their locations are not likely to change appreciably. The goal—using "natural channel design"—is to restore stability based on current conditions, using the hydrology and hydraulics that shape and maintain natural channels (Rosgen, 1997). Carefully planned, compatible improvements can incrementally be made to roads and bridges, reducing river constriction. Properly applied, natural channel design techniques and tools can help to build resilience for the river's human and aquatic communities.

<u>Geomorphic Assessment</u>

All streambanks erode to some degree; it is an ongoing process that is incremental in streams that are dynamically stable and in equilibrium. Accelerated bank erosion is a symptom of a compromised stream, and causes further erosion, sedimentation and changes in channel structure—changes that can threaten human infrastructure and communities.

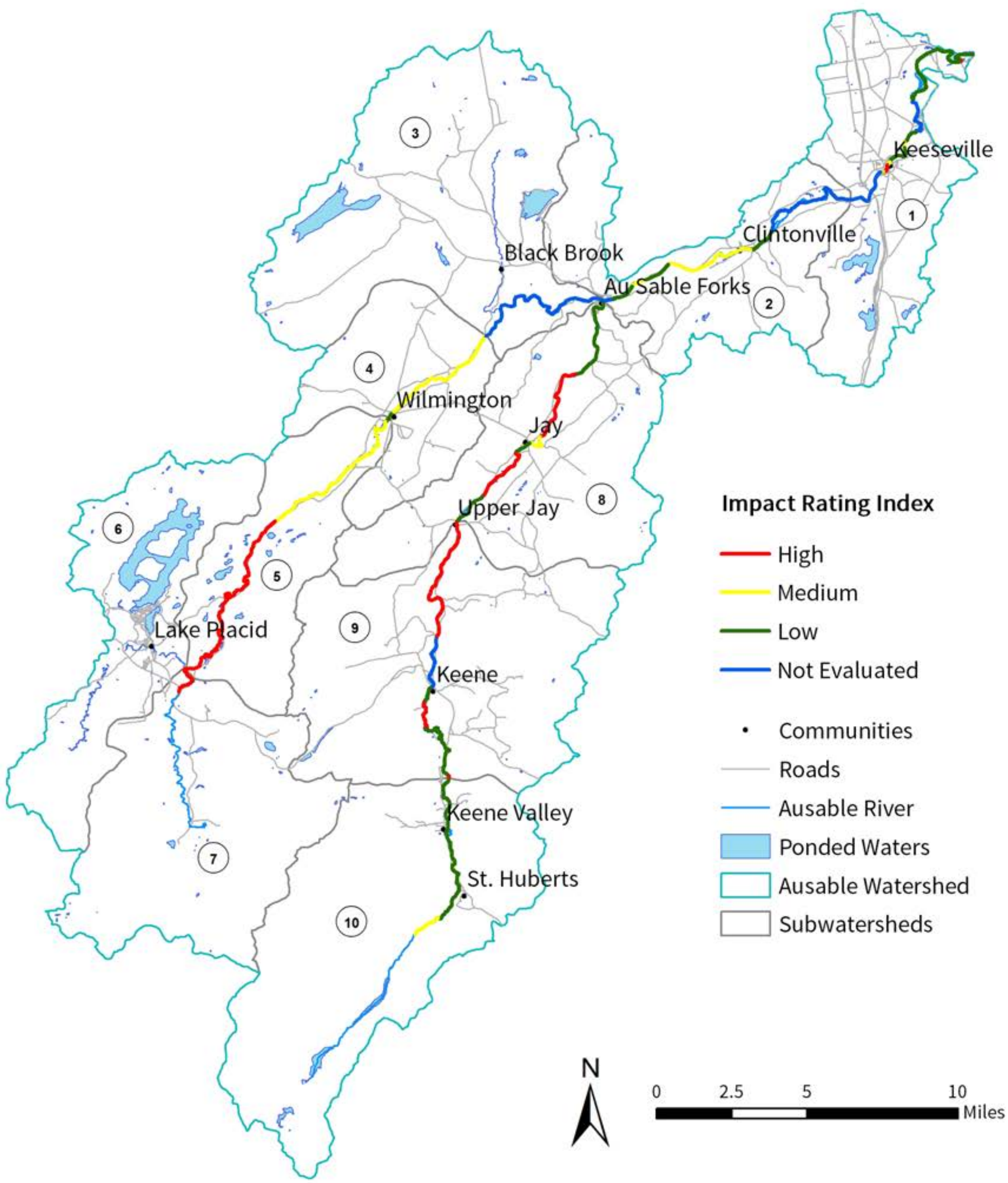
The Ausable River is the second steepest river in New York State, collecting water from 512 square miles and descending almost 4,000 feet from its steep mountain tributaries to flow through low gradient valleys on its way to Lake Champlain. In moderate flows, where its waters encounter sandy soils and banks compromised by the loss of trees, incompatible development, or other disturbances, severe bank erosion and channel widening occurs, leading, in turn, to aggradation of sediment in the channel and loss of flood capacity. Substantial flooding events exacerbate problems on the most degraded sections of the river, toppling banks, carving new channels and redefining floodplains. Much of the Ausable River is in disequilibrium. In order to address this cycle of degradation and implement natural channel design effectively, we need to know which sections of the river are most vulnerable, which are most stable, and how to prioritize these costly and labor-intensive efforts while protecting stable sections. Where do we start?

In order to identify priorities for stream restoration, AsRA began measuring key indicators along sections of the river in 1999. In 2006, to complete a comprehensive survey, AsRA's staff walked the majority of the main channel of the river, assessing and cataloguing the extent and severity of erosion, using methodology developed by the Vermont Agency of Natural Resources (VANR) and described in their Vermont Stream Geomorphic Assessment Phase 1 Handbook (VANR, 2004). Two key measures were the focus of this survey: the extent of bank erosion in a given reach, and bank height, measured from the streambed to the top of the bank or slope. Identifying the extent of bank erosion provides a measure of current vulnerability. Measuring bank height is important in assessing the potential for bank failure and landslides. The VANR Handbook assigns ranks for the combined results of these two measurements, shown in the "Bank Erosion Impact Rating" map (Map 14).

Erosion, and the resulting undercutting and eventual collapse of banks, releases additional fine sediment into waterways. Another measure of stream health—embeddedness—quantifies and ranks the amount of space between gravel, cobbles, and boulders in a channel that is filled with fines (sand, silt, and clay). High embeddedness ratings are an indication of excess sediment supply from streambank erosion, roadways, stormwater outfalls or other sources. Streams with high embeddedness do not support salmonid spawning. AsRA's staff employed visual measurements of embeddedness to confirm their findings on bank erosion.

As Map 14 shows, geomorphic assessment of the river (pre-Tropical Storm Irene) rated erosion impacts as "high" for 22.3 miles of stream channel, "moderate" for 11.5 miles, and "low" for 24 miles. The river is deeply incised, with its channel carving into the riverbed, over a total of 13.6 miles, moderately incised over 36 miles, while 4.2 miles have low banks. In addition, the assessment found that 58 of the Ausable River's 94 miles are embedded. On the East Branch, 75 percent of study sites between Styles Brook and Au Sable Forks have embeddedness levels above those thought to impair fish reproduction. On the West Branch, embeddedness levels at three of 12 sites limit healthy fisheries reproduction (Schoch, 1994).

Bank Erosion Impact Rating



NEW YORK STATE OF OPPORTUNITY. Department of State

This map was prepared with funding provided by the New York State Department of State under Title 11 of the Environmental Protection Fund.

AUSABLE RIVER Association

MAP 14. The impact rating is a composite measure of the amount of bank erosion present in a river reach and the bank height on the same reach. The resulting index defines levels of vulnerability of the river to bank erosion. Pre-Tropical Storm Irene data.

Priority Stream Segments

Geomorphic and embeddedness studies indicate that several locations along the Ausable do not have good stream or habitat conditions. It is easy to visualize the need for streambank stabilization, but harder to determine which repairs will have the greatest impact. To create a watershed-wide assessment of streambank erosion and prioritize sites for stabilization, AsRA divided the river into segments based on similar morphology and valley type and developed a scoring system. Categories scored included the degree of threat to structures, especially potential damage to residential or hamlet areas with vulnerable homes, buildings, roads, and bridges; severity of eroded banks, using the bank erosion impact rating; riparian cover; density of stormwater outfalls; and the potential feasibility of stream restoration projects, in terms of permitting, access, and landowner approvals. The scoring matrix can be found at the back of this report. Table 3 provides a list of priority sites for restoration, referencing natural channel design tools and techniques, described in Appendix A.

Restoration Approaches in the Ausable Watershed

Identifying the problems and priority areas is the first step. Addressing these problems requires that government managers, the public, and landowners look beyond quick fixes to embrace the intensive, sometimes costly, long-term solutions natural channel design can provide. In 2010, a public/private partnership undertook a demonstration bank stabilization project at Intervale Lowlands Preserve on the Ausable's West Branch in the Town of North Elba, stabilizing a badly eroding bank using root wad spikes and other woody material. The success of this effort was immediate, halting bank erosion, redirecting stream flows to the center of the channel, increasing water velocity, moving sediment more efficiently, shifting sediments to stream margins and floodplains, and restoring habitat for fish and other wildlife. It also served to acquaint permitting agencies and municipalities with a method new to many of them.

The success of this project solidified a partnership that continues to implement natural channel design projects throughout the watershed. Partners include the US FWS, Trout Unlimited, local SWCDs, NYS DOS, and AsRA, working with support from federal, state, and local permitting authorities, municipal partners, and landowners. In 2012, over 1100 feet of streambank was restored on public and private lands immediately downstream of Keene Valley. In 2013, 900 feet of John's Brook, just above the Route 73 bridge in Keene Valley, was restored, improving an emergency repair done in the aftermath of Tropical Storm Irene. In 2014, over 600 feet of critical trout habitat was restored on the West Branch near the border of the Towns of Jay and Wilmington. And in 2015, a "W" weir was constructed to replace a recreational dam destroyed by Tropical Storm Irene at the Keene Town Beach, opposite Marcy Field. Stream restoration techniques were also used by the engineering firm ESPC in 2014, in an effort to stabilize and balance the lower reach of Gulf Brook in the hamlet of Keene.

The use of natural channel design to recreate stable channels is only one piece of the puzzle. Efforts to protect stable stream sections by replanting riparian buffers, restricting development, minimizing road expansion and other incursions on floodplains and riparian buffers is essential. Restoration of compromised stream channels produces savings over time by reducing maintenance and emergency response costs and protecting healthy balanced stream sections—thus providing the greatest cost benefit to communities.

Table 3: Priority River Segments for Restoration

Rank	Segment description*	Location	Town	Score	Number of projects	Recommended improvements	Status	Purpose†
1	Rt. 73 to Holcomb Brook adjacent to River Rd.	West Branch	North Elba	19	5	Toe wood, log vanes; address transverse bar	1 project completed (Intervale), 2 proposed, 2016	S - PS - H
2	Downstream of Jay Covered Bridge	East Branch	Jay	17	1	Toe wood structure	Rock stabilization project, 2014	PS
3	Upstream of Stickney Bridge	East Branch	Jay	17	1	Restore flood-plain drainage	Assessment planned 2016	H - PS
4	Keene to Lacy Bridge	East Branch	Keene	15	1	Toe wood; riparian buffer	Assessment underway	PS - H - S
5	Lacy Bridge to Upper Jay pull-out	East Branch	Jay	15	2	Inner berm/bench & vanes; riparian buffer	Assessment underway	PS - H
6	Upper Jay pull-out to Jay pull-out	East Branch	Jay	14	1	Riparian buffer planting	N/A	H - S
7	Keene Valley to Marcy Field	East Branch	Keene	13	2	Toe wood, log vanes, riparian buffer	1 project completed (Rivermede), 1 proposed, 2017	H - S - R
8	Keeseville downstream of Rt. 9 bridge	Main Stem	N/A	13	1	Bank & sediment stabilization	Re-assessment required	S
9	Holcomb Brook mouth to Rt. 86,	West Branch	North Elba	12	?	Possible toe wood, riparian buffer	Re-assess after upstream repairs (see #1)	H - S
10	Lacy Bridge to Upper Jay	East Branch	Keene	11	1	Rootwad spikes, boulder clusters	Assessment planned 2016	H
11	Wilmington to Black Brook mouth	West Branch	Wilmington & Jay	11	2	Toe wood, log vanes, riparian buffer	1 project completed (Riverlands), 1 in planning	H - S - R
12	Jay pull-out to Covered Bridge	East Branch	Jay	11	1	Riparian buffer planting	N/A	S

*Descriptions give a general idea of project locations. Projects do not run the length of reaches but indicate where work can be completed in a season. †H-Habitat, PS-Public Safety, S-Stabilization, R-Restoration

Two categories of natural stream restoration methods are being applied in the Ausable watershed. To protect streambanks and create flood resilience and habitat where a stream is well connected to a functioning floodplain, banks and floodplains are planted with native trees and plants. In cases where erosion and other factors have led to significant imbalances of stream hydrology, endangering critical infrastructure, natural channel design methods are used to restore channel dimension, pattern, and slope and reconnect streams with their floodplains using a variety of structures made of natural materials. Riparian buffer restoration is non-invasive and pro-active, and can engage a wide variety of participants with a minimum of planning and expense. The realignment of a channel and placement of structures in a stream to restore pattern, slope, and dimension requires natural channel design expertise, extensive preparation and permitting, and the use of heavy machinery.

Riparian Buffer Replacement
Trees, shrubs, and other types of vegetation that grow along waterways are referred to as riparian buffers. Ideally, these streamside forests line waterways and buffer them from the impacts of surrounding land use. Streamside forests perform many beneficial functions. They:

- Slow flood waters by creating floodplain "roughness";
- Reduce the volume of flood water through root absorption;
- Improve water quality by filtering runoff and promoting sediment deposition;
- Provide canopy cover, which shades and cools the stream, improving habitat conditions for in-stream organisms (fish, salamanders, frogs, invertebrates, etc.);
- Provide food, shelter and nesting sites for birds and small mammals, and corridors for other wildlife;
- Provide recreational opportunities such as fishing, hiking, bird watching, picnicking and camping.

Healthy riparian buffers stabilize banks with their dense root structures and protect them from encroaching invasive plants. The Army Corps of Engineers estimates that bank strength is reduced 1000-fold when trees and shrubs are removed. The USDA's Natural Resource Conservation Service recommends a riparian buffer at least twice as wide as the active channel width on both sides of a stream channel. At a minimum, AsRA works to assure a riparian buffer of at least half the actual channel width on both sides of a channel. If one side of the bank is impaired or managed in a way that makes this impossible, AsRA works to ensure a minimum 50-foot buffer is in place, provided the opposite bank has a riparian buffer protecting its floodplain.

Table 4 contains a short list of trees and shrubs appropriate for riparian plantings along the Ausable River. Vermont's Natural Resource Conservation Service maintains a longer list. Private landowners on the river or its tributaries can contact AsRA or the Essex County SWCD for advice and assistance.

Table 4: Selected Native Plants for Riparian Restoration						
Common Name	Scientific Name	Height (ft.)	Soil	Shade Tolerance	Growth	Bank Position
Trees - Deciduous						
green ash*	*Fraxinus pennsylvanica*	60	wet-moist	mod./tolerant	fast	mid-high
white ash*	*Fraxinus americana*	80	moist	intolerant	fast	high
black cherry	*Prunus serotina*	80	moist	intolerant	moderate	high
eastern cottonwood	*Populus deltoides*	80	moist	intolerant	very fast	mid-high
red maple	*Acer rubrum*	70	moist	mod./tolerant	mod./fast	mid-high
silver maple (East Branch only)	*Acer saccharinum*	80	moist	intolerant	fast	mid-high
northern red oak	*Quercus rubra*	100	moist-dry	moderate	mod./fast	high
quaking aspen (trembling aspen)	*Populus tremuloides*	65	moist	intolerant	very fast	high
black willow	*Salix nigra*	50	wet-moist	intolerant	fast	mid-low
yellow birch	*Betula alleghaniensis*	50	moist-dry	mod./intolerant	very fast	mid-high
gray birch	*Betula populifolia*	50	moist-dry	intolerant	very fast	mid-high
Small Trees - Deciduous						
speckled alder	*Alnus rugosa*	15	wet-moist	intolerant	moderate	low
downy serviceberry (shad bush)	*Amelanchier arborea*	25	wet-moist	mod./intolerant	–	mid-high
pussy willow	*Salix discolor*	15	wet-moist	mod./intolerant	–	mid-low
Shrubs - Deciduous						
speckled alder	*Alnus incana*	16	wet-dry	mod./tolerant	moderate	low
high bush blueberry	*Vaccinium corymbosum*	8	wet-moist	mod./tolerant	–	mid-low
black chokeberry	*Aronia melanocarpa*	8	wet-moist	moderate	–	mid-low
red chokeberry	*Aronia arbutifolia*	10	moist-dry	moderate	fast	high-mid
American highbush cranberry	*Viburnum trilobum*	14	wet-moist	mod./tolerant	–	mid-low
red osier (red-stem) dogwood	*Cornus sericea*	5	wet-moist	mod./intolerant	fast	mid-low
black elderberry (common)	*Sambucus canadensis*	10	moist-dry	tolerant	–	low
red elderberry	*Sambucus racemosa ssp. pubens*	12	moist	moderate	–	mid-low
spicebush	*Lindera benzoin*	8	wet-moist	tolerant	–	high-mid
wild raisin (witherod)	*Viburnum nudum var. cassinoides*	10	wet-moist	moderate	–	mid-low
winterberry (winterberry holly)	*Ilex verticillata*	8	wet	moderate	–	low

* Concerns about the emerald ash borer beetle have reduced the use of ash trees in restorations.

Height: average maximum potential height on a good Adirondack site
Soil: wet = soil is wet during much of the growing season, i.e wetland or poorly drained soil
moist = soil is moist during much of the growing season, i.e. moderately-well to well drained soils
dry = soil is dry during much of the growing season, i.e. rocky areas, sandy soils, excessively drained soils
Growth: plant growth measured against other species of the same type

Natural Channel Design
Although there are various approaches to natural channel design, all entail restoring normal channel functions to regain natural stability. On occasion, where the instability is localized and not systemic, it may be possible to stabilize an eroding bank by deflecting energy away from it and restoring bank strength with vegetative bioengineering or similar means. But, if the system is very disturbed, it is essential to restore the channel to its natural stable dimension, pattern, profile, and roughness. In such circumstances, localized solutions that do not consider this bigger picture risk project failure by treating bank erosion symptoms in isolation. The goal should be to remove the cause of disequilibrium.

Either way, the goals of a project, the mechanisms in play, and the funding available, determine the details of each restoration. While a hard armoring approach may be necessary in the short term, where road infrastructure is at risk, aspects of natural channel design still may be incorporated to reduce the erosion that commonly occurs downstream of an armored structure.

Increasingly, channel restoration methods have been shifting from such hard engineering practices to full restoration of complex natural channel functions essential to a healthy stream. This involves mimicking an existing stable reference reach. While the price tag for the fullest application of this type of restoration may be unaffordable to many Adirondack communities, an efficient and cost effective adaptation has been developed by the USFWS and is being applied in the Ausable watershed. It addresses stream dynamics, using natural channel design and locally available materials.

Techniques employed in the Ausable River include:

- Bank stabilization: reinforcing banks under stress with an engineered combination of natural fiber mats, turf, brush mattresses, or live stakes. Because these projects do not correct dimension, pattern and profile, they are seen as temporary repairs.
- Bank protection: root wad spikes and revetments, along with toe-wood structures, utilize large trees in-stream to rebuild bank structure in a manner that supports stream dimension, pattern, and profile, while providing critical fish habitat.
- Flow deflection: log and rock vanes, as well as J-hook structures, are used in-stream to deflect water flows to protect banks, reinforce channel thalweg, and in some cases create pools for habitat.
- Grade control: W-weirs, or their cousins the S-weir, cross-vanes, and Newbury weirs are installed to control stream gradient (grade control), create fish habitat, protect banks and reconnect streams to their floodplains.
- Structures to introduce roughness: boulder clusters are groups of large rocks placed in a stream to reduce stream energy and velocity and improve habitat by creating scour holes; naturally occurring large woody debris can be engineered to create cover habitat in streams and along banks, contributing to pool formation, sediment retention, and macroinvertebrate production.

Appendix A provides an account of each these stream restoration techniques; Appendix B provides an overview of permitting requirements for stream restoration projects.

A river undisturbed by human interventions is constantly adjusting to changes within the watershed to maintain its dynamic equilibrium. A river in equilibrium is able to transport the sediment, water, and debris that come from the watershed without aggrading, degrading, or migrating appreciably. Changes in watershed land cover, constrictions in valley width, immovable human infrastructure, and other channel-changing variables, will alter and disrupt equilibrium. Out-of-control erosion or deposition are symptoms of disequilibrium.

To “fix” the entire river is not feasible, but implementing restoration techniques that work with the natural hydrology of meandering rivers can restore a self-sustaining river. A summary of recommendations for natural stream restoration projects along priority reaches of the Ausable River is found in Table 3. In each case, habitat, flood resilience, and public safety are critical and can be achieved using these minimally invasive and cost effective methods.

4.10 Summary

While the list may be daunting, especially in a time of stressed municipal budgets, improving land use management practices is within the grasp of every Ausable watershed municipality. This review shows there are several clear paths for restoring the river, protecting water quality, and improving the resiliency of our watershed and its communities. Choosing to act to protect the river and its water quality is an investment in the future of our communities.

Table 5: Subwatershed Characteristics

			Land Cover				Physical Characteristics				Existing Water Quality			Water Quality Threats				Development	
Subwatershed	Miles of Stream	Total Acres	% Urban	% Crop	% Wetland	% Forest	% Riparian Buffer Forested	Acres of Highly Permeable Soil	Acres of Soil with High Runoff Potential	Invasive Species Infestations	Waterbody Inventory, Miles Threatened	Waterbody Inventory, Miles Stressed	Miles Suited to Trout (T) or Trout Spawning (TS)	Miles of High Impact Bank Erosion	Miles of Road within 200' of Stream	% Area of Road over Aquifer	Outfalls / Stream Mile	% Hamlet, Moderate Intensity, Low Intensity	% Forest Preserve
1	71	26,754	10.7	14.4	4.0	63.3	46.0	8529	1	40	13	0	20	0.4	3.1	10.4	1.1	34.3	5.0
2	83	24,557	3.8	0.3	3.6	85.3	58.9	4625	980	10	14	0	68	0.0	6.4	3.0	0.6	16.6	0.1
3	124	46,382	2.4	0.2	4.0	87.1	59.4	3452	0	5	0	6	95	UA	3.9	1.1	0.3	16.4	26.1
4	52	19,575	2.6	0.7	4.7	89.0	66.1	200	0	13	0	5	99	0.4	3.7	2.5	0.8	28.1	37.7
5	82	21,667	2.9	0.3	5.4	89.1	48.0	1090	0	11	0	15	99	9.0	3.8	0.8	0.9	6.7	85.8
6	79	26,429	6.6	1.0	7.0	76.0	44.9	3135	0	1804	0	15	45	UA	0.7	2.3	UA	15.3	60.4
7	106	37,112	1.7	1.4	8.2	88.1	56.6	2392	0	2	0	0	100	1.6	2.4	0.5	0.9	0.7	78.0
8	119	34,657	4.0	4.1	3.3	85.5	46.3	5293	0	19971	0	12	94	4.9	7.1	1.8	1.2	26.7	19.1
9	129	44,121	2.4	0.8	1.6	94.6	71.9	1831	0	778	0	11	96	5.8	12.8	1.4	1.8	2.7	56.0
10	139	46,549	0.9	0.1	3.1	94.2	74.3	1796	0	12	0	5	89	0.1	2.5	0.7	1.5	3.2	67.1
Total	984	327,803	5.5	2.1	4.3	86.3	58.8	32343	981	22646	27	69	805	22.2	46.2	24.5	1.0	13.4	44.8

V: Subwatershed Assessments

This discussion has focused at a watershed-wide scale so far, noting current conditions, practices, resources, and threats, as well as priorities and concerns within specific communities or reaches along the river. But the diversity of the watershed, its varying patterns of geography, hydrology, and land use, mean that effective planning and implementation may look very different in the vast forests of the West Branch, with its dense cover and state lands, compared with the bucolic pace of the Main Stem as it winds through open fields and private lands.

The table headed “Subwatershed Characteristics” (Table 5) takes a close-up look at the ten subwatersheds that comprise the Ausable River watershed, focusing on land cover, development potential, current water quality, and threats to water quality in each of them. (The subwatersheds are delineated on all the maps in this report.)

Maintaining water quality in the Ausable River that supports swimming, recreation, and wildlife has been identified as a top priority by citizens of the watershed and visitors. Stormwater runoff from hamlet areas and roads is the greatest threats to water quality in the Ausable. Other threats include streambank erosion, aging and inadequate on-site wastewater treatment facilities, limited flood hazard mitigation measures for pollutant sources in the floodplain, and invasive species. A summary of the priorities for reducing these hazards in each subwatershed is listed in Table 6.

Table 6: Subwatershed Priority Areas for Improvement

Subwatershed	Stormwater Controls	Mark "Drains to River" on Stormwater Inputs	Public Education Workshops on Stormwater	OSWWT Permit Renewal	Streambank Restoration Measures	Restore Riparian Buffer	Protect Aquifer Recharge Area	Flood Hazard Mitigation Measures	Invasive Species Management/Control	Junk Tire Reduction Measures	Address Possible Chemical Releases from Riverside Businesses
1	x	x	x			x	x			x	
2	x						x			x	x
3											
4	x				x		x				
5	x			x	x	x					
6	x	x	x						x		
7	x										
8	x	x	x		x	x	x	x	x		
9	x	x	x		x			x	x		
10	x	x	x					x			

VI. Assessment of Local and Regional Laws Affecting Water Quality

The protection of water quality within a large watershed such as the Ausable's is a shared responsibility. The actions of residents, landowners, visitors, towns, county, state and federal governments all make a difference. To guide these efforts, thoughtful, comprehensive, and detailed laws and regulations that create standards for water quality protection in land use, development, and related practices are essential. This section provides an overview of the laws protecting the Ausable River, its floodplain, tributaries, and other essential resources.

NYS DEC:
Under New York State's Environmental Conservation Law (ECL), Title 5 of Article 15, certain waters of the state are protected on the basis of their classification. Map 3 of this report (p. 20) details the various classifications of Ausable watershed streams. Streams and small water bodies located in the course of a stream that are designated as C (T) or higher (i.e., C (TS), B, or A) are collectively referred to as "protected streams"—the (T) indicating streams that provide habitat for trout. A Protection of Waters Permit issued by NYS DEC is required prior to any physical disturbance of the bed or banks of a stream classified C (T) or higher.

Small ponds and lakes with a surface area of 10 acres or less, located within the course of a stream, are considered part of a stream and subject to regulation under the stream protection category of Protection of Waters.

In 2003, the US EPA's Clean Water Act was revised to include Stormwater Phase II, part of a nationwide effort to maintain clean surface water. At the same time New York State adopted regulations to address stormwater threats, though both the federal and state regulations affect larger urban systems, Municipal Separate Storm Sewer Systems (MS4s), than are found in the watershed. Construction activity that disturbs one acre or more of land requires a permit from the NYS DEC with planning, inspection, and supervision requirements for controlling soil erosion and stormwater runoff during construction, and—for projects over five acres—post-construction management.

Adirondack Park Agency:
The Adirondack Park Agency (APA) administers the Adirondack Park Agency Act that provides the general terms for protections of land and waters in the park. The APA administers two other statutes in the park, both are specific to water quality issues, the Freshwater Wetlands Act (Article 24, ECL) and, for private lands within the Adirondack Park, the Wild, Scenic, and Recreational Rivers System Act (Article 15, title 27, ECL). DEC oversees this latter statute on public lands in the park. APA jurisdiction plays an important role in the protection of land and water in each of the Ausable watershed towns, thus a brief review of the primary regulations relevant to water quality is presented here.

The entire length of the Ausable is part of the State Wild and Scenic River System, which affords additional protections to public stretches of high value rivers. The East Branch is designated as Scenic from Marcy Swamp (above the Ausable Lakes) to the hamlet of St. Hubert's. The remainder of the river is listed as Recreational. Under the law, on private lands that are designated as Low Intensity Use, Rural Use, or Resource Management (Map 2, p. 13), setbacks for new development along Scenic Rivers are 250 feet from the mean high water mark. Development is limited within a quarter mile of the river—designated as the river "corridor." New development setbacks for Recreational Rivers (again, on lands designated as Low Intensity Use, Rural Use, or Resource Management) are 150 feet from the mean high water mark. APA also requires shoreline setbacks in hamlets and moderate intensity use areas.

For both Scenic and Recreational rivers, modifications to the course, banks, or bed of the river can only occur with an appropriate permit from the APA or the NYS DEC. Timber management and creation of unpaved woods roads or trails for motorized use are also regulated. No substances can be discharged into Scenic or Recreational rivers, except in compliance with NYS DEC standards.

Wetlands protections under the Freshwater Wetlands Act require landowners to receive permits for activities in or near wetlands that are larger than one acre in size or are adjacent to a permanent water body. Activities subject to permitting include:

- Draining, dredging, or excavating a wetland;
- Placing fill, including soil, stone, sand, gravel, mud, trash, structures, pilings, roads, or any other obstruction or substance, into a wetland;
- Clear cutting more than three acres;
- Releasing any form of pollution into a wetland, including pesticides and sewage effluent or other liquid waste;
- Installing any sewage drainage field or seepage pit, or any sewer outfall in or within 100 feet of a wetland;
- Undertaking any other activity within or outside of a wetland that substantially impairs the functions served by or the benefits derived from the wetland, including the diversion of surface or subsurface drainage or natural water flow that adversely affects the natural hydrological regime of or substantially increases erosion of or siltation or sedimentation into the wetland. (Excerpted from: http://apa.ny.gov/Documents/Flyers/FreshwaterWetlands.pdf)

As noted earlier (Section 2.4), the APA *Land Use and Development Plan* categorizes all private watershed lands in the Adirondack Park for specific use and development potential (Map 2 and Table 1). All but 7% of the Ausable River watershed is inside the park boundary. Close to 40% of the watershed is public land, held in the Forest Preserve as "forever wild," and designated as "wilderness," "wild forest," or "primitive" land, each classification allowing for a different intensity of development. An additional 22% of the watershed is designated "resource management" land—mostly privately held timberlands scattered throughout the watershed that have, in some recent cases, been approved for residential development.

The private lands that dominate the downstream portions of the watershed have varying density caps. These caps are far from realized, allowing the potential for considerable development both in floodplains and upland. Further development—especially in the case of increasing confinement of the floodplain by additional structure—would have consequences for stream stability, resilience, and water quality.

Clinton and Essex Counties:

The East and West Branches of the Ausable River run through Essex County. At their confluence in the hamlet of Au Sable Forks, the Main Stem of the River becomes the dividing line between Essex and Clinton Counties. The counties hold no direct regulatory responsibility for the river's protection, but county management of culverts, bridges, roads, and roadside stormwater management has a profound impact on the river's health and resilience. Municipalities must refer to county planning boards certain zoning matters before taking final action on those matters, and each county holds responsibilities for new development within 500 feet of county roads. Both counties have additional regulations that augment NYS DEC fishing regulations, and Essex County maintains a fish hatchery and stocks streams in the watershed with native and non-native species. All of these activities impact the river and its tributaries.

Local Laws:
New York is a home rule state, so every municipality has the legislative authority to create land use codes and regulations to protect the water quality and the ecosystem resources of the Ausable River and its watershed. Even with strong federal, state, or regional laws, municipal governments might choose to develop and enforce regulations to protect the Ausable River watershed. Municipal laws can take into account unique resources and circumstances and respond to local concerns. River corridor and water quality protection laws can be integrated with local land use laws, including ordinances for floodplain management; erosion, surface and stormwater control; and roadway management. Assuming towns have access to expert advisors, review may be more comprehensive and take into account specific challenges in a community. Enforcement at the local level may be more swift than relying on regional resources. In the end, watershed residents, landowners, and business owners rely on and care most deeply for the Ausable, its water quality and tremendous resources. Local governments have a vested interest in protecting the watershed for its own sake and for the communities they serve.

At the same time, because the river runs through seven towns, one incorporated village, and two counties, consistency across municipalities is essential to water quality and resource protection across the watershed and to cost efficiency for each municipality. Many local governments lack the capacity to take on increased responsibilities that would come with new regulations. Nevertheless, working toward increased local regulatory authority in each watershed town, while striving for consistency in the protection of river resources across towns, is a valuable goal.

Table 7 summarizes existing land use codes, zoning, site plan review, subdivision regulations, and other ordinances promulgated by each municipality within the Ausable watershed. The Town of North Elba and the Village of Lake Placid follow a joint code. This information was assembled and assessed by the Essex County Planning office with input from a SUNY Plattsburgh Environmental Management class in 2011. A "no" in the table indicates that no specific local regulation exists for the indicated category; regulations promulgated by the APA, state agencies and federal law apply but are not indicated here.

Local laws must address a vast array of residential, commercial, safety, and infrastructure issues. Water protection is only one piece of the larger suite of municipal responsibilities, though a surprising variety of activities can negatively impact local water resources. And water quality impairments in one town, more often than not, travel downstream and affect the next town.

Summary: This overview provides a first step for organizing and understanding the regulatory frameworks that attempt to manage the effects of human activity on the Ausable River, its tributaries, and lakes. A full assessment of local laws that identifies gaps, and provides frameworks and tools to address them, would strengthen protections for the river and broaden regulatory consistency and efficiency among its communities. It would also bring the responsibility for stewardship and protection of the Ausable River directly to those who benefit most from its resources—those who live and work in watershed communities and rely on its high water quality and recreational value. The recommendations section of this plan suggests next steps for achieving these goals.

Table 7: Municipal Regulations Summary							
	AuSable	Black Brook	Chesterfield	Jay	Keene	North Elba/ Lake Placid	Wilmington
Planning Tools							
Comprehensive Plan	Yes	No	No	Yes	No	Yes	Yes
Zoning Laws	No	Yes	No	No	No	Yes	Yes
Site Plan Review	No	No	Yes	No	Yes	Yes	Yes
Subdivision Regulations	Yes	Yes	Yes	Yes	No	Yes	Yes
Land Use Code	No	Yes	No	No	No	Yes	Yes
Stormwater/Drainage Regulations							
Local Wetland Restrictions	No	No	Yes	No	Yes	Yes	No
Flood Prevention Ordinance or Flood Damage Protection	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stormwater Management	No	No	No	Yes	No	No*	Yes
Erosion Control	No	No	No	Yes	No	Yes	Yes
Junk Storage Ordinance	Yes	Yes	No	Yes	No	No	Yes
River/Shoreline Protections							
Waterfront Setback	No	No	Yes	No	No	No	No
Shoreline Cutting Restrictions	No	No	Yes	No	No	Yes	Yes
Public Infrastructure							
Septic	No	No	Yes	No	No	No	No
Mandated Septic Inspection	No	No	No	No	No	No	No
Agricultural							
Timber Harvest Setback/Ordinance	No	No	No	Yes	No	No	Yes

*A sediment erosion control program is contained in the North Elba/Lake Placid Site Plan Review

VII: Management Planning and Public Participation

The Ausable River is shaped by the people who have lived alongside it. The river, in turn, helps to define the watershed's communities—past and present. Their fates are intertwined. For this reason, the planning process that resulted in this document asked open questions, relied on the expertise of scientists, planners, managers, and residents, and is committed to sharing its findings broadly. The success of this plan—its implementation—is dependent upon the involvement of people who care about the river for a variety of reasons.

Citizens were involved in the watershed management planning process in many ways. AsRA's staff attended meetings of each town and village board in the watershed to provide an overview of the planning process and its goals, to gather input and answer questions. The advisory committee that helped to guide this process included representatives from each of the seven watershed towns and two incorporated villages (including the former village of Keeseville, dissolved at the end of 2014). A full list of committee members and other partners can be found in the Acknowledgments.

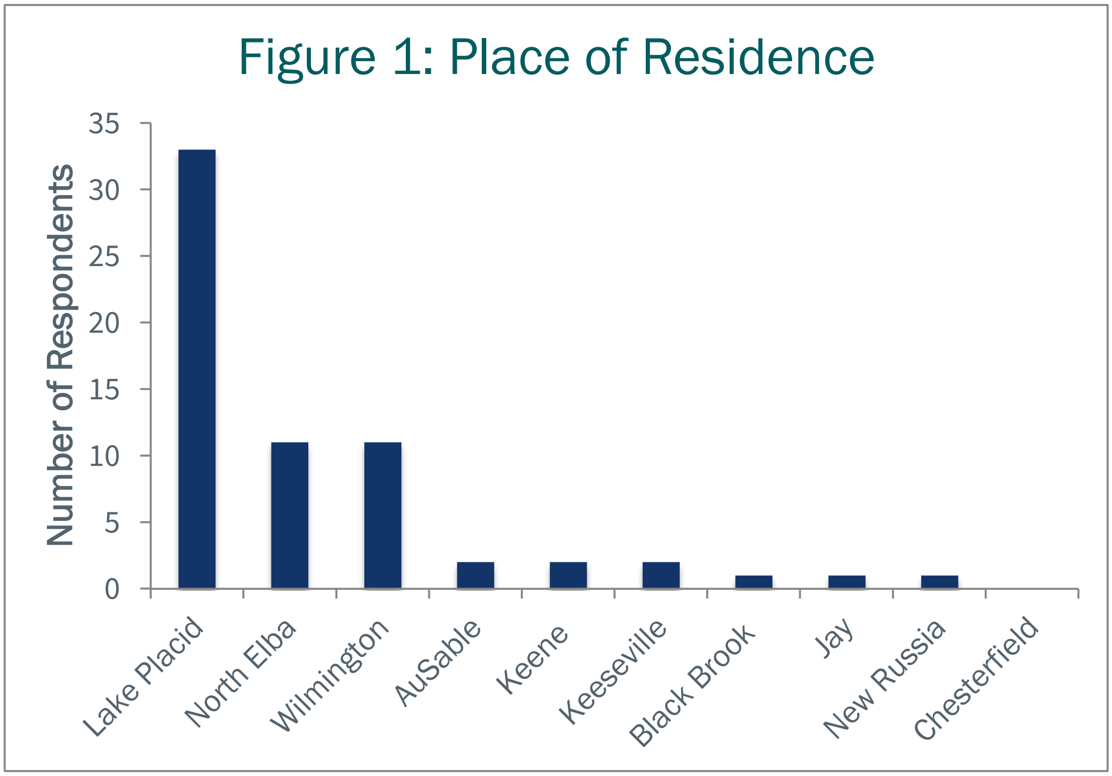
In addition to the community representatives who served on the advisory committee, 80 watershed residents participated in the planning process at four public meetings in the autumn of 2007 and spring of 2008. Three were held at central locations along the West and East Branches of the river and on its Main Stem: the North Elba Town Hall in the Village of Lake Placid, the Wells Memorial Library in Upper Jay (Town of Jay), and the Keeseville fire station (Town of Ausable). A fourth meeting was held at a meeting of the Tri-Lakes chapter of Trout Unlimited. These sessions were designed to identify the issues participants felt posed the greatest threats to the health and beauty of the river and its tributaries, by asking a set of questions to each group. Responses are summarized in Table 8.

Table 8: Primary Issues of Concern to Watershed Citizens

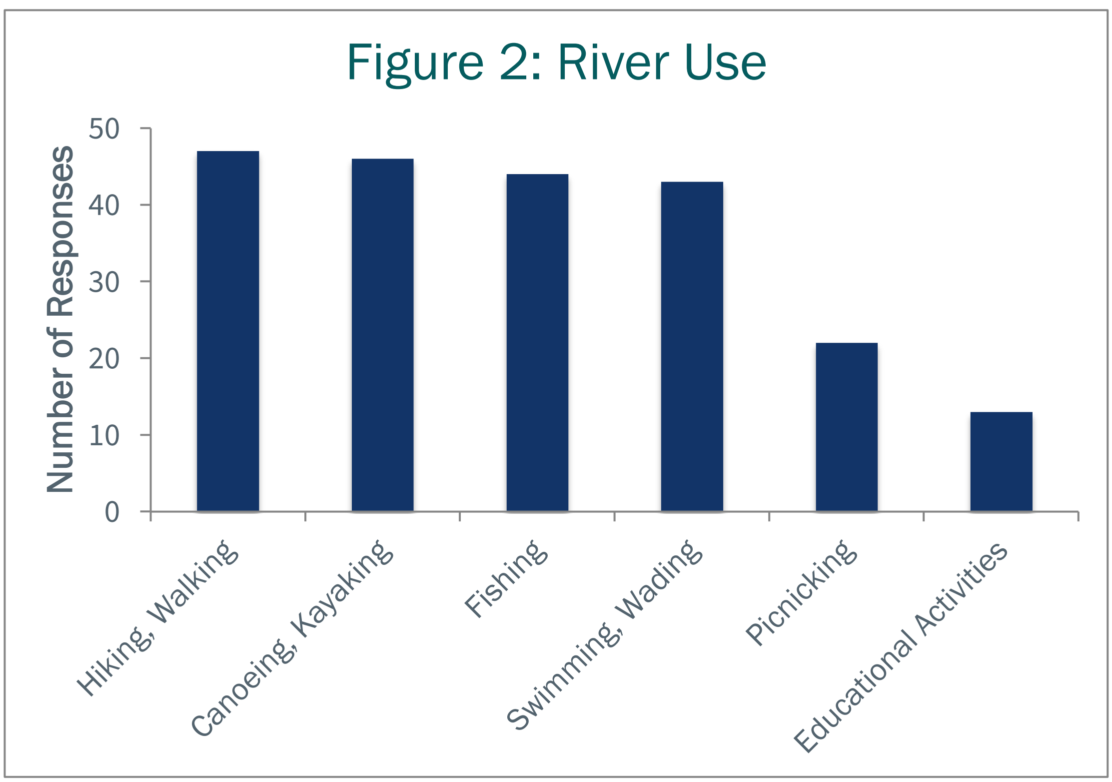
Main Stem	East Branch	West Branch
Flooding from ice jams	Streambank erosion	Education: Land use planning tools, local governments, state agencies, communities
Bank erosion	Sedimentation	Reduce stormwater runoff from roads, impervious surfaces, construction sites, work with NYS DOT
Trash in the river and unauthorized dumping	Water quality	Streambank erosion (esp. River Road section)

Comments were also gathered via a questionnaire, sent to AsRA members and made available at each public meeting, and wherever the meetings were advertised. The 64 completed surveys represent a fraction of the watershed's population—less than half of a percent—still, the results offer insights into the perceptions and concerns of local citizens.

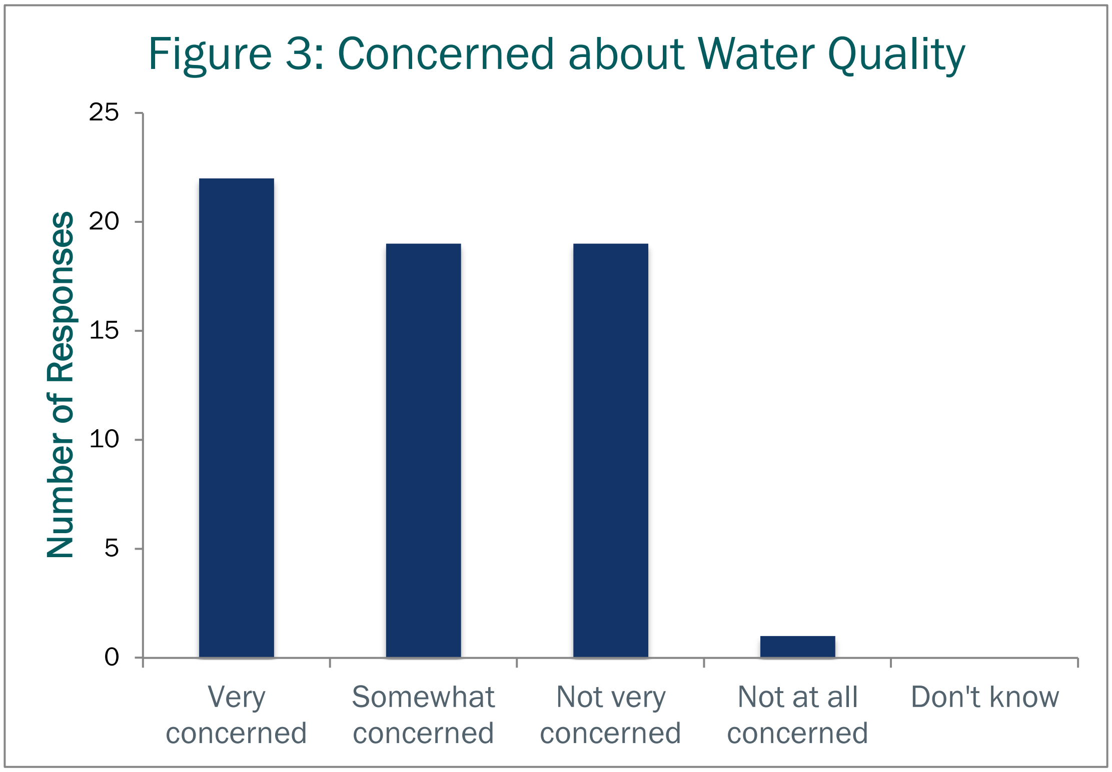
The bulk of respondents identified towns along the West Branch as their place of residence (Figure 1).



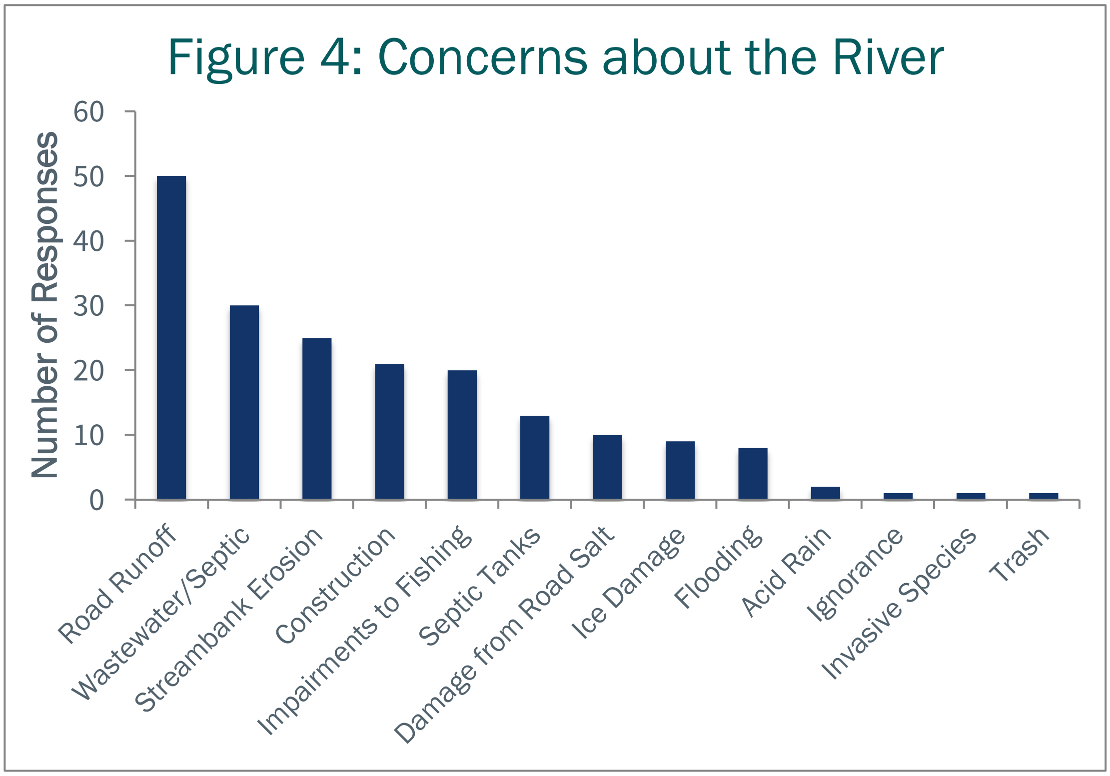
Respondents participate in a wide range of recreational river uses (Figure 2).



A majority of survey participants were concerned about water quality in the Ausable River (Figure 3).



Respondents identified a wide range of concerns. Roadway runoff, wastewater management, and streambank erosion ranked highest (Figure 4).



When it came to tackling and fixing problems, salt/sand/stormwater runoff topped the list.

A final question asked survey respondents if they felt the Ausable River had improved, worsened, or stayed the same over the past 15 years. A majority (nearly 75%) perceived the river as not improved or in worse condition compared with 15 years ago. This concern highlights the importance of comprehensive watershed management planning and implementation.

Recommendation	Priority	Primary Partners	Status & Next Steps
Water Quality & Temperature			
Continue water quality monitoring in the Ausable River watershed measuring (at minimum) temperature, dissolved oxygen, conductivity, and pH. Use these measures to inform additional testing based on results.	High	AsRA, AWI with support from DOS, DEC	Ongoing program begun in 2015 with AsRA as lead. Next steps: make data available via AsRA website.
Gather scientific monitoring data that describes the nature, extent, and primary effects of chloride levels in Mirror Lake. Use this information to advance discussion of management practices that restore and maintain water health and biodiversity and protect native coldwater fish.	High	AsRA, MLWA, AWI with Town of North Elba, Village of Lake Placid and private support; other partners: DOS, DOT, DEC	Data collection underway. Results expected in Autumn 2016. Next steps: convene stakeholders to discuss alternatives.
Gather scientific monitoring data that describes the nature, extent, and primary effects of chloride levels in the Cascade Lakes. Use this information to advance discussion of management practices that restore and maintain water quality and biodiversity and protect the endangered round whitefish.	High	AsRA, AWI, NYS DEC with support from NYS DOS; other partners: DOT, Town of Keene	Data collection underway. Results expected in 2016-17. Next stesp: convene stakeholders to discuss alternatives.
Maintain and extend a network of temperature loggers throughout the Ausable watershed.	Medium	AsRA, DEC, TU, DOS	AsRA has placed 13 year-round loggers in the river and tributaries.TU has 2 seasonal loggers in the East Branch. Next steps: make data publically available.
Establish and maintain a monitoring program to identify sources of phosphorus thoughout the watershed.	Medium	AsRA, AWI, DOS	Expected start date : 2016-2017.
Establish and maintain a water quality testing program (such as ALAP) for representative watershed lakes.	Medium	AsRA, lake associations, AWI, DOS, DEC, Towns	Monitoring as of 2016: Mirror, Upper and Lower Cascade Lakes, Lake Everest, Taylor and Butternut Ponds.
Identify opportunities to include Ausable watershed data in regional academic and management conferences, publications, and meetings on water quality issues.	Low	AsRA, AWI, DEC, DOS	
Follow up on 2009 data sampling that identified possible urea contamination in Whiteface Brook to check whether cessation of urea use has caused subsequent decline in nitrogen levels.	Medium	ORDA, AsRA, AWI	Planning underway.
Choride: Winter Road Deicing			
Continue exploring methods to reduce chloride applications on town, county, and state roadways; consider seasonal speed limit reductions as a complementary measure to ensure public safety.	High	Municipalities, NYS, ADK Action SWCD, ALA, AsRA, other environmental NGOs.	Adirondack Park-wide conversations began in 2014 but need reinvigorating. Individual towns and the Village of Lake Placid have been planning and implementing measures.
Continue to monitoring salt storage residue in Norton Brook watershed and assist with any town concerns.	High	AsRA, Town of Keene, other towns, DOS	AsRA has responded to a request from the Town of Black Brook to test chloride levels in Palmer Brook below town salt storage; work in progress.
Develop drinking water testing program to establish extent of chloride movement to groundwater.	High	AsRA, AWI, DOS, Towns	Next steps: AsRA will work with AWI to establish a protocol for groundwater monitoring in key areas on the East and West Branches in 2016 or 2017, funding dependent.
Develop river-sensitive winter sand/salt sweeping protocols in each town to minimize sand transport into surface waters; explore grant funding opportunities to purchase sand vacuum trucks for spring cleanup.	High	Town road departments with support from counties, SWCDs, and DOT	Identify parameters for creating a prioiritization tool easily used by town DPW supervisors.
Convene town, county, and state roadway managers and stakeholder organizations to pursue an agreement reducing road salt applications in the Ausable River watershed.	High	ADK Action, town supervisors and DPW/highway department heads, DOT, environmental NGOs, watershed groups.	Restart regional conversation led by ADK Action, community and regional NGO leaders; if needed, create a working group focused on options in Ausable watershed.
Phosphorus: Wastewater Management			
Explore feasibility and funding sources to establish a fund to assist home and small business owners with septic system pump-out and possible upgrading/replacement of outdated systems. Use LCBP funded AsRA pump-out program as one model.	Medium	WQCC, CWICNY, LCBP, AsRA, MLWA, SOA	First explore potential for a state or regionally held revolving fund or other mechanism that would provide funding over multiple years.

Recommendation	Priority	Primary Partners	Status & Next Steps
Continue AsRA port-a-john program on East and West Branches with financial support from towns, businesses, organizations, and individuals.	Medium	AsRA, with support from DEC, towns, private donors	Program partially funded and ongoing.
Explore community-based alternatives to centralized wastewater treatment systems and funding opportunities for their use in Ausable River watershed communities. Identify areas in need of new treatment systems. Support the Town of Wilmington feasibility study and consider it a potential model for use in other communities.	High	Town of Wilmington, DOS, RCDC, towns, Essex and Clinton County agencies, DOS, APA, AsRA	Next steps: Identify lead stakehold to convene meeting. Identifiy funds to pinpoint areas where alternatives are most needed and would have greatest impact.
Invasive Species			
Continue to inventory, identify, and address new incidents of aquatic or terrestrial invasive species in the Ausable watershed.	High	AsRA with support from APPIPP, LCBP and DOS	AsRA will continue monitoring efforts for terrestrial and aquatic invasive species with funding from LCBP and DOS.
Establish a watershed-based staff position to take the lead on invasive species education, prevention, and eradication and work with the Adirondack Park Invasive Plant Program and the Lake Champlain Basin Program on this issue.	Medium	AsRA w/ support from LCBP, DOS, private donors	AsRA's river steward is full-time, funding dependent as of 2015. Next steps: consolidate funding to make position permanent.
Organize lake and river associations to share knowledge, management strategies, and funding opportunities to identify and eradicate/control invasive species and other in-common water quality issues.	Medium	ALA, APPIP, AsRA	Recently formed Adirondack Lakes Alliance is working Park-wide; AsRA is actively reaching out to lake groups in the watershed.
Identify and implement mechanisms and management approaches to protect wild trout populations, especially brook and lake trout.	High	AsRA, TU, EBTJV, DEC, SUNY,	Next steps: AsRA will convene a watershed-focused working group to identify scale of threat, discuss monitoring options and/or management alternatives protective of native brook trout.
Stormwater Runoff			
Assess stormwater controls in hamlets with an eye toward reducing sediment and pollutant runoff into natural waterways (installing settling basins, intake collection structures, and stormwater retention structures) and managing flood flows in low-lying areas (flood proofing, elevating structures or other measures). Priority locations include: Front Street in Keeseville, Au Sable Forks, Keene Valley along SR 73, and the intersection of Springfield Road and SR 9N in Upper Jay recommended in the NY Rising Community Reconstruction Plan of 2014 (p.115).	High	DOT, Counties, Towns, DOS	Two examples: in the hamlet of Au Sable Forks, Town of Jay via DOS funded Long-Term Community Recovery planning is underway; the Village of Lake Placid is pursuing funding for a stormwater collection system along Mirror Lake Drive.
Pursue improvements to Whiteface Mountain Ski Center parking areas and road; consider update of sediment/stormwater management plan.	Medium	ORDA with input from DOS, DEC, SWCD, AsRA	
Continue to offer training opportunities for town highway crews and provide advice and technical assistance regarding the management of storm flows along roadways.	Medium	SWCD, CWICNY,	Essex County SWCD offers Flood Resiliency Training; SWCD are hubs for contractor and DPW training opportunities in erosion control.
Complete the 62 critical roadway erosion projects detailed in the Lake Champlain Watershed Water Quality Management Planning Roadside Erosion Assessment and Inventory (2012).	Medium	SWCD	Ongoing
Roadways, Culverts, Bridges			
Complete inventory of culverts throughout the watershed to identify undersized or impaired structures.	High	TNC, AsRA, FWS, SWCD, DOS	Phase one completed in 2014. Next steps: AsRA and TNC are using the NAACC protocol to continue assessment in 2016-2017.
Develop and disseminate recommendations/best management practices for repairing culverts on rural roads to ensure flood resiliency and fish passage.	High	TNC, AsRA, FWS, DOS	Development delayed until 2017.
Work toward an agreement to ensure priority impaired culverts are replaced not in-kind but according to NYS DEC guidelines and best management practices.	High	AsRA, SWCD, TNC, USFWS, towns, counties	
Pursue cost-share implementation of priority culvert replacement projects throughout the watershed.	High	AsRA, TNC, FWS, SWCD, DOS, towns, counties	Two culverts completed in 2014; 3 in 2015; 2 planned for 2016; 2-4 in 2017
Inventory state and county roads that block the Ausable River from its floodplain.	High	AsRA, FWS, DOS	Next steps: acquisition and review of LIDAR data.

Recommendation	Priority	Primary Partners	Status & Next Steps
Disseminate Rural Roads Active Management Plan manuals to all town and county highway departments, pursue training opportunities, and provide ongoing advice and support.	Medium	SWCD, CWICNY	Initial distribution in 2014.
Continue to obtain, train town and county workers on, and share use of equipment such as hydroseeders and sand vacuum trucks to improve roadway and roadside maintenance.	Medium	SWCD, Essex and Clinton Counties	
Establish an MOU with NYS DOT to encourage complementary stream restoration projects in the Ausable River and its tributaries when aging road and bridge infrastructure are repaired or replaced.	Medium	AsRA, USFWS, DOT, DOS	Initial meeting between DOT and AsRA delayed.
Sedimentation, Bank Erosion, and Stream Restoration			
Pursue stream restoration projects laid out in Table 3 Priority River Segments for Restoration using natural stream techniques demonstrated by USFWS with support of AsRA, SWCD, and TU.	High	AsRA, SWCD, TU, USFWS, DOS	Three projects completed as noted on Table 3. Two priority projects in planning.
Identify further stream restoration needs in watershed towns that improve flood resilience and public safety, protect infrastructure, enhance the functional integrity of large and small streams, and expand riparian habitat.	Medium	AsRA, towns, TU, USFWS, DOS, Counties	Projects identified in Towns of Jay and North Elba.
Encourage and incentivize the maintenance or restoration of riparian buffers along streams that are (a) made up of native riparian species and (b) are, at minimum, equal in depth to the width of the stream they border.	High	AsRA, SWCD, TU, USFWS, DOS, towns	AsRA has piloted a successful riparian restoration methodology for large parcels; plans underway to provide landowners with native plants and planting guidance.
To better manage flood waters especially above vulnerable hamlets (e.g. Au Sable Forks), identify areas where floodplain access can be improved and, where feasible, floodplains can be expanded and wetlands recreated or enhanced.	Medium	Towns, DOS, DEC, AsRA, FWS	A strategy being discussed as part of the ongoing Jay and Keene Long-Term Community Recovery Plan process.
Proceed with core sampling & sonar analysis of existing sediment deposits behind Wilmington and Rome dams.	Medium	Towns of Wilmington & Jay, DOS, AsRA, Queens University, DEC	Winter 2016 did not allow teams to go out on solid ice for core samples; reassessing next best opportunity.
Proceed with evaluation and planning for removal of the Rome dam and restoration of the downstream reach on the West Branch above Au Sable Forks.	Medium	Town of Jay, USFWS, DOS, AsRA, DEC, APA, Milone & MacBroom	Feasibility study awarded to Milone & MacBroom 2016. USFWS has agreed to act as advisor to Town of Jay.
Investigate sources of sediment collecting at the Wilmington dam to determine whether additional land management practices, stream restoration, or filtration infrastructure is needed to limit sediment build up.	High	Town of Wilmington, DOS, DEC, AsRA,	Develop plan as part of DOS LWRP awarded for study of dam repairs.
Re-engineer existing dam gate in Wilmington and include mechanisms for continuous sediment passage.	High	Town of Wilmington, DOS, DEC, AsRA,	Study funded by DOS LWRP pending in 2016-2017
Conduct ongoing re-inventory of bank erosion and instability throughout the watershed on a rotating basis to identify and address vulnerable areas.	Medium	AsRA, TU, USFWS	AsRA will implement partial survey on East and West Branches in 2016 with LCBP funds.
Explore methods for reducing ice jams and their impacts.	Low	AsRA, USFWS, Town of Jay, SWCD, TU, DEC, APA, DOS	Most experts agree that single solutions to ice jam formation are lacking. Next steps: restore stream segments in Town of Jay prone to ice jams to assess the importance of efficient hydrologic flows as key component of reducing jam size and/or frequency.
Agriculture			
Encourage best management practices for agricultural land, including livestock exclusions, water management, manure management, and no-till cropping.	High	SWCD, NRCS, WQCCs	Ongoing.
Encourage the maintenance or restoration of riparian buffers along streams that are (a) made up of native riparian species and (b) are, at minimum, equal in depth to the width of the stream they border.	High	AsRA, SWCD, TU, USFWS, DOS	
Inform riverfront landowners with crop or fallow land of opportunities through the federal Conservation Reserve Program and riparian restoration opportunities.	Medium	SWCD, AsRA	Initial properties identified for outreach in 2016.

Recommendation	Priority	Primary Partners	Status & Next Steps
Local Land Use Planning and Regulation			
Encourage proactive floodplain management programs, strong local floodplain development regulations, and enforcement of regulations to protect floodplains.	High	Towns, Counties, DEC, DOS, AsRA	Lake Champlain Sea Grant is organizing a effort to bring floodplain regulation planning tools to towns. DOS has an informative brochure due for release in 2016.
Develop listing of recommended stormwater regulations to assist municipalities lacking such guidance or with insufficient protections.	High	Towns, WQCC, Counties, DOS, watershed groups	
Evaluate existing codes for residential and commercial development and recommend enhancements based on available best practices to minimize impervious surfaces, maximize native plantings and tree cover - especially streamside, ensure proper filtration of water flow off impervious surfaces and proper filtration of wastewater, and protect streamflows and floodplains from impairment by development and roadway infrastructure.	Medium	Towns, WQCC, Counties, DOS, watershed groups	
Develop a checklist identifying best practices for town-wide water quality and stream resource protection. Work with communities to integrate these into existing laws or develop new laws to ensure consistent protection and management of river resources throughout the watershed.	Medium	Towns, WQCC, Counties, DOS, watershed groups	
Seek formal agreement (via above checklist or another tool) across watershed communities to minimize impervious surfaces and maximize native plantings and tree cover throughout the watershed, especially in riparian corridors, floodplains, and near wetlands (i.e. within 500 to 1000 feet of waterbodies).	Medium	Towns, WQCC, Counties, DOS, watershed groups	
Where salvage yards are in the floodplain, explore incentives for clean-up and/or relocation.	Medium	Towns, WQCC, Counties, DOS, watershed groups	
Identify and recommend management practices to watershed communities that prevent pollutants from entering the river during floods: floodproofing structures, securing propane tanks and other fluid tanks, repair/replace vulnerable OSWWT fields.	High	SWCD, Counties, Towns, State agencies	
Public Engagement & Recreational Access			
Ensure watershed residents and business owners have access to methods for safe transport and disposal of household and commercial solvents, oils, and other toxins.	Medium	WQCC, towns, AsRA	AsRA Stewardship Brochure in development for watershed residents.
Create and disseminate a brochure providing watershed citizens with common sense solutions and contacts for assistance with water quality or stream health concerns.	Low	AsRA, DOS	Brochure in development. Next steps: dissemination to watershed residents.
Promote citizen engagement in river stewardship through trash clean-ups and workshops to encourage riparian planting on private lands.	Low	AsRA	Ongoing.
Increase and improve opportunities for low-impact recreation and public access to the river.	Low	Towns, AsRA, DEC	
Explore funding for conservation easements on privately owned properties in the river floodplain to limit further development (reducing flood risk and damage).	Medium	Towns, Counties. Local and Regional Land Trusts, AsRA.	

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Appendix A: Geomorphic Restoration Techniques

This appendix outlines a variety of in-stream and bank stabilization tools that may be used to implement natural channel design (NCD) techniques. NCD aims to recreate lost aquatic habitat and restore stream pattern, dimension, profile, and roughness. Dollar estimates for each structure are given as a general price range, based on estimates of cost per linear foot. It is important to note that site access, project size, relationships to infrastructure, availability of materials, and complexity can alter costs.

Very High = >$500/linear foot, or, for an average project >$100K

High =$250-500/linear foot, for an average project $50 to 100K

Moderate = $100-250/linear foot, or for an average project $20-50K

Low = <$100/linear foot, or for an average project <$20K

This is not meant to be a comprehensive list of restoration techniques, nor is it a textbook on engineering and design for river restoration. The hope is to give a sense of the process of restoration by natural stream design techniques, using materials found onsite or nearby. The selection, design, and installation of these structures is challenging. Knowledgeable and experienced personnel with a thorough grasp of stream dynamics are essential in the assessment, design and installation of such structures.

Full Channel Restoration of Incised Streams
Geomorphic assessment surveys indicate that significant portions of the Ausable River are incised, while others are aggraded, and some are stable. Steep walled channels with high banks and valleys confined by development do not allow floodwaters onto a functional floodplain. These conditions exacerbate vertical channel incision and cause extensive lateral bank erosion during high flows.

For the repair of incised segments of streams, Rosgen (1997) and others recommend restoring a channel to mimic the form and functions of a stable reference reach that has similar valley type, slope, soils, and geology. This may require raising the channel through the use of grade control measures (cross vanes, W-weirs, J hooks, or boulder clusters). In other cases, the channel may be put back into its original meandering path (Figures 7a and b) then stabilized. This is done by relocating it into abandoned ox-bows and other relict channel landforms. This method effectively lengthens the path of the river and reduces channel slope, decreases downward erosion, slows stream velocities, reduces stream energies, and reduces downstream flood peaks.

Cost: moderate to very high.

Bank Stabilization
Reducing the shear stress that causes erosion in incised streams can be accomplished by reclining the slope of the banks. In this method vertical banks are cut back to a 2:1 (Horizontal: Vertical) slope. Once the bank is cut back a number of bio-engineering applications can be place on the bank to protect exposed sediment. These include natural fiber mats, turf, brush mattresses, live stakes.

Natural fiber mats are placed on bare slopes and secured with trees and shrubs. Salvaged topsoil is applied to the slope and is seeded prior to placing the matting. Brush mattresses are formed from dormant live branches that are bound together to create a mat used to protect against erosion. This mat is secured to the bank by live and/or dead stakes and partially covered with topsoil. Live stakes are dormant woody cuttings that are driven into the soil and grow into vegetative cover, which stabilizes the streambank (willow works best).

Because these projects do not correct dimension, pattern and profile, they are likely to remain susceptible to shear stress, which can erode streambanks. They may be seen as a temporary or emergency repairs and should be designed not to impair more permanent restoration techniques. When combined with rock or log vanes to roll stream energy away from problem banks, they may suffice.

Cost: low to moderate.

Bank Protection
Bank protection measures are often combined with river stabilization measures. Protection is placed at the toe of an eroding streambank on the outside of meander bends or anywhere stream energy threatens the bank. A few options using natural building materials are listed below.

Root Wad Revetments are lower bank and toe protection structures used on the outside of meander bends where rigid stabilization and habitat enhancement are needed. A root wad revetment consists of the trunk and root ball of a tree, a footer log, and large boulders.

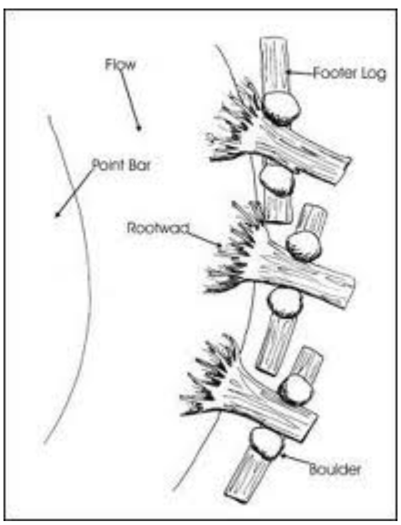

Figure 1. Arrangement of root wads in a root wad revetment structure. (Image courtesy of stormwatercenter.net)

A trench is excavated along the toe of the streambank to slightly *below* the projected channel scour depth. Footer logs are placed in the trench parallel to the streambank. Root wads of at least 10-15’ length are placed so the top of the wad rests on the footer log and all wood is secured in place with boulders then reburied to prevent buoyancy. Root wads are orientated with the root fan perpendicular to flow and along a curve that mimics the natural meander geometry (Figure 8). All logs are set low enough to remain submerged year-round to prevent wood deterioration.

Cost: moderate to high.
The cost of root wad revetments depends upon the length of bank to be stabilized. Using trees growing on-site makes this an affordable structure. Root wads are often used to repair streams following major floods when trees are readily available, making this approach relatively inexpensive.

Root wad Spikes: Individual root wads of 10-15’ may be sharpened with a chain saw and driven into the bank with a track hoe if the soil is cohesive enough to anchor the structure.

Cost: low to moderate.

Using trees growing on-site makes this an affordable structure. Root wads are often used to repair streams following major floods when trees are readily available further reducing costs.

<u>Toe Wood Structures</u>*:* A more robust and resilient use of root wads involves their incorporation into a bankfull bench, constructed to the elevation of mean high water. This tough structure provides multiple benefits: reconnecting an incised channel to a small floodplain bench, protecting eroded banks, and narrowing and deepening over-widened channels. A sod mat, or live willow or alder transplants placed just below ordinary high water, finishes the top of the bench to provide a very erosion resistant unit that enhances fish habitat. The first layer of the toe wood structure is built as described in the root wad revetment application. This is followed by alternating branch, gravel, and soil layers resulting in a resilient structure that is topped off with a locally harvested sod mat or live willow or alder transplants at or just below ordinary high water (bankfull stage). (Figure 9). All material needed for constructing these benches, save for anchoring boulders, can be harvested on site, making these structures cost effective to build.

Cost: moderate to high.

A toe wood sod mat bench constructed on the Ausable's West Branch in 2011 cost $250-320 per lineal foot, while donated locally sourced materials reduced costs to under $100/LF on the East Branch in 2012.

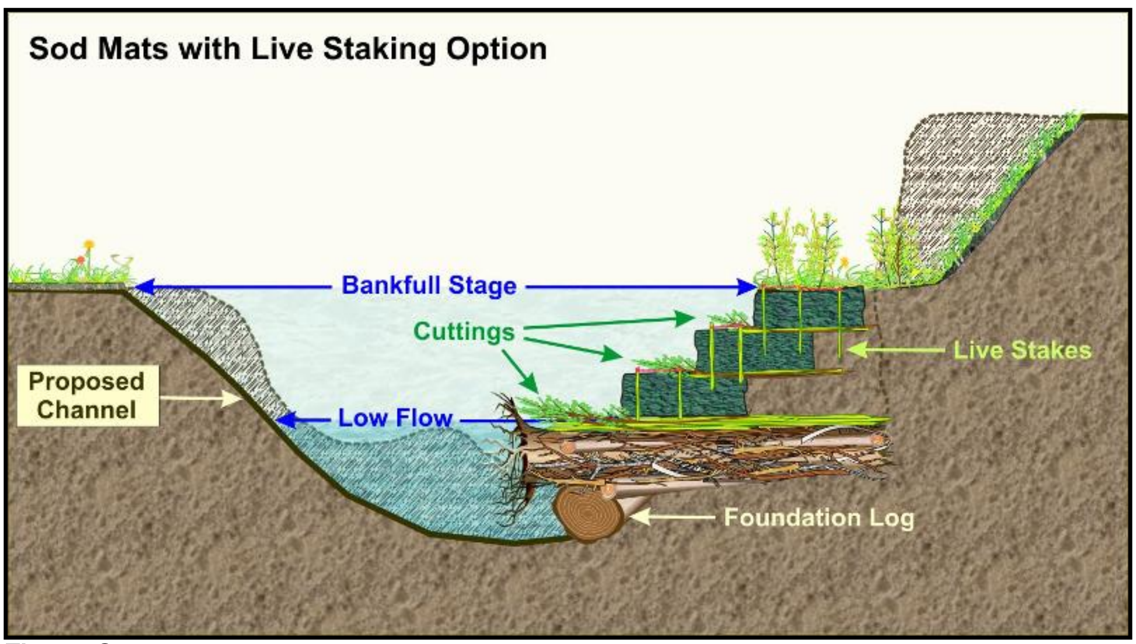

Figure 2. Toe wood with sod mat bench incorporating root wads, sod mats, and live cuttings to create a bankfull bench. Final slope of the upper bank is cut back to 2:1 (Rosgen, 2009).

Flow Deflection
<u>Rock or log vanes:</u> Rock or log vanes deflect stream energy away from a vulnerable bank to halt erosion in their vicinity. They are usually built in conjunction with other toe protection structures (typically bankfull benches), never extend above bankfull elevation and are always well tied into

the bank. Vanes are spaced 2-3 vane lengths apart along the bank and extend into the channel to 1/3 of the bankfull width. They are set at an angle of 20-30 degrees from the upstream bank (Figure 10). The bank end of the vane is at bankfull elevation and the vane slopes into the channel at an angle of 4-6 degrees. Log vanes are embedded into the channel bottom with large boulders, while rock vanes are set upon buried rock footers below scour depth. Both rock and log vanes are infilled along the upstream face with locally excavated stream gravels to form long smooth wedges extending the length of the vane. Commonly vanes are used at the top and bottom of toe wood structures for added stability, keeping flows parallel.

Cost: low, moderate to high (depending upon the availability of sufficient rock and/or fresh logs on site, or the need to purchase and haul from local quarries).

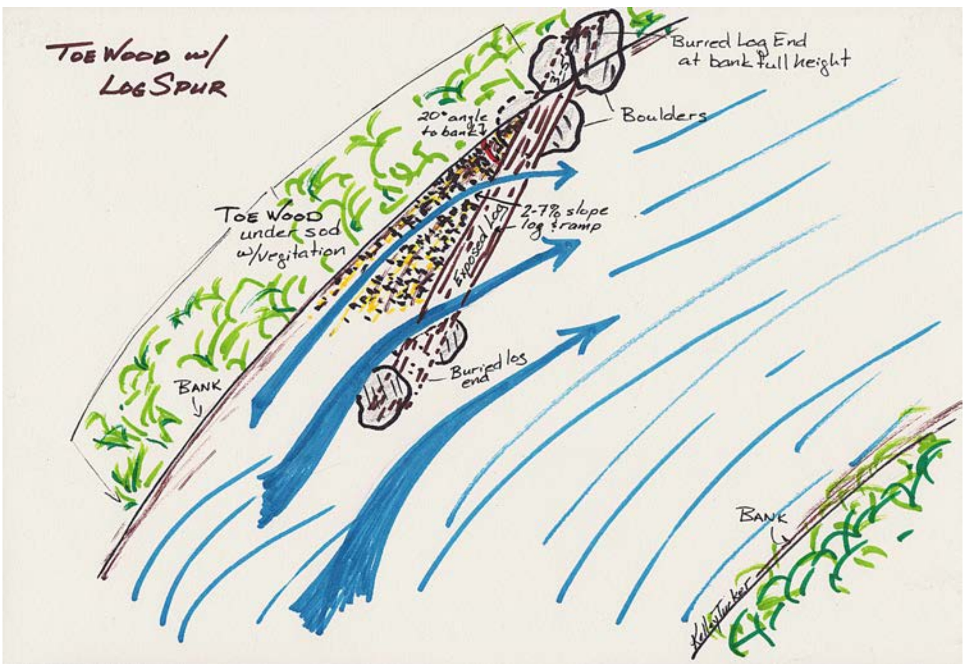

Figure 3. Log vane as part of toe wood, plan view. Boulders secure the log at the bankfull elevation. The log is angled 20-30 degrees from the upstream bank, gravel infill along the upstream face. (K.Tucker for AsRA)

J-Hook Vane: J-hook vanes are rock vanes with curved rock extensions on the end and fully inset cutoff sills that extend across the active channel beyond the end of the curved extension. These structures are typically placed in a riffle at the start of a meander bend, where they act to deflect stream flow away from the bank and downstream, into a scour pool to dissipate stream energy and create fish habitat. The geometry of the arm of the J-hook is the same as a standard vane construction. The arm extends to 1/3 of bankfull width and the hook spans the center 1/3 of the channel (Figure 4). The hook is constructed of large rock 2.5-4 feet or more in diameter. Footer rocks support and brace the structure below, at the level of the channel bottom; the upper rocks of the hook are spaced with gaps to create turbulent convergent flow. Alternatively, a log vane may be used to substitute for the rock vane arm of a J hook.

Cost: moderate to very high.
The cost of placing J-hooks is dependent upon the number of vanes, the accessibility of the site with large equipment, and the length of stream to be restored. Large rocks with at least one flat side, and the contractor's understanding of the need to place rocks snuggly with excellent support from underlying rocks, is critical to the success of such projects.

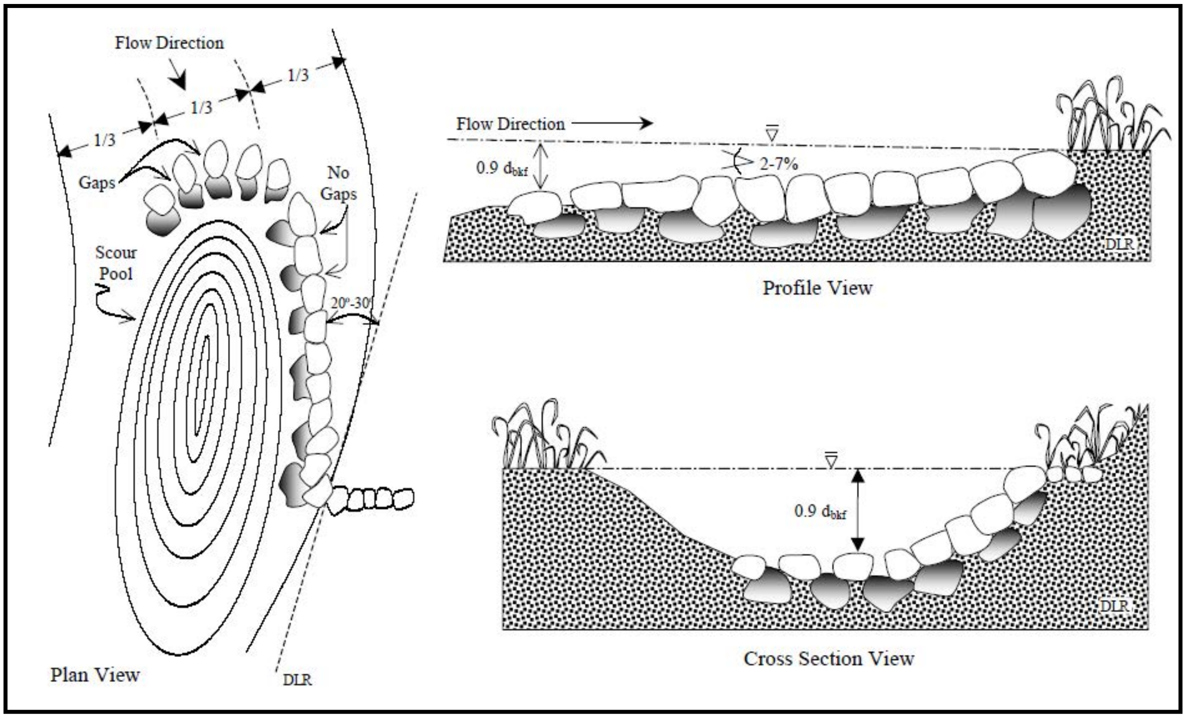

Figure 4. J-hook vane plan (map) view, cross-section view, and river longitudinal profile view (Rosgen, 2006).

Grade Control Structures

Weirs: W-weirs, or their cousins: the S-weir, cross-vane, converging rock cluster grade control and the infrequently used Newbury weir are installed to control a stream gradient (grade control), prevent head cut formation, or raise stream elevation. They also serve to create fish habitat. (Note: Newbury Weirs and S weirs may not confer bank protection.) The W creates a natural zigzag of rocks with two apexes pointing upstream and the arms of the W diverting flow away from the banks. The structure creates two pools in the channel to dissipate stream energy and provide fish habitat. The geometry of the arm of the weir is the same as a standard vane construction. The arms extend from bankfull into the channel at a slope of 2-7 degrees (Figure 5). Footer rocks are inset into the channel bottom so that only 1/3 of the apex upper tier of rock is exposed above the stream bottom (Figure 5).

Cost: moderate to high.
The cost of placing a W-weir is dependent upon access to the site for large equipment, and the availability of natural stone or and the distance to a source for appropriate quarried rock.

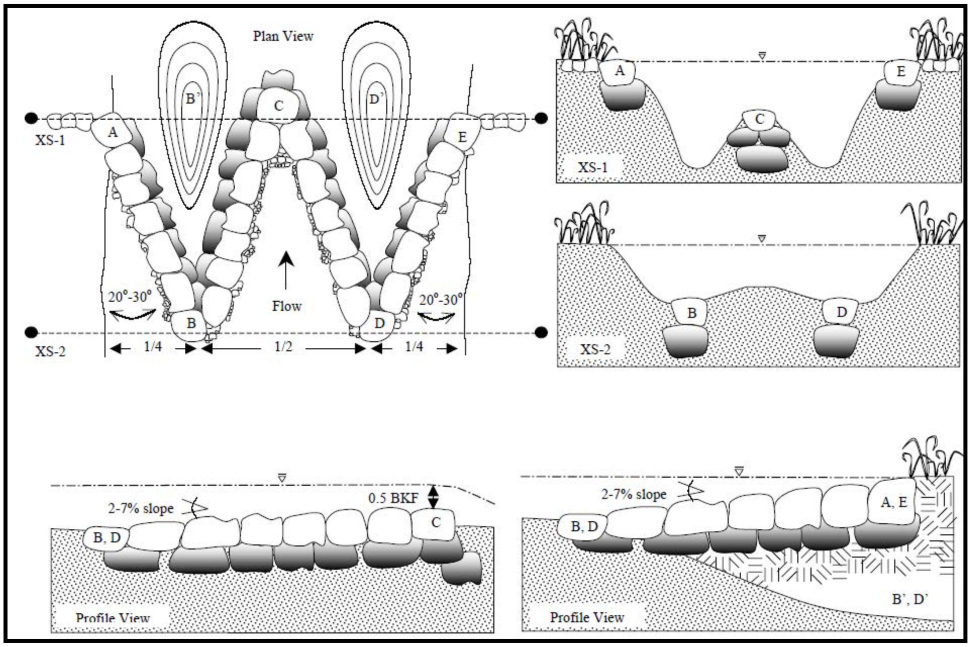

Figure 5. W-weir (map) view, two cross-section views, and two river longitudinal profile views (Rosgen, 2006).


Figure 6. A W-weir installed in the Town of Keene on the East Branch of the Ausable River in 2015 replaced an old wooden recreational dam. Upstream (right) the weir protects a swimming hole. Downstream roughness creates fish habitat for native trout. Photo taken immediately after bankfull event.

Structures to Introduce Roughness and Habitat:
Boulder clusters are groups of large rocks placed in a stream to improve habitat by creating small areas of scour and reduced velocity near the clusters. They improve oxygenation and are

used where cover and diversity are the limiting habitat characteristics in the stream. The boulders create eddies or vortices in their wake and create overhead cover for fish by diffusing sunlight (Fischenich and Seal, 1999). Under high flows, boulder clusters also reduce stream velocity and energy, contribute to channel stability, and lessen flood impacts.

Boulder clusters are most effective in shallow stream segments with coarse gravel or cobble beds, provided excessive bedload is not being mobilized. They can be prescribed for stream reaches that have: a) a dominance of riffles over pools and b) riffles comprised of coarse gravel to cobble substrate, with few boulders and other associated forms of channel roughness or cover.

Groups of 3-5 boulders in an apex upstream triangular configuration staggered along a riffle or a very shallow run are most effective, but individual boulders may be effective in small streams if used with an embedded footer rock (FISRWG, 1998). To maximize turbulence and scour, rock should be spaced with approximately 0.5-1.0 boulder diameter between them. Successive downstream clusters are placed in a zigzag pattern so that flow is outside the wake of the upstream boulder.

The method for placing the boulders depends upon site access and equipment availability. Using a large excavator with a hydraulic bucket thumb allows boulders to be placed from the bank, keeping equipment out of the water. Boulders should never be end-dumped from the bank into the stream.

Cost: low to moderate.
It is not difficult to find boulders in the Adirondacks. Using rock located on-site can reduce project costs, but if transport is required, the cost of these projects can escalate. A moderately sized project might cost approximately $5,000.

<u>Large Woody Debris:</u> Trees that fall into a stream because of floods, disease, natural mortality, erosion, beaver activity, or wind throw are commonly referred to as large woody debris (LWD) (Connecticut DEP). LWD is recognized as being critical to the formation of cover habitat in streams, contributing to pool formation, sediment retention, macro invertebrate production (Cox, 2011), while providing roughness to help control flood energy.

The role of LWD to stream health and habitat is frequently underestimated. In the past, many landowners, or recreational groups removed LWD for the mistaken purpose of river “improvement.” An example from the Batten Kill River in Vermont illustrates the importance of LWD as a component of a healthy ecosystem. LWD was removed from this river in order to facilitate boating and log driving. By the mid-1990s yearling and adult brown trout in the main stem of the Batten Kill had declined by 70% (Cox, 2011). Inadequate cover exposed fish to increased predation and other environmental stresses, contributing to low fish populations across all age classes (Cox, 2006). Following the installation of LWD, yearling fish numbers increased five times in pools and doubled in riffles. Significant increases in numbers of adult trout also took place. The role of LWD in controlling stream energy and channel morphology under higher flows has also been shown to be significant in smaller streams.

Installation of LWD to enhance cover habitat and provide channel boundary roughness can follow the installation recommendations suggested above in the sections on root wad revetments and toe wood structures. Additional large anchored or embedded wood can be beneficial even when located on bars and active floodplains adjacent to the stream. Needless removal of beneficial natural LWD can be avoided by following DEC guidelines and permit requirements, which stipulate that removal of LWD should only be done when it creates a clear and imminent threat to public or private infrastructure, navigation, or streambank erosion. If overhanging or falling riparian trees must be cut, leaving the root wad and a 6 to 12 foot segment of the trunk in the streambank will add stability to the bank and provide cover habitat. The cut portion can be floated and secured against the downstream bank and secured to provide bank protection and cover.

Cost: low.

Restoring wide and shallow rivers:
Overly wide and shallow, straight reaches of rivers represent another aspect of stream instability, namely the failure of normal passage of sediments (sands, gravel, and cobble) through the stream segment. This causes deposition that fills the spaces between rocks and smoothens the bed, harming all aquatic life. Bank erosion can result, reducing channel capacity and leading to more frequent overbank events. Such conditions contribute to the formation of ice jams—another source of overbank flooding.

A long-term solution to all these problems uses river mechanics to shift energy back to the central part of the channel, restoring normal sediment transport while reducing the stream energy along the banks that causes deposition. Low profile log barbs (15-20' long root wads) are embedded along one or both sides of the river. These rock-braced and rock-anchored barbs project into the channel at a 45-degree angle upstream and slope downwards at a 1-2 degree angle from ½ bankfull elevation to the tip of the half-buried root wad. This shifts stream energy away from the banks toward the center of the channel. With less energy along the banks during high flows, transported sediments are deposited bankside to effectively narrow the open channel, while higher energy in the central channel restores normal transport. Over time, this causes the open channel to deepen and expose larger (immobile) rock – effectively reversing several problems in stream mechanics and ecosystem function while potentially lessening local flood risks from minor events.

Cost: low to moderate, depending upon the availability of local materials. This technique can be very cost effective long-term, eliminating "channel maintenance" costs and potentially lowering local flood impacts.

In short, using river science to restore the river's ability to effectively do work can pay multiple dividends.

Appendix B: Permitting a Stream Restoration Project

Any stream restoration work conducted within the Adirondack Park requires permits from the Army Corps of Engineers, the Adirondack Park Agency (APA), and the New York State Department of Environmental Conservation (NYS DEC).

A permit is required from the Army Corps of Engineers under Section 404 of the Clean Water Act for any activity that results in discharge to waters of the United States. Article 27 regulates any activity that disturbs a navigable waterbody. APA permits are required for all shoreline disturbance and tree cutting. A guide to APA permitting requirements, the "Citizens Guide to Land Use within the Adirondack Park," can be found at: http://apa.ny.gov/Documents/Guidelines/CitizensGuide.pdf.

Any restoration work done that will disturb the bed or banks of a river listed as Wild, Scenic, and Recreational requires a permit under Article 15 of New York State law. A Protection Of Waters Permit from the NYS DEC is required for streams with a classification and standard of C(T) or higher (disturbance may be either temporary or permanent in nature).

The NYS DEC website defines banks as the land area immediately adjacent to and sloping toward the bed of a watercourse and which is necessary to maintain the integrity of the watercourse.

Examples of activities requiring this permit are:

- placement of structures in or across a stream (i.e., vanes, weirs, bridges, culverts or pipelines);
- fill placed for bank stabilization or to isolate a work area (i.e., logs, root wads, rip-rap or coffer dams)
- excavations as part of a construction activity;
- lowering streambanks;
- utilization of equipment in a stream to remove debris or to assist in-stream construction.

All in-stream work in NYS DEC Region 5 is required to be finished by October 1 so as not to interfere with trout spawning season.

In recent years, a partnership has formed in the watershed between the US Fish and Wildlife Service, Ausable River Association, Essex County Soil and Water Conservation District (SWCD) and Trout Unlimited. These groups are working with a variety of public and private funds to restore sections of the river prioritized by this watershed management plan.

For more details on the specific definitions, activities, and permitting requirements see the appropriate agency websites:
http://www.dec.ny.gov/permits/6335.html

http://apa.ny.gov/property_owners/permitProcess.html

http://www.americanrivers.org/library/reports-publications/citizens-guide-to-corps.html

For further questions and clarifications contact the permitting staff at each agency.

Appendix C:

C1: River Segments for Restoration – Ranking Criteria											
Threat to Structures Proximity to structures that could be damaged by bank erosion (highest value is given if more than one threat is present)		**Bank Erosion Impact**	Bank Heigh t	Erosio n	**Feasibility** Access or permitting issue could make streambank restoration unfeasible		**Riparian Cover** Percent riparian cover on entire segment length		**Density of Outfalls** Data from Outfall Report and Subwatershed Prioritization Outfall Map	
Commercial Building/Home on top of bank	4	High	4	4	Access through wilderness or wild forest	-4	0-24%	4	> 1.2/mile	4
Buildings near bank or bridge	3	Medium	3	3	Limited access	-3	25-49%	3	0.7-1.1	3
Culvert	2	Low	1-2	2	Erosion caused by infrastructure	-2	50-74%	2	0.4-0.6	2
Roadway	1	Not Significa nt	0	0	Landowner Issues	-1	75-100%	1	<0.4	1

C2: River Segments for Restoration - Priorities							
	Threat to Structures	Bank Height	Erosion	Feasibility	Riparian Cover	Density of Outfalls	Final Score
West Branch							
Rt. 73 to Holcomb Brook	4	4	4	0	4	3	19
Holcomb Brook to Rt. 86	1	4	4	-4	3	3	11
Rt. 86 to Copperas Pond	1	3	4	-4	3	3	10
Copperas Pond to Wilmington	0	3	0	-4	3	3	5
Wilmington to Black Brook mouth	0	3	2	0	3	3	11
Black Brook mouth to Au Sable Forks	0	0	0	0	2	0	2
East Branch							
Ausable Lake to St. Huberts	0	4	1	-3	1	0	3
St. Huberts to Keene Valley	1	3	1	-2	3	4	10
Keene Valley to Keene	1	3	3	-2	4	4	13
Keene to Lacy Bridge	3	3	2	0	4	3	15
Lacy Bridge to Upper Jay	0	3	4	-2	3	3	11
Upper Jay to Upper Jay Pull-out	3	3	1	0	4	4	15
Upper Jay Pull-out to Jay Pull-out	1	3	4	0	4	2	14
Jay Pull-out to Covered Bridge	0	4	1	0	3	3	11
Covered Bridge to Stickney Bridge	4	4	4	0	4	1	17
Stickney Bridge to Au Sable Forks	1	2	1	-2	4	2	8
Main Stem							
Au Sable Forks to Clintonville	1	3	1	-1	4	2	10
Clintonville to I-87	0	3	2	-3	3	2	7
I-87 to Rt. 9 Keeseville	?	?	?	?	3	?	--
Rt. 9 Keeseville to Carpenters Flats	3	2	2	-1	3	3	13
Carpenters Flats to mouth	1	3	3	-4	1	0	4