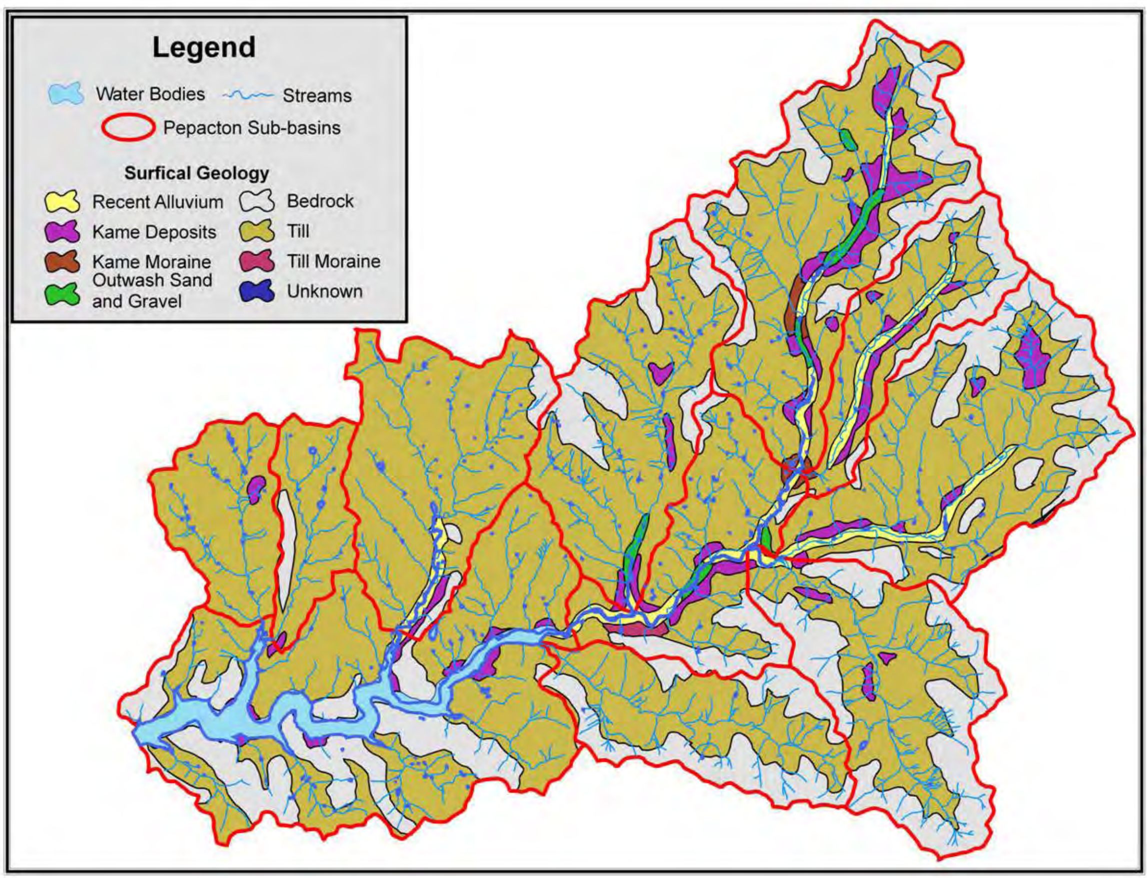
~ 2. Geology and Soils ~

GEOLOGY

The following section describes the basic geology of Delaware County and the East Branch Delaware River watershed, how this affects the stream channel form or fluvial morphology, and water quality of the basin.

Bedrock Geology

The bedrock underlying all of Delaware County is of sedimentary origin. Geologic research indicates that the sediments resulted from the erosion of a large mountain range that once existed to the east during the upper Devonian Period, some 370 million years ago. Westward flowing rivers carried the eroded sediments into the "Catskill Delta," a vast marshy plain that was developing at the time. There the waters deposited layers of *sand*, *gravel, silt* and *clay* that eventually became the beds of sandstone, conglomerate (sandstone with pebbles), siltstone and shale rocks of today.



Map 2.1 Surficial Geology

Eventually, long periods of pressure from overlying sediments and cementation by mineral-carrying waters lithified sands into sandstones, silts into siltstone and silty clays into shale. The thickest and most uniform beds of certain sandstones are now valuable for local "bluestone" quarries. As one travels from north to south across Delaware County, bedrock outcrops tend to expose progressively younger rocks. **Map 2.1**[3] shows the occurrence of bedrock types in the East Branch watershed (Fisher et al., 1971).

The regional dip of these relatively flat-lying rock layers is towards the south-southwest at angles less than 10 degrees, although thin zones of steeply sloping "crossbedding" within individual rock units also occurs. Rock colors are shades of red or bluish gray due to deposition in environments of high oxygen (terrestrial) or low oxygen (tidal or alluvial plain), respectively. Fossils are typically few, poorly preserved plant fragments, trace fossils, and some marine fauna; the dominance and abundance of each varies between locations and individual beds. Studies of bedrock types, layer sequences and fossil records indicate ancient delta-like and shallow marine environments within a tropical climate that was alternately wet and dry.

Important rock groups and some of their component rock formations in the East Branch watershed are shown in **Table 2.1**. None of these formations contain beds of limestone, but rather contain much silica; they are therefore considered to be "acidic" rocks, and spring water arising from bedrock cracks and fissures tends to be low in dissolved calcium and magnesium carbonates ("soft" water).

Some 330 to 250 million years ago, long after the sedimentary rocks had been formed, mountain-building forces began raising the large Appalachian mountain chain to the south. Being at the northern end of these rising mountains, the plateau that we know as the Catskill region was uplifted, acquiring vertical fractures in its rock layers during this time. Long periods of weathering and erosion wore down this plateau and created a drainage network along joints or fractures in the bedrock – an early version of the stream valleys we have today. Thus, the Catskill Mountains were created both by forces of erosion as well as those that build mountains upward. However, the shapes of the landscape have also been significantly remolded by glacial events, as described below.

Table 2.1. Bedrock Types in the East Branch Basin*

Geologic Group	Rock Formation	Type of Rocks Included
West Falls	**Honesdale**	Sandstone & shale
West Falls	**Slide Mountain**	Sandstone, shale & conglomerate
West Falls	**upper Walton**	Shale, sandstone & conglomerate
Sonyea	**lower Walton**	Shale, sandstone & conglomerate
Genesee	**Oneonta**	Shale, sandstone & conglomerate

* Like the bedrock formations themselves occur, the oldest rocks are listed on the bottom, the youngest at the top of the table.

[3] Map 2.1 is based in part on the work of Rich and others. Isachsen and others (1991, pp. 161-193) discuss the glacial epoch and its effects on NY landscapes. Reynolds (2004), Titus (1998) and Rich (1935) give more detailed descriptions of glacial landforms in the Catskills Region than the summary provided here.

Glacial Geology

A number of major glaciations have occurred in North America. Geologic age dating techniques imply that the most recent glaciation to leave this area (the Wisconsin glaciation) did so only some 10 to 12 thousand years ago. At its furthest advance, glaciers covered the county with moving ice nearly one mile thick, extending hundreds of miles northward. This caused tremendous amounts of erosion by abrasion and bedrock "plucking", the pressure-melting and refreezing of ice as the glaciers flowed over hills. The generally rounded and smoothed profile of hills and the U-shaped cross section of larger valleys resulted. The processes of glacial erosion also crushed and fragmented rocks into a slurry of *boulders*, angular stones and *gravel*, sand, silt and clay. This mixture was transported beneath, within and on top of the glacier, sometimes for many miles before being deposited by the ice or its meltwaters. Called glacial till, most uplands in the East Branch basin are covered with this kind of deposit (**Map 2.1**). For example, about 95% of Dry Brook's watershed is covered by varying thicknesses of glacial till.

Because layers of sandstone and siltstone were continuously ripped up and incorporated into the till, our upland soils are commonly stony (or very stony) throughout their depth. On many hilltops and north-facing slopes, till was deposited as a relatively thin layer (less than 40 inches to bedrock), and in thicker layers over other areas. Certain south-facing hillsides received unusually massive accumulations of till (over 60 feet thick) where they were on the "lee" side of hills that obstructed the flow of advancing ice.

After long periods of glaciation, the climate warmed again and the glaciers melted back northward faster than they were flowing southward. This melting created tremendous amounts of sediment-laden water in rivers and lakes. However, tongues or flows of ice tended to remain in the larger valleys long after the uplands were relatively ice-free. Eventually these valley ice masses stopped flowing and melted away, creating landforms and deposits that are distinctly different from those in the uplands. Large amounts of meltwater flowed along the sides and beneath the stagnant valley ice masses, washing through the rocky and muddy debris. This tended to separate and remove the finer silt and clay from sand and gravel. In locations where washed and sorted debris was deposited, usually the margins of major valleys such as the mouth of the Platte Kill along the East Branch, gravelly terraces and kame deposits occur (**Map 2.1**). These give such parts of the landscape a somewhat lumpy and bumpy appearance. Such deposits are often valuable sources of sand and gravel, although they typically contain more silt and clay than is desirable. Sand and gravel deposits can also store considerable amounts of ground water, which is released gradually to form the base flow of streams. By contrast, the extensive glacial till deposits contribute only a minor amount of ground water to base flow (Reynolds, 2004).

The stagnating remains of the valley glaciers blocked off the outlets of some meltwater streams, creating lakes until the dams of ice could melt, which took many years. In the quiet waters of deeper lakes, silts and clays settled out and accumulated while in shallower, more agitated lakes fine sand and silt was deposited. The finest-textured (clayey) sediments formed relatively small deposits. Coarser lake-laid deposits occur in the East Branch and other valleys, although more recent *floodplain* deposits often overlie them. The river itself winds through the relatively flat surface of accumulated sediments over the much deeper valley carved into the bedrock. Reynolds (2004) reported about 150 feet of sediment filling the valley floor where the Pepacton Reservoir's Downsville dam was constructed.

Where relatively fast-flowing tributary streams enter major valleys, water *velocity* slows as they flow across the flatter river floodplain. The abrupt slowing of the stream's velocity causes it to drop its bedload of sand and gravel on the floodplains as a subtle fan or delta-shaped alluvial fan deposit. This process has been continuing since the waning stages of glaciation, and alluvial fans are commonplace in larger valleys. Because these deposits are fairly level and well drained, they make good farmland and building sites; the center of many villages and hamlets, including parts of Margaretville and Roxbury, are on alluvial fan landforms.

The glacial deposits described above are the parent materials in which the soils of today have developed. In terms of geology and soil formation, the Epoch since the glaciers left their deposits on the Delaware County landscape is a short period of time. Processes of erosion and sediment accumulation continue to affect the landscape, although their rates can be greatly accelerated by man's activities.

Applied Geology

An understanding of geology can be useful background to stream corridor management because bedrock and glacial deposits influence the stream system within its drainage basin. Dendritic stream patterns (having branches like those of a tree) that occur in this watershed tend to develop where horizontally-bedded, sedimentary bedrock had a gently sloping regional dip at the time the initial drainage channels began forming[4]. The bedrock's jointing pattern (system of deep, vertical fractures) also influence stream pattern formation.

The region's geologic history has favored the development of non-symmetric drainage basins in the East Branch, as it has in the West Branch basin, too. Notice in **Map 2.1** how stream sub-basins that slope to the south-southwest are more numerous and extensive than those that slope towards the north-northwest. The occurrence of bedrock also directly affects streams wherever the stream channel contacts bedrock instead of stream deposits. In such places, rates of stream channel downcutting, bank *stability* and lateral migration are dramatically reduced. Examples where the stream has cut down to bedrock occur in the middle and upper reaches of Dry Brook.

Thin soil materials typically cover fractured bedrock on the hilltops, while thicker deposits of glacial till occur at some distance downslope. As a result, precipitation is able to infiltrate bedrock fractures on upper hillsides and hilltops, creating and recharging the

[4] Ritter, 1978, p. 171

bedrock aquifer. Water stored in and released from the bedrock aquifer is relied on for individual drinking water wells and springs. Small springs are quite common throughout the basin, and often are the places where creeks originate. Springs and other groundwater sources comprise the majority of stream base flow in drier, summer months. In general, the quality and taste of this groundwater is excellent since it usually has low levels of dissolved solids and chloride, but may contain considerable iron.[5] A study in the Batavia Kill basin indicates that shallow groundwater has spent less than 10 years underground.[6]

Probably one of the least known but most appreciated aspects of geology in this region of the Catskills is closely related to maintaining fish habitat. It is well known that various sport fish, including trout, require relatively clean and cold water for their survival and especially for spawning. The best trout streams tend to have a steady supply of base flow from cool groundwater. This requires a means of water storage and release, either natural or man-made, especially through the warm summer months. As mentioned before, the glacial till that covers over 90% of the East Branch watershed contributes little groundwater to maintain base flows between precipitation events, largely producing runoff instead. The primary soil materials that can store and steadily release groundwater are extensive areas of sand and gravel, due to their porosity. But the entire East Branch basin has only minor amounts of these deposits (5 to 7%) as kame, kame moraine, outwash and alluvium (**Map 2.1**).

The answer to this puzzle was first alluded to by a geologist from Binghamton University (Coates, 1971) and was more recently deduced by the USGS (Reynolds, 2000 & 2004). It turns out that of the sandstone, siltstone and shale bedrock types of the Catskill Mountains, sandstone is the most permeable, due primarily to its extensive joints and other fractures. A bedrock aquifer underlies the entire East Branch watershed, with the most massive sandstone occurring in the Mill Brook and Tremper Kill sub-basins. While all of the East Branch exhibits unusually high base flows for the small amount of sand and gravel deposits, these two sub-basins have the capacity to store and slowly release relatively large amounts of groundwater to stream base flow — capacities greater than nearly all other basins in the Catskills (exceeded only by the Beaver Kill and Willowemoc Creek to the south). Stored groundwater is thus released from sandstone by springs and subsurface seepage into streams for extended periods through the summer, which maintains favorable trout habitat for most of the year.

The glacial till deposits tend to be relatively coarse textured, often including a substantial amount (15 to 35% by volume) of gravel- to boulder-sized rock fragments. This reduces soil erodibility by providing a sort of "armoring" effect[7], and physical stability of stream beds and banks may similarly be increased, especially where the rock fragments are firmly held within firm till deposits. The pervasive sandstone layers in local bedrock tend to form relatively flat clasts (rock fragments) in the till. In stream deposits, such as gravel bars, point bars and alluvial fans, flowing water often arranges these flat stones into a shingled or imbricate form, where one clast rests on a slight angle on top of

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[5] Soren, 1963
[6] Heisig, 1998
[7] McCormack and others, 1984.

another. Imbricated streambeds require a larger flow to move the bed material than do non-imbricated beds.

The streambanks of the mainstem of the East Branch are mostly made up of its own floodplain deposits (called "recent alluvium" on **Map 2.1**). In places, however, steep eroding streambanks have been created where the river has cut into kame, kame moraine or till moraine deposits. These loose materials tend to form unstable slopes, contributing excessive amounts of sediment that can de-stabilize downstream reaches as the streambed rises from added bedload. By contrast, upper reaches of tributaries to the mainstem are more likely to contact glacial till in the uplands, which tends to be more cohesive and therefore less erosive. Compared with, for example, the Schoharie Reservoir watershed, the East Branch, its tributaries, and the Pepacton Reservoir do not contain extensive deposits of glacial lake-deposited clays. The relatively rare occurrence of fine textured soils limits periods of high *turbidity* to times immediately bracketing high-flow events.

SOILS

In New York State, soils have been classified into four Hydrologic Soil Groups based on *runoff* potential and infiltration rates. These four runoff groups are defined as follows:[8]

> Group A soils exhibit low runoff and high infiltration even when thoroughly wetted. They are chiefly sands and gravels that are deep and well drained to excessively well drained.
>
> Group B soils exhibit moderate infiltration when thoroughly wetted. They are moderately deep to deep, moderately drained to well drained, and are moderately fine to coarse textured.
>
> Group C soils exhibit low infiltration rates when thoroughly wetted. They have a layer that impedes downward movement of water, such as hardpan subsoils or bedrock at 20 to 40 inch depths, and are moderately-fine to fine textured. This is the predominant hydrologic soil group, covering most of the basin. These soils can contribute substantially to runoff.
>
> Group D soils exhibit high runoff and very low infiltration when thoroughly wetted. They are chiefly shallow over nearly impervious material (bedrock).
>
> In many areas of the basin, dual hydrologic groups are also mapped. This fifth group of Group C/D soils generally is found where bedrock is close to the surface. If the bedrock is not fractured, the soils exhibit Group D characteristics (high runoff). Where the bedrock is fractured, allowing some infiltration, the soils exhibit Group C characteristics.[9]

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[8] National Engineer Handbook 649.00

[9] Personal communication with Laurence Day, Soil and Groundwater Specialist, Delaware County Soil & Water Conservation District.

In practical terms, the extensive areas of glacial till in the basin have thus developed permeable, upper soil layers, often 1 to 3 feet thick, that overlie relatively dense and slowly permeable subsoils. This would be typical of soils in Hydrologic Group C. Such abrupt changes in permeability with depth create saturated zones (perched water tables) at the contact between the two materials, particularly during the wetter seasons. On lower portions of hillslopes, the upper soil layers often become saturated to the surface from the accumulation of lateral flow of shallow groundwater. This in turn influences where erosive rills begin to form on a slope, and where new stream channels may begin to form.

Since approximately 90% of the soils in the East Branch basin are C and/or D, runoff potential is usually high. This is an important factor when performing stream assessments and developing mitigation protocols.

WETLANDS

Wetlands can greatly affect the way water travels through the landscape, and so it is important to describe what wetlands are, where and in what forms they occur, and the reasons they are important in the watershed.[10]

The term "wetlands" generally describes areas of the landscape that are periodically wet enough to limit uses of the land — farming is usually not possible in these areas without draining, and building is usually difficult without filling. Such areas include marshes, wet meadows, swamps (forested wetlands), bogs, the shallow margins surrounding ponds, lakes or reservoirs, and seasonally-flooded floodplains.

Because such areas were difficult to utilize for food or fiber production, wetlands used to be perceived more for what they were *not* (e.g., productive farmland) than valued for their ecological characteristics. In their natural condition, wetlands provide flood control, erosion control, water quality protection, fish and wildlife habitats, and opportunities for recreation, aesthetic appreciation and education. Over the last few decades, society and the scientific community have increasingly become aware of the functions of wetlands, their values to society, and the variety of forms they take. Differences arise from variation in vegetation, soils, hydrology, and position in the landscape, all of which can make some wetlands more "valuable" than others.

A number of laws have been created specifically to protect wetlands from being drastically harmed by human activities. These regulations are considered necessary because the U.S. has already filled or otherwise destroyed 30 to 50% of the wetlands that once existed in the lower 48 states.[11] Regulations usually require clear definitions of what is being regulated. For the purposes of conducting a nationwide inventory, the U.S. Fish and Wildlife Service developed a technical definition of wetlands:

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[10] Basic descriptions about wetlands in this section were paraphrased from a short publication by R. Tiner (1997); additional analyses and descriptions specific to the East Branch watershed provided by L. Day, Delaware Co. SWCD.
[11] Liebesman, 1993, p.10

> "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes [wetland plants]; (2) the substrate is predominantly undrained hydric soil [usually grey-colored, with low oxygen content]; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."[12]

The U.S. Fish & Wildlife Service used this definition and a wetland classification system to inventory wetlands (based largely on interpretation from color infrared aerial photography) within the NY City watershed. The result was a series of maps at 1:24000 scale that show where certain wetland types are likely to occur. A portion of one of these maps is shown in **Figure 2.1**. While it may appear that wetlands have been clearly defined, classified and mapped, proposed construction projects often require more precise delineations of wetland boundaries and types. These evaluations rely on onsite observations of plants, soils, and hydrology by trained professionals that use a more technical definition of wetlands than the one quoted above. It is the more technical definition that is followed by the U.S. Army Corps of Engineers.

[12] Cowardin, et al., 1979

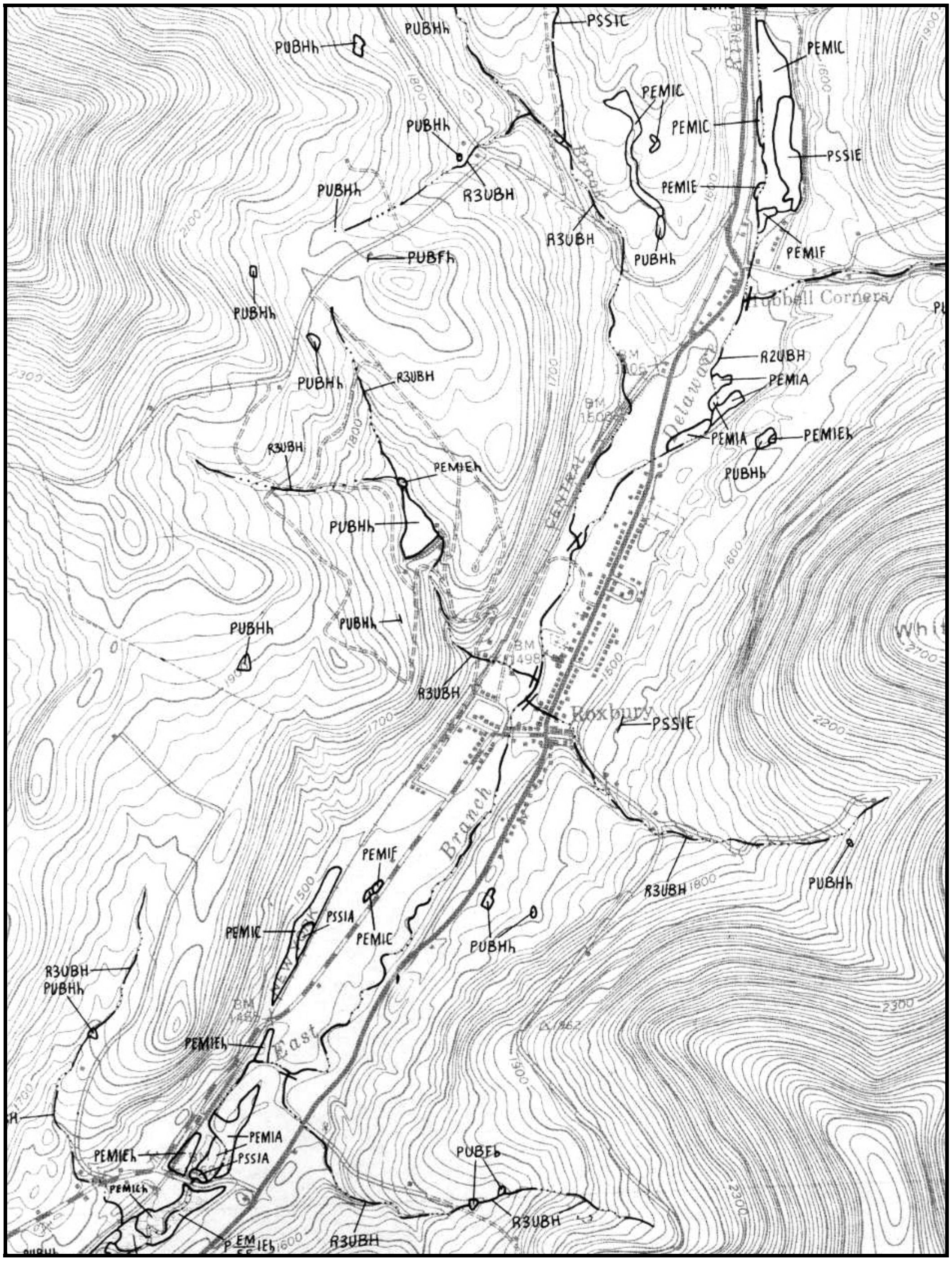

Figure 2.1 Wetlands around the Village of Roxbury as identified by the U.S. Fish & Wildlife Service in their National Wetland Inventory mapping (1995). The letter symbols (such as PUBHh) refer to wetland type.

Wetland Types

Considering the definition above, wetlands can take a variety of forms: shallow parts of a lake or pond, a wet marshy area just downslope from a hillside seep or spring, the low floodplain adjacent to a perennial stream, and so on. One can go into great detail when describing subtle traits that separate various wetland types. For the purposes of this SCMP, only the major types of wetlands will be described here.

One thing in common with all wetland types in the East Branch watershed is that they have freshwater hydrology; no salty marine or brackish water environments (which form another group of wetland types) exist. Freshwater wetlands are divided into three ecological systems – palustrine, lacustrine, and riverine. Palustrine wetlands, which are the most common general type in the East Branch watershed, are mostly vegetated wet areas such as cattail marshes, hemlock swamps and bogs, but they also include man-made ponds. Besides palustrine types, most of the other freshwater wetlands in the basin are associated with lakes and reservoirs. These are called lacustrine wetlands and are usually limited to aquatic beds (e.g., floating lily pads that grow in shallow water), wet marshes, and the shallow water zone (less than 6.6 feet deep) that may have no vegetation. Riverine wetlands are contained within the river channel (where water is usually flowing). Most of the riverine wetlands are non-vegetated, periodically-exposed shores, such as gravel bars.

While the above paragraph generally describes the three main ecological types of wetlands, the other major wetland subdivision considers the dominant kind of vegetation. Emergent wetlands (commonly called marshes or wet meadows) have mostly grasses, sedges, and other non-woody plants. Scrub-shrub wetlands (including alder or dogwood swamps and bogs) are represented by low- to medium-height (less than 20 feet tall) woody plants. Forested wetlands (mostly wooded swamps and bottomland forest) are dominated by trees over 20 feet tall. **Figure 2.2** illustrates where various types of palustrine wetlands occur in the landscape.

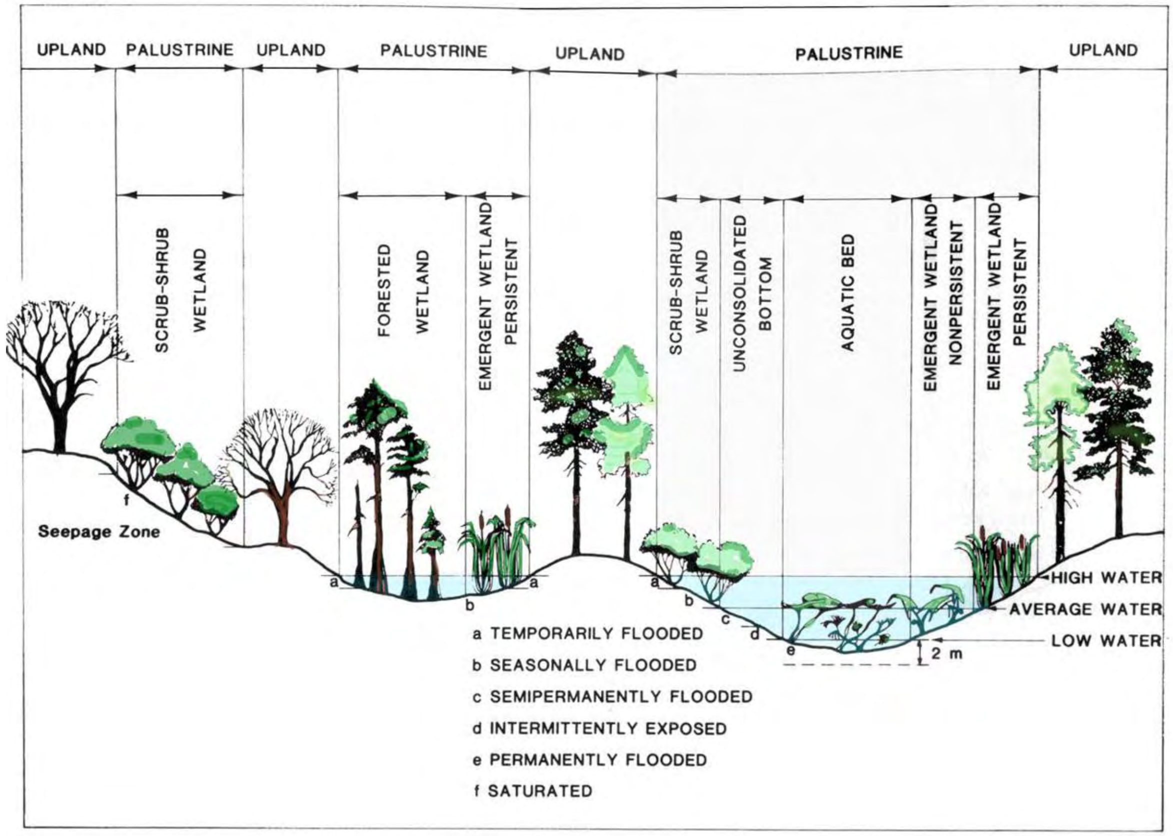

Figure 2.2: Diagram of palustrine system of wetlands (more commonly known as marshes and swamps) and their typical positions in the landscape.[10]

East Branch Watershed Wetlands Inventory

The U.S. Fish and Wildlife Service published their inventory of wetlands in the entire NY City watershed in 1996. Their data is available as printed maps, such as **Figure 2.1**, and also in digital format as a spatial and tabular database. Using GIS, the area of each sub-basin within the East Branch watershed was clipped from the NY City watershed-wide coverage of wetlands, and then rearranged in order to simplify comparison between sub-basins. This information is presented in **Table 2.2**.

As shown in the table, the largest sub-basin is the Pepacton Reservoir, which is 73.4 mi^2 or nearly 47,000 acres in size (column C). Because so much of this sub-basin is the Pepacton Reservoir itself, it has the largest amount of deepwater habitat (surface water bodies more than 6.6 feet deep) of any of the sub-basins (column E). (Because deepwater habitat is outside the definition of "wetlands," these areas were omitted from remaining calculations.)

The sub-basin with the most wetlands is the East Branch Headwaters. Its total of 359 acres of wetlands constitutes only 1.1% of this sub-basin, however (column F). This relatively small proportion is still near the maximum observed, since wetlands cover from

0.3% to 1.4% of all sub-basins. The East Branch Headwaters also has more individual wetlands (239) than the other sub-basins (column G).

Most wetlands in each sub-basin are relatively small, with median wetland size ranging from 0.64 to 1.48 acres (column H). The most extensive wetland type is small marshes with emergent vegetation (abbreviated as PEM in table – column I). The next most common wetland type is small ponds (abbreviated PUB in table – column J), followed by scrub-shrub swamps and lower portions of perennial streams (R2US).

Table 2.2 Summary of Wetland (WL) Information for East Branch Sub-basins

A	B	C	D	E	F	G	H	I	J	K
Sub-basin	**Sub-basin Size (sq. miles)**	**Sub-basin Size (acres)**	**WL Area in Sub-basin (acres)[1]**	**Deepwater Habitat (acres)**	**WL Area per Sub-basin (%)[1]**	**# of WLs in Sub-basin**	**Median WL size (acres)**	**Most Extensive WL Type[2]**	**2nd-most Extensive WL Type[2]**	**# of WLs per sq. mile**
Batavia Kill	19.3	12,352	66.2	–	0.536	85	0.64	PSS (34%)	PEM (34%)	4.4
Bush Kill	47.2	30,208	164.7	–	0.545	85	0.95	PEM (34%)	PUB (32%)	1.8
Dry Brook	35.2	22,528	116.3	–	0.516	76	1.25	PSS (30%)	PUB (26%)	2.2
E Branch Headwaters	50.0	32,000	*359.2*	28.73	1.123	239	1.23	PEM (59%)	PUB (23%)	4.8
E Branch Mainstem	25.8	16,512	*229.1*	221.82	1.387	141	1.19	R2US (25%)	PFO (22%)	5.5
Fall Clove	11.2	7,168	*71.2*	.01	0.993	44	1.30	PUB (48%)	PEM (26%)	3.9
Mill Brook	25.4	16,256	*42.5*	25.39	0.261	47	1.14	PEM (47%)	PUB (32%)	1.9
Pepacton Reservoir	73.4	46,976	*149.7*	5,379.11	0.319	181	1.16	PUB (50%)	PEM (27%)	2.5
Platte Kill	35.4	22,656	*91.0*	2.51	0.402	150	1.05	PEM (43%)	PUB (27%)	4.2
Terry Clove	15.1	9,664	68.5	–	0.709	62	0.95	PUB (40%)	PEM (36%)	4.1
Tremper Kill	33.5	21,440	252.0	–	1.175	164	1.48	PUB (43%)	PEM (31%)	4.9

[1]Omits deepwater habitat (water depth >6.6 ft) from calculations
[2]PEM = Palustrine, emergent (e.g. marshes, wet meadows)
PUB = Palustrine, unconsolidated bottom (e.g. small ponds)
PSS = Palustrine, scrub/shrub (e.g. alder marsh)
R2US = Riverine, lower perennial, unconsolidated shore (e.g. temporarily-flooded stream banks)
PFO = Palustrine, forested (e.g. hemlock or red maple swamp)

The geology section (see **Volume 2, Section 2** above) described the surface topography as asymmetric — sub-basins with slopes that largely drain southward tend to be longer and have gentler slopes than those sub-basins that drain northward. Consequently, it would not be surprising to find that sub-basins with steeper slopes have fewer wetlands than those that are less sloping, since water tends to run off more quickly from steeper slopes. **Table 2.3** shows that three sub-basins that largely slope northward (Dry Brook, Mill Brook and Pepacton Reservoir) have about half the density of wetlands compared to the other eight basins that mostly flow southward.

Table 2.3 Wetland Density in North-facing vs. South-facing Sub-basins

Sub-basin	# of Wetlands per sq. mile
North-facing Aspect	
Dry Brook	2.2
Mill Brook	1.9
Pepacton Reservoir[1]	2.5
Mean = 2.2 ± 0.31*	
South-facing Aspect	
Batavia Kill	4.4
Bush Kill	1.8
E Branch Headwaters[1]	4.8
E Branch Mainstem[1]	5.5
Fall Clove[1]	3.9
Platte Kill[1]	4.2
Terry Clove	4.1
Tremper Kill	4.9
Mean = 4.2 ± 1.10*	

[1] Omits deepwater habitat (water depth >2m) from calculations
* The two means are significantly different (.05 level)

Wetlands identified in the East Branch Mainstem sub-basin appear to differ from the wetlands typical to the other sub-basins. The East Branch Mainstem sub-basin contains the greatest density of wetlands per square mile (column K). The most extensive wetland type is the unconsolidated shores of lower perennial streams (R2US type, column I), and the second most common type is forested swamps (PFO type, column J). Neither of these wetland types is common in the other sub-basins.

Significance of Wetlands

As stated previously, wetlands provide important functions. Some functions may be more obvious than others, but they are all significant: flood control, erosion control, water quality protection, fish and wildlife habitats, and opportunities for recreation, aesthetic appreciation, and education. This section describes how wetlands affect these functions.

Flood Control — Wetlands have often been referred to as "natural sponges" that absorb flood waters, yet they actually function more like "natural tubs," storing flood waters that overflow streambanks or surface water that collects in isolated depressions. By temporarily storing flood waters, wetlands help protect adjacent and downstream property owners from flood damage. Trees and other wetland plants help slow the speed of flood waters. This action combined with water storage allows wetlands to lower flood heights and reduce the water's erosive force.

Erosion Control — Because wetlands are located between rivers and high ground, they are in a good position to slow the effects of soil erosion. Wetland plants are most important in this regard, since they increase the durability of the sediment through binding soil with their roots, and dampen wave action and current velocity through friction. Planting of wetland vegetation is being used to control streambank erosion in some places. Bioengineering techniques (such as biodegradable mats with wetland plants) are in many ways preferable to structural erosion control measures (such as rock rip-rap) because they provide habitat and aesthetic values while protecting the streambank.

Water Quality Protection — Wetlands can be effective filters by intercepting surface water runoff from higher land before it reaches open water, and at least partially removing nutrients, processing chemical and organic wastes, and reducing sediment loads to receiving waters. This function is important in both urban and agricultural settings. A vegetated buffer strip along a stream can significantly improve water quality in many areas, often at less cost than alternative measures. When streams are channelized and wetlands are eliminated, stormwater moves off the landscape more quickly; thus, streambank erosion can become accelerated, water in the stream becomes more turbid, and groundwater recharge can be diminished.

Aquatic Productivity — Wetlands are among the most productive natural ecosystems in the world, some rivaling our best cornfields in biomass production with over 10 tons per acre. The plant material produced in the form of dead leaves and twigs eventually fall and partially decompose to form small particles of "detritus", which serves as the principal food for many small invertebrates and forage fishes. These are food for larger predatory fishes, such as trout and bass, which are of course a favorite food for many people. Thus, wetlands provide a source of food for both people and aquatic animals.

Fish and Wildlife Habitats — Wetlands are critical habitats for various animals like the wood duck, muskrat, beaver, salamander and snake. Relatively rare animals like the bald eagle use wetlands for food, water, cover or reproduction. Almost all important recreational fishes, including bass, spawn in aquatic portions of wetlands. Streamside forests provide shade that keeps water temperatures cooler than if exposed directly to sunlight, which is important to trout habitat. A variety of birds including ducks, geese and redwinged blackbirds, along with a large number of songbirds, feed, nest and raise their young in these areas. White-tail deer use wetlands for food and shelter, especially evergreen forested wetlands in winter. The black bear also finds refuge and food in forested and shrub swamps of the Catskills.

Natural Products — Timber, fish, wildlife and wild berries are some examples of products that originate in wetlands. For agriculture, wetland grasses might be hayed for winter livestock feed, while livestock can also graze on wet meadow grasses during the spring and summer.

Quality of Life — Not many people take advantage of recreational activities in or adjacent to wetlands, but opportunities abound. Wetlands serve as habitat for waterfowl hunting, fishing and trapping, hiking, bird watching and photography. Many people simply enjoy the beauty and sounds of nature, the trilling of spring peepers, observing frogs and turtles, looking for marsh marigolds in spring or red maple leaves in fall.

Wetland Functions in the East Branch Watershed

While **Table 2.2** shows the most extensive types of wetlands in each sub-basin, it does not indicate where the wetlands occur in the landscape (except, by inference, the riverine wetlands that dominate in the East Branch Mainstem). Small areas (±1 acre each) of wet meadows might be expected to occur most anywhere except on steep hillsides, and the same could be said about small man-made ponds. Actually, most wetlands in this area tend to occur in recurring patterns.

While **Figure 2.1** shows the approximate location of individual wetlands on a base map of 20 ft. topographic contours around the Village of Roxbury, **Figure 2.3** covers a larger area of the same region in smaller scale. These maps illustrate the tendency of many wetlands to occur near natural drainage pathways — both in major valleys and their upland tributaries — in the East Branch watershed. This tendency is largely due to both stream corridors and wetlands developing where water naturally collects, and where surface slopes are flatter. Drainage patterns are, in turn, controlled by geologic history of the region, as discussed above in **Section 2 Geology and Soils**. Aside from the near-stream areas where wetlands occur, most of the uplands are relatively steeply sloping and well drained by comparison, and so wetlands typically form less than 1% of each sub-basin (**Table 2.2**).

While the majority of wetlands do occur in close association with streams (as opposed to being spread out evenly across the landscape), they do not have a strong tendency to reduce flooding due to their comprising a small proportion of the East Branch watershed. The limited ability of wetlands to help reduce flooding arises more from wetlands' ability to store surface runoff that would otherwise reach stream channels, thereby slowing the rise of stream waters. Stored runoff is released more gradually through small outlets (i.e., small in comparison to a stream channel), by allowing slow infiltration of stored water through upper soil layers, thus allowing time for evaporation and transpiration by plants. When wetlands are relatively dispersed across a drainage basin they also have the effect of de-synchronizing the pattern of surface runoff. This also slows the rise of stream waters during runoff events because an increased range of times is introduced into the storage, release and post-release travel-time of stored runoff. So, although the capacity of wetlands in the East Branch watershed to abate flooding is somewhat reduced by their small aerial extent and close association with streams, they still do provide this important function albeit to a limited degree. This function is especially important near developed areas along streams, such as upstream from the Villages of Roxbury or Margaretville.

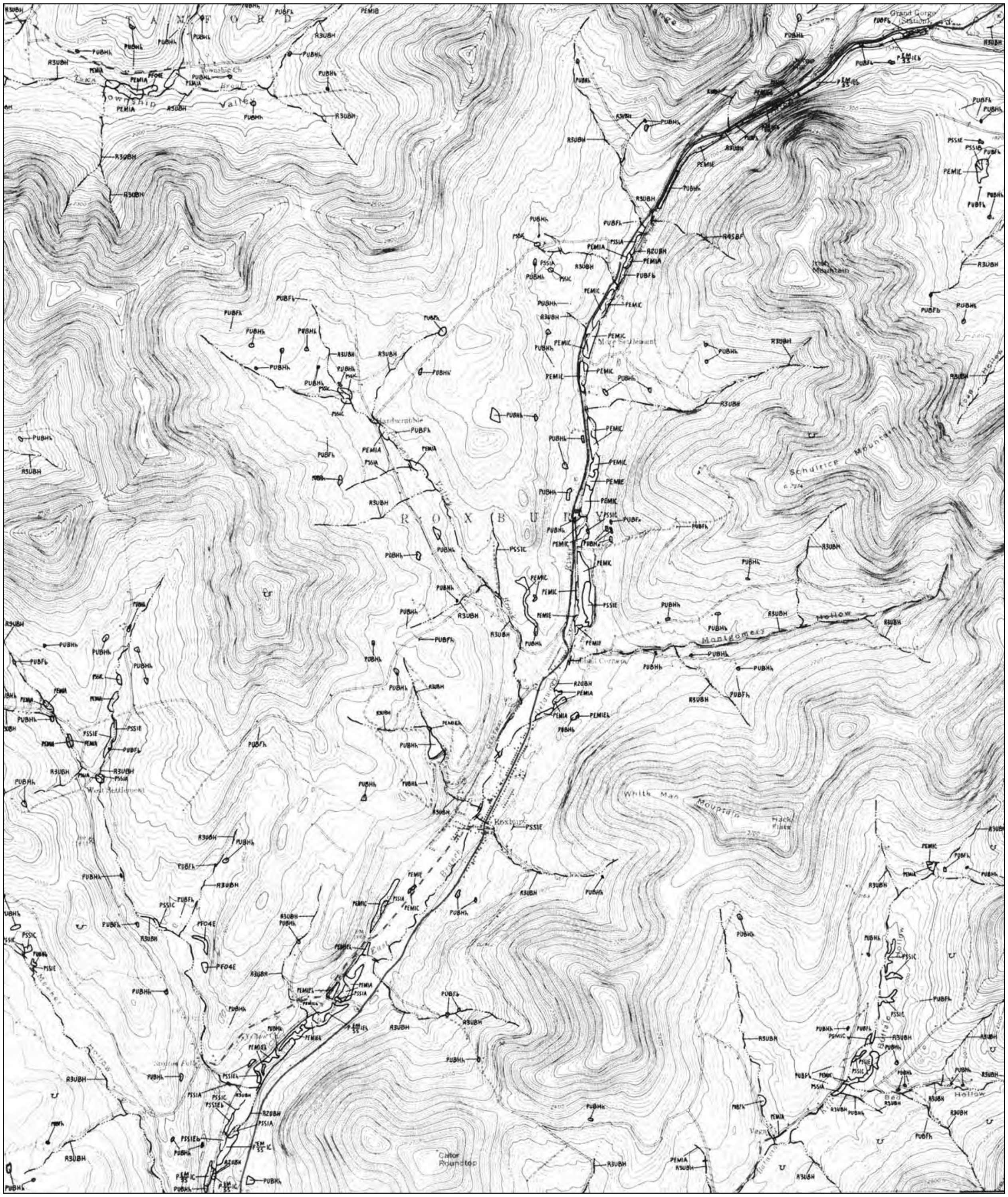

Figure 2.3 Small-scale portion of wetlands mapping, Roxbury quadrangle, by the U.S. Fish & Wildlife Service. Note how most wetlands occur in close association with the local stream network.

Across much of the Catskills, small springs and seeps commonly appear in places where slopes abruptly change from massive, steep hillsides to more gentle gradients. These groundwater discharge areas have long been favored for constructing livestock-watering ponds. Often, drainage from the spring forms the origin of streams, or the excess water draining from a pond flows a short distance before it reaches a nearby watercourse.

Wetland functions, as generally described in the previous paragraphs, can be more precisely evaluated using various "yardsticks" or methods of measurement. For example, the specific ability of a particular wetland to improve water quality is largely based on its capacity to promote: (1) sedimentation of particulate matter on its surface, before the sediment-laden water reaches a stream; (2) plant uptake of excess nutrients and/or contaminants; (3) leaf litter decomposition, slowly releasing sorbed nutrients for incorporation into the food web of the local biota; and (4) soil retention of dissolved and particulate matter into its near-surface or deep sediments.[13]

This type of science- or ecology-based approach is most often used to compare two wetlands' functional capacities rather than to measure the absolute values of such specific characteristics. In a much more general way, the tendency of wetlands to provide certain functions can be summarized based on wetland type. The types of wetlands that occur most commonly in the East Branch basin were listed in **Table 2.2**. Although detailed assessments of wetland functions require on-site review, a generalized evaluation of the principally occurring wetland types follows[14]. Other functions could be evaluated in addition to those discussed, depending on the approach used and opinions of what functions are more important.

Palustrine/Emergent (PEM): Many of these wetlands form in low spots or depressions on the landscape surface that accumulate surface runoff. Because they comprise a small proportion of the watershed, their effect on flooding is probably small, yet still of some significance in terms of runoff storage and flow desynchronization. Those emergent wetlands that are (1) adjacent to free-flowing streams or other water bodies, (2) are at least seasonally inundated with water, and (3) provide an abundance of cover, can provide fish habitat. Where vegetative cover is good and water flow is dispersed these areas can filter excess sediments from surface runoff. Dense stands of actively growing vegetative cover may help attenuate nutrients in runoff before it enters surface waters, and help stabilize shoreline against erosion (if adjacent to a water body). Where these wetlands are relatively large, in good condition and a there is a variety of cover in it and the surrounding terrain, these wetlands provide wildlife habitat for a variety of species. Recreational and aesthetics uses can be significant where these wetlands offer public access, are in relatively unpolluted condition, are physically accessible, and are regularly visited by wildlife.

Palustrine/Unconsolidated bottom (PUB): These small ponds tend to occur both within and above the floodplain. Because they comprise a small proportion of the watershed and may typically be near-full with groundwater discharge and surface runoff water

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[13] Bartoldus, et al., 1994.
[14] Adapted from U.S. Army Corps of Engineers, 1999; Reschke, 1990; and Cowardin et al., 1990.

inputs, they provide limited capacity to store floodwater. They potentially provide fish habitat; however, unless there is a direct connection with a nearby stream this largely depends on fish-stocking history. Sediments and attached pollutants can be retained to the extent that sediments traveling in runoff can settle out in quiet water; similarly, excess nutrients can be filtered from surface runoff with sediments. These wetlands offer wildlife habitat, especially for amphibians, and also serve as a water source for mammals, especially if surrounded by brush or forest cover. Recreational and aesthetics uses can be significant where these wetlands offer public access, are in relatively unpolluted condition, are physically accessible, and are regularly visited by wildlife.

Palustrine/Scrub-Shrub (PSS): Comprising a very broadly-defined type, Scrub-Shrub wetlands may represent a successional stage leading to forested wetlands, or they may be relatively stable communities. Although they are one of the most widespread wetland types in the U.S.[15], these wetlands are not especially widespread in the East Branch basin. Functions are similar in many ways to those of PEM wetlands (described above), with certain functions being enhanced where there is a dense cover provided by shrub or sapling tree growth. These include shoreline erosion protection (where adjacent to water bodies), and wildlife habitat, especially when the vegetative cover is of diverse types. To the extent that these areas are difficult to physically walk through, they may offer limited recreational functions.

Riverine/lower perennial, unconsolidated shore (R2US): Characterized by flowing, non-tidal waters and a well developed floodplain, these areas along the margins of streams lack persistent and emergent vegetation. The substrate usually is composed of sand and gravel with mud. These wetlands are important as local fish habitat. Parts of wetlands associated with floodplain help retain sediments if in stable stream reaches; otherwise, excess nutrients and organic material tends to be "flushed" through this zone. Recreational uses of these areas are usually high if available to the public. Opportunities for wildlife can be high in healthy stream systems that offer adequate cover.

Palustrine/Forested (PFO): Dominated by trees over 20 ft. tall — such as hemlocks, red maples, poplars or willows — these wet woodlands are uncommon across most of the East Branch basin except some portions of the mainstem. Water levels often fluctuate seasonally, being flooded in spring and relatively dry by late summer. Sediments and attached pollutants can be retained to the extent that sediments traveling in runoff can settle out in quiet water; similarly, excess nutrients can be filtered from surface runoff with sediments. Ground cover may be fairly sparse, in which case these areas can be vulnerable to streambank erosion. These wetlands provide valuable wildlife habitat. When surrounded by upland forest, "vernal pools" are critical for amphibian spawning.

Deepwater habitat: These areas do not meet the definition of wetlands as defined at the beginning of this section, but rather can be described as other "aquatic systems." As seen in column E of **Table 2.2**, extensive areas exist in the Pepacton Reservoir sub-basin, with minor amounts in the East Branch Mainstem. The extent of deepwater habitat in these sub-basins varies widely depending on season, rainfall and consumptive use patterns.

[15] Cowardin et al., 1979.

Protecting Wetlands

The value of wetlands to perform functions described above has been recognized by federal, state and NY City governments, each of which have created their own methods of wetland protection.

The federal government regulates wetlands primarily by enforcing Sections 401 and 404 of the Clean Water Act by the U.S. Army Corps of Engineers. There are no publicly-available maps of where such wetlands occur, although maps produced by the U.S. Fish & Wildlife Service's National Wetland Inventory are often consulted as a good indicator of where such wetlands might occur. While each situation is unique, most disturbances over $1/10^{th}$ acre in size require a permit. Permit questions should be directed to the Corps of Engineers' Troy office, 518-270-0589. In agricultural settings, the "Swampbuster" provision of the 1990 Farm Bill (administered by the USDA's Natural Resources Conservation Service) and Wetlands Reserve Program (administered by the Farm Service Agency) help protect wetlands from being converted into cropland or other agricultural uses.

Through Article 24 of the Freshwater Wetlands Act the NYS DEC primarily regulates activities in wetlands greater than 12.4 acres (5.0 hectares) in size, plus an adjacent area 100 ft. out from the wetlands' perimeter. All wetlands regulated by NY State are shown on an official Freshwater Wetlands Map. A portion of one map that covers the Roxbury area is shown in **Figure 2.4**. Compare this map to that of **Figure 2.1** to see how only the larger-sized wetlands are protected by NY State. A permit is required by the DEC if disturbing land within the 100 ft. buffer zone. Permit questions should be directed to the DEC's Schenectady office, 518-357-2234.

The NYC DEP uses a variety of tools to protect wetlands. DEP watershed Rules and Regulations define allowable setbacks from wetlands, defining wetlands as being only DEC-protected wetlands (12.4 acres or larger). However, because the DEP's field staff note the presence of all watercourses and wetlands on proposed project sites, and the DEP insists on compliance with other permitting agencies (such as the U.S. Army Corps of Engineers) before issuing their own permits, this has the effect of adding enforcement to all existing regulations. Other DEP programs include the Conservation Easement and Land Acquisition Programs, both of which remove land development opportunities and thus prevent wetland impacts that might affect wetlands. Permit questions should be directed to the DEP's Kingston office, 845-340-7500.

Public education is essential to increase awareness and understanding of the natural functions provided by wetlands, including the protection of local and regional water quality. This SCMP report is one part of this process. In addition, other state, regional and local agency staffs are available to assist interested local governments in developing local wetland protection strategies.

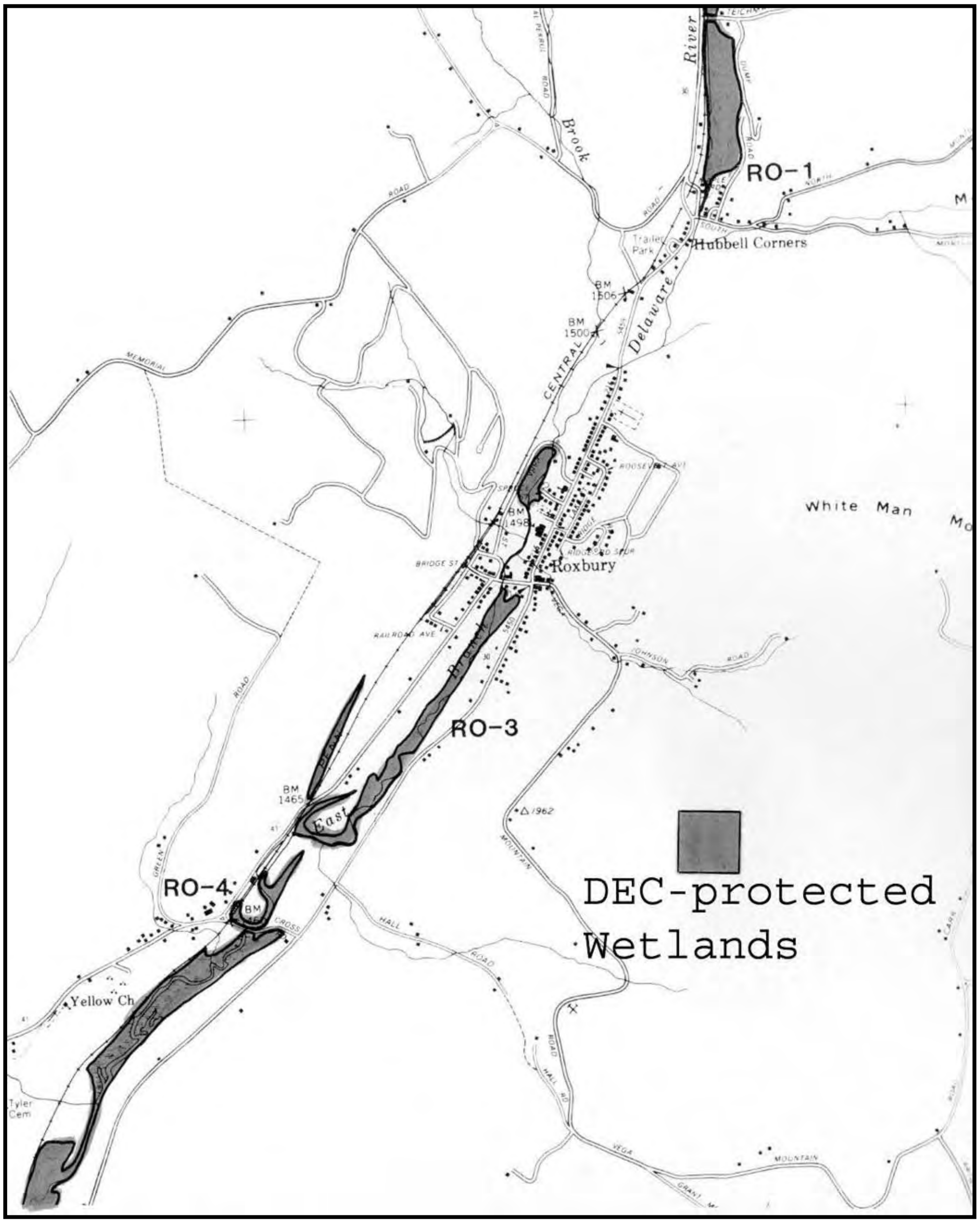

Figure 2.4: Location of DEC-protected wetlands around the Village of Roxbury (1974 edition, shading added). In contrast to Figure 2.1, only wetlands (or areas with wetland-upland complexes) greater than 12.4 acres in size are recognized for state protection.