## 2.4 Hydrology and Flood History

### Introduction

Hydrology is the study of the properties, distribution, and effects of water on the Earth's surface, in the soil and underlying rocks, and in the atmosphere. The hydrologic cycle includes all of the ways in which water cycles from land to the atmosphere (as water vapor and clouds) and back (as snow, rain and other forms of precipitation) (Figure 2.4.1).

Understanding the hydrology of the Manor Kill will assist us with making land use decisions that work within the constraints of the hydrologic cycle and won't exacerbate flooding or cause water quality impairment.

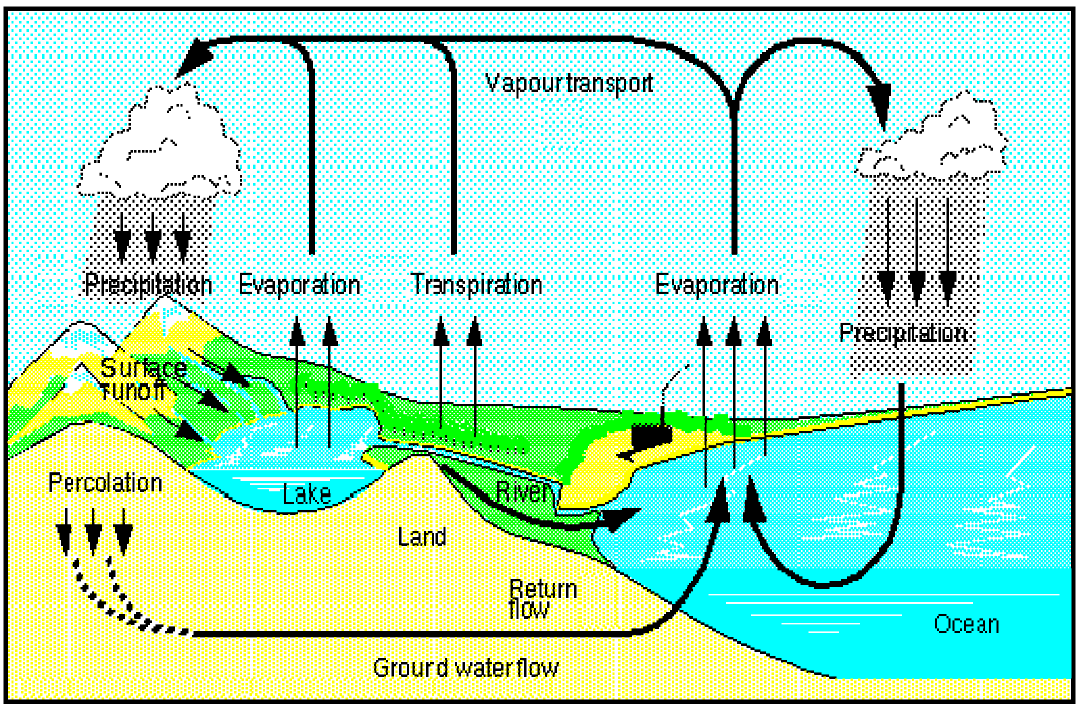



*Figure 2.4.1. Graphic illustrating the hydrologic cycle.*
*(http://www.educ.uvic.ca/faculty/mroth/438/WEATHER/watercycle.html)*

Water flowing through the Manor Kill reflects the integrated effects of all watershed characteristics that influence the hydrologic cycle. Characteristics include climate of the drainage basin (type and distribution patterns of precipitation and temperature regime), geology and land use/cover (permeable or impermeable surfaces and materials affecting timing and amount of infiltration and runoff, and human-built drainage systems), and vegetation (uptake of water by plants, protection against erosion, and influence on infiltration rates). These factors affect timing and amount of stream flow, referred to as the streams hydrologic regime. For example, a stream with an urbanized watershed where water will run off the hardened surfaces directly into the stream will have higher peak discharges following storms than a watershed, such as the Manor Kill, which is predominantly forested and agricultural and as a result allows a higher percentage of rain water to infiltrate before it reaches the stream, releasing it more slowly over time. Understanding the hydrology of a drainage basin is important to the stream manager because stream flow patterns affect aquatic habitat, flood behavior, recreational use, and water supply and quality.

**Manor Kill Basics**

Encompassing approximately 34.4 square miles, the Manor Kill is located primarily in Schoharie County, NY. The stream drains the town of Conesville, NY. The Manor Kill is typical of major streams within the Schoharie watershed in that it is a long, narrow watershed running east to west. This drainage pattern is controlled by the steep topography, formed in large part during the last period of glacial activity. Streams in the Schoharie valley are primarily perennial streams, that is, they flow year-round except in smaller headwater streams or in extreme drought conditions. The Manor Kill watershed averages approximately 36.8 inches of precipitation per year. This more damaging rainfall often comes in dramatic summer downbursts, remnants of autumn hurricanes, or late winter rain-on-snow events. Drainage density, or how much stream length is available to carry water off the landscape per unit area of watershed is about average for the Catskills, at 0.0016m/m2. Given the average drainage density, combined with steep mountainous slopes, and high precipitation, the system is relatively flashy, that is, stream water levels rise and fall quickly in response to storm events. This flashiness is somewhat mitigated by heavy forest cover throughout much of the watershed. Therefore, efforts to protect upland, as well as riparian, forest are important to reducing flooding impacts.

**Stream flow Primer**

There are two general categories of stream flow: storm flow (also called flood flow) and base flow, between which streams fluctuate over time. Storm flow fills the stream channel in direct response to precipitation (rain or snow) or snowmelt, whereas base flow is primarily groundwater fed and sustains stream flow between storms and during subfreezing or drought periods. A large portion of storm flow is made up of overland flow, runoff that occurs over and just below the soil surface during a rain or snowmelt event. This surface runoff appears in the stream relatively quickly and recedes soon after the event. The role of overland flow in the Manor Kill watershed is variable, depending upon the time of year and severity of storms or snowmelt events. In general, higher stream flows are more common during spring due to rain, snowmelt and combination events, and during hurricane season in the fall. During summer months, actively growing vegetation on the landscape draws vast amounts of water from the soil through evapotranspiration. This demand for groundwater by vegetation can significantly delay and reduce the amount of runoff reaching streams during a rain storm. During winter months, precipitation is held in the landscape as snow and ice, so precipitation events do not generally result in significant runoff to streams. However, frozen ground may increase the amount of overland flow resulting from a rain storm if the air temperature is above freezing, particularly in spring on north facing slopes. Subsurface storm flow, or interflow, comes from rain or snow melt that infiltrates the soil and runs down slope through the ground. Infiltrated water can flow rapidly through highly permeable portions of the soil or displace existing water into a channel by "pushing" it from behind. In the Schoharie valley, subsurface flow can occur fairly rapidly along layers of essentially impermeable glacial lake silt/clay deposits. Subsurface storm flow shows up in the stream following overland flow, as stream flow declines back toward base flow conditions.

Base flow consists of water that infiltrates into the ground during and after a rain storm, sustaining stream flow during dry periods and between storm flows. The source of base flow is groundwater that flows through unsaturated and saturated soils and cracks or layers in bedrock or other impermeable layers adjacent to the stream. In this way, streams can sustain flow for weeks or months between precipitation events and through the winter when the ground surface and all precipitation is otherwise frozen. Stable-temperature groundwater inputs keep stream water warmer than the air in winter and cooler than the air in summer – this is what enables fish and other aquatic life to survive in streams year-round.

Hydrologists use a hydrograph of a stream, a graph showing amount or depth of flow over time, to analyze flow patterns and trends such as flood frequency or drought cycles. A stream gage, a device that primarily measures water level, is necessary to monitor stream discharge and develop a hydrograph. The United States Geological Survey (USGS) maintains a network of stream gages throughout the country, with a gage located on the Manor Kill in the town of Conesville (Figure 2.4.2).

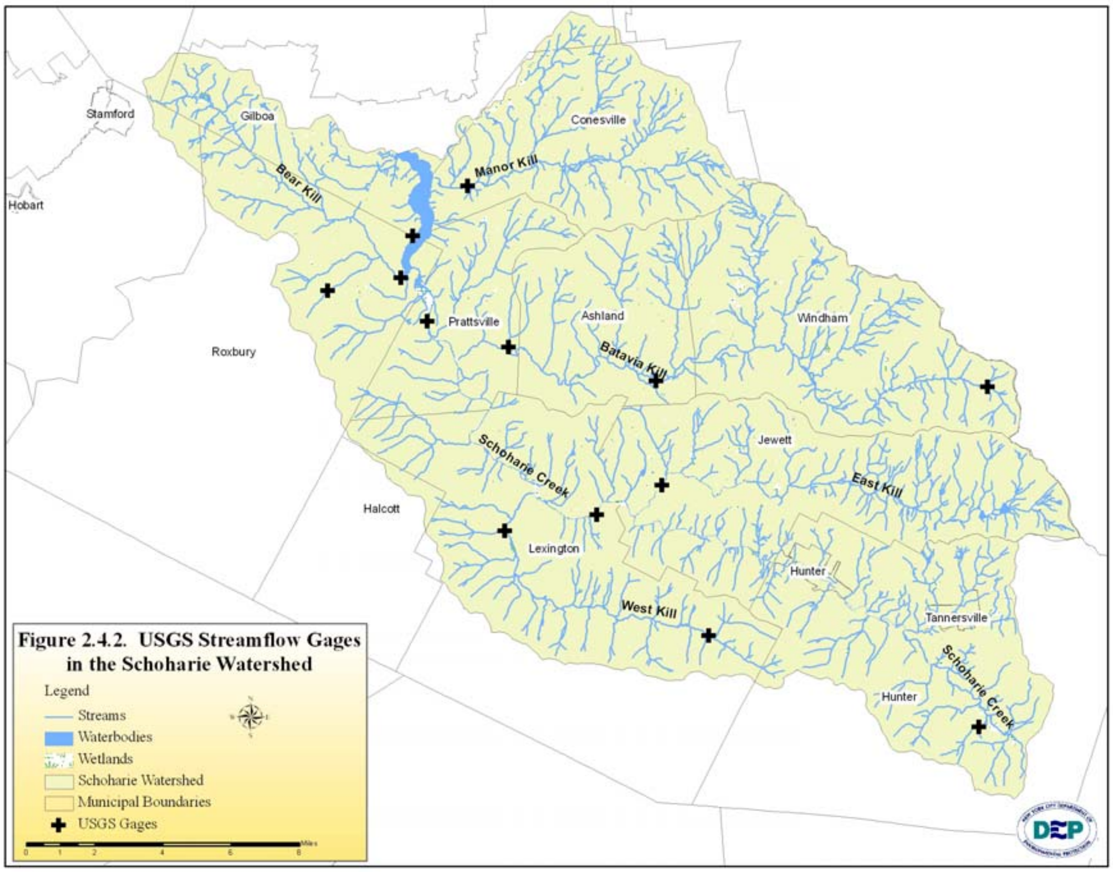



**Figure 2.4.2. USGS Streamflow Gages in the Schoharie Watershed**

These gages measure the stage, or height, of the water surface at a specific location, typically updating the measurement every 15 minutes. By knowing the stage we can calculate the magnitude of the discharge (flow), or volume of water flowing by that point, using a relationship developed by USGS called a rating curve. Using this rating curve, the magnitude of flow in the Manor Kill at the gage location can be determined at any time just by knowing current stage. Flow can also be calculated for any other stage of interest. Additionally, we can use the historic record of constantly changing stage values to construct a picture of stream response to rain storms, snow melt or extended periods of drought, to analyze seasonal patterns or flood characteristics.

The United States Geological Survey (USGS) maintains one continuously recording stream gage on the Manor Kill (established 1986, drainage area 32.4 mi2, USGS ID# 01350080). All gage information is available online at the USGS website: http://waterdata.usgs.gov/ny/nwis/uv/?site_no=01350080&PARAmeter_cd=00065,00060.

The Manor Kill gage has a long enough period of record to prepare a hydrograph covering several years for the stream (Figure 2.4.3). Each spike on the gage graph represents a peak in stream flow (and stage) in response to rain storms (Figure 2.4.3). Stream level rises (called the "rising limb" of the hydrograph) and falls as the flood recedes (called the "falling (or receding) limb" of the hydrograph). We can analyze long time periods to see seasonal trends or long-term averages for the entire length (period) of gage record. We can see the hydrograph for the gage shows higher flows in fall (hurricane season) compared to winter (water held in ice and snow), and higher flows in spring (snow and ice melt, with rain-on-snow events) compared to summer (drought conditions with vegetation using a lot of water). The highest flows of the year are generally associated with the hurricane season in the fall, followed by winter and spring snowmelt or rain-on-snow events. Overland flow accounts for most of water that causes the sharp peaks in the hydrograph.

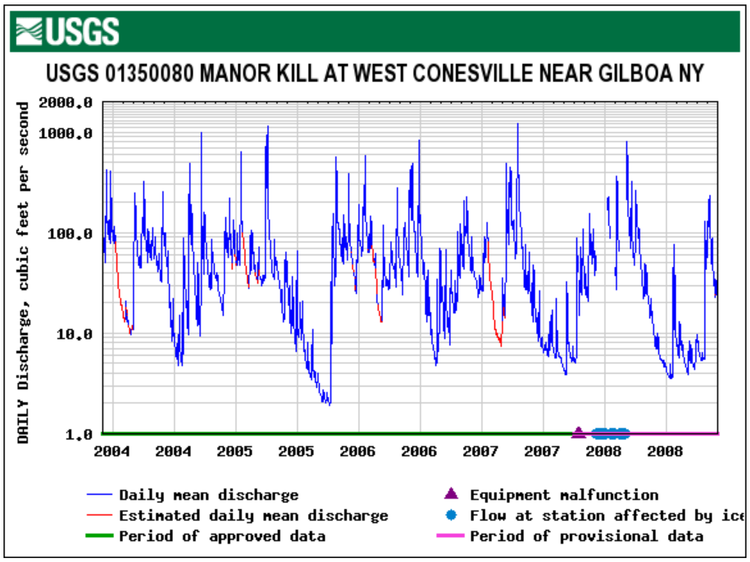
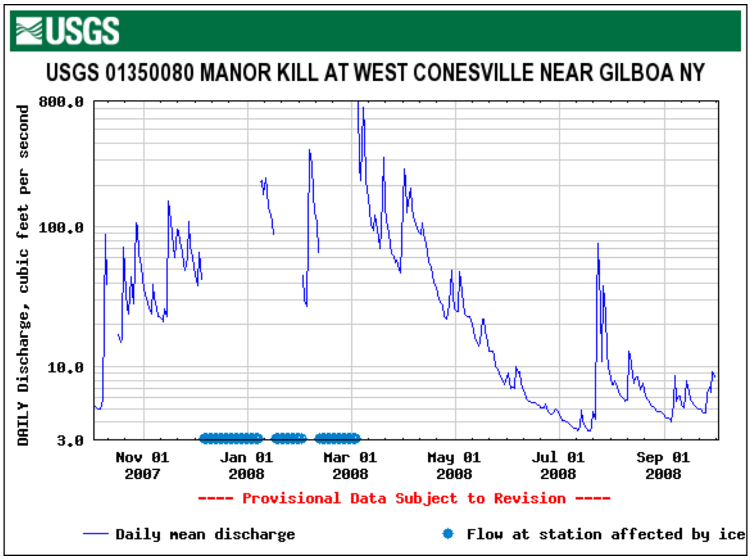



*Figure 2.4.3. This hydrograph represents the daily average flow from 12/03 through 12/08.*

We can analyze long time periods to see seasonal trends or long-term averages for the entire length (period) of gage record. We can see the hydrograph for the gage shows higher flows in fall (hurricane season) compared to winter (water held in ice and snow), and higher flows in spring (snow and ice melt, with rain-on snow events) compared to summer (drought conditions with vegetation using a lot of water) (Fig. 2.4.4). The highest flows of the year are generally associated with the occasional hurricane in the fall, followed by winter and spring




*2.4.4. Hydrograph illustrating mean discharge per month.*

snowmelt or rain-on-snow events. Overland flow accounts for most of water that causes the sharp peaks in the hydrograph. Stream flow always rises and peaks following the height of a precipitation event because it takes time for water to hit the ground and run off to the stream (this is known as lag time). Knowing storm timing, we could also calculate lag time for the Manor Kill at the gage location for particular storms or types of storms, and determine how the stream responds to storms both in timing and flood magnitude and recession. Through analysis of the long-term flow and flood records provided by the USGS, the town, its residents and resource managers can begin to better understand the cause/effect of various precipitation amounts on flooding.

**Manor Kill Flood History**

Flooding can be caused by excessive precipitation, rapid snowmelt, ice jams, beaver dams, or dam failure. Steep slopes make the area very prone to flash flooding. Slow moving thunderstorms often produce flash floods, particularly during summer months. Remnants of tropical storm systems can produce both flash floods and river flooding. Rapid thawing in the winter produces runoff from snowmelt and ice jams. Flooding can occur at any time of the year. According to Hazards of NY (HAZNY) reviews, Schoharie County is at high risk for flood potential (Schoharie County, 2006).

There was some historical documentation of an event that took place in 1874. It is remembered as follows:

*"The village of Conesville was known as 'Stone Bridge' for many, many years because of the great arched stone bridge that stood where the present bridge crosses the Bearkill. This bridge was washed away in the flood of 1874. Before the stone bridge was*

*built the road* (Susquehanna Turnpike*) closely followed the Manorkill Creek south of the village, crossed the Manorkill approximately by the Makely bridge, then recrossed the Manorkill and came on the present near Russell Germond's. These streams apparently were crossed by fording (driving through the water)."* (Whitbeck, 1995).

Though there is very limited detail to this event, it tells us that damaging floods did occur during this time period.

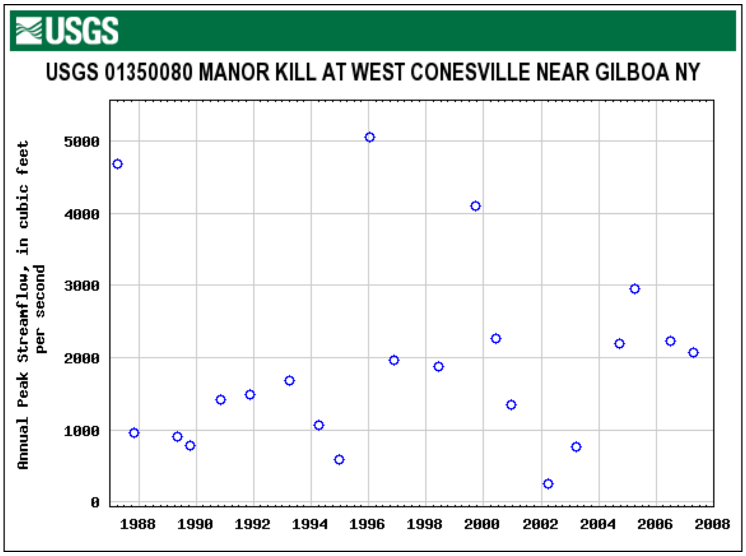



*Figure 2.4.5. Peak stream flows recorded at the Manor Kill gage between 1987 and 2007.*

Due to the relatively short period of record of the USGS gage (1986-2008) there is limited information regarding flood history specific to the Manor Kill. The highest recorded stream flow was recorded in 1996 (Figure 2.4.5 and Table 2.4.1). During spring of that year the flow gage recorded a maximum discharge of 5,050 cfs (Figure 2.4.5 and Table 2.4.1). Discharges above 4,000 were also recorded in April 1987 and September 1999 (Figure 2.4.5 and Table 2.4.1). These numbers are so far outside of the mean peak stream flow of 2,029.1 cfs for this 20 year time frame that they could easily be considered potential flood events. It is not clear what types of structural damage may have resulted during these periods of high flow, but it would have certainly resulted in heavy erosion and subsequent loss of fertile soils and possible crop damage.

*Table 2.4.1. Peak Stream flow for Manor Kill 1987-2007 USGS*

Schoharie County, New York
Hydrologic Unit Code 02020005
Latitude 42°22'37", Longitude 74°24'48" NAD27
Drainage area 32.4 square miles
Gage datum 1,255.95 feet above sea level NGVD29

| Water Year | Date | Gage Height (feet) | Stream-flow (cfs) | Water Year | Date | Gage Height (feet) | Stream-flow (cfs) |
|---|---|---|---|---|---|---|---|
| 1987 | Apr. 04, 1987 | 9.76 | 4,680 | 1997 | Nov. 09, 1996 | 5.94 | 1,970 |
| 1988 | Oct. 28, 1987 | 4.17 | 955 | 1998 | Jun. 14, 1998 | 5.77 | 1,870 |
| 1989 | May 11, 1989 | 3.97 | 904 | 1999 | Sep. 16, 1999 | 9.04 | 4,100 |
| 1990 | Oct. 20, 1989 | 3.67 | 783 | 2000 | Jun. 07, 2000 | 6.42 | 2,260 |
| 1991 | Nov. 10, 1990 | 5.06 | 1,410 | 2001 | Dec. 17, 2000 | 4.77 | 1,340 |
| 1992 | Nov. 23, 1991 | 5.19 | 1,480 | 2002 | Mar. 27, 2002 | 2.38 | 257 |
| 1993 | Mar. 30, 1993 | 5.49 | 1,680 | 2003 | Mar. 21, 2003 | 3.46[2] | 756 |
| 1994 | Apr. 14, 1994 | 4.24[2] | 1,060 | 2004 | Sep. 18, 2004 | 6.31 | 2,190 |
| 1995 | Dec. 24, 1994 | 3.17 | 587 | 2005 | Apr. 03, 2005 | 7.49 | 2,960 |
| 1996 | Jan. 19, 1996 | 10.20 | 5,050 | 2006 | Jun. 28, 2006 | 6.35 | 2,220 |
| | | | | 2007 | Apr. 16, 2007 | 6.10 | 2,070 |

The North Eastern United States has been experiencing more severe storms over the past several years, and Schoharie County has been taking steps to minimize risks to human populations. In April of 2004 the Schoharie County Emergency Management Department and the Federal Emergency Management Agency conducted a Flood Insurance Study. One of the products was Flood Insurance Rate Maps (FIRMs) that were developed for every town and village in Schoharie County (Figure 2.4.6). These maps help to illustrate flood prone areas which would experience inundation in the event of a 100 year flood event.

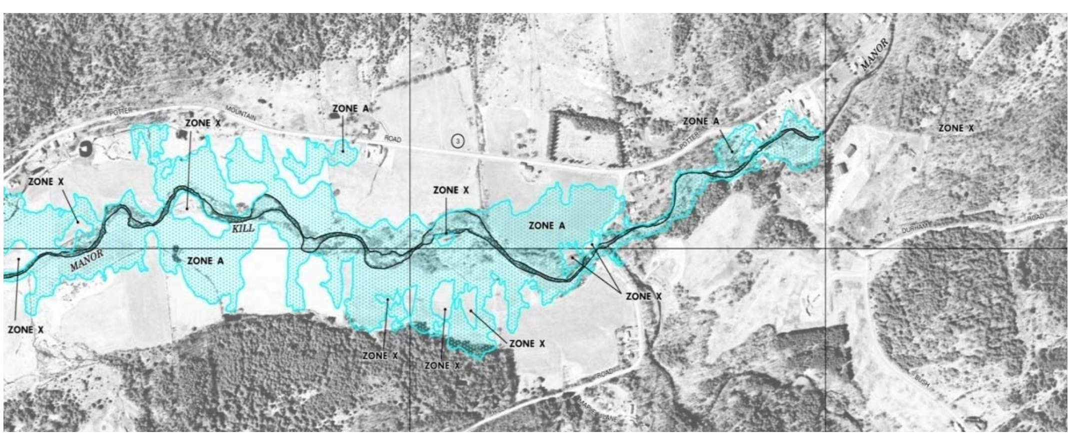



*Figure 2.4.6. FIRM of Manor Kill illustrating base flood elevations near the head waters.*

## Implications of Manor Kill Flooding

The unique hydrology of the Manor Kill has consequences for how the stream corridor should be managed. Flood history and dynamics play a large role in determining the shape, or morphology, of stream channels and the hazards associated with land uses on the banks and in the floodplain. For example, applications for stream disturbance permits (from NYS DEC) typically increase following floods as landowners and municipalities attempt to repair damage caused by flooding. If we want to minimize impacts to property, infrastructure and other damages or inconvenience, it is critical that we understand and plan for flooding behavior. Historically, this "planning" has emphasized attempts to constrain and control stream channels, rather than working with processes we can measure and, to some extent, predict. The results are often costly and sometimes catastrophic, such as when berms or levees fail or bridges wash out. These "control" approaches typically result in ongoing maintenance costs that can draw valuable community resources away from other projects. With a better understanding of stream and floodplain processes, we can reduce these costs. For more information, see Section 3.2, Introduction to Stream Processes.

## References

Schoharie County, 2006. Schoharie County Hazard Mitigation Committee and Schoharie County Planning and Development Agency, Schoharie County All Hazards Mitigation Plan.

Whitbeck, Lester E. & Anne, 1995. *The Sloughter's History of Schoharie County Bicentennial Edition 1795-1995.*