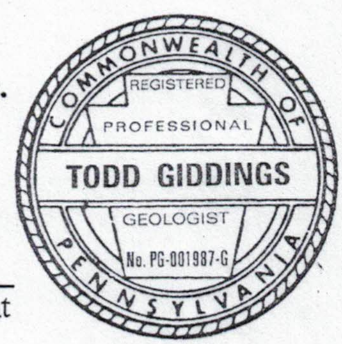
SOURCE WATER PROTECTION PLAN
FOR THE MILFORD SPRINGS
MILFORD TOWNSHIP
PIKE COUNTY
PENNSYLVANIA

June, 2006

Prepared for:
The Municipal Authority
of the Borough of Milford
120 Pear Alley, Box 459
Milford, PA 18337
570-296-6556
Public Water Supply ID # 2520046

Prepared by:
Todd Giddings and Associates, Inc.
3049 Enterprise Drive
State College, PA 16801
814-238-5927

Todd Giddings, Ph.D., P.G., President



"Water is the most critical resource issue of our lifetime and our children's lifetime.

The health of our waters is the principal measure of how we live on the land."

Luna Leopold

TABLE OF CONTENTS

Page

TABLE OF CONTENTS – Continued

Page

TABLE OF FIGURES

Page

APPENDICES

SOURCE WATER PROTECTION PLAN for the MILFORD SPRINGS
Milford Township, Pike County, Pennsylvania

EXECUTIVE SUMMARY

This report is a reference and educational document that describes the sources and vulnerabilities of the Milford Springs, and summarizes the actions taken by the Milford Water Authority to develop a comprehensive program to protect the quality of the springs. Its future use is to support and guide educational and protection activities. The Milford Water Authority telephone number is 570-296-6556.

Steering Committee

The Milford Water Authority formed an Executive Committee to manage this project and a Steering Committee to provide opportunities for public participation in this project. The first Steering Committee meeting was held on April 18, 2002, and subsequent Steering Committee Meetings were held on November 7, 2002, March 20 2003, and December 18, 2003, and the final wrap-up meeting was held on January 20, 2005. Each meeting was advertised in the local newspaper, and an opportunity for public participation was provided during each meeting. The chairman of the Steering Committee is Tom Hoff, who is Vice-Chairman of the Milford Water Authority. The Executive Committee met following each Steering Committee meeting.

Public Education and Participation

The public education activities undertaken by the Milford Water Authority as part of this project began early and will continue into the future. First, the Milford Water Authority commissioned the preparation of a series of 6 educational articles, titled "The Water We All Share", that were published periodically in the local newspaper, the Pike County Dispatch. The articles explained the Source Water Protection project, the water cycle, and how the residents in the Sawkill Creek Watershed could protect both the surface and ground-water quality in the source area of the springs.

Recognizing that the direct hydraulic connection between Sawkill Creek and Vantine Brook and the springs was not known or understood, the Milford Water Authority commissioned the construction of a custom ground-water flow model. The table-top model is comprised of a clear plastic tank containing simulated bedrock and sand and gravel layers modeling the glacial outwash aquifer source of the springs. See Figure 1, Ground-Water Flow Model. Tim Gartner, the Water Treatment Plant Operator, traveled to all elementary schools in the watershed, operated the ground-water flow model, and explained the importance of source water protection to more than 500 fifth graders during 2004. This program will be repeated each year to educate a new group of fifth graders in the schools. Source water protection presentations using the ground-water flow model were also made to the high school environmental club, the boy scouts, the Pike County Commissioners, and the planning commissions of Milford Borough, Milford Township, and Dingman Township.

The Authority also commissioned the preparation of an educational brochure that contained much of the information that was presented in the series of newspaper articles. This brochure is titled "The Water We All Share" and contains a block diagram of the water cycle, a map of the Sawkill Creek Watershed and the springs, and a detailed hydrogeologic map of the springs, monitoring wells, and the outwash aquifer source area. The Milford Water Authority mailed a copy of the brochure with an explanatory cover letter to 1,850 residents in the entire source water area. The final report of the public and school education campaign is in Appendix 1.

History

The Milford Springs have been the source of drinking water for the residents of Milford Borough for more than 100 years. The two springs are located at the foot of a steep slope, west of Milford Borough in Milford Township, Pike County. Members of the Milford Water Authority have known for decades that the source of their spring water was in the glacial outwash aquifer that the springs discharge from. They also understood that both Sawkill Creek and Vantine Brook loose water into the glacial outwash aquifer in the immediate vicinity of the springs. The springs were observed to discharge turbid water immediately following some flood flows in these streams.

In 1966, when Interstate Highway 84 was being constructed in the glacial outwash aquifer within 3,000 feet of the springs, small rainstorms caused high turbidity in the springs. Following some PennDOT investigations, the highway grading design was modified and mitigation measures were implemented by PennDOT to protect the water-quality of the springs. When a mall was proposed to be constructed on the glacial outwash aquifer within 3,000 feet of the springs, the Milford Water Authority commissioned a chemical tracer study to evaluate the hydraulic interconnection between Sawkill Creek, the proposed mall site, and the springs. The chemical tracer study documented that some water from Sawkill Creek seeped through the stream bed and discharged from the springs. The mall proposal was withdrawn after completion of the chemical tracer study.

Following another series of turbidity episodes, the Milford Water Authority commissioned an investigation of a gravel pit operating in the outwash aquifer only 2,800 feet from the springs. The gravel mining operation was causing its own very turbid storm water to infiltrate directly into the outwash aquifer more than 50 feet below original ground level. Within 8 hours following an intense rainstorm (where a large volume of very turbid gravel pit water was observed entering the aquifer in the gravel pit), the springs discharged very turbid water. Graphs of turbidity and dissolved solids concentrations are in Appendix 2. The Authority and its consultant documented these events and the gravel pit operator eventually withdrew his permit and restored and revegetated the pit area. Storm-related turbidity in the springs decreased very significantly following the gravel pit closure and restoration.

The chemical tracer study demonstrated that water from Sawkill Creek was infiltrating into the glacial outwash aquifer through the creek's bed and flowing to and discharging from the springs. Therefore, this chemical tracer study demonstrated that a) Sawkill Creek looses water through stream-bed infiltration in the vicinity of the springs, b) the glacial outwash aquifer receives recharge directly from surface-water infiltration, and c) the springs are vulnerable to impacts from contaminants in the surface water flowing in Sawkill Creek in the vicinity of the springs.

Hydrogeologic Setting of the Springs

Pike County was last glaciated approximately 20,000 years ago during the Wisconsinan stage. The advancing ice sheet eroded bedrock hilltops and slopes, and scoured and deepened bedrock valley bottoms where the valleys were oriented north-south, parallel to the direction of ice movement. Thus the valley of Sawkill Creek was deepened where it flows north-south from upstream of Interstate Highway 84 downstream to the Pinchot Falls where the bedrock of the Mahantango Formation forms waterfalls in the stream bed.

During the period of climatic warming at the end of the Wisconsinan glaciation, the ice sheet began to melt down at its surface and back at its leading edge that was located more than 35 miles south of Milford. The masses of valley ice in the smaller valleys completely melted away first, and then runoff from the bedrock uplands deposited more sand and gravel in the valley bottoms. When the last of the ice melted in the Sawkill Creek bedrock valley, glacial ice still remained in the Delaware Valley due to its great thickness and width. The outwash sand and gravel deposits in the Sawkill Creek valley ended at the mass of ice remaining in the Delaware Valley, and this ice supported and held back sand and gravel deposits in many tributary valleys until it melted. The Milford Springs discharge from the toe of a steep slope composed of sand and gravel deposits that were once supported by the residual Delaware Valley ice. When the Delaware Valley ice finally melted away, the sand and gravel deposits collapsed to the steep slope seen today. Figure 2, Surficial Geology at the Milford Springs reproduces a portion of the surficial geology map from Water Resources Report 65.

Conceptual Ground-Water Flow Model

A conceptual ground-water flow model is a theoretical replica of the ground-water flow system supplying the Milford Springs, and should not be confused with the table-top ground-water flow model described elsewhere in this report. The geographic area encompassed by the conceptual ground-water flow model for the Milford Springs consists of the adjacent watersheds of Sawkill Creek and Vantine Brook, from their headwater areas downstream to the Milford Springs. The four sources of water that comprise the discharge of the Milford Springs are 1) rainfall and snowmelt that directly infiltrates into the outwash aquifer, 2) upland tributary stream water that infiltrates into the outwash aquifer before reaching the channel of Sawkill Creek, 3) ground water in the underlying bedrock aquifers that discharges under artesian pressure up into the outwash aquifer, and 4) stream water in the channels of Sawkill Creek and Vantine Brook that seeps into the outwash aquifer.

Source Area Delineation

The Milford Water Authority had been taking source water protection actions and doing source area delineation long before this source water protection project was funded and begun. Some of these actions were summarized in the History and other preceding sections of this report. The specific additional rigorous delineation actions that were completed in the field during this project were 1) measurement of water-table levels in residential wells within the source area, 2) measurement of water-table levels in PennDOT monitoring wells 3) measurement of stream channel elevations relative to adjacent wells, 4) measurement of vertical hydraulic gradients in a stream bed piezometer, and 5) a reconnaissance of reaches of Sawkill Creek tributary streams that were perched.

Source Water Protection Areas are comprised of zones. The Zone 1 area for the Milford Springs is proposed to be 400 feet based on the hydrogeologic setting of the springs and the aquifer characteristics. However, this Zone 1 area is only a half-circle because the springs do not receive water from the 360 degree area surrounding them as is the case for drilled water wells. See Figure 3, Milford Water Authority Property.

The Zone 2 area for the Milford Springs is the upgradient area of the Olean ice-contact stratified sand and gravel deposit that the Milford Springs discharge from, as defined on the surficial geology maps in County Report 52 and Water Resources Report 65 (see references). This is the capture zone (zone of diversion) of the Milford Springs. See Figure 4, Zone 2 Area for the Milford Springs.

The Zone 3 area for the Milford Springs is the watershed area of Sawkill Creek and Vantine Brook that is hydraulically upgradient of the Milford Springs. This is the contributing area that provides recharge to the Zone 2 Olean ice-contact stratified sand and gravel aquifer. See Figure 5, Source Water Area of the Milford Springs.

The capture zone (Zone 2) of the Milford Springs was further defined in the field by going to residences in the source area, obtaining permission to open the drilled well, and measuring the depth to the water table. Water-table levels measured in these wells were used to construct the map titled Inferred Ground-Water Flow Directions that is shown on Figure 6.

Potential Contaminant Threats

The hydrogeologic setting of the Milford Springs, together with the high infiltration capacity and locally high permeability of the Olean ice-contact stratified sand and gravel aquifer in the Sawkill Creek Valley make large-volume liquid-contaminant spills the greatest threat to the springs. A spill of a large volume of a dry chemical contaminant during a heavy rainstorm would also pose a very significant threat to the springs. Interstate Highway 84 carries a high volume of petroleum and chemical tank truck traffic and there are approximately 4 miles of this highway in the source water area of the Milford Springs. This interstate highway is as close as 3,000 feet from the springs, and has bridges over both Sawkill Creek and Vantine Brook. It also passes next to Sawkill Pond, the headwaters of Sawkill Creek, so an accidental spill into the pond would eventually flow down Sawkill Creek to the vicinity of the springs where the creek looses water into the aquifer. Vantine Brook is a second surface water flow route for a spilled contaminant to travel to within 400 feet of the springs.

As described in the History section above, a large commercial store and shopping center located in the Zone 2 area would be the second greatest threat to the springs. The storm water system designs for the two previously proposed shopping centers would have directly recharged parking-lot runoff water into basins excavated into the sand and gravel aquifer. Therefore any chemical product purchased at the store, such as a toxic herbicide or pesticide, if spilled on the parking lot would have the easy opportunity to recharge directly into the sand and gravel aquifer. The now-closed gravel pit operation demonstrated that deep excavations into the sand and gravel aquifer provided a short-circuit flow pathway for turbid storm water to enter the aquifer and impact the Springs.

Existing Contaminant Sources

There are no contaminant materials located within the Zone 1 area either on the Milford Water Authority property or on the Grey Towers National Historic Landmark property. The Zone 2 area for the Milford Springs is the Olean ice-contact stratified sand and gravel aquifer in the Sawkill Creek valley and the Vantine Brook valley, as shown on Figure 4, Zone 2 Area for the Milford Springs. There are probably less than 50 private year-round residences located on the sand and gravel aquifer and all have on-lot sewage disposal systems. There are two convenience stores, a motel, and an office center that have larger capacity on-lot sewage systems. There are a few seasonal camps or cottages that have on-lot systems or outhouses. There are no active farms, so there are no fertilizer impacts from farming. There is one horse stable with only a few horses. PennDOT has a maintenance facility with a salt storage building at the intersection of Route 6 and Interstate Highway 84.

The Zone 3 area for the Milford Springs is the watershed area of Sawkill Creek and Vantine Brook upgradient of the springs and is shown on Figure 5, Source Water Area of the Milford Springs. It is fortunate that a significant portion of the northern part of this watershed area is in the Delaware State Forest and State Game Lands 209, the Pike County Park, and the Milford Experimental Forest, and is thereby protected from contaminant sources. Because this Zone 3 area is approximately 25 square miles in area, there are several hundred year-round and seasonal residences that have on-lot sewage systems. A stone quarry and some gas transmission pipelines are located in the Zone 3 area. The existing contaminant sources that are not residences are shown on the map in Figure 7, Contaminant Source Locations.

The Milford Water Authority recognized that because there are approximately 1,350 year-round and seasonal residences located in the Zone 2 and Zone 3 areas, a significant number of heating oil tanks for these homes could be located underground. The residential underground fuel oil tanks posed a threat to the springs because if they were leaking at a slow rate, the leakage would not likely be detected or corrected. Tom Hoff, Water Authority Vice-Chairman and Chair of the Steering Committee designed a survey that was mailed to 1,338 residences in the source water area. The heating oil tank survey report is in Appendix 3.

Source Water Protection Area Management

The predominant land uses in the source water Area (the Sawkill Creek and Vantine Brook watersheds upgradient of the Springs) are forests, residences, both year-round and seasonal, and major highways. There is some limited commercial development along Route 6 more than 2 miles from the Springs. The Authority has met with the quarry manager and inspected the site. A spill notification procedure is being developed by the manager.

The Source Water Protection Area management methods include 1) acquire land, 2) obtain conservation easements, 3) inspect existing facilities, 4) review proposed land development plans, 5) education and 6) coordination with DEP programs. The Milford Water Authority is actively pursuing each of these six management methods and will continue to do so in the future.

Contingency Planning

Three ground-water quality monitoring wells were constructed during this project and they are a key component of the contingency planning done by the Milford Water Authority. The three monitoring wells are located so that by sampling them, the quality of the ground water before it reaches the springs can be evaluated. Depending on the location of the spill, the nature of the contaminant, and the contaminant concentrations found in the monitoring wells, the Authority could take the appropriate responses.

The Water Authority has developed and implemented a Spill Response Plan to respond to a spill within the Zone 2 area. PennDOT will be erecting 'public water supply area – spill response' informational signs on the westbound lane of Interstate Highway 84 and on the westbound lane of Route 6 at the east watershed boundary of Vantine Brook. Corresponding signs will be erected on the eastbound lane of Interstate Highway 84 and on the eastbound lane of Route 6 at the western watershed boundary of Sawkill Creek. Additional informational signs will be erected along Route 6 to notify traffic exiting from Interstate Highway 84 onto Route 6 at exit number 46. The phone number on the signs will reach the Pike County Emergency Management Office.

The Milford Water Authority, Penn DOT, Pike County Emergency Management, and the Milford Fire Department have agreed on a plan to assure prompt interagency communications concerning spills. Their Interagency Spill Response Agreement is in Appendix 4.

New Sources

In the event a spill occurred that was going to impact both springs and render them non-potable even with treatment, water from Vantine Brook could be piped to the treatment plant, filtered, chlorinated, and used on a temporary basis. If a spill occurred that would render the springs non-potable for a long period of time, there is an existing drilled well that could be used as a replacement source. This well was constructed to public water-supply standards and is located adjacent to Interstate Highway 84 at a distance of 4,000 feet from the springs. If the outwash aquifer was contaminated by a spill on Interstate Highway 84, and both springs were rendered non-potable, a replacement source well could be constructed in the outwash aquifer more than one mile upstream from the Interstate Highway 84. Depending on the concentration and nature of the contaminant, additional treatment could be undertaken at the site of the springs to render the contaminated spring water potable. The Authority signed a conservation easement on March 1, 2005 with the right to drill two wells on 60 acres of a property in the south quadrant of the Route 6 and Interstate Highway 84 interchange.

INTRODUCTION

Purpose of this report

This report is a reference, management, and educational document that describes the sources and vulnerabilities of the Milford Springs, and summarizes the actions taken by the Milford Water Authority to develop a comprehensive program to protect the water-quality and the flow of the springs against both existing and future potential threats. Its future use is to support and guide educational, management, and protection activities of the Milford Water Authority. This report is also a specific work-product requirement of the Source Water Protection grant that was received by the Milford Water Authority. This Source Water Protection Plan is available to the public at the offices of the Milford Water Authority, and at the offices of Milford and Dingman Townships, and at the offices of the Pike County Planning Department, Milford Borough, and the Pike County Conservation District.

Terminology

The Pennsylvania Department of Environmental Protection (DEP) uses the term Wellhead Protection (WHP) to apply to either wells or springs used as public water supplies, and they use the term Watershed Protection (WSP) to refer to surface water (streams, reservoirs, etc.) sources of public water supplies. Because the aquifer supplying ground water to the Milford Springs receives some of its recharge from streambed leakage from Sawkill Creek and Vantine Brook, this report addresses the source areas of these two streams in addition to the ground-water source area of the springs. So instead of requiring the reader to 1) think "spring" if the DEP term wellhead was used, and 2) to also remember surface water from two streams directly recharges the aquifer supplying the Milford Springs, this report uses the encompassing term "source water". Thus this report is a source water protection plan that includes both the ground-water sources and surface-water sources of the Milford Springs.

The term aquifer refers to a geologic unit that can yield a significant quantity of water to a well or to a spring. The geologic unit can be either bedrock formations or unconsolidated sand and gravel deposits. The term outwash refers to sand and gravel removed from a glacier by water and deposited near its margins. When the sand and gravel was deposited against the margin of the glacial ice, this is an ice-contact deposit. This report uses the formal name "Olean ice-contact stratified sand and gravel deposit" when referring to the specific outwash deposits shown on maps published by the Pennsylvania Topographic and Geologic Survey.

The Municipal Authority of the Borough of Milford is the formal and legal name of the entity formed under the Pennsylvania Municipal Authorities Act that owns the Milford Springs and is the Pennsylvania public water supplier that treats and provides spring water to its customers. This municipal authority is called the "Milford Water Authority" or "Water Authority" or just "Authority" in this report. Similarly, the Milford Springs are sometimes referred to as just "the springs".

The principal author of this report was Todd Giddings, Ph.D., P.G. Tom Hoff, Vice-Chairman of the Water Authority and Tim Gartner, Operator of the water treatment plant were the primary editors.

1. STEERING COMMITTEE AND PUBLIC PARTICIPATION

Steering Committee

The Milford Water Authority held the first Steering Committee meeting on April 18, 2002. Subsequent Steering Committee Meetings were held on November 7, 2002, March 20 2003, and December 18, 2003, and the final wrap-up meeting was held on January 20, 2005. Each meeting was advertised in the local newspaper, and an opportunity for public participation was provided during each steering committee meeting. All Steering Committee meetings were held in various public buildings in or near the Borough of Milford. The contact telephone number for the Steering Committee Chairman, Tom Hoff, is 570-296-6556. An Executive Committee was formed from members of the Steering Committee to manage this project, and met following each Steering Committee meeting.

Meeting Date	Meeting Subjects
April 18, 2002	Kickoff meeting: form the committee and present an overview of the source water protection project to the committee
November 7, 2002	Present the hydrogeologic setting of the source water area and the results of the residential well inventory program and select executive committee members
March 20 2003	Present and obtain committee approval of the design and locations for three proposed monitoring wells
December 18, 2003	Review the hydrogeology of monitoring well 1 and develop a spill response call list. View the ground-water flow model. Review the final education program.
January 20, 2005	Receive report additions. Summarize the project for the members.

Milford Springs Source Water Protection Project Steering Committee

Executive Committee of the Steering Committee Members	
Name	**Affiliation**
Tom Hoff, Committee Chairman	Milford Water Authority, Vice Chairman of Authority
Susan Beecher, District Manager	Pike County Conservation District
Roger Maltby	Pike County Emergency Management Director
Matt Osterberg	Milford Borough Council President
Peter Pinchot	Milford Exp. Forest & Pinchot Institute for Cons.
Kevin Stroyan	Milford Township Planning Board Chairman
Committee Members	
Ron Gregory	Chairman, Milford Water Authority
Robert Hendricks	Milford Water Authority, Treatment Plant Operator
Tim Gartner	Milford Water Authority, Treatment Plant Operator
Todd Giddings, Ph.D., P.G.	Consulting Hydrogeologist
John Jose, Watershed Specialist	Pike County Conservation District
Joel Jordan, Source Water Specialist	Pennsylvania Rural Water Association
Andrew Augustine	Geologic Specialist, DEP
D. Brink	Chairman, Dingman Township Supervisors
D. Cooke	National Park Service Watershed Planner
S. Corrigan	Planner, Pike County Office of Community Planning

R. Litzenberger	Watershed Landowner
M. Mrozinski	Director, Pike County Office of Community Planning
K. Thiele	Chairman, Westfall Township Supervisors
J. Zenes	Chairman, Shohola Creek Watershed Association
R. Banach	Columbia Gas Company
E. Brylawski	Board Member, Milford Water Authority
J. Donahue	Superintendent, Delaware Water Gap Nat'l. Rec. Area
G. Hansen	Pike County Commissioner
J. Rose, Esq.	Beecher, Rose & Klemeyer, Solicitor for the Authority
C. Wildermuth	Vice Chair, Pike County Planning Committee, and Member, Delaware Highland Conservancy
Patrick Bowling	Hydrogeologist, DEP
R. Cioppa	President, Twin Walker Creek Conservancy
R. Fish	Member, Milford Borough Planning Commission
N. Krause	Chairman, Matamoras Water Authority
G. Myer	Treasurer, Milford Water Authority
S. Sheldon	Member, Milford Water Authority
G. Williams	Chairman, Milford Township Supervisors
E. Brannon	Director, Pinchot Institute for Conservation and Director, Grey Towers National Historic Landmark
R. Cochrane	Former Manager, Milford Penn DOT
G. Fluhr	Chairman, Shohola Township Supervisors
A. Greening	Supervisor, Milford Township
Don Quick	Former Chairman, Milford Township Supervisors
J. Leighty	Board Member, Milford Water Authority
C. Orbser	Pike County Office of Community Planning
M. Tan	Sanitarian, Pennsylvania DEP
Peter Wulfhorst	Pike County Cooperative Extension
Robert Collins	Current Manager, Milford Penn DOT
Judy Muehl	Pennsylvania Rural Water Association

The December 18, 2003 meeting provides an excellent example of the value of the support and participation of Steering Committee members in this project. The Pike County Emergency Management Director and the Pike County Penn DOT manager were present at the December 18 meeting and took an active part in the discussion of the types and locations of spills and other accidents that would threaten the springs. A ground-water flow model was used at the meeting to illustrate the subsurface flow routes that contaminants would follow to reach the springs. Maps were also presented defining the extent of the source area of the springs in the glacial outwash aquifer.

The next morning after this evening meeting of the Steering Committee, the Authority received a phone call from the Pike County Emergency Management Office advising them of a diesel fuel spill onto the ground at the PennDOT maintenance yard located on the glacial outwash aquifer 5,100 feet from the springs. Water Authority personnel responded immediately, and found that due to the quick containment actions taken by the PennDOT personnel when they discovered the spill upon arriving for work, the diesel fuel spill was completely contained on site. Following the removal of fuel-contaminated soils and absorbent materials, water-quality samples were collected from the monitoring wells existing at the maintenance site. The analyses indicated that ground-water quality had not been impacted. Penn DOT will be testing these wells biannually for volatile organic compounds and sodium.

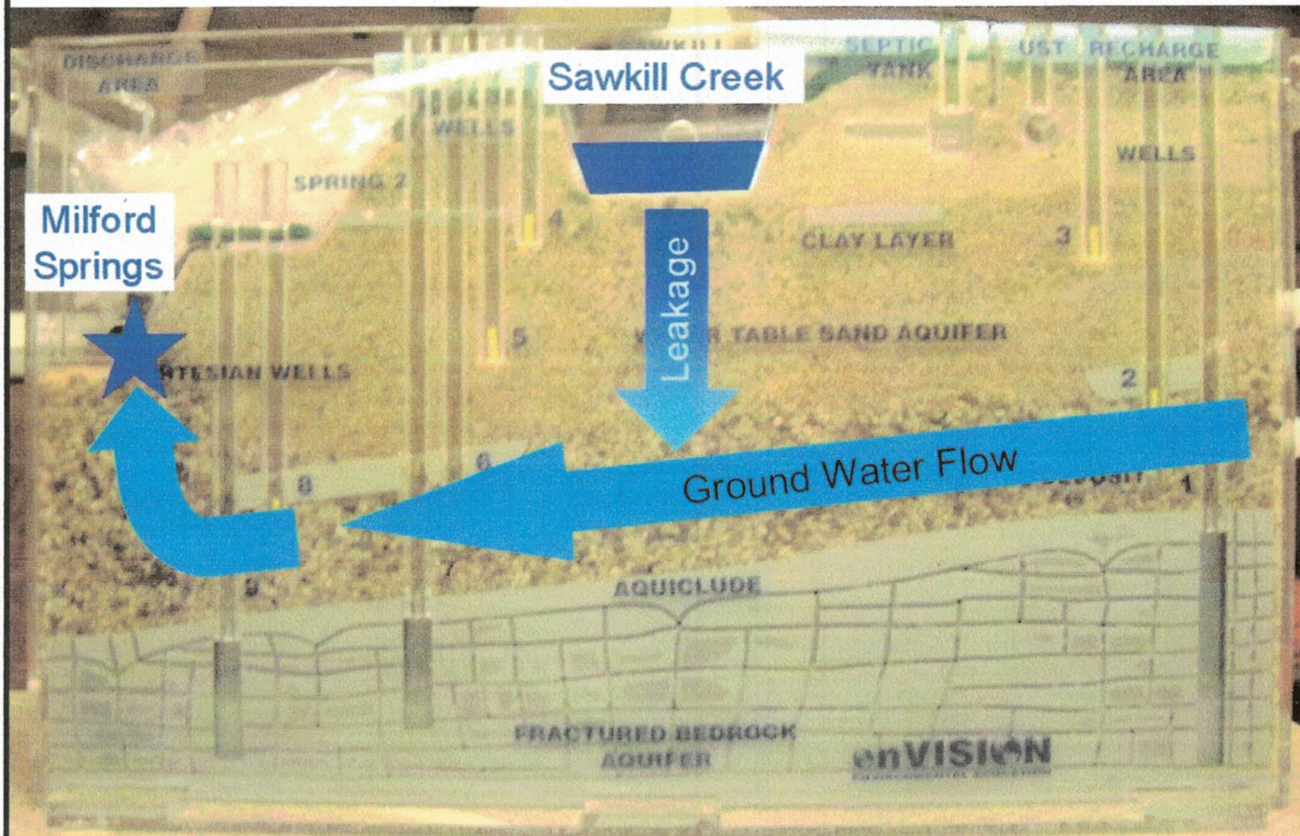
Public Participation and Public Education

The public participation and education activities undertaken by the Milford Water Authority as part of this Source Water Protection project began early and will continue into the future. First, the Milford Water Authority commissioned the preparation of a series of 6 educational articles that were published periodically in the local newspaper, the Pike County Dispatch. The series was titled "The Water We All Share". This newspaper's circulation area included Milford Borough, Milford Township, Westfall Township, Shohola Township, and Dingman Township. These four townships encompass the entire watershed area of Sawkill Creek and the outwash aquifer. Milford Borough is where almost all of the water system customers are located. The articles explained the Source Water Protection project, the water cycle, and how the residents in the Sawkill Creek Watershed could protect both the surface and ground-water quality in the source area of the springs. These educational newspaper articles provided Water Authority contact information so the public could contact the Water Authority to ask questions and to make comments.

Recognizing that the direct hydraulic connection between Sawkill Creek and Vantine Brook and the springs was not known or understood, the Milford Water Authority commissioned the construction of a custom ground-water flow model. The table-top model is comprised of a clear plastic tank containing simulated bedrock and sand and gravel layers modeling the glacial outwash aquifer source of the springs. See Figure 1, Ground-Water Flow Model. By placing food-coloring dye into Sawkill Creek in the model, the flow path that the water leaking from the creek follows through the aquifer to the springs is highlighted. The model simulates other threats to the springs, including a malfunctioning on-lot septic system and a leaking underground gasoline storage tank. An aquarium pump causes the water to flow through the sand and gravel layers in the model, and the various flow pathways are depicted by different colors of food-coloring dye. Tim Gartner traveled to all elementary schools in the watershed, operated the ground-water flow model, and explained the importance of source water protection to more than 500 fifth graders during 2004. This program will be repeated each year to educate a new group of fifth graders in the schools. Source water protection presentations using the ground-water flow model were also made to the high school environmental club, the boy scouts, the Pike County Commissioners, and the planning commissions of Milford Borough, Milford Township, and Dingman Township.

The Authority also commissioned the preparation of an educational brochure that contained much of the information that was presented in the series of newspaper articles. This brochure is titled "*Protecting Your Drinking Water Supply*" and contains a block diagram of the water cycle, a map of the Sawkill Creek Watershed and the springs, and a detailed hydrogeologic map of the springs, monitoring wells, and the outwash aquifer source area. This detailed map also shows the directions of ground-water flow within the sand and gravel outwash from the recharge areas to the springs. Contact information in the brochure provides an opportunity for the public to contact the Water Authority to ask questions and to make comments. This brochure is a primary reference and student take-home that is used in the Delaware Valley, Shohola, and Dingman/Delaware elementary schools to teach fifth grade students about source water protection for the Milford Springs.

Ground-Water Flow Model



This table-top model simulates the flow of ground water through the sand and gravel aquifer to the Milford Springs. Dye is used to trace the leakage of water from Sawkill Creek into the aquifer and the flow to the springs. Dye also shows how a leaking heating oil tank and a malfunctioning septic system seepage bed can contaminate ground water. Arrows have been added to this photo to indicate the paths of flow when the model is operated using an aquarium pump.

SOURCE WATER PROTECTION PLAN FOR THE MILFORD SPRINGS

Milford Township, Pike County
Pennsylvania

Figure 1. Ground-Water Flow Model

With the full support of the Superintendent of the Delaware Valley School System, all fifth grade teachers participated in a curriculum development program on ground water, and each school was supplied with a Pennsylvania American Water Works Association Tap Water kit which includes classroom teaching resources and a curriculum guide approved by the Pennsylvania Secretary of Education. The program will be implemented annually in all three elementary schools. All materials including the custom ground-water flow model were acquired using WREN grant funding. The ground-water flow model is being used for classroom demonstrations that are part of the educational component of this plan. The Milford Water Authority also mailed a copy of the brochure with a explanatory cover letter to 1,850 residents in the entire source water area. A detailed report on the WREN grant funded educational program was filed with the Pennsylvania League of Women Voters in June, 2004 and approved by them (See Appendix 1).

During the residential water well inventory phase of this project, informational handouts were given to the homeowners, and the role of measuring the water level in their well in the source water area was explained to them. This individual homeowner contact provided another opportunity for public participation in the project.

This Source Water Protection Plan for the Milford Springs will be accessible to the public at the Milford Water Authority office, the Milford Borough office, the Pike County Planning office, the Pike County Conservation District office, and the offices of Milford, Westfall, Shohola, and Dingman Townships.

2. SOURCE WATER PROTECTION AREA DELINEATION

History

The Milford Springs have been the source of drinking water for the residents of Milford Borough for more than 100 years. The two springs are located at the foot of a steep slope, west of Milford Borough in Milford Township, Pike County. Prior to 2000, chlorine was added in the spring pools and two rectangular reservoirs received the water flowing from the two springs. Intake pipes in the reservoirs conveyed the water to the distribution piping system, where the water flowed by gravity to the customers in Milford Borough and parts of Dingman and Milford Townships. In 1999 a water treatment plant was constructed at the site of the springs to filter the spring water prior to distribution and consumption. Today, filtered spring water is chlorinated, treated for corrosion control, and pumped into a 548,000 gallon storage tank, and then flows by gravity through the distribution system to the customers. The Milford Springs provide water to a total of 658 household and business customers, and the total number of persons served is approximately 2,200.

Milford is located in the Delaware River Valley at the eastern edge of Pike County and the source area of the Milford Springs is in the Pocono Plateau physiographic province. This area of Pike County is growing rapidly, due in large part to people who work in New York City and New Jersey choosing to commute from their homes located in this predominantly forested and rural area. The topography of the Pocono Plateau is rolling hills.

Members of the Milford Water Authority have known for decades that the source of their spring water was in the glacial outwash aquifer that the springs discharge from. They also understood that both Sawkill Creek and Vantine Brook loose water into the glacial outwash aquifer in the immediate vicinity of the springs. The springs were observed to discharge turbid water immediately following some flood flows in these streams. In 1966, when Interstate Highway 84 was being constructed in the glacial outwash aquifer within 3,000 feet of the springs, small rainstorms caused high turbidity in the springs. The Authority contacted PennDOT and explained the cause-and-effect relationship. Following some PennDOT investigations, the highway grading design was modified and mitigation measures were implemented by PennDOT to protect the water-quality of the springs.

When a mall was proposed to be constructed on the glacial outwash aquifer within 3,000 feet of the springs, the Milford Water Authority commissioned a chemical tracer study to evaluate the hydraulic interconnection between Sawkill Creek, the proposed mall site, and the springs. The chemical tracer study documented that some water from Sawkill Creek seeped through the stream bed and discharged from the springs and that water infiltrating into the aquifer at the proposed mall location also discharged from the springs. The mall proposal was withdrawn after completion of the chemical tracer study.

Following another series of turbidity episodes, the Milford Water Authority commissioned an investigation of a gravel pit operating in the outwash aquifer only 2,800 feet from the springs. The gravel mining operation was causing its own very turbid storm water to infiltrate directly into the outwash aquifer more than 50 feet below original ground level. Within 8 hours following an intense rainstorm (where a large volume of very turbid gravel pit water was observed entering the aquifer in the gravel pit), the springs discharged very turbid water. Graphs of turbidity and dissolved solids concentrations are in Appendix 2. The Authority and its consultant documented these events and held a series of meetings with the gravel pit operator and with the Bureau of Mining and Reclamation where the Authority requested that the gravel pit cease operation. The gravel pit operator eventually withdrew his permit and restored and revegetated the pit area. Storm-related turbidity in the springs decreased very significantly following the gravel pit closure and restoration.

Both the construction of Interstate Highway 84 and the operation of the gravel pit created deep excavations into the glacial outwash aquifer and allowed highly turbid storm-water runoff to enter directly into the aquifer. The consequences were episodes of turbidity in the springs, some occurring within as little as 8 hours following a severe rainstorm. The highly turbid storm water was a colorimetric (dye) tracer that demonstrated the direct hydraulic connections between the infiltration points and the springs. Therefore, these turbidity events demonstrated that a) the glacial outwash aquifer was the source area of the water discharging from the springs, b) there were zones of high permeability material in the outwash aquifer that caused the short travel times for the turbid water from the point of infiltration to the springs, and c) the springs are vulnerable to impacts from point-source recharge into the glacial outwash aquifer below its original ground surface.

The chemical tracer study demonstrated that water from Sawkill Creek was infiltrating into the glacial outwash aquifer through the creek's bed and flowing to and discharging from the springs. Therefore, this chemical tracer study demonstrated that a) Sawkill Creek looses water through stream-bed infiltration in the vicinity of the springs, b) the glacial outwash aquifer receives recharge directly from surface-water infiltration, and c) the springs are vulnerable to impacts from contaminants in the surface water flowing in Sawkill Creek in the vicinity of the springs.

Because the Milford Water Authority members had seen their two springs impacted by excavation activities in the glacial outwash aquifer, and understood the hydraulic connection to Sawkill Creek, they were vigilant and took action when a very large building supply store and associated shopping center was proposed on a land parcel only 3,500 feet from the springs. The shopping center design proposed direct recharge of its storm-water runoff into the glacial outwash aquifer, and also posed a threat to the springs from accidental spills of herbicides, pesticides, and other chemicals that would be sold at the proposed building supply center. The authority members and the authority's hydrogeologist met with the building supply center developers and their hydrogeologists and presented the vulnerabilities of the springs and the history of activities, impacts, and tracer studies. The building supply center company selected an alternate site and constructed their building along the Delaware River more than 4 miles north of Milford Borough.

The Milford Water Authority members knew that Pike County has been the fastest growing county (on a percentage basis) in Pennsylvania for the previous decade. They also recognized that the intersection of Interstate Highway 84 and Route 6 was a development target. This highway intersection is underlain by the glacial outwash aquifer that is the source of the two Milford Springs, and hence the Authority members were remaining vigilant and were seeking additional means of protecting their springs. When the Source Water Protection Grant Program was announced, the Milford Water Authority applied for and was awarded a Source Water Protection Project grant by the DEP. This report presents the source water protection activities funded by that grant and the matching funds and in-kind services of the Milford Water Authority.

Hydrogeologic setting of the springs
Pike County was last glaciated approximately 20,000 years ago during the Wisconsinan stage. The advancing ice sheet eroded bedrock hilltops and slopes, and scoured and deepened bedrock valley bottoms where the valleys were oriented north-south, parallel to the direction of ice movement. Thus the valley of Sawkill Creek was deepened where it flows north-south from upstream of Interstate Highway 84 downstream to the Pinchot Falls where the bedrock of the Mahantango Formation forms waterfalls in the stream bed. The Wisconsinan ice flowed south over the eroded Pocono Plateau and was diverted to the southwest by the pre-existing valley of the Delaware River, which was deepened to a depth of up to 250 feet below the present river level.

During the period of climatic warming at the end of the Wisconsinan glaciation, the ice sheet began to melt down at its surface and back at its leading edge that was located more than 35 miles south of Milford. As the ice sheet thinned, its forward motion effectively ceased, and the ice down-melted in place. Bedrock hilltops were the first land to be exposed through the ice sheet as it down-melted, and ice masses remained in the valley bottoms the longest due to the greater thickness of glacial ice. The climate was still severe, and was similar to the climate of the North Slope in Alaska today. The melt water running off the exposed bedrock uplands and off of the melting valley ice masses was very heavily laden with sediment deposited on the uplands and contained within the glacial ice remaining in the valleys. The runoff streams deposited much of this sand and gravel material along the bedrock margins of the valley ice masses in deposits called kame terraces. When severe storms and floods occurred, the gravel and boulder deposits forming a stream channel on a kame terrace surface would be buried as the torrent of runoff quickly filled the area between the bedrock valley wall and the valley ice with many feet of new sand and gravel deposits.

The masses of valley ice in the smaller valleys completely melted away first, and then runoff from the bedrock uplands deposited more sand and gravel in the valley bottoms. When the last of the ice melted in the Sawkill Creek bedrock valley, glacial ice still remained in the Delaware Valley due to its great thickness and width. The outwash sand and gravel deposits in the Sawkill Creek valley ended at the mass of ice remaining in the Delaware Valley, and this ice supported and held back sand and gravel deposits in many tributary valleys until it melted. The Milford Springs discharge from the toe of a steep slope composed of sand and gravel deposits that were once supported by the residual Delaware Valley ice. When the Delaware Valley ice finally melted away, the sand and gravel deposits collapsed to the steep slope seen today.

Each of the two Milford Springs discharges from a small pool in the outwash gravel that is less than four feet in diameter. More than 200 gallons per minute discharges from each spring pool. These two concentrated flows of ground water require that the sand and gravel outwash aquifer contain a discrete zone of high permeability capable of conveying the ground-water flow to the spring pools. Permeability is the capacity of a sand and gravel aquifer or a bedrock aquifer to convey ground-water flow. A buried stream channel deposit, composed of coarse gravel and boulders is the likely permeability zone within the outwash deposits that conveys ground water to the spring pools. The short, 8-hour travel time for turbid water to flow 2,800 feet from the gravel pit to the springs also demonstrates the presence of a high-permeability buried stream channel deposit within the outwash aquifer.

Conceptual ground-water flow model

This report section presents text that describes a conceptual ground-water flow model for the Milford Springs. A conceptual ground-water flow model is a theoretical replica of the ground-water flow system supplying the Milford Springs, and should not be confused with the table-top ground-water flow model described elsewhere in this report. The table-top model is an actual miniature replica of the outwash aquifer and springs, and water actually flows through that model.

Model background

This conceptual (theoretical) ground-water flow model for the Milford Springs was developed by Todd Giddings, and has its foundation in his extensive experience in observing, field mapping, and evaluating glacial outwash aquifers in Connecticut. The important hydrogeologic similarity between Connecticut and Pike County, Pennsylvania is that in both areas, the glacial outwash aquifers developed due to the down-melting in place of the glacial ice. This critical characteristic made the landforms and sand and gravel deposits in the Milford area instantly recognizable and familiar to him.

Giddings began to develop his conceptual ground-water flow model for the Milford Springs 17 years ago when he was retained by the Authority to assist them in evaluating the potential impacts from a proposed mall to be located within 3,000 feet of the springs. He used a harmless salt compound as a chemical tracer to document the direct hydraulic connection between the proposed mall site and Sawkill Creek and the Milford Springs. During the 1990's, Giddings assisted the Authority is determining the cause of intermittent turbidity episodes in the springs. A sand and gravel pit was identified as the source of the intermittent turbidity, and a gravel pit site inspection with a hydrogeologist from the DEP Bureau of Mining and Reclamation took place during a very intense, 3+-inch rainstorm. Several hundred gallons per minute were observed flowing directly into the outwash aquifer in the bottom of the gravel pit more than 50 feet below original ground level. Coincidentally, the Authority was operating a continuous recording turbidimeter at the springs during and after this rainstorm. The turbidimeter recorded a peak turbidity level of more than 10 turbidity units (NTU's), thereby documenting the rapid flow of the turbid water to the springs in less than eight hours. Graphs of the turbidity and dissolved solids concentrations are in Appendix 2. The turbidity functioned as a colorimetric (dye) tracer, and the short travel time of eight hours for the 2,800 foot distance indicated a zone of high permeability gravel and boulders within the outwash aquifer. Buried stream channel deposits were exposed and observed in the banks of the gravel pit where the turbidity originated.

During the investigations in both the 1980's and 1990's, Giddings installed piezometers in the bed of Sawkill Creek in the vicinity of the springs. A piezometer is a very small diameter (one-half inch in this case) well that has a very short open screen section that has hydraulic communication with the aquifer material. After wading out into the water flowing in the channel of Sawkill Creek, a steel rod was driven several inches into the stream bed between the boulders and then removed. A length of one-half inch diameter steel electrical conduit was then inserted into the hole in the stream bed and clay soil material was placed around the conduit at the stream bed to stop vertical leakage of water right around the electrical conduit. The conduit had its bottom end pinched closed and a few hacksaw cuts in the end provided a short zone of well-screen type open slots where ground water could flow into or out of the conduit. When the piezometer was filled up with water, the water level in it slowly dropped to a level below the water surface in the stream channel. The difference in water levels inside and outside the piezometer was often as much as six inches.

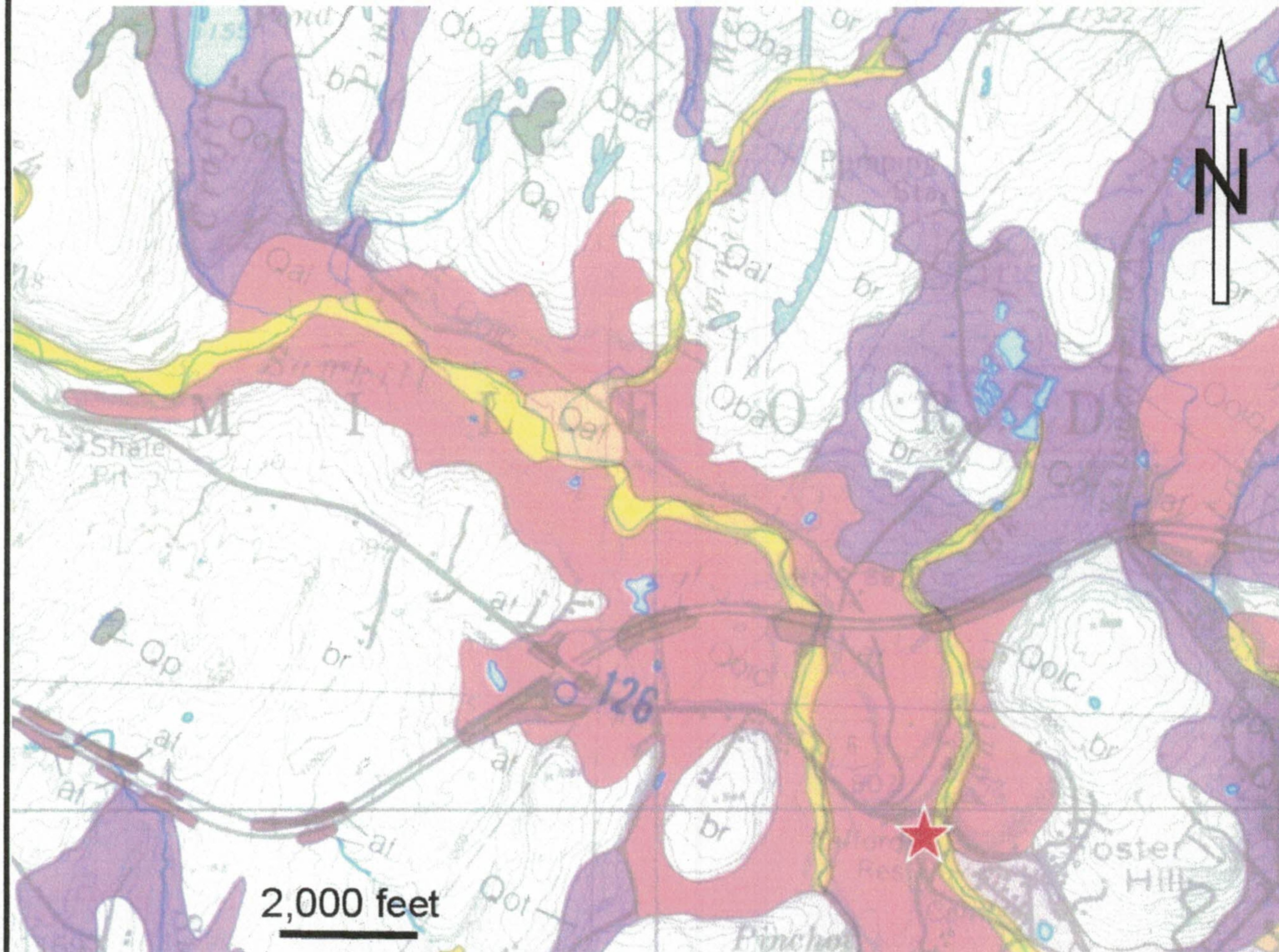
So what is the significance of this difference in water levels? The lower water level inside the streambed piezometer demonstrates directly that water is seeping from the stream channel into the aquifer below the stream bed. The difference in water levels compared to the length of the piezometer below the streambed is a measure of the vertical hydraulic gradient of the infiltrating water. Where water is flowing in a stream channel and the streambed is at an elevation higher than the underlying water-table surface, the stream is said to be 'perched'. Sawkill Creek is a perched stream for several hundred feet of its course as it flows south of Interstate Highway 84 down to Pinchot Falls. The surface water in the channel of Sawkill Creek that infiltrates through the stream bed becomes part of the ground water that flows to and discharges from the Milford Springs. A water-table level measured in a residential well located adjacent to Sawkill Creek and more than one mile upstream from the springs was more than two feet below the stream bed. Sawkill Creek is a perched stream at this location also.

In 1989, Swistock and DeWalle (see references) used oxygen-18, a natural isotope of oxygen in water, to evaluate the sources of the water discharging from the Milford Springs. Their study found that surface (stream) water was a measurable component of the total flow of water from the springs. Deep ground-water flow was the predominant source of water discharging from the springs.

The water discharging from the Milford Springs does not have a high natural mineral content as does some ground water from deep water wells drilled into the bedrock aquifers. Water flowing through fractures and joints in the bedrock aquifer often has a residence time in the bedrock measured in decades and centuries. This long residence time provides the opportunity for iron, manganese, and other natural minerals in the bedrock to dissolve into the ground water. Ground water infiltrating into the sand and gravel outwash aquifer generally has a residence time measured in months and years as it flows through the pore spaces between the sand and gravel grains. The mineral content of the Milford Springs' water indicates its outwash aquifer source. Surface water flowing in stream channels is composed of recent precipitation, with no appreciable mineral content. When the surface water in the channel of Sawkill Creek enters the outwash aquifer and becomes ground water it contributes to the low mineral content of the spring water.

Maps of the bedrock and the surficial geology of Pike County were published in 1989 in County Report 52 titled *Geology and Mineral Resources of Pike County, Pennsylvania* (see references). This report provides a detailed map of the location and extent of the Olean ice-contact stratified sand and gravel deposit that the Milford Springs discharge from. Also published in 1989 was Water Resources Report 65 titled *Groundwater Resources of Pile County, Pennsylvania.* This report describes the occurrence, movement, and quality of ground water in Pike County. The Olean outwash deposits and the Olean ice-contact stratified sand and gravel deposits are described as excellent aquifers. Figure 2, Surficial Geology at the Milford Springs reproduces a portion of the surficial geology map from Water Resources Report 65. The Mahantango Formation siltstone, claystone, clay shale, and silt shale bedrock that underlies the Milford Springs is described as an aquifer that yields adequate supplies of ground water for domestic and non-domestic wells. Wells completed in the Olean ice-contact stratified sand and gravel deposit were reported to have up to 20 times the yields of wells completed in the Mahantango Formation

Surficial Geology at the Milford Springs



= Olean Ice-Contact Stratified Sand and Gravel

★ = Springs

= Olean Till

= Peat

= Boulder Accumulations

= Alluvium

= Artificial Fill

= Bedrock/Thin Till

Surficial Geologic Map from Water Resources Report 65.

SOURCE WATER PROTECTION PLAN FOR THE MILFORD SPRINGS

Milford Township, Pike County
Pennsylvania

Figure 2. Surficial Geology at the Milford Springs

bedrock. The combined flow of the Milford Springs is approximately 800,000 gallons per day or more than 500 gallons per minute.

The conceptual model

The geographic area encompassed by the conceptual ground-water flow model for the Milford Springs consists of the adjacent watersheds of Sawkill Creek and Vantine Brook, from their headwater areas downstream to the Milford Springs. The four sources of water that comprise the discharge of the Milford Springs are 1) rainfall and snowmelt that directly infiltrates into the outwash aquifer, 2) upland tributary stream water that infiltrates into the outwash aquifer before reaching the channel of Sawkill Creek, 3) ground water in the underlying bedrock aquifers that discharges under artesian pressure up into the outwash aquifer, and 4) stream water in the channels of Sawkill Creek and Vantine Brook that seeps into the outwash aquifer.

This conceptual ground-water flow model explains why the source water area of the Milford Springs is not limited to the few hundred acres area of the outwash aquifer, but includes the watersheds of Sawkill Creek and Vantine Brook comprising an area of approximately 25 square miles. The stream-water infiltration provides significant additional recharge to the outwash aquifer and thereby sustains a higher flow of the springs during droughts. The negative aspect of this additional recharge is that a contaminant could enter Sawkill Creek or Vantine Brook upstream from the springs and quickly impact the springs. The rates of flow of water in stream channels are commonly more than 1,000 times faster than the rates of flow of ground water in the underlying aquifers.

This conceptual ground-water flow model of the Milford Springs is based on extensive hydrogeologic training, more than 40 years of field experience, published and unpublished reports and maps, and detailed field studies of the Olean ice-contact stratified sand and gravel aquifer, Sawkill Creek, Vantine Brook, and the springs. Direct field observations and measurements and three tracer studies have documented the four sources of water discharging from the springs.

Source area delineation

The Milford Water Authority had been taking source water protection actions and doing source area delineation long before this source water protection project was funded and begun. Some of these actions were summarized in the History and other preceding sections of this report. The specific additional rigorous delineation actions that were completed in the field during this project were 1) measurement of water-table levels in residential wells within the source area, 2) measurement of water-table levels in PennDOT monitoring wells 3) measurement of stream channel elevations relative to adjacent wells, 4) measurement of vertical hydraulic gradients in a stream bed piezometer, and 5) a reconnaissance of reaches of Sawkill Creek tributary streams that were perched.

All of these field activities were completed by Todd Giddings, Ph.D., P.G. He then evaluated these field data to again test his conceptual ground-water flow model that he previously developed for the Milford Springs. He also reviewed the previous chemical, colorimetric, and isotope tracer study results, stream-bed piezometer measurements, field notes on bedrock and outwash aquifer materials, and the published and unpublished reports listed in the references section of this report. His conclusion is that the additional field data collected during this project confirmed the validity of the conceptual ground-water flow model for the Milford Springs.

The required justification of the use of this methodology is that it is the scientific method, wherein one develops a hypothesis (the conceptual ground-water flow model in this case), and then collects data and determines if the data support the hypothesis. The field data (collected both before and during this project) and the published and unpublished reports all support the conceptual ground-water flow model for the Milford Springs.

The Zone 1 area for the Milford Springs is proposed to be 400 feet based on the hydrogeologic setting of the springs and the aquifer characteristics. However, this Zone 1 area is only a half-circle because the springs do not receive water from the 360 degree area surrounding them as is the case for drilled water wells. The Milford Water Authority owns the 25.7 acre parcel of land that surrounds the springs and contains almost all of the Zone 1 area, two surface reservoirs, the water treatment plant, and a storage tank. The westernmost part of the Zone 1 area is owned by the U.S. Forest Service, and is part of their Grey Towers National Historic Landmark property. This federal ownership affords the same land use protections for that section of the Zone 1 area as if the Milford Water Authority owned the land. See Figure 3, Milford Water Authority Property.

The Zone 2 area for the Milford Springs is the upgradient area of the Olean ice-contact stratified sand and gravel deposit that the Milford Springs discharge from, as defined on the surficial geology maps in County Report 52 and Water Resources Report 65 (see references). This is the capture zone (zone of diversion) of the Milford Springs. See Figure 4, Zone 2 Area for the Milford Springs.

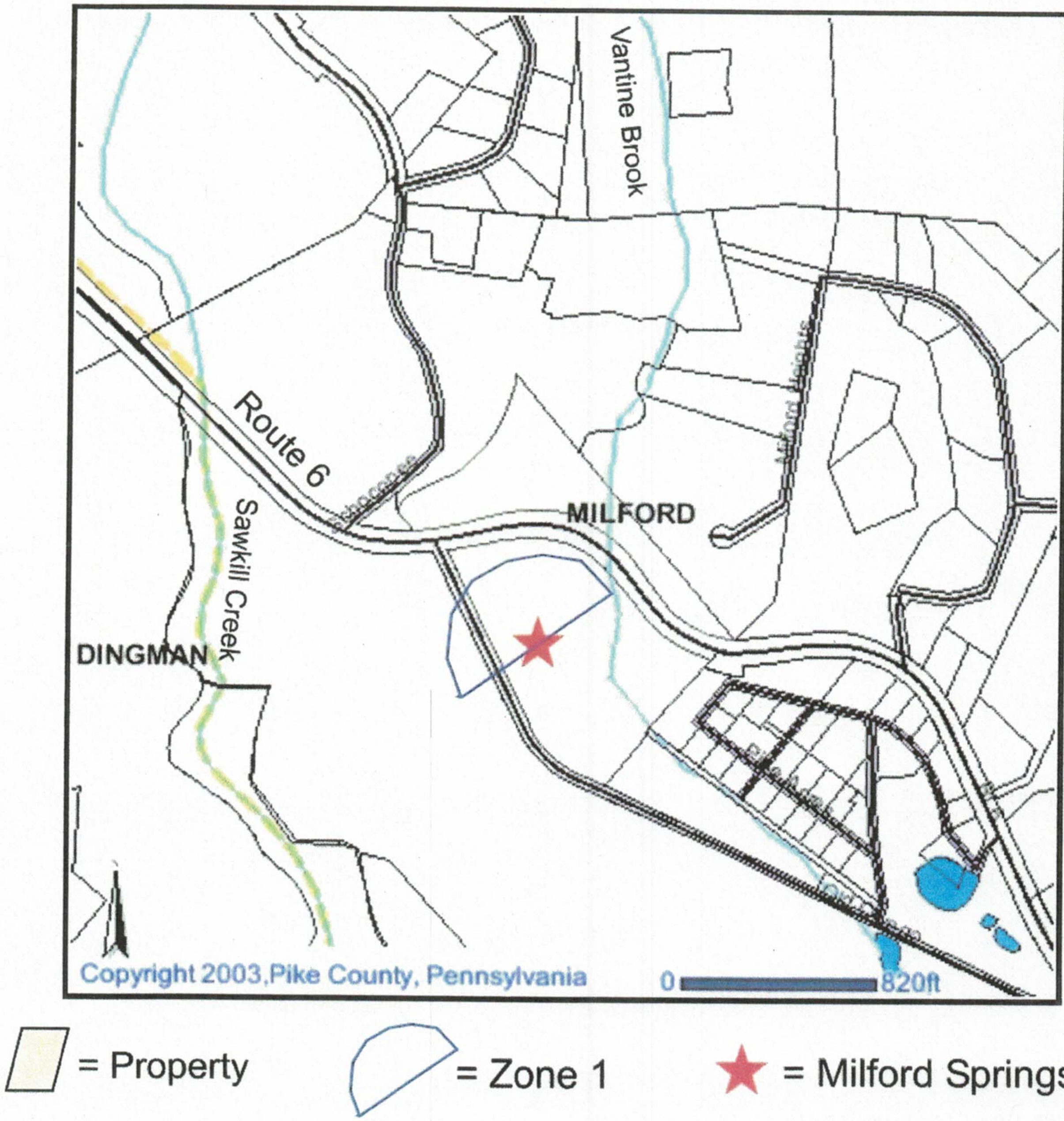
The Zone 3 area for the Milford Springs is the watershed area of Sawkill Creek and Vantine Brook that is hydraulically upgradient of the Milford Springs. This is the contributing area that provides recharge to the Zone 2 Olean ice-contact stratified sand and gravel aquifer. See Figure 5, Source Water Area of the Milford Springs.

Source Area Delineation Activities Completed During This Project

Measurement of water-table levels in residential wells

These water-level data were collected by going to a residence in the source area and obtaining permission to open their drilled well and measure the depth to the water table. The owners were also asked if they knew the total depth of their well and the casing length. These meetings were also used to explain the source water protection project and to provide an opportunity for public participation. An informational handout was provided to the homeowners. This field work was conducted during weekdays, on evenings, and on weekends to find people at home. Some homes were visited as often as five times before someone was contacted. The residential wells were all completed within the bedrock underlying the sand and gravel aquifer. None of the casings were grouted, and most of the wells derived part of their yield from the sand and gravel aquifer by leakage into the well bore at the fractured top of bedrock. A few drilled wells had their casings tightly seated into the underlying bedrock and some of these wells exhibited high water levels due to the artesian pressure within the bedrock aquifer. One well was seasonally a flowing artesian well. These unusually high water levels were not used to construct the map titled Inferred Ground-Water Flow Directions that is shown on Figure 6.

Milford Water Authority Property

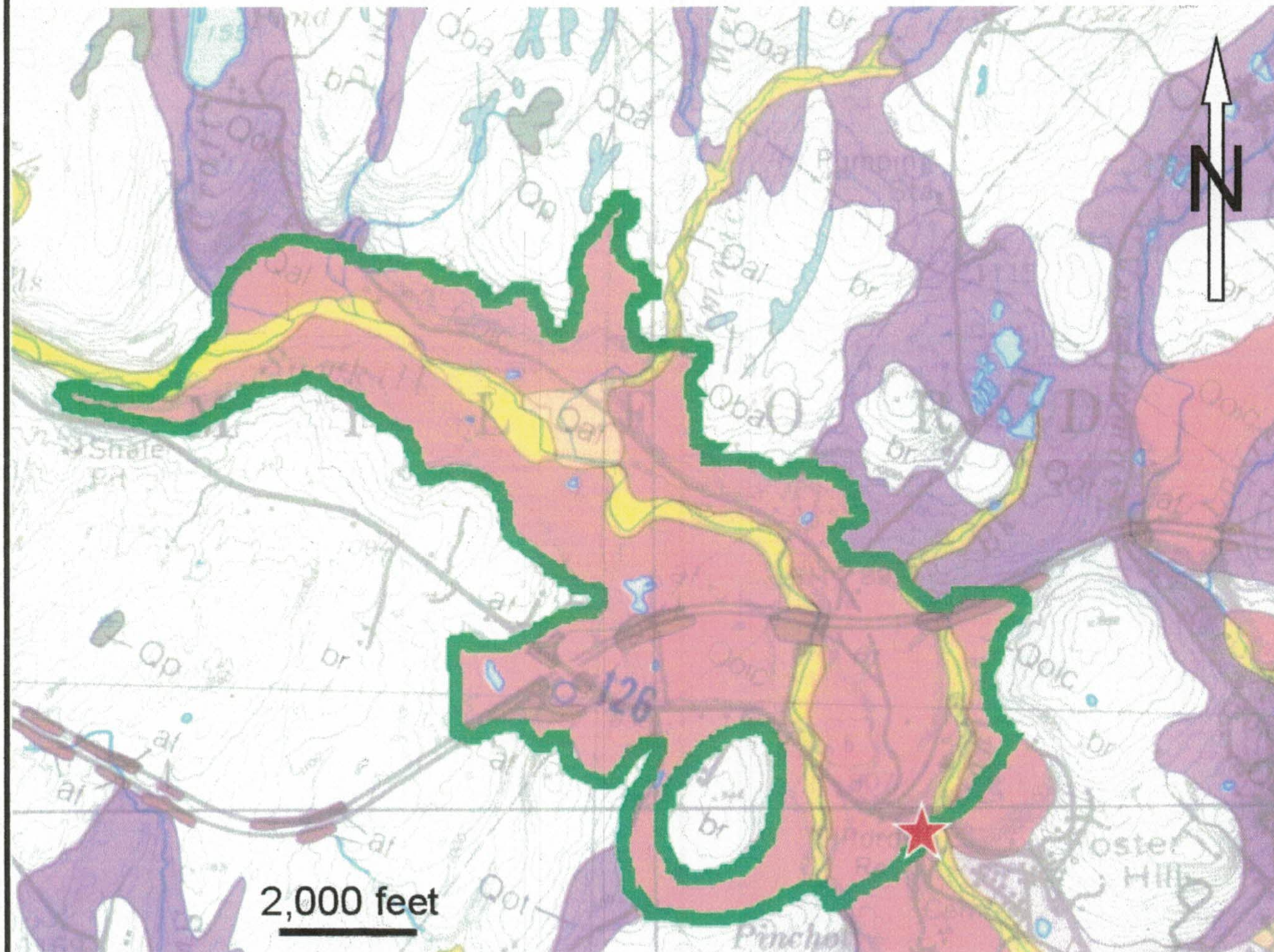


SOURCE WATER PROTECTION PLAN FOR THE MILFORD SPRINGS

Milford Township, Pike County Pennsylvania

Figure 3. Milford Water Authority Property

Zone 2 Area for the Milford Springs



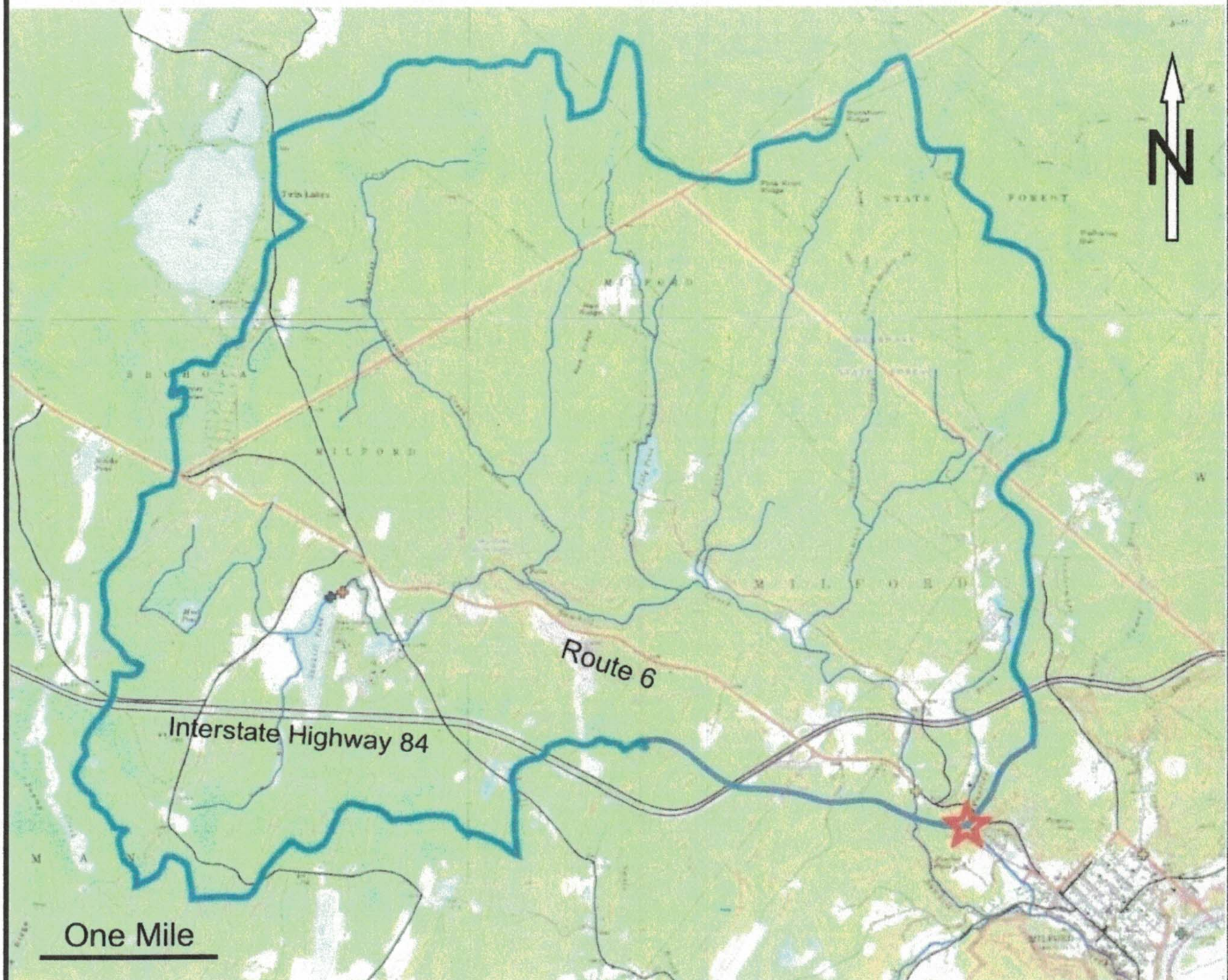
= Olean Ice-Contact Stratified Sand and Gravel
= Springs
= Olean Till
= Peat
= Boulder Accumulations
= Alluvium
= Artificial Fill
= Bedrock/Thin Till
= Outline of the Zone 2 Area for the Milford Springs

SOURCE WATER PROTECTION PLAN FOR THE MILFORD SPRINGS

Milford Township, Pike County Pennsylvania

Figure 4. Zone 2 Area for the Milford Springs

Source Water Area of the Milford Springs



☆ = Milford Springs   = Watershed Boundary

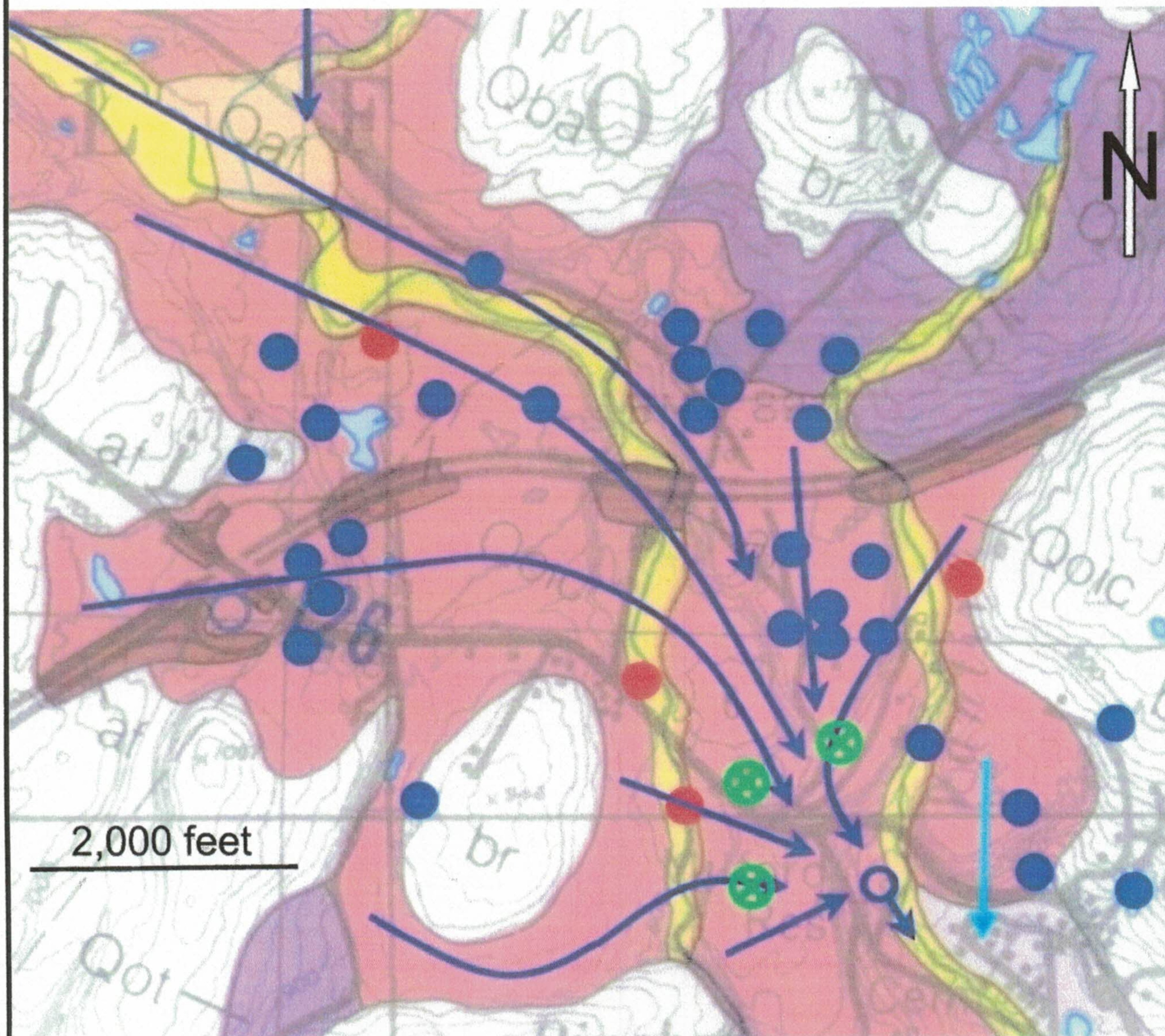
The blue line outlines the watersheds of Sawkill Creek and Vantine Brook upgradient of the Milford Springs. This is the Zone 3 area of the springs.

SOURCE WATER PROTECTION PLAN FOR THE MILFORD SPRINGS

Milford Township, Pike County Pennsylvania

Figure 5. Source Water Area of the Milford Springs

Inferred Ground-Water Flow Directions



⊗ = Monitoring Well ● = Residential Well ● = Perched Stream

Blue arrows show inferred ground-water flow directions ○ = Springs

SOURCE WATER PROTECTION PLAN FOR THE MILFORD SPRINGS

Milford Township, Pike County Pennsylvania

Figure 6. Inferred Ground-Water Flow Directions

Measurement of water-table levels in PennDOT monitoring wells

The PennDOT foreman at the Maintenance Yard was asked to provide access to the three monitoring wells that are used to determine if the road salt stored inside a building at this site is impacting ground-water quality. Access to the wells was provided and water-table levels were measured in the three wells. This Maintenance Yard is located in the east quadrant of the intersection of Interstate Highway 84 and Route 6, and is 4,800 feet from the springs.

Measurement of stream channel elevations relative to adjacent wells

A water-table level was measured in a residential well that is located at the top of a kame terrace escarpment that forms a bank of the channel of Sawkill Creek. Because the water-table level appeared significantly lower than the bottom of the adjacent stream channel, the vertical elevation difference between the stream channel bottom and the top of the well casing was measured. The water-table level in the well was more than two feet lower than the stream channel bottom, thereby documenting that Sawkill Creek was perched in this reach due to the influence of the Milford Springs. This location, shown by the red dot north of Interstate Highway 84 on Figure 6, is more than one mile from the springs and documents that the capture zone of the springs extends far upstream beneath Sawkill Creek.

Vantine Brook is also a perched stream in its reach south of Interstate Highway 84 and overlies the capture zone of the springs. Measurement of the water-table level in a residential well adjacent to the brook showed that the water table was more than 10 feet below the brook channel. Therefore, some Vantine Brook surface water infiltrates into the outwash aquifer and discharges from the Milford Springs. This location is shown by the red dot next to Vantine Brook south of Interstate Highway 84 on Figure 6.

Measurement of vertical hydraulic gradient in a stream bed piezometer

A piezometer was installed in the bed of Sawkill Creek at a location 250 feet downstream from the Route 6 Bridge and within 1,800 feet of the springs. Repeated water-level measurements in this piezometer found the vertical hydraulic gradient to be greater than 100%, confirming that Sawkill Creek is a perched and loosing stream in this reach.

A reconnaissance of reaches of Sawkill Creek tributary streams that were perched

A reconnaissance of the upstream extent of the Olean ice-contact stratified sand and gravel aquifer in the Sawkill Creek Valley found tributary streams that were flowing from the bedrock uplands out onto the outwash aquifer and loosing water into their stream beds. This determination was based on observing a significant diminution in flow in their channels over the outwash aquifer.

3. CONTAMINANT SOURCE INVENTORY

Potential Contaminant Threats

The Greatest Potential Contaminant Threat

The hydrogeologic setting of the Milford Springs, together with the high infiltration capacity and locally high permeability of the Olean ice-contact stratified sand and gravel aquifer in the Sawkill Creek Valley make large volume liquid contaminant spills the greatest threat to the springs. A spill of a large volume of a dry chemical contaminant during a heavy rainstorm would also pose a very significant threat to the springs. Interstate Highway 84 carries a high volume of petroleum and chemical tank truck traffic and there are approximately 4 miles of this highway in the source water area of the Milford Springs. This interstate highway is as close as 3,000 feet from the springs, and has bridges over both Sawkill Creek and Vantine Brook. It also passes next to Sawkill Pond, the headwaters of Sawkill Creek, so an accidental spill into the pond would eventually flow down Sawkill Creek to the vicinity of the springs where the creek looses water into the aquifer. Vantine Brook is a second surface water flow route for a spilled contaminant to travel to within 400 feet of the springs.

Route 6 is also heavily traveled by trucks and is as close as 400 feet from the springs. At its closest point to the springs, Route 6 is has a steep grade with sharp curves as it traverses the steep slope of the sand and gravel aquifer. There are approximately 5.5 miles of Route 6 in the source area of the springs. See Figure 5, Source Water Area of the Milford Springs. Interchange 41 on Interstate Highway 84 connects to Route 6 and is located one mile from the springs.

The Old Owego Turnpike is a secondary road that connects to Route 6 at the top of the steep slope of the sand and gravel aquifer, traverses the steep slope between the springs and Grey Towers National Historic Landmark, and reconnects to Route 6 in Milford Borough. See Figure 3, Milford Water Authority Property. Companies using home heating oil delivery trucks have been asked to not use this road due to its steep slope, lack of guide rails, and proximity to the springs. This Pocono Plateau area has very severe winter storms, and the steep grades and sharp curves increase the risk of a truck accident.

The Second-Greatest Potential Contaminant Threat

As described in the History section above, a large commercial store and shopping center located in the Zone 2 area would be the second greatest threat to the springs. The storm water system designs for the two previously proposed shopping centers would have directly recharged parking-lot runoff water into basins excavated into the sand and gravel aquifer. Therefore any chemical product purchased at the store, such as a toxic herbicide or pesticide, if spilled on the parking lot would have the easy opportunity to recharge directly into the sand and gravel aquifer. The now-closed gravel pit operation demonstrated that deep excavations into the sand and gravel aquifer provide a short-circuit flow pathway for storm water to impact the springs.

Potential Contaminant Threat Summary

Because the potential contaminant threats have a far greater likelihood of impacting the springs than do the existing contaminant sources, the Source Water Protection Area Management Section and the Contingency Planning Section below focus more on potential threats than on existing contaminant sources.

Existing Contaminant Sources

Methods of Identification

The DEP Northeastern Regional Office provided maps from DEP and US EPA database searches that showed the locations of two previously leaking underground storage tanks, a gas transmission pipeline, the Eureka Stone Quarry, and the Architectural Iron Company. The maps stated the locations shown were not field checked, and field checking revealed that all of the map locations were incorrect. The method used to determine the locations for this report was a field verification using published topographic maps, GIS maps of properties from the Pike County Assessment Office, and the DEP maps. The field verification method used was to go to each potential contamination location and perform an inspection. This work was done by Tom Hoff and Todd Giddings in the Spring of 2004.

Zone 1 Area

There are no contaminant materials located within the Zone 1 area either on the Milford Water Authority property or on the Grey Towers National Historic Landmark property. The water treatment plant building is within 400 feet of the springs but is outside the Zone 1 area because it is hydraulically downgradient of the springs. All liquid chemicals stored in this building are stored in areas with secondary spill containment.

Zone 2 Area

The Zone 2 area for the Milford Springs is the Olean ice-contact stratified sand and gravel aquifer in the Sawkill Creek valley and the Vantine Brook valley, as shown on Figure 4, Zone 2 Area for the Milford Springs. There are probably less than 50 private year-round residences located on the sand and gravel aquifer and all have on-lot sewage disposal systems. There are two convenience stores, a motel, and an office center that have larger capacity on-lot sewage systems. There are a few seasonal camps or cottages that have on-lot systems or outhouses. The sand and gravel aquifer would filter out and thereby remove almost 100% of bacteria released from a malfunctioning on-lot system. Because the water from the springs is filtered and chlorinated, there would be no health impacts to the water customers if an on-lot sewage system malfunctioned in the Zone 2 area. There are no active farms, so there are no fertilizer impacts from farming. There is one horse stable with only a few horses.

Table of other existing contaminant sources in the Zone 2 area.

Facility Name	Contaminant Description	Risk Rank	Map ID
John's Power Equipment	Gasoline, oil, solvents	Low	1
Sawkill Business Center	Paint and Powder Coating	Low	2
Architectural Iron Company	Solvents	Low	3
Kwik Joe's Convenience Store & Gas Station	Gasoline, kerosene	Medium	4
Columbia Gas Pipeline	Compressed gas	Low	5
Residences with oil heat	Heating oil in in-ground tanks	Low	
Penn DOT Maintenance Facility	Salt, liquid de-icers, diesel fuel	Medium	9

Zone 3 Area

The Zone 3 area for the Milford Springs is the watershed area of Sawkill Creek and Vantine Brook upgradient of the springs and is shown on Figure 5, Source Water Area of the Milford Springs. It is fortunate that a significant portion of the northern part of this watershed area is in the Delaware State Forest, State Game Lands 209, the Pike County Park, and the Milford Experimental Forest, and is thereby protected from contaminant sources. Because this Zone 3 area is approximately 25 square miles in area, there are several hundred year-round and seasonal residences that have on-lot sewage systems.

Facility Name	Contaminant Description	Rank	Map ID
Xtra Mart Convience Store	Gasoline, kerosene	Medium	6
New Jersey Y Camp Center	Heating Oil & Sewage treatment plant discharge to pond	Low	7
Eureka Stone Quarry	Diesel fuel, oil, solvents	Medium	8
Eureka Stone Quarry	Storm water runoff	Low	8
Columbia Gas Pipeline	Compressed gas	Low	5
Residences with oil heat	Heating oil in in-ground tanks	Low	
Shohola Elementary School	Sewage treatment facility	Low	10

The existing contaminant sources in the two tables above are shown on the map that is Figure 7, Contaminant Source Locations.

Residential Underground Heating Oil Tank Survey

The Milford Water Authority recognized that because there are approximately 1,350 year-round and seasonal residences located in the Zone 2 and Zone 3 areas, a significant number of heating oil tanks for these homes could be located underground. Residential heating oil tanks of less than 1,000 gallons capacity are exempt from the underground storage tank regulations that require registration and leak detection and monitoring. The residential underground fuel oil tanks posed a threat to the springs because if they were leaking at a slow rate, the leakage would not likely be detected or corrected.

Tom Hoff, Water Authority Vice-Chairman and Chair of the Steering Committee designed a survey that was mailed to 1338 residences in the source water area. This survey generated a 38.5% response rate. The responses provided information that 179 respondents heat with oil, 309 do not heat with oil, and 17 did not respond. 119 respondents had their oil tank in their residence, 38 respondents had a buried tank, and 29 had an above-ground tank. Of all the tanks, 85 were 1 to 10 years old, 46 tanks were 11 to 20 years old, and 38 tanks were more than 20 years old. Four respondents indicated that they have some type of bulk diesel or gasoline storage facility on their property and four respondents indicate they are concerned about materials that have been or are being dumped onto property near their parcel. The heating oil tank survey report is in Appendix 3.