813B95006

Benefits and Costs of Prevention: Case Studies of Community Wellhead Protection

Volume 2

Detailed Case Studies of Seven Communities

Source Water Protection
Business and Economics Series
Report No. 3

November 30, 1995

Office of Ground Water and Drinking Water
U.S. Envoronmental Protection Agency
Washington, D.C. 20460

Acknowledgements

This project and report were completed under Environmental Protection Agency Contract No. 68-C4-0011,Work Assignment 1-14 by the CADMUS Group, Ron Bergman, EPA Work Assignment Manager. Charles Job provided technical direction. This Volume 2 is the report of the summaries resulting from information provided by officials from the States of Louisiana, Maine, Massachusetts, Ohio, Pennsylvania, and Washington, and from the communities of Gilbert, LA, Norway, ME, Dartmouth, MA, Middletown, OH, Gettysburg, PA, Lancaster County, PA, and Tumwater, WA. Without the cooperation of these officials, this study would not have possible. EPA expresses its appreciation to them for their assistance.

TABLE OF CONTENTS

PART ONE

DETAILED CASE STUDIES OF SEVEN COMMUNITIES

PART TWO

LESSONS LEARNED

PART ONE

1. INTRODUCTION

In 1994, EPA initiated this study of the benefits and costs of wellhead protection (WHP). The purpose of the study was to compare the cost of local wellhead protection to the cost of contamination which could have potentially been avoided as a wellhead protection program is crried out. Additionally, the information is these case studies is intended to assist local decisionmakers assess the value, cost and feasibility of implementing wellhead protection in their communities. While the results reported below for the seven communities are neither exhaustive nor statistically representative of all communities, they do provide an indication and present the potential extent and range of benefits for a prevention program to protect community drinking water sources. EPA also was interested in collecting observations on the study communities' experiences in responding to contamination incidents and in developing and implementing WHPPs.

Substantial information exists on the direct costs of remediating, treating, or replacing contaminated drinking water. Some information also is available on the costs of developing and implementing preventive ground water protection programs. Less information is available on the indirect costs of unremediated groundwater contamination. These various types of data have not been systematically compiled, analyzed, and compared, however.

The project development and methodology are presented below. Benefits are considered to be the possible avoided costs to government and the private sector of remediating contamination and threats to ground water sources of drinking water for community water systems. Costs are the local, State, Federal and private sector funds spent for wellhead protection development and implementation. The seven communities included in this study are:

Borough of Gettysburg, Pennsylvania
Eastern Lancaster County, Pennsylvania
Village of Gilbert, Louisiana
Town of Dartmouth, Massachusetts
City of Tumwater, Washington
City of Middletown, Ohio
Town of Norway, Maine

A detailed analysis of the results of these case studies is reported in: "Benefits and Costs of Prevention: Case Studies of Community Wellhead Protection; Volume 1; Source Water Protection Business and Economics Series Report No. 2, November 30, 1995," Office of Ground Water and Drinking Water, U.S. Environmental Protection Agency, Washington, D.C. 20460.

1.1 Definition of Benefit

The benefits that individuals and businesses realize from WHP fall into two categories. The first is the benefit accruing from the use of water as a *commodity* for drinking, and for agricultural and industrial purposes. Because markets exist for water, the commodity value usually can be calculated. The second type of benefits are called *resource* benefits. They include the benefit of: (1) being able to use groundwater as a resource sometime in the future, (2) having a source of water for future generations, and (3) knowing the ground water is not contaminated, even if it is not used. Because markets generally do not exist for resource benefits, they are not usually calculated.

The technique used in this study to measure commodity benefits is known as the *avoided cost method.* This technique estimates the costs that would be incurred in the absence of a WHPP. Because a WHPP is designed to prevent these costs, they are treated as "benefits" of the program and are called *avoided-cost benefits.*

The use of the avoided cost technique is premised on *response* costs. If ground water may be contaminated, communities and others that rely on that water can expect, at some point, to incur costs associated with responding to contamination. The expected value of these costs depends on:

- The cost of actions taken in response to contamination, which generally include remediating or treating the water, or in cases of severe contamination, developing alternative water supplies;
- The costs of damages that result from the contamination, such as losses in agricultural crop production or increased industrial production costs; and
- The probability of contamination.

An effective WHPP will significantly reduce the likelihood of contamination, thereby reducing the expected cost of contamination responses and damages. If the costs associated with responding to contamination can be avoided by implementing a WHPP, the avoidance of these costs is regarded as a quantifiable or tangible benefit.

The second step in quantifying the benefits and costs of WHP is to assess:

- The cost of developing and implementing the WHPP; and
- The probability that the WHPP will prevent contamination.

For purposes of calculating benefits and costs, we assume that a contamination incident has a 100 percent probability of occurring and that the WHPP will be completely effective. We note, however, in Part 2, that some of the WHPPs have weaknesses which may reduce their effectiveness in certain circumstances.

This report encompasses the results of five case studies of communities which have experienced contamination of ground water sources and have implemented WHPPs.[1] The objective of each case study was to quantify, to the maximum extent possible, the costs of responding to contamination and the costs of developing and implementing the WHPP.

1.2 Methodology

Three broad types of information guided the development of the study methodology and the selection of case studies:

- Community/public water system (PWS) description (e.g., population, land use patterns, geology and hydrology, number of wells, and financial and management characteristics of the PWS);
- History of the contamination incident and WHPP development (e.g., discovery, characterization, and response to contamination, and development and implementation of preventive measures); and
- Cost data (e.g., cost to provide replacement water, aquifer remediation costs, and costs of developing and implementing a WHPP).

The study team developed a comprehensive list of required data elements within each of the three categories. The team also identified probable sources of information for each data element (e.g., data bases, knowledgeable staff, or local/state/federal agencies). The team consulted with EPA staff on the proposed data element list, and refined the list based upon EPA's input.

1.2.1 Pilot Study

The study team conducted a pilot study to validate the proposed case study methodology. Early in the development of the methodology, the team proposed that two geologically and socioeconomically similar communities could be studied and compared. One community would

[1]The study also included two pilot case studies: one each of a community that has experienced contamination and a community with a wellhead protection program.

serve as the subject of analysis on the costs and effects of WHP, and another as a "reference" community from which to compile data on contamination.

To minimize project costs, the study team decided to focus on a pair of communities within a few hours' travel by car from Washington, DC. At the recommendation of EPA Region 3 and the Pennsylvania Department of Environmental Resources, the team selected Gettysburg, Pennsylvania and four communities in nearby Lancaster County for the pilot study. A well in Gettysburg has been contaminated by a nearby dry cleaning facility. The four localities in Lancaster County are co-developing a regional WHPP. The two communities appeared to be similar enough that their costs could be compared.

The pilot study validated the proposed methodology for collecting data and demonstrated that the types of data sought were appropriate. The project team discovered, however, that despite a similarity in geology, the socioeconomic differences between the two communities would not permit an accurate comparison of costs. As a result of the pilot study, the project team decided that each subsequent case study would focus on a single community that had experienced a contamination incident and developed a WHPP. This would eliminate the time-consuming step of identifying an analogous reference community and simplify the analysis.

1.2.2 Case Study Selection

To be certain that the project would be representative of the nation as a whole, the project team made an effort to include case studies in several geographic regions of the country. The EPA Work Assignment Manager asked ground water protection and/or drinking water staff in several EPA Regional offices to recommended points of contact in state environmental agencies. Because state staff often work closely with local communities on contamination and WHP issues, the project team consulted with them early in the case study selection process. The team asked state staff to recommend communities where:

- The response to a contamination incident is underway and the cost has been documented reasonably well;
- WHPP development is sufficiently far along to permit estimation of both development and implementation costs;
- Local staff would be willing to participate in interviews and assist in gathering cost data.

The availability of data became a driving factor in the selection of case studies: where contamination incidents occurred long ago, or were the subject of litigation, reliable or complete data might not be available. Similarly, cases where contamination incidents or WHPP development had occurred recently would not provide sufficient data on ongoing costs.

State staff typically nominated several potential case study communities in their states. The project team then contacted local officials in the communities to determine their interest in participating in the study, and to request information on the contamination incident and the WHPP. The team reviewed preliminary data on the community, such as recent sanitary surveys, WHP project reports, or contamination assessments.

The decision to seek communities that had experienced contamination and had developed a WHPP simplified the analysis, but greatly increased the difficulty of case study selection. The study team screened several communities that have well-documented contamination incidents, but are only in the early stages of WHPP development, or vice versa. The study team tried to select communities that offered the most complete documentation on both contamination and WHP. In some cases, this meant rejecting communities that offered more complete information on either contamination or WHP, but not both.

1.2.3 Site Visits

As indicated in Section 1.2.2, EPA Regional offices and/or state environmental staff provided the name of a primary contact person (usually the PWS operator) in the communities. Upon selecting a community as a case study, the project team contacted the PWS operator to schedule a visit, and to inquire about other appropriate contacts.

The team set up interviews with local, state, or EPA Regional staff involved with either responding to the contamination or developing the WHPP. These staff included: PWS operators; state/local health department officials; property owners, real estate agents, or tax assessors who would be familiar with the effects of contamination or WHP on property values; consultants and engineers working with the community on contamination or WHP; officials at the agency responsible for aquifer remediation; state drinking water program staff; and private citizens.

The team traveled to the communities to interview these staff in person. By being on-site, the team was able to interview multiple staff within the same offices, gather decision documents or project files, and collect background information on the community. The team also visited the contamination sites and wellfields when possible to establish a visual point of reference.

1.2.4 Assessing Costs and Benefits

While onsite, the project team collected data on the costs of responding to contamination and developing and implementing the local WHPP. The study team consulted decision documents, consultant reports, WHPP documents, PWS budgets, equipment invoices, and contract information.

The most problematic costs to identify were indirect costs (e.g., financial effects of contamination and WHP on businesses and property owners). None of the incidents has affected a large geographic area, so the number of potentially affected residences and businesses is relatively small. Often, the volume of property transactions would not permit a comprehensive analysis of effects on real estate values or property salability. Further, aquifer remediation has not begun in several of the communities (Gilbert, Tumwater, Middletown), so visual clues about contamination (e.g., air strippers, soil removal) are not present. In these communities, the extent of the contamination may not be apparent, or the incident may not have immediacy for local citizens. Thus, it may be too early for indirect effects to manifest themselves. In the few cases where indirect costs appear to be present, only anecdotal data were available.

Because many communities are in the early stages of responding to contamination or developing their WHPPs, the project team frequently had to estimate out-year costs. For contamination incidents, the team relied on preliminary decision documents (e.g., conceptual design reports) and presented costs of the most likely or preferred remedial scenarios. To estimate ongoing WHP costs, the team asked knowledgeable staff to estimate the "unit" cost of an element of implementation, such as an inspection or a round of monitoring. Using this information, the team projected annual WHPP implementation costs.

Based upon the data collected, the team arrayed costs to date (i.e., from the discovery of contamination/inception of the WHPP until September 1995) and projected future costs (from October 1995 to September 2005) into cost spreadsheets. For purposes of comparison, all costs were adjusted to constant 1994 dollars. Future cost streams were discounted to the present at a 7 percent annual interest rate.

1.2.5 Preparation of Case Study Reports

The study team developed a prototype case study report format and submitted it to EPA for review. Based on EPA's comments, the team revised the report format. The reports describe the community and PWS, the contamination incident, the response to the contamination, the costs of contamination, the WHPP, and costs of WHP. The case study reports, accompanied by the benefit/cost spreadsheets, appear as an appendix to this report.

1.3 Organization of this Report

The remainder of this report is organized as follows:

- ***Benefit/Cost Case Study Reports*** contain the summaries of the seven case communities.

- ***Part Two - Lessons Learned*** summarizes observations made by the project team in the course of preparing the case studies and discusses the policy implications of some of the case study findings.

2. BENEFIT/COST CASE STUDY REPORTS

The Benefit/Cost Case Study Reports for the seven communities in this study appear below in the following order:

Borough of Gettysburg, Pennsylvania

Eastern Lancaster County, Pennsylvania

Village of Gilbert, Louisiana

Town of Dartmouth, Massachusetts

City of Tumwater, Washington

City of Middletown, Ohio

Town of Norway, Maine

Contract No. 68-C4-0011
Work Assignment No. 1-14

Benefit/Cost Analysis of Preventing Contamination: Gettysburg, Pennsylvania

September 30, 1995

Submitted to:

U.S. Environmental Protection Agency
Ground Water Protection Division
Technical and Information Management Branch

TABLE OF CONTENTS

LIST OF EXHIBITS

BENEFIT/COST ANALYSIS OF PREVENTING CONTAMINATION GETTYSBURG, ADAMS COUNTY, PENNSYLVANIA

One of the water supply wells in the historic borough of Gettysburg, PA is contaminated by carcinogenic volatile organic chemicals. The contamination, discovered during state-required pre-operation water sampling, has been traced to a floor drain inside a dry cleaning establishment located 600 feet from the well.

As a result of the contamination, the Gettysburg Municipal Authority (GMA) must conduct extra monitoring and treat the water with an air stripper prior to usage. The Pennsylvania Department of Environmental Resources (PADER) has listed the dry cleaners site on its priority list of contaminated sites. PADER intends to install a complex treatment system that will treat the highly contaminated ground water around the site.

1.0 COMMUNITY DESCRIPTION

The Gettysburg Municipal Authority (GMA) provides drinking water to the borough of Gettysburg, and portions of the surrounding townships of Straban and Cumberland.[1] Gettysburg, the seat of Adams County, is located in south-central Pennsylvania. Its year-round population is approximately 7,025. Much of the local economy is centered around agriculture, tourism, and two local colleges.

1.1 Land Use

Gettysburg, located at the junction of several principal routes through Adams County, has evolved into a relatively busy commercial, institutional, and residential center. In contrast, much of the rest of the county remains rural in character, consisting of farms, orchards, open fields, and woodlands. The population of Adams County is centered in Gettysburg: the population density in the borough is 4,391 persons per square mile, in contrast to the county's overall population density of 149 persons per square mile.

According to the 1992 U.S. Census of Agriculture, 56 percent of the land in Adams County is farmland. The county is one of Pennsylvania's top producers of apples, peaches, turkeys, and eggs. Agricultural production generates over $123 million in annual revenues.

The Gettysburg National Military Park and Eisenhower National Historic Site draw more than 1.3 million visitors each year, mostly during the summer months. The two parks consist of more than 6,000 acres which nearly surround the borough. In 1990, Congress passed legislation authorizing the National Park Service to acquire additional lands for the Gettysburg National Military Park. Although both parks pump more than $50 million into the local economy each year, the historical nature of the region tends to impede development.

---

[1]In Pennsylvania, boroughs, townships, and cities have considerable rulemaking and enforcement powers. County governments have limited authority.

All new construction must be preceded by archaeological surveys to protect Civil War artifacts. In addition, Adams County tries to discourage development that would adversely affect the historical character of the region.

In recent years, extensive commercial and residential strip development along major roads has begun to threaten the region's rural character. Recent county planning efforts have been geared toward encouraging development in community centers and discouraging development in outlying areas.

1.2 Geology/Topography

Much of Adams County is rolling lowlands, which form a part of the Piedmont physiographic province known as the Gettysburg Plain. The average elevation of Gettysburg is approximately 526 feet above mean sea level.

The Gettysburg region is underlain by Triassic sedimentary rocks. These rocks consist primarily of relatively nonresistant red shale and sandstone, and minor amounts of limestone. Intrusions of diabase, or trap rock, are found throughout the sedimentary rock. These intrusions form ridges and hills within the lowland areas.

1.3 Hydrology/Climate

Adams County is located in two major watersheds tributary to the Chesapeake Bay. The Susquehanna River watershed drains the northeastern half of the county, and the Potomac River watershed drains the southwestern half of the county. Marsh Creek is the only major body of surface water in the vicinity of Gettysburg.

Much of Gettysburg and Adams County relies on ground water for drinking. Based on field observations and geophysical data, two principal ground water flow zones appear to exist within Gettysburg. Monitoring performed at the J.C. Cleaners site (discussed in Section 3.2) has indicated the presence of a shallow waterbearing zone at a depth of roughly 70 to 105 feet and a deep waterbearing zone at a depth of about 250 to 275 feet. The deep zone appears to be semi-confined to confined. Within the shallow ground water zone, natural flow is toward the north; in the deep zone, flow is to the northeast and east.

Ground water in Adams County is relatively plentiful. Hydrologic investigations have estimated that in a year with average rainfall, approximately 98 million gallons per day (mgd) of ground water are potentially available for use within the Triassic waterbearing rocks underlying the county. Most of the wells in the Gettysburg area exhibit a low-to-moderate yield. Sandstones and shale aquifers typically have relatively low transmissivity; water is transmitted through fractures.

The average annual precipitation in Gettysburg is 39 inches, and is evenly distributed throughout the year. Of this, 24 inches is lost to evapotranspiration, eight inches runs directly into creeks and streams, and seven inches infiltrate into the ground. Pennsylvania lies within the temperate climate zone. The average annual temperature in the region is 53 degrees, ranging from 30 degrees in January to 70 degrees in July.

2.0 PWS CHARACTERISTICS

GMA provides drinking water to Gettysburg, along with portions of Straban and Cumberland Townships. GMA (PWS ID #7010019) is located within the borough of Gettysburg, at approximately 39° 49' 27" north and 77° 14' 03" west. GMA operates a filtration plant at Marsh Creek, eight wells, two primary transmission lines into Gettysburg, and three storage facilities.

2.1 Water Supply

GMA relies on a mixed ground water/surface water supply (see Exhibit 1). Fifty-four percent of its water comes from ground water, and the remaining 46 percent is withdrawn from Marsh Creek. The average demand on the system is approximately 1.5 mgd during most of the year, rising to about 1.8 mgd during the height of the summer tourism season. The safe yield of current water sources is about 2.2 mgd. GMA cannot easily connect with neighboring PWSs because of the distances between communities and the hilly terrain surrounding Gettysburg.

Tourists and students have traditionally placed seasonal demands on the drinking water supply. Gettysburg College and the Lutheran Theological Seminary increase the Borough's population during the school year. In the past, the summer tourism season and the school year at the local colleges did not overlap; consequently, Gettysburg had a relatively steady year-round population. In recent years, however, the schools have initiated summer camps and tourism at the National Parks has extended into the spring and autumn. The combined factors have increased overall water demand, especially during the summer.

The Gettysburg region has historically enjoyed high quality surface and ground water. The water in Marsh Creek is of high quality, except that it sometimes does not meet the primary drinking water standard for turbidity and the secondary standard for color after heavy rains. Two of the PWS' eight wells currently are unusable due to hardness (i.e., high concentrations of calcium chloride), which is GMA's most significant water quality problem. Although GMA currently has no plans to drill new wells, the PWS would like to have all its existing wells available to meet demand.

EXHIBIT 1
Characteristics of PWS Sources

Source	Depth	Capacity (MGD)	Status
Marsh Creek	N/A	.96	Active
Well #1	550	0	Off-line due to excessive hardness
Well #2	Unavailable	0	Off-line due to chlordane contamination
Well #3	500	.40	Active
Well #4	655	.22	Active
Well #5	420	.37	Active
Well #6	900	.43	Active
Well #7	Unavailable	Unavailable	Active
Well #8	Unavailable	0	Off-line due to excessive hardness

2.1.1 Surface Water Sources

GMA is permitted to withdraw 960,000 gallons per day from Marsh Creek. To increase the available water supply, the PWS pumps water from Well #1 into the creek at times of high water flow. Although the water withdrawn from the well is too hard for drinking, it may be discharged into the creek without adverse effects to aquatic life. The PWS lets the aquifer recharge while it is withdrawing from the creek. Water is drawn from Marsh Creek via a 24-inch main and routed through a filtration plant. The water also is treated for taste and odor. GMA intends to ask the Pennsylvania Department of Environmental Resources (PADER) for authority to withdraw up to 2 mgd from Marsh Creek.

2.1.2 Ground Water Sources

GMA operates eight wells, six of which are currently online. The wells are located in and around the borough of Gettysburg: some are close to the Gettysburg commercial center; others are in outlying areas. The total capacity of currently operating wells is 1.42 mgd. The wells tap the deep waterbearing zones of the Gettysburg Formation. The ground water generally is of good quality, but contains high concentrations of dissolved calcium carbonate.

GMA's eight wells are connected to a central distribution system via 8-inch and 10-inch water mains. Water from all sources is routed to a central distribution unit prior to transmission to users. Treatment within the system consists of disinfection and particulate removal.

In 1983 GMA shut Well #2 down after monitoring indicated the presence of trichloroethene (TCE) and chlordane. Recent testing indicates that the TCE concentration is 0.7 ppb (the MCL is 5 ppb), and chlordane is below detectable levels. GMA currently is working with PADER to restart this well.

PADER requires PWSs to obtain operating permits for new wells. In 1986 GMA applied for an operating permit for Well #6. PADER sampled the well and determined that ground water drawn by the well was contaminated by halogenated volatile organic compounds (VOCs). The contamination and the response to contamination are described in Sections 3.0 and 4.0.

Well #8 exhibits a continuing hardness problem. Hardness levels were relatively stable when the well was permitted in July 1992, but recently these levels have risen sharply. GMA believes that the cone of depression for the well has interacted with another well. When GMA stopped pumping at the well, water quality improved. When pumping resumed, the hardness levels rose again.

2.2 Financial/Management Characteristics

GMA, which provides both drinking water and wastewater services, is an independent authority. Its annual operating budget of $870,000 is funded entirely from user charges. Each customer pays a flat quarterly fee which depends upon the size of the meter. In addition to the base charge, GMA has a declining block rate structure for customers whose usage exceeds specified amounts, which vary depending on the size of the meter. The average residential water bill is $43 per quarter; the average quarterly residential usage is 15,000 gallons. Water rates have increased only about 15 percent since 1985.

To fund capital improvements, GMA has adopted "tapping fees" on new residential and commercial connections. The fee is $1,979 per equivalent daily unit (EDU) of expected water use. GMA defines an EDU as 250 gallons per day.

GMA has approximately $2.5 million in outstanding debt related to it water supply operations. The borough of Gettysburg backs GMA debt with its full faith and credit.

2.3 Population Served

The GMA serves a combined population of 12,200 in Gettysburg, Cumberland and Straban. The PWS serves the entire population (7,025) of Gettysburg; five percent (250) of the population of Straban, and 10 percent (550) of Cumberland's population. In addition, GMA serves a student and tourist population equivalent to about 4,375 permanent residents. Outside of the borough, most residents rely on private wells. The PWS has 3,105 service connections, 55 percent of which are commercial, and 45 percent of which are residential. The PWS also supplies water to the National Parks.

3.0 CONTAMINATION

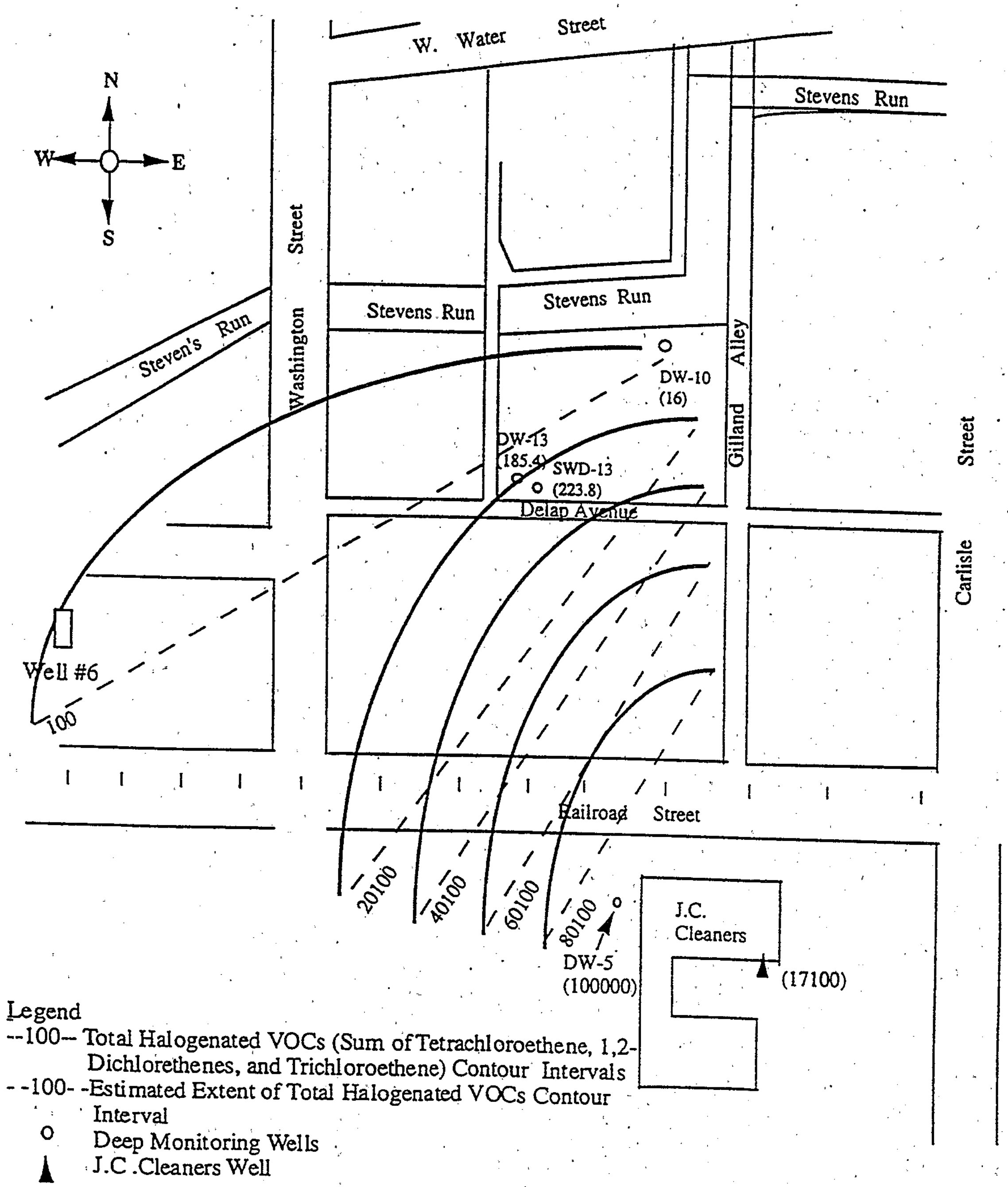
The primary VOCs present at Well #6 are tetrachloroethene (PCE), trichloroethylene (TCE), and 1,2-dichloroethenes (1,2-DCE). GMA's state operating permit for Well #6 requires it to treat the raw water and monitor quarterly for benzene, toluene, xylene, gasoline, and fuel oil and semi-annually for phenols. Currently the total VOC concentration is 18 ppb; however, concentrations of up to 56 ppb were indicated as recently as 1990.

3.1 Contamination Source

GMA first discovered VOC contamination at its Well #6 in 1986, during State-required pre-operational monitoring. PADER conducted a preliminary search for the source of contamination at the well in late 1986. It focused on dry cleaners located in the vicinity of the well because PCE is a solvent commonly used in the dry cleaning process. PADER identified J.C. Cleaners, located about 600 feet east-southeast of Well #6, as the likely source of contamination. PADER subsequently determined that a drain located inside the J.C. Cleaners building was the source of the contaminated ground water. J.C. Cleaners had been using the drain for legal discharge of wastewater into the Gettysburg sewer system. For undetermined reasons, the drain failed and leaked wastewater into the soil. On October 8, 1986, PADER issued a Notice of Violation to J.C. Cleaners. In response, J.C. Cleaners discontinued use of the drain system.

PADER evaluated the J.C. Cleaners site using EPA's Hazard Ranking System (HRS) for Superfund sites. The site scored 35.68 and has been listed on the Pennsylvania Priority List of Hazardous Sites for Remedial Response (PAPL), the state equivalent of the National Priorities List (NPL) under CERCLA. Exhibit 2 is a map of the area surrounding J.C. Cleaners.

EXHIBIT 2
Site Map



3.2 Contaminants

Between July 1990 and March 1991, PADER conducted a two-phase contamination assessment at the site. Phase I included a literature review, a site survey, mapping, and a soil-gas survey. Phase II included installation of shallow and deep monitoring wells, aquifer characterization, pump and packer testing, and soil boring characterization. The monitoring well network at the site consists of ten shallow monitoring wells and ten intermediate-to-deep monitoring wells.

The contamination assessment determined that soil and ground water in the vicinity of J.C. Cleaners is contaminated with halogenated VOCs. The contamination is concentrated in the area immediately around the J.C. Cleaners building. Contaminants are generally moving to the north in the shallow zone. In the deep ground water zone, pumping from Well #6 is drawing contamination toward the west and northwest. The shallow and deep ground water zones exhibit minimal hydrologic connection. PADER's contamination assessment concluded that a former private well on the J.C. cleaners site may have caused contamination to migrate from the shallow to the deep ground water zone.

3.2.1 Contaminants in Soil

Subsurface soil in the immediate vicinity and north of J.C. Cleaners contains PCE, TCE, and 1,2-DCE. Total contaminant concentrations range from Not Detected to 492 ug/kg. Near the J.C. Cleaners building, soils appear to be contaminated to the top of the bedrock, a depth of 6.5 to 7.5 feet.

3.2.2 Contaminants in Ground Water

Contamination in the shallow waterbearing zone is primarily concentrated around the J.C. Cleaners building. The primary contaminants are PCE, TCE, 1,2-DCE, benzene, and vinyl chloride. PADER has concluded that the benzene is probably unrelated to the dry cleaners, but is likely the result of leaks or spills from nearby service stations. The contaminant plume extends north of Railroad Street, but at significantly lower concentrations. Concentrations near the J.C. Cleaners building range from 210 ppb to 36,300 ppb. Offsite concentrations range from not detected to 84 ppb. Contamination in the shallow ground water zone is moving north toward Stevens Run at an estimated rate of 22.6 feet per year.

In the deep waterbearing zone, contamination is concentrated in the immediate vicinity of the dry cleaners with decreasing levels extending to the west, north, and northeast. Contaminant concentrations generally increase with depth. Near the J.C. Cleaners building, contamination extends to a depth of at least 300 feet. The primary contaminants present are PCE, TCE, and 1,2-DCE. In contrast to the shallow zone, the deep zone does not contain vinyl chloride and benzene. Concentrations at Deep Monitoring Well #5 (adjacent to the building) and at the J.C. Cleaners well are 100,000 ppb and 17,100 ppb, respectively. Offsite concentrations range from not detected to 224 ppb. Contamination in the deep zone is being drawn westward as a result of pumping from GMA Well #6. The estimated rate of contaminant movement is 54 feet per year.

3.3 Effects of Contamination

Data available from State and local documents and interviews did not reveal any explicit health or ecological effects associated with the J.C. Cleaners site, other than the contamination of ground water.

Although there have been no reports of contaminant-related illnesses among the population served by GMA, exposure to TCE and PCE can have potentially serious health effects. Both chemicals are carcinogens. Oral exposure to TCE can cause vomiting, abdominal pain, and unconsciousness; long-term exposure may damage the liver. Studies on PCE exposure have linked the contaminant to abnormal effects on the liver, kidney and central nervous system in humans.

4.0 RESPONSE ACTIVITIES

GMA and PADER are undertaking two distinct activities in response to the contamination at the J.C. Cleaners site. Since 1987 GMA has ensured safe water by treating the raw water at Well #6. PADER intends to install a ground water collection and treatment system to remediate the contamination plume in both waterbearing zones. The system is currently in the design phase; PADER hopes to begin construction in early 1996.

Both GMA and PADER have selected air stripping to remove contaminants from the ground water and PADER will use soil vapor extraction to remove contaminants from the soil. The following sections describe the specific response actions GMA and PADER are taking or intend to take.

4.1 Response to Contamination of the Water Supply

In 1987 GMA installed a treatment system on municipal Well #6 to remove the halogenated VOCs from raw water. The system consists of an air stripping tower and pumping system. According to GMA's monitoring data, the air stripper achieves nearly 100 percent contaminant removal. The treated ground water is mixed with water from other sources and pumped into the GMA distribution system.

4.2 Response to Aquifer Contamination

On April 11, 1994 PADER filed a Statement of Decision describing its remediation objectives and selected remedy for the J.C. Cleaners site. PADER's objectives are to:

- Treat contaminated soil in order to prevent further degradation of ground water; and
- Remediate ground water to background levels consistent with the Pennsylvania Ground Water Quality Protection Strategy.

PADER will install a soil vapor extraction system to remove contaminants from the soil. Ground water recovered during the treatment process will be discharged to the ground water treatment system and treated onsite.

PADER will use an extraction well to remove the most highly contaminated ground water nearest the J.C. Cleaners facility. Contaminated ground water will be treated in a low profile air stripping system with a carbon absorption unit to capture the vapor phase of the contaminants. The treatment system will be housed in a vacant building on the J.C. Cleaners site to minimize the aesthetic impact on the surrounding neighborhood. The deep ground water zone will be remediated first because it is more highly contaminated and because Well #6 draws from it.

Treated ground water will be discharged to Stevens Run through a nearby storm sewer. During the consideration of treatment alternatives, GMA had requested that PADER discharge treated ground water into its air stripper sump at Well #6. PADER determined that the cost of constructing a pipeline to the sump was prohibitive. Shallow ground water and the liquid phase collected from the soil vapor extraction unit would be influenced by surface water and would have required construction of a filtration system before the water could be used for drinking. In addition, the pipeline would have to cross railroad tracks and several major utility lines, which would add significantly to the cost.

PADER anticipates completing pre-remedial design activities by late 1995. At that time, PADER will request bids for construction and the first year of O&M. The agency expects remedial construction to begin in early 1996.

5.0 COSTS OF CONTAMINATION

As of September 1995, the total costs incurred by PADER, GMA, and the Borough of Gettysburg is approximately $1.4 million ($1.7 million in 1994 dollars). Although PADER has not determined the duration of ground water remediation, it estimates O&M costs for both five-year and thirty-year treatment scenarios. Expected future costs will be at least $2.26 million to $3.9 million (on a net present value basis),[2] depending on the remediation scenario.

5.1 Tangible Costs

Exhibits 3, 4, and 5 are detailed tables listing remediation costs for treatment of Well #6, and remediation of contaminated soil and ground water at the J.C. Cleaners site. The following sections summarize these costs.

5.1.1 Costs to Provide Safe Drinking Water

GMA spent a total of $247,013 ($321,117 in 1994 dollars) in capital costs (see Exhibit 3). These costs include $231,732 ($301,252 in 1994 dollars) for designing and constructing the air stripper, and $15,281 ($19,865 in 1994 dollars) for land acquisition. Since 1987, GMA's incremental O&M costs for treating Well #6 have been approximately $27,562 (in 1994 dollars). These additional electrical, monitoring, and repair costs represent approximately two percent of GMA's annual operating budget.

Electricity is the largest component of O&M costs. The annual cost for electricity at Well #6 is approximately $25,000 to $28,000. In contrast, the typical cost of electricity for GMA's other wells is about $15,000. In addition, GMA's state permit for Well #6 requires that it monitor quarterly for benzene, toluene, xylene, gasoline, and fuel oil; and semi-annually for phenols. Since 1987 GMA has spent approximately $10,240 ($10,138 in 1994 dollars), or about $1,280 per year (in 1994 dollars) for this additional monitoring.

GMA has funded both capital and operating costs from its annual operating budget. GMA has recently raised its water rates by five percent, but the increase appears to result from general cost increases rather than the incremental cost of treating Well #6.

[2]Net present value of five-year and 30-year remediation costs are calculated assuming a discount rate of seven percent.

Exhibit 3
Cost of Responding to Contamination: Gettysburg, PA
February 1987 to September 1995
($1994)

Item	GMA	Borough of Gettysburg	PADER	Total
Provide Safe Drinking Water				
One-time costs				
Engineering/construction of air stripper	301,252			301,252
Land acquisition	19,865			19,865
SUBTOTAL:	**$321,117**	**$0**	**$0**	**$321,117**
Incremental operating costs (since 1987)				
Monitoring ($1,280 per year)	10,138			10,138
Electricity ($12,000 per year)	9,504			9,504
Repairs ($1,000 per year)	7,920			7,920
SUBTOTAL:	**$27,562**	**$0**	**$0**	**$27,562**
TOTAL:	**$348,679**	**$0**	**$0**	**$348,679**
Remediate Aquifer				
Pre-remediation				
Contamination assessment/aquifer characterization		500	1,034,666	1,035,166
Remedial design			128,458	128,458
Pre-final design			182,950	182,950
Oversight				
Monitoring			24,195	24,195
Enforcement			11,329	11,329
Planning			223	223
Program Management			18,847	18,847
Administration			112	112
TOTAL:	**$0**	**$500**	**$1,400,780**	**$1,401,280**
TOTAL COST:	**$348,679**	**$500**	**$1,400,780**	**$1,749,959**

Depending on the duration of remediation, GMA will incur incremental costs of between \$58,500 and \$100,000 (net present value). Electricity would account for about 90 percent of these costs.

5.1.2 Costs to Remediate Aquifer

As of September 1995, PADER has spent at least \$1.26 million (\$1.4 million in 1994 dollars) for the contamination assessment and the conceptual design of remedial alternatives. This includes about \$1.21 million (\$1.35 million in 1994 dollars) in contractor costs and roughly \$0.05 million (in 1994 dollars) in staff costs. The actual staff cost is probably higher because PADER did not track costs for the J.C. Cleaners site separately prior to 1989.

PADER's conceptual design alternatives report provides estimates of both capital and O&M costs for the ground water extraction and treatment system and for the soil vapor extraction system.

- Capital costs include direct costs (e.g., purchased equipment and construction materials, equipment and material installation, piping and electrical, buildings, heating and ventilation, health and safety equipment) and indirect costs (e.g., surveying, construction inspection, engineering/design, health and safety, and administration).

- O&M costs include electrical costs, labor costs for maintenance, maintenance materials, administration, insurance, taxes, licenses, equipment replacement costs, trench maintenance, and analytical costs.

PADER projects that remediation of soil and ground water contamination will require approximately \$0.82 million (net present value) in capital expenditures, depending on the remediation scenario chosen. Depending on the duration of the remedy, the net present value of O&M costs between 1995 and 2005 will be approximately \$1.38 million to \$1.93 million. (If remediation takes 30 years, total O&M costs could exceed \$3.9 million.) Exhibits 4 and 5 show future costs through September 2005 associated with five-year and 30-year remediation scenarios, respectively.

PADER will fund the cost of remediation through its Hazardous Sites Cleanup Program (HSCP). It is unlikely that the Agency will be able to recover a significant portion of the remedial costs from J.C. Cleaners. The dry cleaner's only contribution to the cleanup effort is the use of a room in the building in which PADER will house the air stripper.

Exhibit 4
Future Cost of Responding to Contamination (Five-year Scenario): Gettysburg, PA
October 1995 to September 2005
($1994)

Item	GMA	PADER	Total
Provide Safe Drinking Water			
Incremental operating costs			
Monitoring ($1,280 per year)	5,248		$5,248
Electricity ($12,000 per year)	49,202		$49,202
Repairs ($1,000 per year)	4,100		$4,100
SUBTOTAL:	$58,551	$0	$58,551
Remediate Aquifer			
Capital costs			
GW collection		310,593	$310,593
GW treatment		407,556	$407,556
Soil vapor extraction		105,840	$105,840
SUBTOTAL:	$0	$823,990	$823,990
O&M costs			
GW collection		179,330	$179,330
GW treatment		999,296	$999,296
Soil vapor extraction		204,225	$204,225
SUBTOTAL:	$0	$1,382,851	$1,382,851
TOTAL:	$0	$2,206,841	$2,206,841
TOTAL COST:	$58,551	$2,206,841	$2,265,392

Exhibit 5
Future Cost of Responding to Contamination (Thirty-year Scenario): Gettysburg, PA (1)
October 1995 to September 2005
($1994)

Item	GMA	PADER	Total
Provide Safe Drinking Water			
Incremental operating costs			
Monitoring ($1,280 per year)	8,990		8,990
Electricity ($12,000 per year)	84,283		84,283
Repairs ($1,000 per year)	7,024		7,024
SUBTOTAL:	**$100,297**	**$0**	**$100,297**
Remediate Aquifer			
Capital costs			
GW collection		310,593	310,593
GW treatment		407,556	407,556
Soil vapor extraction		105,840	105,840
SUBTOTAL:	**$0**	**$823,990**	**$823,990**
O&M costs			
GW collection		185,135	185,135
GW treatment		1,547,077	1,547,077
Soil vapor extraction		204,225	204,225
SUBTOTAL:	**$0**	**$1,936,437**	**$1,936,437**
TOTAL:	**$0**	**$2,760,426**	**$2,760,426**
TOTAL COST:	**$100,297**	**$2,760,426**	**$2,860,723**

Note:
(1) Costs represent first 10 years of 30-year remediation

5.2 Intangible Costs

A local realtor with considerable experience in property assessment indicated that neither property values nor the salability of properties near J.C. Cleaners have been affected by the ground water contamination. One explanation is that the site is not well known in the community. Other factors are the commercial character of the area surrounding the site and the low turnover of properties.

The realtor speculated that, in general, contaminated sites tend to limit the market for adjacent and/or affected properties. She provided some anecdotal evidence that federal Superfund sites in the county may have had limited effects on the market for adjacent properties. She did not have any hard evidence indicating these effects, primarily because of the small number of property transactions in the area. The county tax assessor indicated that no property owners near J.C. Cleaners have challenged their property assessments on the grounds that the presence of contamination has lowered their property values.

Although GMA provides drinking water to the area around J.C. Cleaners, a few private wells are present nearby. At least two of these wells, including an inactive well at J.C. Cleaners, have been contaminated. The project team could not determine whether or not the other wells were in active use prior to the contamination incident.

6.0 CONCLUSION

Contamination due to an accident at a common type of business facility caused GMA and PADER to incur costs which could potentially exceed $5 million. GMA and PADER have spent nearly $2.26 million (in 1994 dollars) to protect Well #6 and to assess the severity of the contamination. Between 1995 and 2005, future costs of monitoring, ground water extraction and treatment, and soil vapor extraction will total $2.26 million to $2.86 million. If the 30-year remedial scenario is played out, future costs could approach $4 million.

If Gettysburg had a Wellhead Protection Program prior to 1986, the contamination and associated costs may have been avoided. A source identification program could have identified the dry cleaner as a potential source of contamination, and could have led GMA to site the well elsewhere to avoid the contamination. Even if GMA had sited the well, a source management program that included inspections may have detected the leak early enough to prevent, or at least minimize, the contamination.

7.0 REFERENCES

Adams County Office of Planning and Development. *Adams County Comprehensive Plan.* Prepared by Norman Day Associates. 1990.

Hartman, Barbara. Owner, Bigham Realtors. Personal interview, October 19, 1994.

PADER. *Contamination Assessment as the J.C. Cleaners Site; Phases I and II.* Prepared by Baker Environmental, Inc. March 1991.

PADER. *J.C. Cleaners Conceptual Design Alternatives Project; Volume I.* Prepared by Baker Environmental, Inc. January 1993.

Pine, Eugene. Hydrogeologist, PADER Hazardous Sites Cleanup Program. Personal interview, October 20, 1994.

Smith, John. Sanitary Engineer, PADER Environmental Cleanup Program. Personal interview, October 20, 1994.

U.S. EPA, Office of Drinking Water. *Health Advisories for 25 Organics.* PB87-235578, March 1987.

Watson, James. Manager, Gettysburg Municipal Authority. Personal interview, October 19, 1994.

Contract No. 68-C4-0011
Work Assignment No. 1-14

Benefit/Cost Analysis of Preventing Contamination: Eastern Lancaster County, Pennsylvania

September 30, 1995

Submitted to:

U.S. Environmental Protection Agency
Ground Water Protection Division
Technical and Information Management Branch

LIST OF EXHIBITS

TABLE OF CONTENTS

BENEFIT/COST ANALYSIS OF PREVENTING CONTAMINATION EASTERN LANCASTER COUNTY, PENNSYLVANIA

Four small communities in eastern Lancaster County, Pennsylvania are co-developing a regional Wellhead Protection Program. The boroughs of Terre Hill and New Holland and the surrounding Earl and East Earl townships lie in a relatively undeveloped, agricultural portion of Lancaster County. The county is currently one of the fastest-developing rural counties in the nation: residential development is spreading into the county from nearby Philadelphia.

The region was the subject of a pilot test of a Wellhead Protection Area delineation method known as fracture trace analysis by EPA Region 3 and the Pennsylvania Department of Environmental Resources. Wellhead protection areas have been delineated and pollution sources identified in all four communities. The communities have drafted management plans, but have not yet formally adopted them.

1.0 COMMUNITY DESCRIPTION

Lancaster County is located in southeastern Pennsylvania. Four communities in the eastern portion of the county are jointly developing and implementing a regional wellhead protection strategy. These communities—the boroughs of Terre Hill and New Holland and the surrounding Earl and East Earl townships—have a combined population of 19,000.

1.1 Land Use

Agriculture is the primary land use in Lancaster County, the most agriculturally productive non-irrigated county in the United States. According to the 1992 Census of Agriculture, the total market value of all agricultural products sold by the county was $681 million. Of that income, $77 million was from the sale of crops, including apples, corn, oats, and potatoes. Livestock and poultry products, primarily chickens, hogs, and cattle, provided an income to the county of $604 million.

Industry in the county reflects its agricultural nature: it includes farming equipment manufacturing and food processing/animal rendering plants. No data are available on the income from these industries. Over 90 percent of the townships in Lancaster County (309,000 acres) are zoned for agricultural use.

The region is experiencing less development than much of Lancaster county. Recently, residential development spreading into the county from nearby Philadelphia has become a potential concern. The potential for development of farmland for industrial use is the biggest water quality concern in the region. Of the four jurisdictions comprising this case study, New Holland has experienced the most development.

1.2 Geology/ Topography

Eastern Lancaster County is located within the Piedmont physiographic province of the United States. Terre Hill is located within Triassic Lowlands; the remaining three communities are situated on lower areas created by more easily eroded rock.

Terre Hill is underlain by Triassic-age conglomerates, sandstone, and shales of the Hammer Creek Formation. New Holland and Earl and East Earl townships are underlain by the Cambrian-age Elbrook-Zooks Corner dolomite formation. The rock in eastern Lancaster County is highly fractured; that is, cracks, joints, and faults are found within the bedrock. The fracturing, which is manifested by fracture traces, can affect ground water flow patterns.

1.3 Hydrology/Climate

The four communities in the study area are almost completely dependent on ground water (New Holland maintains a surface water reservoir). Terre Hill's wells draw from the water bearing zones within the sandstones and conglomerates of the Hammer Creek Formation. Data on aquifer capacity of the Hammer Creek Formation are not available.

Wells in the other three communities tap the Elbrook-Zooks Corner dolomite. Aquifer tests indicate this is one of the lower-yielding aquifers in Lancaster County. Specific capacities in the aquifer (the rate of discharge per unit of drawdown), range from 0.04 to 46.0 gallons per foot per minute (gal/ft/min), with a mean specific capacity of 2.5 gal/ft/min. The aquifers are confined to semi-confined. As indicated in Section 1.2, the water bearing formations are highly fractured. Fractured-rock aquifers are less homogeneous than porous-media aquifers, and ground water flow is turbulent and rapid. Flow within these aquifers may not be predictable using flow models, potentially complicating the process of delineating wellhead protection areas.

Pennsylvania lies within the temperate climate zone. Average temperatures range from 31 degrees in January to 77 degrees in July. Normal annual precipitation in southeastern Pennsylvania is approximately 41 inches.

2.0 PWS CHARACTERISTICS

Each of the four jurisdictions maintains its own PWS:

- Terre Hill is served by the Terre Hill Borough Water System (PWS ID #7360119);
- New Holland receives water from the New Holland Borough Water Department (PWS ID #7360099);

- Earl Township is served by the Western Heights Water Authority (PWS ID #7360132); and

- East Earl Township is served by the Blue Ball Water Authority (PWS ID #7360005).

The four communities and their water systems are closely linked. For example, because Terre Hill lies within a small geographic area, all four of the borough's wells are physically located in East Earl Township. At each PWS, drinking water is disinfected and treated for color and odor prior to distribution. (This is a relatively minimal level of treatment for southeastern Pennsylvania—for many new water sources, nitrates are a water quality concern.)

2.1 Water Supply

The four communities are almost completely dependent on ground water. Except in New Holland, where a portion of the water supply is from the New Holland surface water reservoir, ground water is the source of all public water. Water quality in the area is good; nitrate levels are the only water quality concern for most of the wells. However, some wells in New Holland have elevated TCE levels which, most likely, are the result of industrial activity in the area. In general, all four communities have adequate water supplies, although New Holland and Western Heights anticipate drilling new wells to meet future water needs.

The four PWSs operate a total of eleven wells. Terre Hill Borough Water System, which taps the Hammer Creek Formation, has four wells. East Earl Township has three wells, and New Holland Borough and Earl Township have two wells each. The PWSs at New Holland, and Earl and East Earl townships tap the Elbrook-Zooks Corner dolomite formation. Exhibit 1 below presents data on the depth and daily withdrawal from the wells at each PWS.

Exhibit 1
Characteristics of PWS Wells

PWS	Average Depth (feet)	Withdrawal (gal/day)
Terre Hill Borough	364	32,000 to 92,000
New Holland Borough	242	1 million
Western Heights (Earl Township)	600	43,200
Blue Ball Water Authority (East Earl Township)	250	162,000

2.2 Population Served

Approximately 20,000 people live in the four communities; each community maintains its own PWS. The percentages of the local populations served by public water varies from one community to the next. New Holland, the largest of the four water systems, serves the entire population of the borough, approximately 4,500 people. The entire population of Terre Hill Borough (approximately 1,300 people) is connected to public water. The Blue Ball Water Authority in East Earl Township serves only about 2% of the residents (300 people), and 4% of the population of Earl Township (approximately 200 people) is served by the Western Heights Water Authority. The latter three water systems rank at the low end of the range of PWS sizes in Pennsylvania.

3.0 WELLHEAD PROTECTION

The four municipalities are co-developing a regional wellhead protection strategy. Each community will implement and enforce a separate ordinance regulating activities in its wellhead protection area (WHPA). Four separate WHPAs have been delineated, sources have been identified, and draft ordinances for managing the WHPA have been developed; however, the Wellhead Protection Program (WHPP) has not been formally implemented.

3.1 State Requirements for Wellhead Protection

Pennsylvania has developed guidance on wellhead protection for municipalities that are implementing wellhead protection programs. Through a variety of incentive grant programs, Pennsylvania is promoting the development of methods and criteria for one rigorous WHPA delineation within each hydrogeologic setting of the Commonwealth.

Pennsylvania's guidance, which applies to new water systems and new wells at existing systems, includes delineation of three protection zones around a well.

- Zone I is a fixed 400 foot radius around each well, which the PWS must own or control.
- Zone II is the zone of contribution (ZOC) to the wells within the ten-year time of travel area.
- Zone III consists of the upland areas recharging zones I and II.

The Commonwealth plans to provide technical guidance for communities wishing to develop a WHPP, but currently is not planning to make wellhead protection (WHP) mandatory. Pennsylvania has not yet submitted its State Wellhead Protection and Comprehensive State Groundwater Protection programs to EPA.

3.2 Local Wellhead Protection Plan

Interest in WHP for eastern Lancaster County began around 1990, when EPA Region 3 wanted to pilot test a WHPA delineation method known as fracture trace analysis. Region 3 chose eastern Lancaster County for the pilot because the area has interesting fractured bedrock geology and is highly dependent on ground water. The communities have not yet formally implemented the WHPP (i.e., they have not passed ordinances for managing their WHPAs).

3.2.1 Wellhead Protection Area Delineation

Three protective zones have been mapped around the four PWSs' wells. Zone I is a simple 400 foot fixed radius around each well. Because hydrogeologic information on the aquifers in eastern Lancaster County is limited, the zone II and III WHPA delineations are based on local and regional hydrogeologic reports and the PWS water supply reports. Zone II, the ten-year time of travel capture zone, was delineated using EPA's WHPA flow model, Version 2.0. A geological method known as fracture trace analysis was employed to delineate Zone III. Fracture trace analysis, which involves reviewing aerial photographs to detect evidence of fractures in rock, accounts for the uncertainties in the Zone II modeling that are common in the highly fractured rock that is typical in Lancaster County. Specifically, the WHPA model assumes laminar, or non-turbulent, groundwater flow; however groundwater flow in fractured rock tends to be turbulent and thus unpredictable by standard models.

3.2.2 Source Identification

Before initiating a property-by-property survey of potential contamination sources in the WHPA, consultants searched EPA and PADER databases for potential sources. These databases include the inventory of registered Underground Storage Tanks (USTs), RCRA-regulated facilities, and hazardous waste sites identified under CERCLA.

The Lancaster County Planning Commission developed a land use inventory using a geographic information system (GIS). The GIS provided the communities with a general understanding of land use patterns in the region and a basis for prioritizing potential threats from industrial, commercial, agricultural, and residential land use.

After the database searches and land use inventory were complete, volunteers and local government officers initiated a door-to-door survey of potential contamination sources. Local residents' knowledge of present and former land uses in the region was an integral part of the source identification. For example, the Town Hall building of Terre Hill borough was a former gas station/truck loading area. The communities entered identifying information on each source (location, source type, and type of material) into the GIS. The survey identified 119 potential sources of contamination.

3.2.3 Management Plan

At the outset of the wellhead protection effort, the four communities planned to implement separate but similar overlay zoning ordinances to manage their WHPAs. To that end, the communities wrote individual draft overlay zoning ordinances. Recently, however, the four communities have chosen to join together and develop a comprehensive zoning ordinance to impose more active zoning controls within the WHPAs. The communities have begun to develop the comprehensive zoning ordinance. Existing municipal agencies in each jurisdiction, e.g., Board of Supervisors, Planning and Zoning Commissions, and the Water Authorities, will implement and administer the zoning ordinance.

As part of the management plan, local authorities will issue Wellhead Protection Area Operating Permits. Permit fees will cover the costs of implementing and administering the plan. The permit application would require the subject facility to document that it is operating in a manner consistent with applicable Federal and state regulations. Implementing agencies in each jurisdiction will conduct periodic inspections (probably biannually) to verify compliance.

The ordinances set design standards for new sources and performance standards for existing sources within the WHPA. For each protective zone, the ordinance lists prohibited activities. The design standards for new construction emphasize compliance with standards established under existing federal and State regulations such as CERCLA, the Clean Air Act, and Pennsylvania's UST regulations. Similarly, the performance standards for existing sources focus on requiring stricter attention to existing requirements, rather than mandating new ones.

The management plan will include a public education program. Literature and articles in community newsletters will discuss the WHPP and opportunities for participation. Education programs will target homeowners with septic systems, and educate residents on proper methods for disposing of hazardous household waste. The communities will post road signs on highways and in residential areas to make people aware of the need to protect recharge areas.

Since the region is highly agricultural, the education program will also focus on farmers. The educational literature will explain that by modifying their pesticide application procedures (e.g., by filling machinery in designated areas), farmers can prevent spills and seepage of pesticides into the ground water.

3.2.4 Contingency Plan

The ordinances will address the need for emergency response and contingency programs. The contingency program will require the local jurisdictions to develop a spill cleanup strategy and arrange for contractors to be available to respond to spills. Local jurisdictions will coordinate responsibilities among local agencies such as fire departments and Community-Right-to-Know programs. The water authorities will also develop plans to interconnect their supply lines to provide alternate water supplies. No contingency plans have been developed in any of the communities.

4.0 COSTS OF WELLHEAD PROTECTION

EPA and PADER grants funded most of the costs associated with implementing the WHPP for eastern Lancaster County. Each community contributed a small match to the EPA/PADER grants. Once the WHPP is implemented, permitting fees paid by regulated facilities/activities within the WHPA will fund the program.

4.1 Tangible Costs

As of September 1995, the costs of developing the WHPP for eastern Lancaster County have totaled $62,000 ($66,180 in 1994 dollars). This amount includes a $30,000 ($32,700 in 1994 dollars) EPA Region 3 grant with $12,000 ($13,080 in 1994 dollars) in community matching funds, and a $20,000 ($20,400 in 1994 dollars) PADER grant. Exhibit 2 summarizes each agency's costs for developing each component of the WHPP.

4.1.1 Wellhead Protection Area Delineation Costs

WHPA delineation was the most expensive developmental activity. The cost of the delineation is a function of the local geology and the number of wells. EPA Region 3 and PADER selected the region for a pilot application of the fracture trace analysis methodology because of its complex, fractured geology. Most of the EPA grant and the community matches was spent on the WHPA delineation, according to a consultant who is providing support to the communities developing the WHPP. No data are available on what percentage of these funds covered the WHPA delineation.

4.1.2 Source Identification Costs

Source identification accounted for a relatively minor portion of total WHPP development costs, primarily because volunteers performed most of the work. However, a portion of the grant from EPA funded the costs of the GIS development and database searches conducted prior to the property-by-property survey.

Exhibit 2
Cost of Wellhead Protection: Lancaster County, PA
1990 to September 1995
($1994)

Item	Earl Township	East Earl Township	New Holland Borough	Terre Hill Borough	PA DER	EPA Region 3	Total
WHPP Development							
WHPA delineation	3,270	3,270	3,270	3,270		32,700	$45,780
Source identification (1)							$0
Develop management plan					20,400		$20,400
Develop zoning ordinance (2)							$0
Write overlay zoning ordinance							$0
Contingency plan (3)							$0
Public education/outreach (4)							$0
TOTAL COST:	$3,270	$3,270	$3,270	$3,270	$20,400	$32,700	$66,180

Notes:
(1)WHPA delineation/source identification costs cannot be disaggregated.
(2) Management plan/zoning ordinance costs cannot be disaggregated
(3) Communities have not yet developed contingency plans
(4) Education costs will be negligable

4.1.3 Management Plan Costs

Costs for developing the management plan are reflected in the cost of writing the draft ordinances. The ordinances for the eastern Lancaster County jurisdictions utilize language from ordinances developed by other communities. A $20,000 ($20,400 in 1994 dollars) Commonwealth grant covered the cost of developing the ordinances for the four communities. No data are available on the costs of developing a public education program.

If the Lancaster County communities implement their proposed management plans, much of the ongoing costs for managing the wellhead protection areas will be associated with periodic inspections of facilities with Wellhead Protection Area operating permits. The communities' consultant estimates that inspections of the facilities likely to be permitted under the management plan would cost approximately $50,000 per year. From 1995 to 2005, the four communities would incur costs of approximately $351,200 to inspect permitted facilities (see Exhibit 3).

The most significant cost to business associated with wellhead protection in Lancaster County will be the costs to farmers associated with modification of procedures for applying pesticides. No data are available on the number of farmers who would be required to modify their pesticide application procedures, or the extent and cost of the necessary modifications.

4.1.4 Contingency Plan Costs

The communities have not yet developed contingency and emergency response plans, and no estimates of what these components will cost are available.

4.2 Intangible Costs

Since the management plan has not been implemented, it is impossible to quantify the indirect costs of the WHPP. However, it is possible that implementation of a wellhead protection program could cause farmland values to decrease, since farmers may no longer be able to sell their land for industrial use. The impacts on property values in each community will be interrelated. For example, because Terre Hill's wells are physically located in East Earl Township, any land use restrictions to protect Terre Hill's wells may impact property values and tax bases in East Earl Township. On the other hand, wellhead protection programs may make property attractive for residential development, providing alternative buyers for farmers who wish to sell their land.

Exhibit 3
Future Cost of Wellhead Protection: Lancaster County, PA
October 1995 to September 2005
($1994)

Item	Earl Township	East Earl Township	New Holland Borough	Terre Hill Borough	Total
WHPP Implementation					
Inspections of permitted facilities (1)	87,795	87,795	87,795	87,795	$351,179
Public education/outreach (2)					$0
TOTAL COST:	$87,795	$87,795	$87,795	$87,795	$351,179

Notes:
(1) Assumes 1 FTE, or $50,000 per year
(2) Education costs will be negligable

5.0 CONCLUSION

Between 1990 and 1995, EPA Region 3, PADER, and the four communities have paid $66,180 (in 1994 dollars) to develop a WHPP in eastern Lancaster County. When implemented, this WHPP will protect eleven wells which supply drinking water to 19,000 people in a 100 square-mile area. The cost per well of the WHPP is approximately $6,000.

The four communities benefitted from EPA and PADER grants. Because the four WHPAs overlap and cross jurisdictional boundaries, the communities benefitted by cooperating and sharing limited resources.

6.0 REFERENCES

1992 Census of Agriculture, Volume 1, Geographic Area Series, Table 1, County Summary Highlights: 1992.

Eastern Lancaster County Wellhead Protection Committee. *Management Program for Control of Potential Sources of Contamination in Wellhead Protection Areas.* February 1992.

Evans, R. Paul. *Semi-Analytical Modeling Technique for Wellhead Protection Area Delineation in Fractured Carbonate Geology, Eastern Lancaster County, Pennsylvania.*

Evans, R. Paul. ACER Engineers and Consultants, Inc. Personal interview, October 21, 1994.

Lee, Joseph. Pennsylvania Department of Environmental Resources. Personal interview, October 20, 1994.

Rissler, Bob. Terre Hill Borough. Personal interview, October 21, 1994.

U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory. *Fracture Trace Analysis for Wellhead Protection Area Delineation, East Lancaster County, Pennsylvania.* August 1991.

Contract No. 68-C4-0011
Work Assignment No. 1-14

Benefit/Cost Analysis of Preventing Contamination: Village of Gilbert, Louisiana

September 30, 1995

Submitted to:

U.S. Environmental Protection Agency
Ground Water Protection Division
Technical and Information Management Branch

TABLE OF CONTENTS

LIST OF EXHIBITS

BENEFIT/COST ANALYSIS OF PREVENTING CONTAMINATION GILBERT, FRANKLIN PARISH, LOUISIANA

The Village of Gilbert, Louisiana, learned in 1992 that its two public water supply wells were contaminated with benzene at concentrations far above the Maximum Contaminant Level (MCL). The contamination was the result of a leaking underground storage tank that had been removed in 1987. The Louisiana Department of Environmental Quality is still determining the extent of the contamination, and remediation has not yet begun.

As a result of the contamination, the Gilbert Water System had to plug its wells and purchase water from neighboring public water supplies for a year and a half. In 1993, the community drilled two new wells in another location outside of the village. Within a week of starting the new wells, manganese levels in one of them exceeded the MCL, and Gilbert stopped using it. Gilbert has instituted a Wellhead Protection Program for the replacement wells, banning certain types of businesses within 1,000 feet of the wellheads. The cost to date of responding to the contamination is approximately 100 times the cost to date of adopting wellhead protection.

1.0 COMMUNITY DESCRIPTION

The Gilbert Water System (GWS) furnishes drinking water to Gilbert and some outlying residences. Gilbert is located in south-central Franklin Parish, in northeast Louisiana. It is a small community, with a population of fewer than 750. The local economy rests on agriculture and a nearby cotton gin.

1.1 Land Use

Gilbert is one of many small villages that lie along Route 15, a two-lane state highway running through northeastern Louisiana. Gilbert, like much of northeastern Louisiana, is almost exclusively rural. Land in and near Gilbert is used mostly for residential and agricultural purposes. A cotton gin operates near the center of town. The only other businesses apparent are retail establishments such as gas stations and a grocery store.

1.2 Geology/ Topography

Gilbert is located on a flat alluvial plain underlain by a sequence of unconsolidated sediments. The alluvium is quaternary in geologic age. Boreholes and monitoring wells in Gilbert indicate that the upper ten feet of the ground is mostly clay, underlain by a layer of clayey silt about five feet deep, and then a layer of silty sand about 14 feet deep, followed by sand and gravel deposits 80-100 feet thick. The sand and gravel layer is very permeable.

1.3 Hydrology

The Mississippi River Alluvial Aquifer (MRAA) is the only significant aquifer in the area. The aquifer, which flows generally west, is quite shallow. Lying approximately 22 feet below the surface, the aquifer recharges with every rain. As a result, ground water is plentiful but easily contaminated. The only surface water body close to Gilbert is Deer Creek, a small creek situated to the east of the village.

2.0 PWS CHARACTERISTICS

GWS (PWS ID #LA1041002) is owned and maintained by Gilbert. GWS maintains two wells, a pipeline, two elevated storage tanks, and a treatment plant. The treatment plant is located in the village center. Treatment includes chlorination, softening, and iron and manganese removal (using potassium permanganate).

2.1 Water Supply

GWS depends wholly on ground water from the Mississippi River Alluvial Aquifer (MRAA). The aquifer's sand and gravel layer is very permeable, yielding as much as 850 gallons of water per minute. Water from the MRAA is of low quality by nature, according to the Louisiana Department of Health and Hospitals (LA DHH).

GWS owns two wells (see Exhibit 1), but one (Well #2A) is offline because of excessive manganese levels. The active well (Well #1A) pumps at 600 gpm (with a top capacity of 800 gpm), and provides enough water to serve the village's needs. The PWS operator expects the well to be an adequate source for ten years. Gilbert uses approximately 95,000 gallons per day.

EXHIBIT 1
Ground Water Sources

Source		Average Depth (feet)	Capacity (MGD)	Status
Original wells:	Well #1	92	0	Abandoned
	Well #2	96	0	Abandoned
Replacements:	Well #1A	120	800	Active
	Well #2A	120	800	Offline due to excessive levels of manganese

2.2 Financial/Management Characteristics

Gilbert maintains a single enterprise fund for its water and sewer utilities; separate data on PWS operations are not available. In the fiscal year ending June 30, 1993[1], the fund's total revenues were approximately $10,000, and its total expenditures were approximately $25,000, resulting in an operating deficit of about $15,000. From time to time, Gilbert has transferred money into the enterprise fund from other accounts to cover operating expenses.

According to the local Farmers' Home Administration (FmHA) office, Gilbert's financial problems are due in part to a past reluctance to raise water rates. Gilbert recently increased its rates, however, and the additional revenue has begun to improve the PWS's financial status. Rates for water consumers are $8.00 for the first 2,000 gallons, and $2 for every additional 1,000 gallons. The previous rates were $1.50 for the first 1,000 gallons, $1.25 for the next 1,000 gallons, and $1 for every 1,000 gallons thereafter.

2.3 Population Served

The population served is slightly over 700 people, with about 250 connections. GWS serves about 90 percent of Gilbert residents, as well as some households just outside the village boundaries, in Franklin Parish. The remaining 10 percent of Gilbert residents draw water from private wells. GWS's largest non-residential customers are the Gilbert High School, the cotton gin, and the fire department.

3.0 CONTAMINATION

LA DHH, which is responsible for all drinking water monitoring in Louisiana, determined on February 17, 1992 that both of GWS's wells were highly contaminated with benzene. On April 1, 1992, after laboratory results had been confirmed, GWS notified residents to stop using the water for all but sanitary purposes.

3.1 Contamination Source

In 1990, Gilbert residents began to complain that their water smelled of gasoline, and the PWS operator called LA DHH to report the problem. LA DHH conducted tests in January 1991 and notified the Louisiana Department of Environmental Quality (LDEQ) that the wells were contaminated with benzene.

[1]Data from FY94 are not available.

LDEQ concluded that the contamination probably resulted from a leaking UST, both because the soil vapors were consistent with those of unweathered gasoline and because most contamination incidents in Louisiana can be traced to USTs. LDEQ identified seven abandoned service stations as possible sources of the contamination. Tests showed that subsurface soil at one of those abandoned stations, Lachney's Citgo, contained levels of benzene greater than 1000 parts per million (ppm). The station had closed in 1980, but its USTs were not removed until 1987. The soil near the station was so saturated that one could light it with a match.

LDEQ identified Lachney's Citgo as the source of contamination, and it initiated enforcement action against the owner (see map, Exhibit 2). Mr. Lachney was excused from financial responsibility by Louisiana courts after he proved an inability to pay mitigation costs. The expense for exploration and delineation of the contamination has been paid from the federal Leaking Underground Storage Tank Trust Fund (LUST Trust Fund), administered by LDEQ's UST Division. The Lachney site is not on the NPL or any similar State list.

3.2 Contaminants

Benzene, a member of the volatile organic contaminant (VOC) group BTEX (i.e., benzene, toluene, ethylbenzene, and xylenes), is the prevalent contaminant found at the PWS. LA DHH also identified trace amounts of the other BTEX constituents at the Lachney site. On January 14, LA DHH discovered a benzene level of 61.6 ppb in Well #2, but no contamination in Well #1. The Maximum Contaminant Level (MCL) for benzene is 5 ppb. In a follow-up test on January 28, LA DHH confirmed the results for Well #2 and found traces of benzene in the PWS distribution system. At that time, LA DHH asked the PWS to take Well #2 offline. By October 28 of that year, Well #2 had a benzene level of 430.9 ppb. In the test that prompted LA DHH to order both wells offline, on February 17, 1992, LA DHH found high levels of contamination in both wells and in the distribution system. Well #1 had a benzene level of 95 ppb, and Well #2 was at 331 ppb. LA DHH found levels in the distribution system as high as 210 ppb in the north end and 180 ppb in the south end.

EXHIBIT 2
Site Map

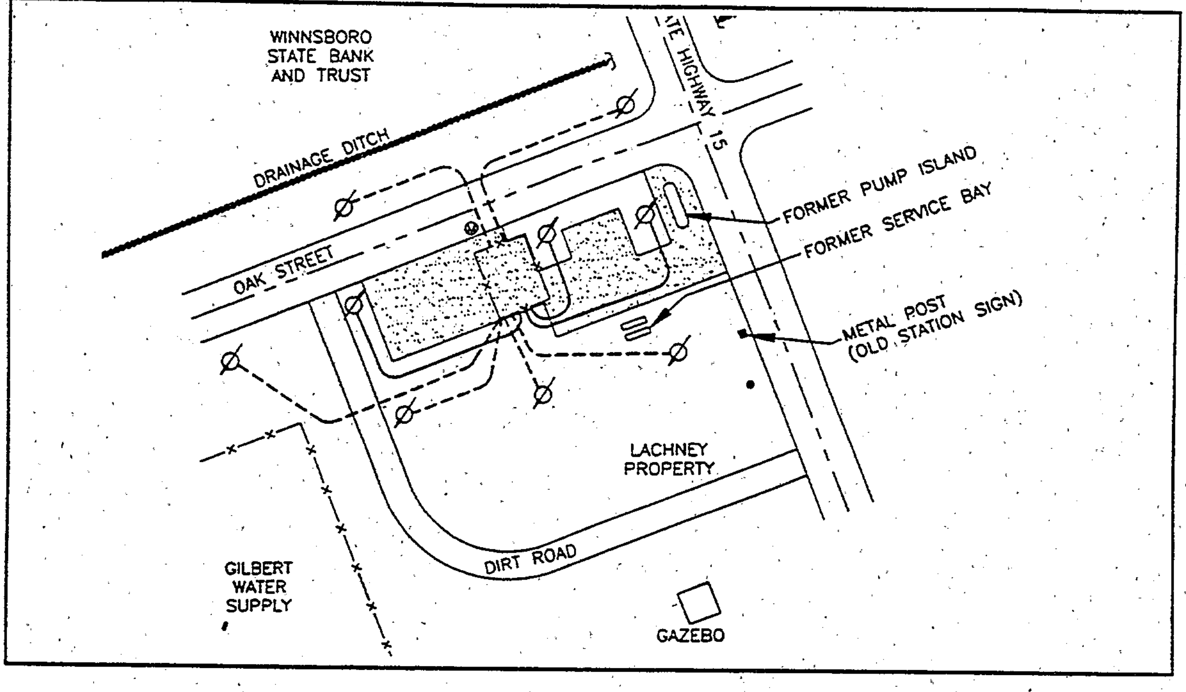


Exhibit 3 summarizes monitoring results between the initial discovery of contamination and the closure of both wells. Over a one-year period, benzene levels increased from 61.6 ppb to 331.0 ppb in Well #2, and from Not Detected to 95.0 ppb in Well #1. Benzene concentrations in the distribution system stayed at or below the MCL until February 1992.

LDEQ tested soil and soil gas vapors at various locations at and near the Lachney site and the wellfield. The soil test showed maximum VOC concentrations (1,360,000 ppb) at the center of the abandoned gas station property, at a depth of 20 to 22 feet. Maximum VOCs were found in soil gas at depths ranging from 12 to 19 feet. LDEQ found 2.5 feet of free-phase unweathered gasoline in a monitoring well on the site.

3.3 Effects of Contamination

No health or environmental effects from the contamination have been documented to date. However, the incident exposed Gilbert residents to benzene at a level many times greater than the MCL. Some residents may still be drinking contaminated water from private wells; many well owners are not willing or able to pay for testing.

Benzene is a known hematological poison, and has been associated with aplastic anemia, acute myelomonocytic leukemia, leukemia, depression of the immune system, and decreased serum levels. Benzene has been known to cause chromosomal aberrations in exposed persons and is a carcinogen.[2]

EXHIBIT 3
Benzene Concentrations Over Time
(ppb)

Date	Well #1	Well #2	Distribution System
1-14-91	ND	61.6	Not sampled
1-28-91	Not sampled	60.6	0.5
2-4-91	ND	122.0	ND
3-11-91	ND	107.0	ND-5.0
7-1-91	Not sampled	99.8	0.8-1.0
10-28-91	ND	430.9	ND
2-1-92	95.0	331.0	180.0-210.0

4.0 RESPONSE ACTIVITIES

Responses to the contamination have come in phases at the Gilbert site, as State agencies and the village reacted to the worsening contamination. Early response activities focused on temporary and then permanent replacement of the water supply; later responses have addressed cleanup of the aquifer itself.

4.1 Alternative Drinking Water Supplies

After the discovery of contamination in Well #2, LA DHH instructed GWS to stop using the contaminated well. Later, when benzene appeared in Well #1, LA DHH ordered that well offline. Gilbert connected to nearby PWSs on an emergency basis, and then drilled replacement wells.

[2]*Health Advisories for 25 Organics*, U.S. EPA Office of Drinking Water, PB87-235578, March 1987.

4.1.1 Shut-down of Well #2

When LA DHH discovered the contamination in Well #2 in January 1991, it instructed GWS to take the well offline. Well #1 was barely able to fulfill Gilbert's water needs, so the village planned to drill another well. The PWS intended to site the new well just 100 yards south of the original wells, as close to the treatment plant as possible. By drilling the new well near the old wells, the village could avoid installing a costly pipeline. Gilbert and LDEQ believed that the contamination in Well #2 was due to a breakdown in the integrity of the well's surface casing, and the village reasoned that a new well with an intact casing would be a viable solution to the water shortage. In the meantime, Gilbert applied for, and FmHA approved, a $46,695 grant for rehabilitation of its wells. The village also arranged with LDEQ to establish a wellhead protection program for Well #1 and the planned well.

4.1.2 Shut-down of Well #1

On February 17, 1992, LA DHH determined that the distribution system and both wells were highly contaminated with benzene. On April 1, 1992, LA DHH sent Gilbert a letter directing the village to find an alternate source of water or implement adequate treatment. LA DHH also instructed GWS to notify customers that the water should be used only for sanitary purposes and not for drinking or cooking. LA DHH required the GWS to distribute the notice through local radio stations, television stations, newspapers, and water bills. It also directed GWS to give copies of the newspaper notice to all of its new customers.

After receiving the notice from LA DHH, the GWS canceled its plans for the new well and started the process of plugging and abandoning the old wells. It completed the process in July 1993. To provide its customers with running water, GWS connected to the PWSs of two neighboring villages, South Bayou Macon and West Winnsboro. GWS purchased water from these communities for approximately a year and a half.

4.1.3 Construction of Replacement Wells #1A and #2A

Gilbert initiated an effort to site two replacement wells at a safe distance away from the contamination. A local hydrogeologist hired by the village proposed a location for the replacement wells just outside the village limits. LA DHH tested the groundwater quality at the site. However, for an unknown reason LA DHH did not sample from the depth at which Gilbert intended to draw water. LA DHH approved the site, Gilbert drilled the two new wells (Wells #1A and #2A), and connected to the replacement wells in September 1993. About a week after starting the new wells, GWS found contained excessive levels of manganese in Well #2A. GWS shut down the well because it could not afford treatment. Well #1A is sufficient to meet the village's current demand for water.

4.2 Ground Water Remediation

In late 1993 LDEQ began to characterize the contamination at the Lachney site. LDEQ awarded a contract to Aquaterra, Inc., for a site assessment, free product recovery, and a corrective action plan. Aquaterra completed a site assessment/corrective action plan in the spring of 1994. The report recommended additional delineation of the contamination, and LDEQ awarded a contract to PPM, Inc. in September 1994. Due to a lack of funding, the additional delineation has not yet begun.

Aquaterra proposed two remedial alternatives, both involving a Soil Vapor Extraction (SVE) Pilot Study and Full-Scale SVE Implementation. Alternative I consists of recovering dissolved gasoline constituents and treating them ex-situ. Alternative II, the recommended option, consists of removing the phase-separated hydrocarbons, testing and implementing the SVE system, and conducting air sparging. Aquaterra recommended Alternative II on the grounds that it would be cheaper and safer. Alternative II is the less expensive option because in-situ treatment requires less equipment. This alternative also is less environmentally hazardous because it would discharge only to air, whereas Alternative I would discharge both to air and water.

5.0 COSTS OF RESPONDING TO CONTAMINATION

Purchasing water, replacing the wells, and cleaning up the aquifer are the primary costs of responding to ground water contamination in Gilbert. Three federal agencies (i.e., Department of Housing and Urban Development, EPA, and the Farmers Home Administration) paid most of the costs of providing alternative drinking water, and all of the costs of the preliminary contamination assessment. Gilbert paid for the purchase of emergency drinking water from nearby communities, and it has experienced higher operating costs for its new wells.

5.1 Tangible Costs

The total costs to date, including those for alternative water supplies and those for remediation, are approximately $420,000 ($447,000 in 1994 dollars). The FmHA, the LUST Trust Fund, and the Department of Housing and Urban Development's Community Development Block Grant (CDBG) program have provided Gilbert with the funds to connect with neighboring water systems and to build its new wells. LDEQ, using federal LUST Trust Fund money, paid for the preliminary assessment of the contamination at and near the Lachney site. LDEQ anticipates using the Trust Fund to pay for remediation, but it has not yet secured the funding.

5.1.1 Costs to Provide Safe Drinking Water

The total costs to date for providing replacement drinking water to Gilbert residents are approximately $370,000 ($395,000 in 1994 dollars). These costs fall into three categories:

- One-time capital costs (e.g., tying into the South Bayou Macon and West Winnsboro water systems, plugging the old wells, siting and construction of new wells);
- One-time non-capital costs (e.g., monitoring contamination in the GWS wells and distribution system, purchasing replacement water); and
- Incremental operating costs (e.g., additional utility and treatment costs associated with the new well).

See Exhibit 4 for a detailed breakdown of the costs to date of responding to the contamination.

One-time capital costs for replacement water total approximately $285,712 ($299,998 in 1994 dollars). Federal grants have provided the funds to cover most of these costs. The LUST Trust Fund reimbursed Gilbert for the $25,043 ($26,295 in 1994 dollars) cost of linking up to the South Bayou Macon and West Winnsboro water systems. Gilbert applied for and received a CDBG to pay for $213,974 ($224,673 in 1994 dollars) of the cost[3] for siting and constructing its new wells. The village used its $46,695 ($49,030 in 1994 dollars) FmHA grant for additional engineering, construction, and legal costs. The FmHA grant also covered the cost of replacing contaminated filter media and plugging the old wells.

One-time non-capital costs for replacement water total approximately $76,256 ($81,013 in 1994 dollars). Both Gilbert and LA DHH incurred these costs. Gilbert paid $71,843 ($75,435 in 1994 dollars) to South Bayou Macon and West Winnsboro for emergency water during the 18 months between the discovery of contamination and the completion of the new wells. This cost was much greater than the cost would have been if Gilbert had produced its own water during that period. Gilbert did not adjust its rates to cover the incremental cost. Much of the $15,000 deficit in Gilbert's FY 1993 enterprise fund can be attributed to the increased cost of purchasing replacement water. LA DHH collected nearly 30 water samples from the wells and the distribution system between January 1991, when it discovered the contamination, and April 1992, when it shut down both of Gilbert's wells. The state laboratory in Baton Rouge analyzed the samples for volatile organics. The cost of the sampling and analysis was approximately $4,413 ($4,633 in 1994 dollars).

---

[3]The exact cost of the wells could not be determined.

Exhibit 4
Cost of Responding to Contamination: Gilbert, LA
April 1992 to September 1995
($1994)

Item	Village of Gilbert	LA DHH(1)	LA DEQ(2)	FmHA(3)	UST Trust Fund	HUD/ CDBG(4)	Total
Provide Safe Drinking Water							
One-time costs							
Emergency water supplies							
Tie-in to adjacent PWSs					26,295		$26,295
Replacement water	75,435						$75,435
Replacement wells							
Engineering/construction of new wells				22,258		184,933	$207,191
Land acquisition						8,715	$8,715
Plugging of old wells				6,300			$6,300
New filter media				12,600			$12,600
Administrative/legal costs				7,872		31,024	$38,896
Initial monitoring of new wells	945						$945
Monitoring/additional oversight of PWS		4,633					$4,633
SUBTOTAL:	$76,380	$4,633	$0	$49,030	$26,295	$224,673	$381,011
Incremental operating costs (since September 1993)							
Electricity ($250 per month)	6,250						$6,250
Telephone ($33 per month)	825						$825
Additional chemicals ($267 per month)	6,667						$6,667
SUBTOTAL:	$13,742	$0	$0	$0	$0	$0	$13,742
TOTAL:	$90,122	$4,633	$0	$49,030	$26,295	$224,673	$394,753
Remediate Aquifer							
Pre-remediation							
Site assessment and corrective action plan							
Planning, site assessment, final assessment report			29,201				$29,201
PSH recovery			9,464				$9,464
Corrective action plan			5,245				$5,245
Contractor oversight			2,989				$2,989
TOTAL:	$0	$0	$46,898	$0	$0	$0	$46,898
Indirect Costs to the Community							
Lost revenue due to private wells ($200 per month)	5,000						$5,000
TOTAL:	$5,000	$0	$0	$0	$0	$0	$5,000
TOTAL COST:	$95,122	$4,633	$46,898	$49,030	$26,295	$224,673	$446,651

Notes:
(1) Louisiana Department of Health and Hospitals
(2) Louisiana Department of Environmental Quality
(3) Farmers' Home Administration
(4) U.S. Department of Housing and Urban Development, Community Development Block Grant

Since September 1993, Gilbert's operating costs for providing drinking water have increased by a total of $8,795, or approximately $550 per month. Because the operating replacement well is further away from the treatment plant than the old wells, GWS's monthly telephone[4] and electricity costs have increased about $33 and $250, respectively. The new well has higher lead and manganese levels than the old wells, and GWS must treat the water with potassium permanganate at a level three times greater than it had before, for an additional cost of about $267 per month.

GWS appears to have borne the only significant indirect costs associated with the contamination. Approximately 10-12 residents abandoned public water and drilled private wells, as a result of the increased water rates. Gilbert's city clerk estimated that this loss of customers deprives GWS of approximately $200 per month in revenue. Given that the village collects approximately $10,000 per year in water and sewer rates, this amounts to a 2 percent drop in revenue. The clerk could not provide information on whether GWS's operating costs have fallen because of the reduced demand.

5.1.2 Costs to Remediate the Aquifer

Assessing contamination, preparing a corrective action plan, and constructing and operating ground water and soil treatment systems are the primary costs for remediating ground water. LDEQ and its contractor, Aquaterra, Inc., have performed a preliminary contamination assessment and developed a corrective action plan, but have not begun installation of treatment. LDEQ has spent approximately $44,665 ($46,898 in 1994 dollars) in contractor and staff effort for these activities. Additional delineation of the contamination will be required before treatment is installed, at a cost of approximately $9,500 ($9,690 in 1994 dollars).

In its corrective action plan, Aquaterra could not provide an estimate of the remediation's duration. For purposes of analysis, ten years' of costs have been estimated. Of the two proposed treatment alternatives, the net present value of the recommended alternative is estimated at $647,994. See Exhibit 5 for a detailed breakdown of the estimated costs to remediate the site. The federal LUST Trust Fund probably will pay for both the additional delineation and the remediation because Lachney cannot afford to pay for the remediation costs.

---

[4]GWS uses a telephone system to control operation of the pumps from the plant. In contrast, GWS operated the old wells manually.

Exhibit 5
Future Cost of Responding to Contamination: Gilbert, LA
October 1995 to September 2005
($1994)

Item	UST Trust Fund
Remediate Aquifer	
Pre-Remediation	
Additional contamination delineation	$9,690
Product Recovery and Ground Water Monitoring	
Install product recovery system in MW-2	$10,394
Product recovery system installation report	$1,907
System operation, maintenance, and monitoring(1)	$179,523
Management, technical assistance and reporting	$84,158
Contingency (10%)	$27,598
SVE Pilot Study	
Installation of manometers	$3,302
SVE pilot test costs	$17,462
Analytical costs	$1,377
Report preparation and final system design	$7,844
Contingency (10%)	$2,999
Full-Scale SVE Implementation	
SVE welll installation	$7,089
SVE equipment installation	$14,637
Operation and maintenance(1)	$175,590
Contingency (10%)	$19,732
Air Sparge Implementation	
Air sparging system implementation	$26,775
Operation and maintenance(1)	$50,219
Contingency (10%)	$7,699
SUBTOTAL:	$647,994
TOTAL COST:	$647,994

Note:
(1) Actual duration of remediation is contingent upon achievement of remediation goals.

5.2 Intangible Costs

Gilbert is a small village in a rural, economically depressed part of Louisiana. Economic effects of the contamination are difficult to distinguish from the poor economic condition of the area as a whole. Despite the statewide publicity Gilbert received due to the contamination, Gilbert's former mayor believes that the contamination has not affected property values. Further, since few property transfers occur in Gilbert, identifying impacts on the volume of property transactions is difficult. Village officials believe that no residents have relocated either their residences and/or businesses in response to the contamination.

The few businesses in Gilbert do not appear to have encountered any permanent impacts from the contamination. They do not appear to have experienced either increased costs or reduced revenues. Some businesses may have experienced temporary disruptions in their water supplies, but the associated costs are probably insignificant.

6.0 WELLHEAD PROTECTION

In January 1991 LDEQ's Ground Water Protection Division contacted Gilbert about establishing a Wellhead Protection Program (WHPP) after learning about the contamination from LA DHH. LDEQ intended to educate the community about the causes of the well contamination and to establish a contingency plan in case Gilbert lost Well #1. When LDEQ staff came to Gilbert for a meeting about the proposed WHPP, they found that the remaining well had become contaminated two days before and that the village was without a source of water.

LDEQ assisted Gilbert in compiling an inventory of potential sources and siting the new wells away from sources. After Gilbert constructed the new wells, LDEQ designated a new Wellhead Protection Area around those wells. The village, aided by LDEQ, has written and adopted a management ordinance and a contingency plan. Gilbert completed its Wellhead Protection Program implementation in October 1993.

6.1 State Participation in Wellhead Protection

Louisiana has an EPA-approved wellhead protection program that is completely voluntary for communities. The LDEQ Ground Water Protection Division sets minimal standards for wellhead protection programs, and certifies WHPPs meeting its standards.

Using data from the LA Department of Transportation and Development (DOTD), LDEQ establishes a vulnerability ranking for PWSs. Larger systems and systems drawing from shallow and unconfined aquifers receive higher rankings. LDEQ visits each community in order of vulnerability to convince local officials and civic leaders to adopt a WHPP.

LDEQ performs most of the work associated with WHPA delineation and source identification.

LDEQ uses a fixed radius to delineate WHPAs because it lacks the detailed geologic information necessary to run an accurate hydrogeologic model for each well. It delineates a two-mile radius around wells drawing from unconfined aquifers, or a one-mile radius around wells drawing from confined aquifers (which are rare in Louisiana).

LDEQ identifies potential sources of contamination within each WHPA and pinpoints their locations with respect to the well. When LDEQ finds actual sources of contamination (such as leaking USTs), it reports the sources to the appropriate State oversight program. LDEQ then creates a map showing the community, the WHPA, and the potential sources. Communities use the maps to prevent contamination of existing wells, and to site new wells in less vulnerable areas.

In order to obtain LDEQ approval for their WHPPs, local communities must adopt either regulatory (e.g., overlay zoning ordinances, design standards) or non-regulatory (e.g., land purchases, public education) management programs. The Ground Water Protection Division supplies local communities with model ordinances and technical assistance in choosing source prohibitions and design standards. To increase public awareness of wellhead protection, LDEQ has prepared public education materials (e.g., pamphlets and a video) for use by local governments.

Other State agencies involved in wellhead protection to a lesser degree are: the DOTD; the Department of Agriculture and Forestry; the Department of Natural Resources; the Wellhead Protection Technical Committee, which assists LDEQ in obtaining information from the other involved agencies; and the Soil and Water Conservation Districts and Water Conservation Districts. The Ground Water Advisory Group, consisting of representatives from each agency, coordinates the agencies' wellhead protection efforts.

6.2 Local Wellhead Protection Plan

In Gilbert, LDEQ delineated WHPAs and identified potential sources for both the existing wells and the replacement wells. Gilbert drafted a contingency plan and an ordinance based on models provided by the Ground Water Protection Division. The contingency plan defines emergency procedures to be carried out in the event of contamination or a water shortage. The ordinance establishes a ground water protection area and prohibits certain activities from occurring within 1,000 feet of the wells. The village is responsible for the day-to-day management of the wellhead protection program.

6.2.1 Wellhead Protection Area Delineation

In Gilbert, LDEQ delineated a two-mile radius around the wells. According to LDEQ, such a distance is conservative and overprotective, given the statewide average travel rates for ground water (50-170 ft/yr). The WHPA should provide Gilbert with enough time to take appropriate measures if contamination occurs. Where the WHPA boundaries intersect highways, Gilbert erected signs by the side of the road.

6.2.2 Source Identification

LDEQ, with the help of Gilbert residents, first performed the source identification step for GWS's original wells. Older citizen volunteers recalled the locations of long-abandoned potential sources in town. LDEQ made a full inventory of the sources and plotted them on a map of the village. When Gilbert shut-down both wells, LDEQ used the list of potential sources to help site the replacement wells. After the new wells were installed, LDEQ revised the list to reflect the new WHPA. The final source inventory identified 27 potential sources of contamination, 13 of which were service stations or garages. The other sources identified included three cemeteries, two dry cleaners, a small airport, sewage lines and disposal ponds, and drainage canals. Gilbert received a copy of the inventory and the map.

6.2.3 Management Plan

Gilbert has not developed a formal management plan for its wellhead protection program. However, the PWS operator periodically conducts informal activities such as visiting potential contamination sources. Further, Gilbert has passed a Groundwater Protection Ordinance establishing a ground water protection area within a half-mile radius of the wellfield. The ordinance prohibits certain new installations within 1,000 feet of any well. These installations are as follows:

- automobile maintenance and repair,
- battery storage and manufacturing,
- chemical productions,
- dry cleaners,
- electroplating,
- furniture production,
- facilities using USTs,
- man-made ponds and retention areas,
- medical clinics,
- paint facilities,
- pest control, and
- photo processing.

In the ordinance, Gilbert resolved to monitor all activities within the WHPA that are potential sources and to site any new wells "properly."

6.2.4 Contingency Plan

Gilbert formulated a contingency plan to coordinate with existing Hazardous Materials Response and Civil Defense Plans. The Contingency Plan establishes a priority of water users in the case of a water shortage or disruption, and it outlines the village's options for alternate water sources, including neighboring water systems and markets that carry bottled water. It also describes notification procedures in case of a ground water contamination emergency.

7.0 COSTS ASSOCIATED WITH WELLHEAD PROTECTION

Gilbert's wellhead protection program has cost approximately $4,580 ($4,666 in 1994 dollars) to date. Almost all of these costs are salary costs for time LDEQ spent developing Gilbert's program. LDEQ officials could not provide the exact number of hours spent on the Gilbert wellhead protection program, so costs are estimated. Gilbert officials are paid only nominal salaries, so any staff costs for the small amount of time spent developing and managing the WHPP are relatively insignificant.

7.1 Tangible Costs

The initial cost of wellhead protection in Gilbert was the presentation that LDEQ made to the community, to convince local officials of the need for a wellhead protection program. LDEQ and LA DHH spent approximately $438 ($446 in 1994 dollars) and $123 ($125 in 1994 dollars), respectively, to prepare for and attend the presentation.

7.1.1 Wellhead Area Delineation and Source Identification Costs

According to estimates by LDEQ's Ground Water Protection Division, the staff spent a total of about $3,282 ($3,347 in 1994 dollars) preparing a map of both WHPAs, identifying potential sources, and situating each source on the map. Delineating WHPAs itself did not require a great investment of time, because each WHPA is a circle with a two-mile radius. Community volunteers assisted LDEQ in the source identification effort, which minimized LDEQ's staff time. No private entities incurred costs for these steps. See Exhibit 6 for a breakdown of the wellhead delineation and source identification costs.

Exhibit 6
Cost of Wellhead Protection: Gilbert, LA
April 1992 to September 1995
($1994)

Item	LA DHH	LA DEQ(1)	Village of Gilbert	Total(3)
WHPP Development				
Presentation to local officials	125	446		$571
WHPA Delineation/Source Identification(2)		3,347		$3,347
Preparation of WHPA map				
Review of existing data on USTs, NPL, RCRA sites/site visits				
Management Plan/Source Controls				
Adoption of overlay zoning ordinance		36		$36
Patrols of WHPA			250	$250
Contingency Plan		231		$231
Modification of model contingency plan				
Public Education/Outreach				
Installation of WHPA signs		231		$231
TOTAL COST:	$125	$4,291	$250	$4,666

(1) Distribution of LA DEQ costs is approximate.
(2) Delineation and source identification costs cannot be disaggregated.
(3) Village of Gilbert incurred nominal costs, but they cannot be quantified.

7.1.2 Management Plan Costs

The only public cost incurred in this step was the time an LDEQ geologist spent to send Gilbert copies of other cities' management ordinances. The village of Gilbert drafted and passed the ordinance, but it did not incur significant costs. As noted earlier, village officials are paid only nominal salaries. See Exhibit 6 for a breakdown of the management plan costs.

Implementation consists of informal visits to potential contamination sources by the PWS operator. These visits cost about $125 per year.

7.1.3 Contingency Planning Costs

LDEQ incurred minor costs for providing Gilbert with some technical assistance in developing a contingency plan. Gilbert officials were responsible for the body of the work involved in writing the contingency plan, but the village incurred no significant costs. See Exhibit 6 for a breakdown of the contingency planning costs.

7.2 Intangible Costs

The WHPP does not appear to have resulted in any quantifiable indirect costs. The management ordinance's prohibition against certain new installations with 1,000 feet of the wells is unlikely to affect property values in that area of town. The wells are located in a residential area. Further, the community is in an economic decline, and development pressures are minimal. As noted in Section 3.3, if a business chose not to move to Gilbert, it would be difficult to show that the decision was a result of the WHPP and not of the economic weakness of the village.

8.0 CONCLUSION

To date, the Village of Gilbert has incurred a total cost of $95,122 (in 1994 dollars) to respond to contamination of its two wells. The Village continues to incur additional operating costs of approximately $550 per month at the new wells. In addition, the PWS loses about $200 per month in revenues as a result of customers who have installed their own wells as a result of the contamination. Assuming that remediation of the aquifer takes five years, the prevent worth of remediation costs is approximately $455,000 to $520,000, depending on the remedial alternative chosen.

Gilbert's wellhead protection program cost approximately $4,400 (in 1994 dollars), or about $2,200 per well. Because Gilbert has a minimal source management program, implementation costs are near zero.

9.0 REFERENCES

Aquaterra, Inc. *Site Assessment and Corrective Action Plan: Lachney Property, Gilbert, Louisiana.*

Arnold, David. Operator, Gilbert Water System. Personal interview, December 9, 1994.

Casanova, Keith L. Environmental Quality Program Manager, Office of Water Resources, Louisiana Department of Environmental Quality. Personal interview, December 8, 1994.

Fielding, Howard. Geologist, Ground Water Protection Division, Louisiana Department of Environmental Quality. Personal interview, December 8, 1994.

Gentry, Mary. Geologist, Ground Water Protection Division, Louisiana Department of Environmental Quality. Personal interview, December 8, 1994.

Ground Water Protection Division, Louisiana Department of Environmental Quality. "BTEX Contamination of a Public Water Supply—Gilbert, Louisiana, A Case Study."

Ground Water Protection Division, Louisiana Department of Environmental Quality. *Gilbert Wellhead Protection Program.* March, 1990.

Griffing, Nelda. Mayor, Village of Gilbert. Personal interview, December 9, 1994.

Guillory, Pat. Assistant Director, Winnsboro District Office, FmHA. Phone interview, December 29, 1994.

Hahn, Michael. UST Program, Baton Rouge Headquarters, Louisiana Department of Environmental Quality. Phone interview, December 13, 1994.

Hill, Jay. Northeast Regional Office, Louisiana Department of Health and Hospitals. Personal interview, December 9, 1994.

Levey, Linda Korn. Administrator, Ground Water Protection Division, Louisiana Department of Environmental Quality. Personal interview, December 8, 1994.

Louisiana Wellhead Protection Program, Louisiana Department of Environmental Quality. Case file.

McManus, Vicki. McManus Consulting Engineers. Phone interview, December 29, 1994.

Schultz, Oliver. President, Oliver Schultz and Associates. Phone interview, December 28, 1994.

Sporl, Philip. UST Program, Northeast Regional Office, Louisiana Department of Environmental Quality. Personal interview, December 9, 1994.

Warbington, Janice. City Clerk, Village of Gilbert. Personal interview, December 9, 1994.

Contract No. 68-C4-0011
Work Assignment No. 1-14

Benefit/Cost Analysis of Preventing Contamination: Town of Dartmouth, Massachusetts

September 30, 1995

Submitted to:

U.S. Environmental Protection Agency
Ground Water Protection Division
Technical and Information Management Branch

TABLE OF CONTENTS

LIST OF EXHIBITS

BENEFIT/COST ANALYSIS OF PREVENTING CONTAMINATION DARTMOUTH, BRISTOL COUNTY, MASSACHUSETTS

Contamination of its drinking water supply prompted the Town of Dartmouth, Massachusetts to voluntarily undertake an innovative wellhead protection program. Two separate sources have contaminated two of the town's drinking water supply wells. The first, an illegal dumping operation, forced the closure of the Route 6 well. The second, an old gravel pit and a clandestine dump, contaminated the town's Chase Road well.

Dartmouth was among the first communities in the country to adopt wellhead protection. Its wellhead protection plan provides many safeguards intended to protect its drinking water supply from potential contamination. The town owes the success of its comprehensive wellhead protection program to the close cooperation among several departments of the local government.

1.0 COMMUNITY DESCRIPTION

Dartmouth is located in Bristol County, in southeastern Massachusetts. The town consists mainly of residential areas, but it also has commercial, industrial, and manufacturing areas. Dartmouth has a population of 27,000. The University of Massachusetts at Dartmouth increases the town's population from fall through spring by about 3,500 students. This increase is complemented to some extent by a similar-size transient summer population of vacationers.

1.1 Land Use

The predominant land use in Dartmouth is residential. Dartmouth's population had remained steady over several decades until around 1985, when the area gained popularity because of its proximity to Cape Cod. Despite the recent population increase, over 50 percent of the land in Dartmouth is undeveloped.

Most of Dartmouth's commercial facilities are centered in a business district along Route 6, which runs through the center of town. Commercial uses consist primarily of retail establishments, restaurants, and gas stations. The industrial and manufacturing facilities in Dartmouth include cable and computer manufacturing facilities and a golf equipment manufacturing plant.

1.2 Geology/ Topography

Elevation in Dartmouth varies from 170 feet above sea level to sea level along the coast. The topography of the town is characterized by hills and valleys which run from the northwest to the southeast. Several southward-flowing streams occupy these valleys.

Dartmouth is underlain mainly by late Precambrian bedrock. The observable bedrock is the Dedham Granodiorite Formation, with intrusions of a fine-to-medium grained schist. The bedrock is characterized by a relative hardness and lack of weathering. Principal mineral constituents of the Dedham Formation are quartz, microcline, and plagioclase.

1.3 Hydrology/Climate

Dartmouth is on the southeastern coast of Massachusetts, bordering Buzzards Bay. Several southward-flowing streams drain into Buzzards Bay and the Atlantic Ocean. These include Buttonwood Brook, Paskamanset River, Shingle Island River, Copicut River, Destruction Brook, Slocums River, and Little River.

Dartmouth relies upon two aquifers for its drinking water. A substantial volume of ground water is found in the highly permeable surficial deposits. All of Dartmouth's municipal wells draw ground water from these deposits. A deeper, slow-moving aquifer within the Dedham Granodiorite is characterized by low porosity and a corresponding low storage capacity. Most low-yield private wells in Dartmouth tap the bedrock aquifer.

Ground water moves from the upland recharge areas in northern New Bedford and central Dartmouth to the lowland discharge areas along the Paskamanset River and the coast. Natural flow is north to south, with a possible additional west-east gradient. Pumping may artificially change the direction of flow near some of the wells.

The aquifers in Dartmouth are recharged by surface water. United States Geological Survey (USGS) studies of eastern Massachusetts indicate that ground water recharge rates range from 0.75 million to 1 million gallons per day (mgd), per square mile.

Precipitation in Dartmouth averages 41 inches annually, ranging from 2.2 to 4.1 inches per month. Of this precipitation, 47 percent enters the ground or runs off into surface water bodies; the remainder is lost to evapotranspiration. The average temperature varies from a low of about 32 degrees in January to about 72 degrees in July.

2.0 PWS CHARACTERISTICS

Until 1960, Dartmouth purchased all of its water from the City of New Bedford. Since then, the Dartmouth Water Division (DWD) has supplied a combination of its own water and purchased water. The DWD, PWS ID #4072000, is owned and operated by the town.

2.1 Water Supply

The Dartmouth Water Division relies on ground water and purchased water from the neighboring city of New Bedford.[1] Ground water in the area historically has been of high quality. The most significant water quality problem, aside from the contamination incidents, has been high levels of naturally occurring iron and manganese.

Dartmouth operates eight sand/gravel wells, seven of which are currently online (See Exhibit 1). The PWS maintains just over 170 miles of mains, with use measured by 7,924 water meters. The DWD disinfects the water from all of its wells and has installed corrosion control measures. Due to the naturally high iron and manganese content of the ground water, DWD applies iron and manganese removal at some wells.

Dartmouth's net water consumption in 1993 was just under 2.6 mgd. To meet this demand, Dartmouth currently purchases 20 percent of its water annually from New Bedford on demand, mainly during the summer months, when consumption rates are highest. The town will probably continue to purchase water in the future, due to the increasing demand of commercial high-end users and real estate development.

The DWD is currently testing four wells, two of which are scheduled to become operational in the fall of 1995. Dartmouth is also reviewing several parcels of land in anticipation of possibly siting an additional two wells.

2.2 Financial/Management Characteristics

The Town of Dartmouth established an enterprise fund for its water and sewer utilities in its fiscal year 1990.[2] The fund is supported entirely by water and sewer fees. The town retains revenue associated with water supply and sewerage in this fund.

The Department of Public Works (DPW) determines rates and fees charged for water consumption. The DPW assesses a minimum annual charge for water ranging from $40 to $1,520, based on meter size. Above the minimum usage, Dartmouth has an increasing block rate structure. For each increment of use, the cost per cubic foot of water increases, up to $29 per 1,000 cubic feet. The DPW last changed water rates on July 1, 1992.

DPW assesses a system development charge of $2,000 for each new service connection. A separate service connection and meter are required for each residential unit, up

[1]New Bedford relies on surface water from a region known as the "Five Great Ponds" for its drinking water supply.

[2]The Town's fiscal year runs from July 1 to June 30.

to four units per building. Any residential building containing more than four units requires a master meter, and the fees are based on a non-residential system development charge, ranging from $2,000 for a 1 inch meter to $76,000 for a 10 inch meter.

EXHIBIT 1
Water Source Characteristics

Source	Average Depth (feet)	Withdrawal (gal/year)
Surface water source, purchased from New Bedford via Faunce Corner Pump Station	N/A	Not metered
Chase Rd. A Well	43.2	81,230,000
Chase Rd. B Well	38.6	131,869,000
Chase Rd. C Well	30	73,573,000
Chase Rd. D Well	41	145,028,000
Old West Rd. V-1 Well	50	85,389,000
Old West Rd. V-2 Well	50	128,277,000
Old West Rd. V-3 Well	52	76,750,000
Allen St. Station	Inactive[a]	--
Route 6 Well	Inactive[b]	--

[a] Pumping station is an emergency interconnection with New Bedford water supply.
[b] Inactive due to contamination (see Section 3)

Dartmouth has used bonds and loans in the past to meet its capital improvement needs. The DWD has a sufficient balance in its enterprise fund to meet the PWS's operating expense for over a year. The PWS plans to pay for any future compliance requirements (none are currently anticipated) by increasing user rates or obtaining grants or loans.

2.3 Population Served

The PWS serves approximately 24,000 (89 percent) of Dartmouth's residents, via 8,300 service connections. The remaining 3,000 residents rely on private wells. The DWD supplies 49.2 percent of its water to residential users, 32.8 percent to commercial users, 10 percent to municipal users, and 6 percent to industrial users.

3.0 CONTAMINATION

Two of Dartmouth's wells were contaminated as a result of two separate incidents. In 1978, the town detected contamination in the Route 6 well from a hazardous waste dumping operation. In the early 1980s, the town discovered that its Chase Road Well D was contaminated by an private sand and gravel operation subsequently used as a dump site.

3.1 Contamination Sources

State officials discovered contamination at the Route 6 site in 1978. Responding to calls from citizens, the Massachusetts Department of Environmental Protection (DEP)[3] found numerous barrels of hazardous waste in a warehouse 1,000 feet from the operating well. Debris from various domestic and building activities was scattered around the site. DEP removed the barrels. Upon returning to the site the next year, DEP found that another 1,000 barrels had been dumped in the warehouse. DEP determined that an illegal hazardous waste dumping operation existed on the premises. Dartmouth successfully sued the owner of the operation, but recovered only a negligible monetary award.

The town detected contamination at the Chase Road well during the siting process. During the well design phase, a caller, noting the town's signs delineating a "Water Supply Area," identified the area as an old dump site. The town immediately halted the siting process and hired contractors to initiate a survey of the area, focusing on three potential sources. The first area proved to be clean; at the second location, the town discovered fish oil waste from a fish processing plant. At the third site, 1,500 feet from the proposed location of the well, the town found a pond within an abandoned pit containing buried automobiles and automotive crank case oil. The town has not taken any enforcement actions against responsible parties.

3.2 Contaminants

After discovering the illegal dumping operation, DEP and the Town of Dartmouth conducted two rounds of sampling and analysis on the Route 6 well between 1978 and 1980. The U.S. Environmental Protection Agency (EPA) collected and analyzed the contents of the stored drums. EPA's analysis of the drum contents revealed the presence of 2-ethyl hexanal, toluene, methyl isobutyl ketone, ethyl benzene, butanol, heptanol, trichloroethylene, xylene, 1-methoxy-2-propanol, nonyl alcohol, hydrocarbon (7c), cholorobutane, and propanol.

DEP's initial sampling of water from the Route 6 well indicated the presence of chloroform at concentrations of 4.4 to 5.4 parts per billion (ppb), and 1,1 dichloroethylene at

[3] At the commencement of activities at the Route 6 well, DEP was known as the Massachusetts Department of Environmental Quality Engineering (DEQE). Throughout this report, "DEP" refers to both organizations.

concentrations of 1.0 to 1.1 ppb. The date of this sampling was unavailable. In 1980, the town hired contractors to drill monitoring wells and conduct groundwater sampling and analysis. Samples taken 380 feet from the Route 6 well indicated the presence of 1,1,1 trichlorethane (3.5 ppb), trichloroethylene (2.1 ppb), and tetrachloroethylene (1.7 ppb). Samples taken 850 feet from the Route 6 well indicated the presence of five contaminants. In this sample, trichloroethylene (540 ppb), 1,1,1 trichlorethane (1,250 ppb), and 1,1 dichloroethylene (56.5 ppb) were found in the greatest concentrations.

After discovery of contamination at the Chase Road site, Dartmouth initiated several surveys of the area to determine the extent and potential effects of the buried auto parts and oil. Geochemical surveys and samples from monitoring wells detected crank case oil, acetone, methylethylketone, and 1-1-1 trichloroethylene. The town conducted seismic and resistivity surveys and located one buried car.

3.3 Effects of Contamination

No documented health effects could be attributed to the contamination incidents. In fact, the only reported health effects that could be attributed to water quality are gastrointestinal problems from excess manganese in drinking water. This has never been decisively ascribed to groundwater quality, however.

Although no one has been made ill due to contamination of either the Chase Road or Route 6 wells, the potential for adverse health effects is real. For example, acetone (found in the Chase Road well) is readily absorbed into the body via ingestion. The main effects of acetone exposure are central nervous depression and irritation of the eyes.

The health effects of the contaminants identified in the Route 6 well include damage to the brain, heart, lungs, and kidneys. Exposure to 1,1 dichloroethylene may cause central nervous system depression. Once ingested, 1,1 tetrachloroethane concentrates in organs with high levels of fat, including the brain, and may also affect the heart, lungs, liver, and kidneys. Long-term oral exposure to TCE may damage the liver. PCE may cause abnormal effects on the liver, kidney and central nervous system.

No natural resource damage due to the contamination in Dartmouth's wells has been documented.

4.0 RESPONSE ACTIVITIES

In each contamination incident, EPA, DEP, or the town responded by conducting surveys to assess the extent of contamination and removing the source of the contamination.

4.1 Response to Contamination of the Water Supply at Route 6 Well

After discovery of hazardous materials at the Route 6 site, DEP ordered the town to remove the well from service. DEP initiated cleanup activities in 1979. DEP dug an interceptor trench and two test holes adjacent to the primary disposal area. It stockpiled drums and debris for future disposal, and removed, aerated, and spread contaminated soil. The Department removed a total of 1,054 drums, 20,500 gallons of liquid waste, and 320 tons of heavily contaminated soil and debris. A large pile of less severely contaminated debris remains at the site. DEP completed its cleanup in February 1980.

The town collected samples at the site in 1980 to investigate the prospect of siting a new well. According to the sampling results, the site was still seriously contaminated, despite the cleanup. DEP also warned the town that the contamination was likely to migrate further toward the well. DEP indicated that it would approve the use of the Route 6 well, provided that the town sample the well and two nearby monitoring wells monthly for VOCs. The town decided not to use the well until it had studied the situation further.

In 1983, Dartmouth installed a system of 13 monitoring wells to better define the site hydrogeology and conducted sampling from February through October. Analyses indicated that aquifer contamination was widespread and locally severe. They also indicated that pumping the well reversed the ground water's natural flow and tended to direct contamination towards the well. The town decided not to reopen the well.

In 1991, Dartmouth reexamined the possibility of using the well in light of advances in groundwater treatment technologies. The town rejected this course of action after determining that pumping would draw contamination into the well's cone of influence. DEP informed Dartmouth that it would not approve reopening the Route 6 well unless the town could prove that it had exhausted all other sources of water. The town is currently purchasing water from New Bedford to replace this well.

4.2 Response to Contamination of the Water Supply at Chase Road Well

After discovering the contamination and investigating the contamination sources near the Chase Road well, Dartmouth removed the fish oil from the site. To determine the extent of contamination from the automotive dump site, the town installed monitoring wells, conducted seismic surveys, sampled the ground water, and conducted geochemical testing.

The town attempted to remove the buried car. Because the car was located close to the water table, the holes quickly filled with water, preventing extraction of the entire automobile. The town was able to extract portions of the car, including the engine block.

During the delay in the well siting process, DEP requirements for new wells became more stringent. The Waste Division of DEP now required Dartmouth to show that the site was not hazardous and that the town had no further responsibilities to clean up the site. Dartmouth performed a Phase II Assessment[4] and a Risk Assessment and determined that the site was no longer hazardous. DEP accepted these studies as documentation of the well's suitability as a drinking water source, and the town resumed siting the well.

The town conducted pump testing at the well to determine whether pumping would pull the remaining contamination into the well. The pump tests showed that, although the aquifer around the well was contaminated, none of the contaminants had reached the well. DEP approved the well in 1988.

Dartmouth designed the Chase Road pump station to ensure that its water supply would not be interrupted by future contamination. As a precautionary measure against contamination which could potentially migrate toward the well, the pump house contains an operating state-of-the-art air stripper and greensand filtration plant. It is fitted with excess piping to allow additional filtration equipment to be installed in a relatively short period of time in the event that further contamination is discovered. The consultant who designed and built this plant indicated that the plant has excess treatment capacity, providing "insurance" against an extended interruption of water supply due to future contamination.

5.0 COSTS OF CONTAMINATION

The total costs of discovery, characterization, cleanup, and water replacement at the Route 6 and Chase Road wells is $1,334,934 ($1,380,694 in 1994 dollars). At the Route 6 well, the Town of Dartmouth incurred costs totaling $44,000 ($89,760 in 1994 dollars). Furthermore, since the closure of the Route 6 well, the town has lost revenue from the sale of water netting $934,838 ($513,687 in 1994 dollars). At the Chase Road well, the town paid a total of $734,259 ($777,247 in 1994 dollars) to respond to contamination. A $13,000 ($15,470 in 1994 dollars) Aquifer Contamination Grant from the Commonwealth helped defray these expenses. These costs are described in the sections below.

---

[4]A Phase II Assessment is an in-depth quantitative characterization of the hydrogeology and geochemistry of an area.

5.1 Tangible Costs

Exhibit 2A presents the costs of responding to contamination at the Route 6 Well as of September 1995; Exhibit 3A presents future costs associated with contamination at the well. Exhibit 2B presents the costs to September 1995 of responding to contamination at the Chase Road Well. Between 1995 and 2005, O&M costs associated with contamination at the Chase Road Well are presented in Exhibit 3B.

5.1.1 Costs to Provide Safe Drinking Water at Route 6 Well

Between 1980 and 1991, the Town of Dartmouth spent $44,000 ($89,760 in 1994 dollars) studying the contamination at the Route 6 well and the surrounding aquifer. EPA's and DEP's expenses associated with analyzing the materials in the drums and onsite cleanup activities are unavailable.

In addition to incurring the above costs, the town has lost the revenue from sale of water from the Route 6 well. Between 1969 and 1978, Dartmouth pumped an average of 81 million gallons per year from the Route 6 well. At a cost of $1,363 per million gallons (the amount charged by New Bedford), the "market value" of this quantity of water is $110,403 per year. The total loss of water between 1978 and 1995 from the Route 6 well would therefore be valued at $1,419,442 (in 1994 dollars).

This figure represents only the value of the water itself. By purchasing water, the town did not incur any expenses related to maintaining and operating the well. According to DWD, the operating cost savings over 17 years at the Route 6 well were $975,755. This figure is based on the per-gallon electrical, chemical treatment, and labor costs at similar wells. The net lost revenue due to contamination and closure of the Route 6 well was $543,476 (in 1994 dollars). From 1995 to 2005, Dartmouth will pay over $389,000 to purchase replacement water.

5.1.2 Costs to Provide Safe Drinking Water at Chase Road Well

The total costs of responding to contamination at the Chase Road site totaled $734,259 ($777,247 in 1994 dollars). The Phase II assessment cost $75,000 ($89,250 in 1994 dollars) and the Risk Assessment cost $13,000 ($15,470 in 1994 dollars). The town paid $65,000 ($81,250 in 1994 dollars) for an air stripper tower and a new greensand filtration plant. Annual air stripper operating costs for electricity, heat, chemicals, and labor associated with daily inspections are $83,038 (in 1994 dollars). The O&M costs from 1988 to the present total $591,277 (in 1994 dollars). Between 1995 and 2005, O&M of the air stripper/filtration plant will total approximately $583,000.

Exhibit 2A
Cost of Responding to Contamination at Route 6 Well: Dartmouth, MA
1978 to September 1995
($1994)

Item	Town of Dartmouth
Provide Safe Drinking Water	
One-time costs (1)	
Site Cleanup/Monitoring Wells	
Analysis of Dumped Drums	$89,760
SUBTOTAL:	**$89,760**
Incremental operating costs	
Purchase of Water from New Bedford	$1,489,442
Well operating costs (savings)	($975,755)
SUBTOTAL:	**$513,687**
TOTAL COST:	**$603,447**

Notes:
(1) Massachusetts DEP and U.S. EPA also paid to remove and analyze drums; costs are unavailable

Exhibit 2B
Cost of Responding to Contamination at Chase Road Well: Dartmouth, MA
1988 to September 1995
($1994)

Item	Town of Dartmouth	Aquifer Contamination Grant Program	Total
Provide Safe Drinking Water			
One-time costs			
Phase II Assessment	$73,780	$15,470	$89,250
Risk Assessment	$15,470		$15,470
Construct Air Stripper/Greensand Filtration Plant	$81,250		$81,250
SUBTOTAL:	**$170,500**	**$15,470**	**$185,970**
On-going costs			
Electricity	$463,512		$463,512
Heat	$8,336		$8,336
Chemicals	$39,021		$39,021
Labor	$80,407		$80,407
SUBTOTAL:	**$591,277**		**$591,277**
TOTAL COST:	**$761,777**	**$15,470**	**$777,247**

Exhibit 3A
Future Cost of Responding to Contamination at Route 6 Well: Dartmouth, MA
October 1995 to September 2005
($1994)

Item	Town of Dartmouth
Provide Safe Drinking Water	
Ongoing costs	
Purchase of Water from New Bedford	$775,424
Annual well operating costs (savings)	($386,100)
TOTAL COST:	**$389,324**

Exhibit 3B
Future Cost of Responding to Contamination at Chase Road Well: Dartmouth, MA
October 1995 to September 2005
($1994)

Item	Town of Dartmouth
Provide Safe Drinking Water	
Ongoing costs	
O&M - Air Stripper/Greensand Filtration Plant	
Electricity	$457,235
Heat	$8,225
Chemicals	$38,496
Labor	$79,317
TOTAL COST:	**$583,273**

Dartmouth applied for an Aquifer Contamination Grant to clean up the site. The town received a $13,000 grant ($15,470 in 1994 dollars) and paid all other costs with its own revenues.

5.2 Intangible Costs

Dartmouth has not seen any effect on its real estate market or experienced any economic dislocation associated with groundwater contamination. In fact, the construction rate in Dartmouth has been rising.

6.0 WELLHEAD PROTECTION

Wellhead Protection (WHP) in Dartmouth began with the passage of an Aquifer Protection bylaw in 1980. Dartmouth was among the first communities in the country, and the first in Massachusetts, to adopt WHP. Dartmouth's Wellhead Protection Plan (WHPP) provides for delineation of three protective zones around its wells and a variety of safeguards intended to protect aquifers from potential contamination.

6.1 State Requirements for Wellhead Protection

The Commonwealth of Massachusetts has implemented WHP via its Source Approval Regulations (310 CMR 22.21). The Regulations apply to new PWS wells that produce at least 100,000 gallons per day (gpd). Massachusetts requires delineation of three protection zones around each water supply well:

- Zone I is a fixed 400 foot radius around each well, of which the PWS must have "direct ownership or control."

- Zone II is the aquifer zone that contributes water to the well under the most severe pumping and recharge conditions that can be anticipated realistically for a 180-day period without any significant recharge to the aquifer.

- Zone III consists of the areas where ground water and surface water recharge Zone II.

EPA formally approved Massachusetts' State Wellhead Protection Program in May, 1990.

6.2 Local Wellhead Protection Plan

Dartmouth first adopted an Aquifer Protection bylaw in 1980. Resident interest in WHP began as a response to the discovery of contamination at the Route 6 well. The wellhead protection areas (WHPAs) are managed through close cooperation among several departments of the local government.

6.2.1 Wellhead Protection Area Delineation

Three protective zones have been mapped around each of Dartmouth's water supply wells as a normal part of the well siting process. Zone I areas are simple 400 foot radii around the wells. The Zone II delineations in Dartmouth were calculated using the USGS MODFLOW model or a conceptual model, such as the Theis equation for non-equilibrium conditions. The final Zone II delineation is based on modeling results and actual pump testing results. Zone III areas are delineated around the radii of the Zone IIs.

6.2.2 Source Identification

A door-to-door survey of potential contaminant sources is not part of the standard procedure for WHPA delineation in Dartmouth. Rather, DWD relies on inventories produced by other departments of the town government to identify potential pollutant sources within the Zone II areas of its wells. For example, the Fire Chief maintains an inventory of underground storage tanks, and the Department of Health (DOH) inventories and inspects septic systems.

A 1993 sanitary survey indicates the presence of potential sources of contamination within the Zone I and II protection areas of Dartmouth's wells. Within the Zone I areas of six wells are propane storage tanks and access roads. An oil storage tank is located within the Zone I area of one well. Diesel oil disposal sites are located within the Zone II areas of two wells. Gravel pits are found within the Zone II areas of three wells. Four wells have multiple contaminant sources within their Zone I areas; two wells have multiple contaminant sources within their Zone II areas. Three wells have sources of potential contamination in both their Zone I and Zone II areas.

6.2.3 Management Plan

Several departments of the town government share management responsibility for the WHPAs. These include the DWD, the Planning Commission, the Building Commission, and the DOH. The DWD's day-to-day management of each WHPA consists of daily visits to the wells and coordination with other departments of the town government. The Planning and Building Commissions propose and enforce bylaws regulating activities within the protective zones.

The Planning Commission has authority to propose bylaws for aquifer protection. The Commission developed a delineation map and proposed methods to manage Zones I, II, and III around Dartmouth's wells. For example, the town's 1988 Growth Management Plan discourages development, which reduces the likelihood of future aquifer contamination. It requires minimum lot sizes of two acres for new development in the northern and southern parts of town. Dartmouth does not provide water or sewer connections to any new developments in those areas.

Another Planning Commission requirement stipulates that a maximum of 10 percent of a parcel of property can have impervious cover. This same requirement also mandates best management practices (such as runoff detention ponds) for parking lots.

The Building Commission implements and enforces the zoning bylaw. The Building Commissioner reviews building permit applications to determine whether proposed construction within the protected zones complies with applicable requirements.

The DOH permits and inspects septic systems in all real estate subdivision plans. DOH requires a four-foot separation between a septic system and the water table, and a six-foot separation with an aquifer. The Health Department also has the authority to recommend new WHP requirements that it deems necessary to protect the health of Dartmouth's residents.

6.2.4 Contingency Plan

Dartmouth has evaluated the vulnerability of its wells to contamination from emergency spills, and it has devised extensive contingency plans. When a spill is reported, the Hazardous Waste Coordinator decides on the action to take and coordinates the cleanup. This individual is responsible for contacting the Massachusetts DEP to respond to hazardous waste incidents when necessary.

Dartmouth's plan focuses on responding to automobile accidents, which pose the most common threat to ground water. Fire departments respond on the scene with absorbent pads, which are kept on fire trucks. At each well pump house, a supply of absorbent pads is kept in stock in case a spill should occur near the well. For larger spills, the town retains hazardous waste cleanup contractors. The town currently is investigating the possibility of equipping police officers with first-response kits, as police officers invariably are the first officials on site when traffic accidents or other spills occur.

7.0 COSTS OF WELLHEAD PROTECTION

The costs associated with WHP in Dartmouth include the costs of developing regulations, delineating wellhead protection areas, running the hazardous waste spill response program, and reviewing activities that might affect WHPAs. As of September 1995, development of the town's bylaw and WHPA delineation costs have totaled $145,500 ($183,510 in 1994 dollars). The annual costs of WHP in Dartmouth are $154,052.

7.1 Tangible Costs

In 1980, Dartmouth spent $30,000 ($53,700 in 1994 dollars) to study its ground water resources before preparing its bylaw. Aside from this initial investment, the costs of developing regulations and reviewing applications have been minimal and are recovered by permit application fees.

Dartmouth's WHPP is financed through the Water Enterprise Fund. The costs to date of developing and implementing WHP in Dartmouth are presented in Exhibit 4. Annual management costs through September 2005 are presented in Exhibit 5.

7.1.1 Wellhead Area Delineation Costs

Dartmouth has delineated eight WHPAs as part of the well siting process. According to a DWD official, WHP is an integral part of Dartmouth's and Massachusetts' siting requirements. Thus, separating the costs of WHPA delineation from other well siting costs is difficult.

A former DEP official estimated that 50 percent of the cost of siting a new well is attributable to the WHP-related components of Massachusetts' new source siting requirements. This percentage of well siting costs is used to calculate the costs of WHPA delineation at Dartmouth's wells.

The total cost of WHPA delineation for Dartmouth's wells was $115,500 ($129,810 in 1994 dollars), from three different contracts for well siting support. Under the first contract, Dartmouth Power Associates (DPA) paid $200,000 ($228,000 in 1994 dollars) to site two wells during the design of an electrical power plant.[5] Half this cost, or $100,000 ($114,000 in 1994 dollars), is attributable to WHPA delineation. Under the second contract, Dartmouth spent $15,500 ($15,810 in 1994 dollars) for the WHP-related components of the well siting, including field surveying, pump testing, and WHPA modeling. The third contract was for siting the Chase Road Well. Once the town convinced DEP that no contamination problem existed at the well, DEP allowed Dartmouth to submit the Phase II and Risk Assessment reports for drinking water source approval. Because the costs of preparing these reports are included in Section 5.2 as costs associated with contamination, they are not counted with WHPA delineation costs.

[5] DPA gave the wells to the Town to compensate for anticipated heavy water usage.

Exhibit 4
Cost of Wellhead Protection: Dartmouth, MA
1988 to September 1995
($1994)

Item	Town of Dartmouth	Dartmouth Power Associates (1)	Total
WHPP Development			
Develop bylaw			
Study· aquifer characteristics	53,700		$53,700
Identify sources			
Develop contingency plan			
WHPA Delineation			
WHPA Delineation: Contract #1		114,000	$114,000
WHPA Delineation: Contract #2	15,810		$15,810
SUBTOTAL:	$69,510	**$114,000**	**$183,510**
WHPP Implementation			
DWD oversight of WHPA since 1988 (2)	$1,042,113	**$0**	**$1,042,113**
TOTAL COST:	**$1,111,623**	**$114,000**	**$1,225,623**

Notes:
(1) DPA Sited 2 Wells and Gave Them to the Town to Compensate for Heavy Water Usage
(2) 5% of DWD annual budget is for WHP management and expenses

Exhibit 5
Future Cost of Wellhead Protection: Dartmouth, MA
October 1995 to September 2005
($1994)

Item	Town of Dartmouth	Building Permit Applicants	Total
WHPP Implementation			
On-going costs			
Day-to-day Oversight by DWD (1)	$1,023,687		$1,023,687
Building Commission Oversight (2)		$58,310	$58,310
TOTAL COST:	$1,023,687	$58,310	$1,081,997

Notes:
(1) 5% of DWD Budget is for WHP Management and Expenses
(2) Assumes $45 to Review a Residential Permit Application and $112.50 to Review a Commercial Permit Application

7.1.2 Source Identification Costs

As noted earlier, Dartmouth does not have a distinct source identification plan. Costs associated with source identification cannot be isolated.

7.1.3 Management Plan Costs

The annual costs of WHP in Dartmouth are $154,052. WHPA management is an integral part of the daily activities of several town government departments. For example, daily oversight of the WHPP by the DWD accounts for five percent of the Division's total annual budget of $2,915,000, or $145,750.

Approximately 45 percent of the Building Commissioner's review of each building permit application is related to WHP, to check aquifer protection maps for potential aquifer zone violations. This cost is recovered from permit application fees, which are $100 for residences ($45 of which is WHP-related), and $250 for commercial applicants ($112.50 of which is WHP-related). In 1993, the Building Commission spent $8,302 for WHPA oversight associated with the issuance of 152 residential building permits and 13 commercial permits.

DOH oversight of the WHPA consists of septic system inspections. Because these inspections are primarily for the purpose of protecting health, with an "incidental" WHP benefit, Dartmouth does not categorize the inspection costs as WHP expenses.

7.1.4 Contingency Planning Costs

The town's chief contingency planning expense is for maintaining supplies to respond to hazardous spills near the wells. This cost is included in the DWD's annual budget for wellhead protection. A DWD official provided price quotes for the types of absorbent pads and oil booms that are commonly kept on hand at the pump houses and in fire/police vehicles. However, it is unclear how often these supplies are used and must be replaced. An annual supply cost therefore cannot be calculated.

7.2 Intangible Costs

The only discernible major indirect costs associated with prevention of contamination in WHPAs results from the requirement that the bottoms of septic systems be at least 4 feet from the water table. This requirement can add $15,000-$25,000 to the basic cost of building a septic system.

Compliance costs associated with regulations under the WHPP have not been prohibitively expensive. Dartmouth remains an attractive location for development. Construction rates have remained high, and much land remains for development. The two-acre minimum lot size requirement has not significantly changed the prices of new homes within the town. As the town's Planning Director said, "a lot is a lot," regardless of its size. He indicated that one-acre lots sold for approximately $45.000, and two-acre lots are selling for around $50,000. The Planning Board has increased construction permit application fees to help defray the costs of reviewing plans.

8.0 CONCLUSION

Between 1988 and 1995, the Town of Dartmouth has incurred a total cost of $1,380,694 (in 1994 dollars) to respond to contamination at two of its drinking water wells. Most of these costs are ongoing: the town continues to pay to purchase water from New Bedford and to run an air stripper at the Chase Road D well. Contamination at the two wells cost the town and its water users $140,769 each year, an average of approximately $70,000 annually per well.

As of September 1995, the total cost of developing Dartmouth's wellhead protection program is $183,510 (in 1994 dollars). Divided equally among the town's seven active wells, wellhead protection costs are approximately $26,200 per well. The annual costs of WHP in Dartmouth are $154,052, approximately $22,000 per well.

Purchasing water to replace the supply lost due to closure of the Route 6 well costs $57,731 per year; annual air stripper operation costs at the Chase Road D well are $83,038. When compared to the annual per-well cost of WHP ($22,000) the benefit of prevention is clear.

9.0 REFERENCES

1993 Dartmouth Annual Town Report. Dartmouth, MA.

Boyce, Len. Supervisor, Dartmouth Water & Sewer Division. Personal interview, December 14, 1994.

Clement Associates. *Chemical, Physical and Biological Properties of Compounds Present at Hazardous Waste Sites, Final Report.* 1985.

DEP/Division of Water Supply. *1993 Annual Community Public Water Supply Statistical Report and Identification Survey - Dartmouth Water Division.* January 1994.

Department of Public Works, Town of Dartmouth. *Pumping Test Report for New Source Approval of the Chase Road Well E-1 & E-2 Sites, Dartmouth, Massachusetts.* Prepared by Woodard & Curran Inc. October 1993.

Dusseault, Roland. Personal interview, February 1995.

Henderson, Wendy. Director, Dartmouth Board of Health. Personal interview, December 14, 1994.

Hickox, David. Assistant Superintendent. Dartmouth Department of Public Works. Personal interview, December 14, 1994.

Krawczyk, John. Vice President, Fay, Spofford, & Thorndike. Personal interview, December 13, 1994.

Massachusetts Department of Environmental Protection. *Drinking Water Facts: The Massachusetts Wellhead Protection Program.*

O'Reilly, Michael. Dartmouth Environmental Affairs Coordinator. Personal interview, December 15, 1994.

Perry, Donald. Dartmouth Planning Director. Personal interview, December 15, 1994.

Planning Board, Dartmouth, Massachusetts. *Dartmouth Groundwater Resource Study.* Prepared by Geoscience Associates. July 1980.

Silveira, David. Dartmouth Building Commissioner. Personal interview, December 15, 1994.

U.S. EPA Office of Drinking Water. *Health Advisories for 25 Organics.* PB87-235578, March 1987.

Contract No. 68-C4-0011
Work Assignment No. 1-14

Benefit/Cost Analysis of Preventing Contamination: City of Tumwater, Washington

September 30, 1995

Submitted to:

U.S. Environmental Protection Agency
Ground Water Protection Division
Technical and Information Management Branch

TABLE OF CONTENTS

LIST OF EXHIBITS

BENEFIT/COST ANALYSIS OF PREVENTING CONTAMINATION
TUMWATER, THURSTON COUNTY, WASHINGTON

On August 3, 1993, the City of Tumwater, Washington detected trichloroethene (TCE) in Wells #2, #4, and #5 at its Palermo Wellfield. The City immediately shut down the three wells and, with the assistance of the Washington State Department of Ecology (WSDOE), conducted a preliminary field investigation of the contamination. The investigation initially identified 19 potential sources of contamination in the vicinity of the wellfield. After further investigation, WSDOE subsequently narrowed the list down to 13 potential sources and turned the investigation over to EPA Region 10.

In early 1995 Region 10 concluded Phase I of an Expanded Site Investigation (ESI)[1] and further narrowed the list to four potential sources: a Washington State Department of Transportation (WSDOT) Materials Laboratory, Southgate Dry Cleaners, Brewery City Pizza, and Tumwater Chevron. In June 1995, the Region began a Phase II ESI, which involved a more comprehensive subsurface investigation and an assessment of the feasibility of remediation.

Upon discovering the contamination, the City accelerated plans to construct two new wells at the George Bush Middle School. WSDOE issued a construction permit for Well #12 in January 1994 and authorized construction under an existing permit for Well #14 in August 1994.

In February 1993, Tumwater applied for and received a $170,500 grant from the State of Washington's Centennial Clean Water Fund to develop a comprehensive wellhead protection plan. To qualify for the grant, the City provided a $170,500 match for the State funds. To date, Tumwater has passed three aquifer protection ordinances, conducted a preliminary delineation of its wellhead protection areas, and developed a preliminary list of potential sources. The City expects to complete its wellhead protection plan by mid 1996.

As of September 1995 the cost of contamination at the Palermo wellfield is approximately $797,541. The total cost of wellhead protection plan development is $347,826.

1.0 COMMUNITY DESCRIPTION

The Tumwater Water System (TWS) supplies drinking water to the City of Tumwater and some unincorporated areas of surrounding Thurston County. Tumwater is a relatively small city situated in central Thurston County, just southwest of the State capital, Olympia. The city is located in one of the fastest growing areas of Washington State. In 1992,

[1]The Palermo Wellfield is CERCLIS #WA0000026534.

Tumwater's population was 10,360. By 1997 the population is expected to reach approximately 14,350, and by 2011 the population is expected to reach 29,000. The local economy rests on state government, retail trade, manufacturing, and professional services. A brewery owned by the Pabst Brewing Company is one of the City's most prominent businesses. Pabst operates its own water system.

1.1 Land Use

The predominant land use in Tumwater is residential, comprising 25 percent of total land area. Industrial uses comprise 13 percent, public uses comprise 9 percent, commercial uses comprise 5 percent, and open space comprises 5 percent of the total land area. Despite recent population increases, almost 35 percent of the land in Tumwater remains undeveloped.

1.2 Geology/Topography

Tumwater, like most of the Puget Sound region, is characterized by glacial deposits. The geology and topography of Thurston County are largely the result of the glacial action that occurred during the Pleistocene ice age. The local elevation ranges between 200 and 400 feet above mean sea level. The area consists of low hills on the northwest and southeast separated by a broad, flat plain which runs from the northeast to the southwest. The plain is cut by the Deschutes River Valley, which runs along the eastern portion, and is bounded by the Black River drainage to the west.

Geologic studies indicate that the upper 25 feet of the ground consists of sand and gravel, underlain by a layer of silt and clay about forty feet thick, followed by a sand and gravel layer 30-135 feet thick. The lowest and oldest geologic unit found under Thurston County consists of Tertiary Bedrock. The sand and gravel layers are highly permeable; ground water is extremely vulnerable to contamination.

1.3 Hydrology

All of Tumwater's ground water resources are developed in unconsolidated sand and gravel in four aquifers, listed in order of increasing depth:

- Quaternary Alluvial -- an unconfined gravel aquifer;
- Vashon Recessional Outwash -- a mostly unconfined sand and gravel aquifer;
- Vashon Advance Outwash -- a mostly unconfined sand and gravel aquifer; and
- Tertiary-Quaternary Undifferentiated Deposits -- a confined sand and gravel aquifer.

The first three of these aquifers are very susceptible to contamination due to their relatively shallow depth, lack of protective aquitards, and highly permeable surficial soils. The Quarternary Alluvial aquifer is suspected of being hydrologically connected to both the Deschutes River and the Vashon Recessional Outwash aquifer.

Ground water flows north to northwest in Tumwater. The region's ground water system is hydraulically isolated and generally does not receive water from the Cascade or Olympic mountains or other distant locations. Rainfall is the primary source of recharge for the area's aquifers. Approximately 34 of the 51 inches of precipitation which typically fall each year infiltrate the ground and recharge ground water.

Water quality in the Quarternary Alluvial and Vashon Recessional Outwash aquifers is generally good, with low concentrations of dissolved solids. The Vashon Advance Outwash aquifer tends to be slightly hard, with moderate concentrations of calcium carbonate. In contrast, water in the Tertiary-Quaternary Undifferentiated Deposits tends to have elevated levels of manganese, chlorides, and sodium, especially at lower depths.

Three principal surface water drainages exist in the Tumwater area. The Black Lake/Black River system to the west of the City drains south to the Chehalis River, the Trosper Lake/Percival Creek system in the north drains north to Capitol Lake and then to Puget Sound, and the Deschutes River flows north through the City into Capitol Lake.

1.4 Climate

Tumwater enjoys a mild marine climate with moderate year-round temperatures. The summers are warm and dry, while the winters are wet and mild. About 51 inches of precipitation fall annually, with the majority falling between November and March.

2.0 PWS CHARACTERISTICS

The City of Tumwater owns and operates TWS.[2] The utility's service area covers approximately 10.7 square miles, and is comprised of four pressure zones. The two lowest pressure zones serve a relatively flat plain on which most of Tumwater is located, and the two higher pressure zones serve a hilly area to the west.

[2]PWS ID #WA5389700.

2.1 Water Supply

TWS maintains 16 wells, six storage tanks, two pumping stations, and a distribution network. The City currently does not treat its water, but anticipates having to install treatment to comply with the Safe Drinking Water Act's Lead and Copper Rule and with the Washington State Department of Health's disinfection requirements.

TWS has two standby interties with the City of Olympia and has an informal agreement to obtain water from the Pabst Brewing Company. One of the two Olympia interties benefits the City of Olympia more than Tumwater, because Tumwater's system operates at a much higher pressure at that location. Water cannot be transferred to Tumwater unless the Tumwater system is extremely depleted or unless a booster pump is installed at the location. At the second Olympia intertie, the pressures are nearly equivalent, and water can be pumped into either system. During periods of peak demand, Pabst historically has allowed Tumwater to obtain water via a fire hose connected to a hydrant on the Pabst property.

TWS depends wholly on ground water drawn from three aquifers: Vashon Advance Outwash, Quarternary Alluvial, and Tertiary-Quarternary Undifferentiated Deposits. Its wells are grouped into five wellfields: Palermo, Port of Olympia (Airport), City Hall, Bush Middle School, and Trail's End. The City of Olympia originally constructed the Port of Olympia wells to serve its airport. Tumwater annexed the airport area in 1986. Four of Tumwater's wells are inactive, one is pumping to waste due to contamination, and one is used only as an emergency supply. The total instantaneous capacity of the operating wells is 6,265 gallons per minute (gpm).

2.2 Financial/Management Characteristics

Tumwater maintains a separate enterprise fund for its water utility. In the fiscal year ending June 30, 1994[3], the fund's total expenditures were approximately $7.5 million. The city's water budget nearly doubled between FY 1993 and FY 1994. Most of this increase can be attributed to one-time capital outlays for construction of a new storage tank and two new wells. To fund various drinking water projects, Tumwater raised nearly $5.4 million in capital by issuing revenue bonds and obtaining loans in FY '93 and FY '94. Exhibit 2 contains a breakdown of the drinking water budget.

[3]Data from FY95 are not available.

EXHIBIT 1
Ground Water Sources

Well No.	Field	Aquifer	Capacity (GPM)	Status
1	Palermo	Quarternary Alluvial	0	Inactive
2	Palermo	Quarternary Alluvial	0	Pumping to waste due to contamination
3	Palermo	Quarternary Alluvial	350	Active
4	Palermo	Quarternary Alluvial	0	Inactive
5	Palermo	Quarternary Alluvial	0	Inactive
6	Palermo	Quarternary Alluvial	450	Active
7	City Hall	Tertiary-Quarternary Undifferentiated Deposits	0	Excessive manganese; emergency supply only
8	Palermo	Quarternary Alluvial	330	Active
9	Port of Olympia (Airport)	Vashon Advance Outwash	400	Active
10	Port of Olympia (Airport)	Vashon Advance Outwash	485	Active
11	City Hall	Vashon Advance Outwash	275	Active
12	Bush Middle School	Vashon Advance Outwash	750	Active
13	Port of Olympia (Airport)	Coarse Grained Glacial Deposits	0	Inactive -- formation collapsed during redevelopment
14	Bush Middle School	Vashon Advance Outwash	2,350	Active
15	Airport	Vashon Advance Outwash	800	Active
20	Trail's End	Quarternary Alluvial	75	Active; recommended for closure

EXHIBIT 2
Drinking Water Budget

Expenditure	FY 1994 Budget (millions)
Capital Outlays	$5.90
Operating Expenditures (e.g., salaries, benefits, supplies, contract services)	$1.17
Debt Service	$0.24
Contingency Reserve	$0.15
TOTAL	$7.46

TWS has a two-tier rate structure, consisting of a monthly base rate which varies by meter size and a consumption charge of $1.15 per one-hundred cubic feet. The average household in Tumwater pays approximately $16.45 per month for water. Tumwater's rates are comparable to neighboring communities of similar size.

Tumwater has adopted water system access charges to cover the cost of new development. These include connection fees and meter installation fees. Connection fees range from $800 to $154,640, depending on the meter size. Meter installation fees range from $295 to $1,200.

2.3 Population Served

TWS supplies a population of approximately 13,000 with about 3,347 connections. The PWS serves all Tumwater residents, as well as some households located in unincorporated areas of Thurston County. Residential customers account for about 90 percent of water users in Tumwater. The largest non-residential customers are Columbia Beverage, the State of Washington[4], the Tumwater School District, Louis Kemp Seafoods, and the Tyee Motor Inn.

[4]Numerous State office buildings are located in Tumwater.

3.0 CONTAMINATION

On August 3, 1993, the City of Tumwater, while conducting monitoring as part of a comprehensive water quality study, detected trichloroethene (TCE) in Wells #2, #4, and #5 at the Palermo wellfield. Tumwater took the wells out of production, but continued to pump them as a safety measure to prevent contaminated ground water from reaching three unaffected wells. The City is still discharging water from Well #2 into a nearby drainage slough. Tumwater, the State Department of Ecology, and EPA Region 10 have conducted investigations of the site to determine the source of contamination.

3.1 Contamination Source

The City and WSDOE conducted a joint field investigation of the contamination between August 11 and August 22, 1993. Investigators concluded that the most likely source of TCE in the wells was a dense, non-aqueous phase liquid (DNAPL) in soil below the water table, somewhere to the west of the wellfield.

Washington's 1989 Model Toxics Control Act requires WSDOE to investigate any suspected release of hazardous substances and identify "potentially liable persons." WSDOE identified 19 potential sources, including a dry cleaning establishment, several gas stations, an illegal dump, and two Washington State Department of Transportation (WSDOT) facilities. WSDOE concluded that 13 of these sources required further study and turned the investigation over to EPA Region 10.

In late 1994 EPA conducted a Phase I Expanded Site Investigation (ESI) of the site, and narrowed the list of potential sources down to four: the Washington WSDOT Materials Laboratory (where asphalt testing occurred), Southgate Dry Cleaners, Brewery City Pizza (allegedly the former site of a dry cleaners), and Tumwater Chevron. Exhibit 3 contains a map of the Palermo wellfield area.

3.2 Contaminants

As part of the initial investigation, the City and WSDOE conducted extensive well water, ground water, soil gas, and soil sampling at the site. TCE, a volatile organic compound (VOC), was the prevalent contaminant found in the PWS wells. TCE was present in Wells #2, #4, and #5, although it exceeded the Maximum Contaminant Level (MCL) only in Well #2. The MCL for TCE is 5 parts per billion (ppb). Concentrations in Well #2 ranged between 7 and 15 ppb; in contrast, the highest concentration found in either Well #4 or Well #5 was 3 ppb. Exhibit 4 contains a summary of sampling results for the three wells.

Limited ground water modelling indicated that pumping from the wellfield altered the natural ground water flow and drew the contaminant plume into the wellfield. About 600 feet to the west-northwest of the wellfield, ground water samples contained TCE concentrations of up to 165 ppb. Low concentrations of trans-1,2-dichloroethene and tetrachloroethene (PCE) also were detected. Investigators concluded that given TCE's high solubility, the relatively low concentrations of TCE in ground water indicated that the source was a considerable distance from the wellfield. They also concluded that the source would persist for many years and continue to generate a plume. The investigators could not determine if the TCE was a breakdown product of PCE, or if the two contaminants resulted from separate sources.

Investigators did not detect TCE in soil samples, but they observed that the soil was dark-stained, smelled of petroleum, and contained low concentrations of toluene, ethylbenzene, and xylene. They determined that this contamination was probably associated with fuel leakage from an automobile and was not related to the contamination present in the wells.

EPA Region 10 conducted ground water and soil sampling at the site during its ESI. In ground water samples, EPA detected TCE at concentrations up to 116 ppb, PCE at concentrations up to 115 ppb, vinyl chloride at concentrations up to 17 ppb, C-DCE at concentrations up to 8 ppb, and T-DCE at concentrations up to 2 ppb. In soil samples, EPA detected TCE at concentrations up to 7 ppb, PCE at concentrations up to 42 ppb, vinyl chloride at concentrations up to 15 ppb, C-DCE at a concentration of >1 ppb, and T-DCE at a concentration of nearly 4 ppb. Region 10 also confirmed the presence of TCE in the three Palermo wells.

3.3 Effects of Contamination

The study team found no evidence of health or environmental effects from the contamination incident. Only one of the contaminated wells had TCE concentrations in excess of the MCL. Prior to discovering the contamination, TWS routinely mixed the water produced from the six wells at the Palermo wellfield, so the TCE concentration in the distribution system probably never exceeded the MCL. The reader should note, however, that the contaminant plume is migrating under a residential neighborhood at a relatively shallow depth. Evidence indicates that long-term exposure to TCE may damage the liver.[5]

In the period between the closure of Wells #2, #4, and #5 in August 1993 and construction of Well #12 in the spring of 1994, Tumwater frequently could not maintain adequate water pressure in its distribution system for fire control. A serious fire could have posed a severe threat to public safety.

[5]*Health Advisories for 25 Organics*, U.S. EPA Office of Drinking Water, PB87-235578, March 1987.

EXHIBIT 3
Site Map

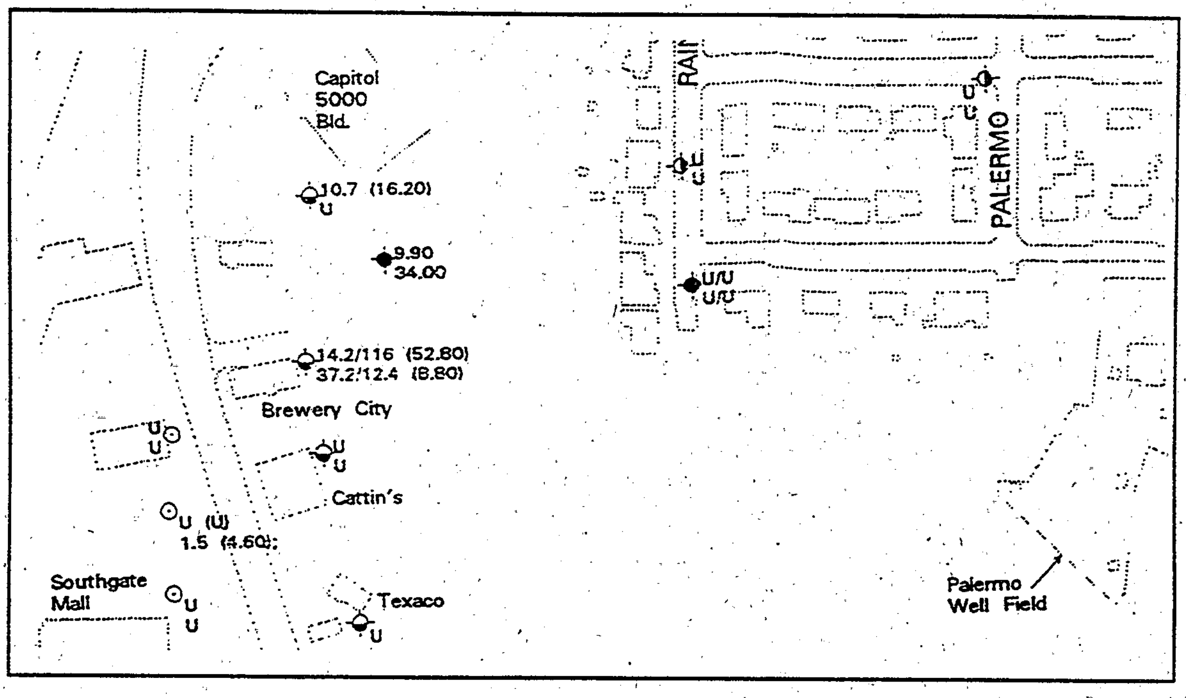


EXHIBIT 4
TCE Concentrations (ppb)

Contaminant	Date	Well #2	Well #4	Well #5
TCE	8/3/93	12.6	1.1	1
	8/11/93	15	2.5	2
	8/12/93	14	3	2
	8/22/93	7	1	3

4.0 RESPONSE ACTIVITIES

Upon confirming the monitoring results, Tumwater informed both the Thurston County Moderate Waste Department and the WSDOE about the contamination. On August 8, 1993, the town informed the public by holding a press conference. During the following months, the City, WSDOE, and EPA Region 10 conducted investigations of the contamination.

4.1 Response to Contamination of the Water Supply

Tumwater responded to the contamination by immediately taking Wells #2, #4, and #5 out of production, imposing emergency water conservation measures, and investigating alternative sources of drinking water. At the time of the contamination incident, the City had two water rights applications before WSDOE. The first was an application for a supplementary water rights permit to allow construction of an additional well at the Palermo wellfield. The second was an application to change the authorized points of withdrawal for several of the Port of Olympia wells. When the contamination occurred, the City amended the permit application for the additional Palermo water right. It sought instead to construct a new well at the George Bush Middle School. Due to the water supply emergency, WSDOE acted rapidly on the amended permit application and issued a construction permit for Well #12 in January 1994. Tumwater began operating Well #12 in June 1994, and WSDOE issued a final permit to withdraw 910 gpm in January 1995. In the meantime, WSDOE acted on the City's Port of Olympia change application by authorizing construction of Well #14 at Bush Middle School in August 1994. The City recently brought the well online.

In 1995, TWS began pilot-scale aeration tests to determine the feasibility of constructing an air stripper at the Palermo wellfield, so it could put the affected wells back in service. Preliminary results show that an air stripper would be very effective.

4.2 Response to Aquifer Contamination

Tumwater's ground water consultant, Pacific Groundwater Group, Inc. (PGG), sampled the Palermo wells, surface water, ground water, soil gas, and soil to determine contamination levels and locate the source of the contamination. Based on the results of ground water modelling, PGG concluded that only Well #2 required continuous pumping to prevent the possible contamination of the other wells. PGG recommended installation of a monitoring well in the wellfield to detect possible movement of contamination toward the unaffected wells. In the meantime, WSDOE identified 19 potential sources of contamination, based on the sources' location in relation to the wellfield and the historical use of the land. WSDOE subsequently narrowed the list down to 13 sources.

At this point, Tumwater and WSDOE turned the investigation over to EPA Region 10. EPA focused on the 13 potential sources, collecting 30 soil gas, 41 ground water, and 34 soil samples. Based on the results of this sampling, EPA narrowed down WSDOE's list to four potential sources of contamination: a WSDOT Materials Laboratory, Southgate Dry Cleaners, Brewery City Pizza, and Tumwater Chevron. Phase II of the investigation began in June 1995 and will be completed by the end of 1995. Phase II consists of ground water, soil, and soil gas sampling at the four suspected sources. EPA estimates that remediation could not begin until the summer of 1996, at the earliest. The remedy, and the duration of remediation, have not been determined.

5.0 COSTS OF CONTAMINATION

The total cost of responding to contamination as of September 1995 is approximately $797,000 (in 1994 dollars). The net present value of expected costs through 2005 is approximately $915,000, assuming a discount rate of 7 percent. Exhibit 5 summarizes costs through September 1995, and Exhibit 6 contains expected costs through September 2005.

5.1 Tangible Costs

Tangible costs consist of the cost to secure alternate sources of drinking water, and the costs to characterize the aquifer contamination and identify potential sources of contamination. The City of Tumwater has incurred the costs to provide safe drinking water, and EPA Region 10 has incurred all but $5,000 of the cost to investigate the contamination.

5.1.1 Costs to Provide Safe Drinking Water

Tumwater incurred a capital outlay for construction of two new wells and has experienced increased operating costs for the three remaining wells in the Palermo wellfield. The total cost for siting and constructing Wells #12 and #14 is approximately $920,000. The *City of Tumwater Comprehensive Water System Plan* (September 1992) indicates that Wells #2, #4, and #5 were in poor condition and were scheduled to be replaced by the end of 1994, at a total cost of approximately $693,079. Thus, the actual incremental capital cost due to the contamination is about $226,921. The difference possibly results from the need to construct transmission lines from Bush Middle School to the distribution system.

Tumwater has increased the frequency of VOC monitoring at the Palermo wellfield, at an additional cost of $1,470 per month. In the 26 months since the contamination was discovered, the cost of this increased monitoring totalled $38,220.

5.1.2 Costs to Remediate the Aquifer

As indicated earlier, Tumwater, WSDOE and EPA Region 10 have conducted two investigations of the contamination at Palermo, at a the total cost approximately $207,000. The City spent $126,000 and WSDOE spent $5,000 for their joint initial investigation. Phase I of EPA's ESI cost approximately $76,000, and Phase II cost approximately $325,400.

Exhibit 5
Cost of Responding to Contamination: Tumwater, WA
August 1993 to September 1995
($1994)

Item	City of Tumwater	WA Dept. of Ecology	EPA Region 10	Total
Provide Safe Drinking Water				
One-time costs				
Replacement wells and transmission line	206,921			$206,921
Staff oversight/administration	20,000			$20,000
SUBTOTAL:	$226,921	$0	$0	$226,921
Incremental operating costs (since August 1993)				
Increased monitoring ($1,470 per month)	38,220			$38,220
SUBTOTAL:	$38,220	$0	$0	$38,220
TOTAL:	$265,141	$0	$0	$265,141
Remediate Aquifer				
Pre-Remediation				
Initial field investigation	120,000			$120,000
Preliminary identification of sources	6,000	5,000		$11,000
Expanded Site Investigation: Phase I			76,000	$76,000
Expanded Site Investigation: Phase II			325,400	$325,400
TOTAL:	$126,000	$5,000	$401,400	$532,400
TOTAL COST:	$391,141	$5,000	$401,400	$797,541

Exhibit 6
Future Cost of Responding to Contamination: Tumwater, WA
October 1995 to September 2005
($1994)

Item	City of Tumwater
Provide Safe Drinking Water	
One-time costs	
Construction of air stripper	$545,899
Engineering/legal/administrative	$139,750
SUBTOTAL:	$685,649
Ongoing costs	
Monitoring	$123,896
Electricity and maintenance	$80,771
Repumping	$24,583
SUBTOTAL:	$229,250
TOTAL COST:	**$914,899**

5.2 Intangible Costs

No firm evidence exists of any impacts on property values in the area, but effects may manifest themselves in the future. A few local real estate agents have noted a slight drop in sale prices and have speculated that the contamination incident may be partly to blame. Also, City officials report that some property owners have expressed concern about the contamination. For example, the owner of some commercial property located near Palermo recently asked the City for reassurance that the incident would not affect his chances of selling the property at a fair price.

6.0 WELLHEAD PROTECTION

Washington's drinking water regulations require public water systems (PWSs) to adopt wellhead protection measures. The Washington State Department of Health's (WSDOH) Wellhead Protection Office is responsible for establishing WHP requirements and providing guidance and technical assistance to PWSs.

6.1 State Requirements for Wellhead Protection

Washington officially adopted its wellhead protection (WHP) regulations in July 1994. The regulations apply to all PWSs in the State, and require that local Wellhead Protection Plans (WHPP) include:

- A delineated wellhead protection area for each well;
- An inventory of potential sources of contamination;
- A management plan to prevent contamination;
- Contingency and spill response plans for responding to contamination; and
- Public participation in the WHP planning process.

The regulations require that PWSs complete these elements according to a specified implementation schedule.

Wellhead Protection Areas (WHPAs) must consist of four or five zones:

- A sanitary control area;

- Three additional zones based on one-, five-, and ten-year time of travel rates; and

- Where appropriate, a larger buffer zone.

The delineation method PWSs must use is based both on system size and on the susceptibility of the well to contamination. The PWS must submit a Susceptibility Assessment Form as part of its WHP effort. Based on how WSDOH ranks the susceptibility of the well, it requires one of the following delineation methods: a calculated fixed radius, an analytically derived model, hydrogeologic mapping, or a numerical flow/transport model. WSDOH requires delineation to be completed by July 1995 for systems using the calculated fixed radius method or by July 1996 for systems using other, more sophisticated delineation methods.

WSDOH requires PWSs to conduct an inventory of potential contaminant sources in their WHPAs. They must compile a list of such sources and notify the appropriate regulatory agencies and local governments, as well as the owners/operators of the potential sources, of their presence in the WHPA. If the PWS fails to do this, it may be held liable in the event of contamination. WSDOH requires completion of the inventory within one year of the completion of the delineation process.

The State requires two management components in the WHPP. The PWS must have both a contingency plan to supply water in the event of contamination and an emergency spill response plan. Both of these plans must be completed within one year of WHPA delineation.

The WHP process in Washington can help systems obtain susceptibility monitoring waivers for Phase II/Phase V regulated compounds, and subsequently reduce monitoring costs. The Wellhead Protection and the Monitoring Waiver processes are closely related: WHPA delineation and source inventories are principal elements of both programs. By completing the WHP process, a PWS also completes a large part of the monitoring waiver process. A typical small to medium PWS can save approximately $5,000 per year in monitoring costs.

The 1990 Washington State Growth Management Act (GMA) requires communities to identify sensitive areas (e.g., aquifer recharge zones) and pass ordinances to protect them. The Act also requires WSDOE to designate ground water protection areas. Counties and cities with high growth rates must develop comprehensive land use plans to protect the quality and quantity of ground water used for public water supplies. Thurston County developed the *Northern Thurston County Ground Water Management Plan* in 1992. The plan established guidelines for wellhead protection plans (similar to the more recent State regulations), and recommended that all major water purveyors establish wellhead protection plans by 1998. Each of the cities in Thurston County—Tumwater, Olympia, and

Lacey—endorsed the plan. They developed a joint Wellhead Protection and Financial Management Committee to coordinate their individual WHP efforts.

6.2 Local Wellhead Protection Plan

In February 1993, Tumwater applied for and received a $170,500 grant from the State of Washington's Centennial Clean Water Fund to develop a comprehensive WHPP. To qualify for the grant, the City provided a $170,500 match for the State funds. The city contracted with Economic and Engineering Services, Inc. (EES) and PGG to develop the program.

To date, Tumwater has passed three aquifer protection ordinances, conducted a preliminary delineation of its wellhead protection areas, developed a preliminary list of potential sources, and ranked the sources according to the threat they pose to Tumwater's wells. The City plans to complete its wellhead protection plan by mid 1996.

6.2.1 Wellhead Area Delineation

PGG used the QuickFlow ground water model to estimate capture zones for six-month, and one-, five-, and ten-year times-of-travel for each of Tumwater's wells. The six-month, one-, five-year time of travel simulation produced three distinct sets of wellhead zones for the Palermo, Bush Middle School, and Port of Olympia wellfields. In contrast, the ten-year zones nearly coalesced into a single zone. Tumwater has adopted a single WHPA encompassing the ten-year time-of-travel zones for Palermo, Bush, and Airport wellfields in order to account for uncertainties in the modelling results.

6.2.2 Source Identification

EES and the City performed a preliminary source identification and developed an initial ranking of contaminated sites within the preliminary WHPA. Later in the WHP effort, the City will conduct a more comprehensive source identification and risk assessment.

In the fall of 1993, EES and the City conducted a "windshield" survey of potential sources in preparation for completing the Department of Health's Susceptibility Assessment Form. The form is the basis for determining whether a system will qualify for monitoring waivers. The survey identified several sources significant enough to warrant follow-up visits to confirm the nature of the suspected source and inform the property owner of its location in the WHPA. During the survey, the City also recorded land uses in the WHPA. EES will use these data to supplement existing land use maps prepared by the City and Thurston County, and then incorporate them into a Geographic Information System.

In addition to the windshield survey, EES reviewed several environmental databases maintained by WSDOE. These included the Leaking Underground Storage Tank List, the Confirmed and Suspected Contaminated Sites Report, Superfund Amendments and Reauthorization Act (SARA) Tier Two Emergency and Hazardous Chemical Inventory Forms, the Underground Storage Tank list, and the Washington Toxics Release Inventory.

EES developed qualitative criteria for ranking the threats posed by these sources. They included:

- Contaminant characteristics (e.g., toxicity, mobility, persistence);
- Hydrogeologic properties (e.g., aquifer in which the nearest well is screened, travel time to the well);
- Location (e.g., 6-month, one-, five-, ten-year time-of-travel zone, Wellhead Protection Area, above or below ground surface); and
- Extent of known soil and ground water contamination.

EES ranked all confirmed sources of contamination using the criteria. Prior to the conclusion of the WHP effort, the City will use the criteria to rank all potential sources identified in the WHPA.

The preliminary survey identified several contaminated sites of particular concern. These include four sites with confirmed ground water and/or soil contamination within the ten-year time-of-travel zones of Wells #9, #10, and #15. The contaminants present include petroleum, chlorinated solvents, and phenols. The survey also identified two leaking petroleum USTs within the five-year time-of-travel zone of the Palermo wellfield.

Using volunteers, the TWS conducted a parcel-by-parcel survey of potential contamination sources in the summer of 1995. As of September 1995, analysis of the survey data has not been completed.

6.2.3 Ground Water Monitoring

Tumwater's wellhead protection effort includes the development of a ground water monitoring network. In its monitoring work plan, PGG recommended construction of five monitoring wells in addition to monitoring wells Tumwater currently operates. The wells will be located either immediately downgradient of known contamination sites or upgradient of PWS wells. One of the proposed monitoring wells will be located immediately downgradient of a Texaco bulk fuel facility where a spill occurred (northwest of Wells #9 and #10), and two will be located southeast of the Palermo wellfield. PGG also recommended using private wells further upgradient of Tumwater's wells to monitor nonpoint contamination.

Based on PGG's recommendation, the City is conducting baseline water quality monitoring in September and October of 1995. The monitoring focuses on VOCs, several inorganics, phenols (near certain industrial sites), and pesticides (near a Christmas tree farm). Beyond the baseline monitoring, long-term monitoring probably will consist of annual monitoring for VOCs and a limited number of inorganics within the five-year time-of-travel zones. The City will monitor for nonpoint contaminants (e.g., nitrate, iron, and manganese) in several private wells.

The Thurston County Public Health Department has six monitoring wells located in Tumwater's preliminary WHPA. Currently, the wells are used to monitor ground water levels; however, the County lacks funding to continue the monitoring effort.

PGG's monitoring work plan calls for maintaining data in a format compatible with data being collected by the Cities of Lacey and Olympia, and by Thurston County. By sharing data, the communities will be able to identify regional ground water quality trends.

6.2.4 Management Plan

EES is developing a management plan for Tumwater's WHPA, which should be completed in mid 1996. According to the wellhead protection work plan, the management plan will consist of recommendations for land use controls, operating standards for sources, and public education.

Although Tumwater does not yet have a formal management plan, it has previously undertaken several activities traditionally associated with wellhead protection management strategies. Pursuant to the GMA, the City developed a *Conservation Plan* which recommends that the city adopt ordinances to protect aquifer recharge areas from contamination.

Ordinances 1279 and 1280, passed in August 1991, designate an aquifer protection overlay zoning district to protect vulnerable aquifer recharge areas in the City. The ordinances prevent the following industries from locating within the district, unless they demonstrate that new technologies and/or application of best management practices will result in no additional threat to ground water:

- Chemical manufacture and reprocessing;
- Creosote/asphalt manufacture or treatment;
- Electroplating;

- Manufacture of flammable or combustible liquids;
- Petroleum products refining and reprocessing;
- Wood products preserving; and
- On- and off-site hazardous waste treatment and storage.

Ordinance 1281, also passed in 1991, requires that new development in the City be designed to eliminate the threat of chemical or biological contaminants' entering ground water. The Ordinance requires that:

- The public works director develop performance standards for stormwater retention facilities;
- New USTs have liners or double hulls, and release detection systems; and
- Above-ground tanks have impervious containment structures underlying and surrounding them.

Developers of projects located outside the aquifer protection district may submit an aquifer protection plan in lieu of meeting the requirements. They must, however, demonstrate that the plans provide equivalent protection of ground water.

6.2.5 Contingency Plan

EES will develop contingency and spill response plans. The contingency plan will analyze alternative source options given existing water rights. The spill response plan will include proposed enhancements to the city's existing spill response efforts.

7.0 COSTS OF WELLHEAD PROTECTION

Tumwater's Centennial Fund grant application projects that the WHPP will cost $348,000 (See Exhibit 7). This total includes both consultant costs and the labor costs of city staff. Consultant invoices submitted to date indicate that the cost is running slightly lower than expected.

Tumwater's wellhead protection work plan is divided into six tasks: (1) project management, (2) establish wellhead protection areas, (3) wellhead inventory/test well construction, (4) wellhead protection management strategies, (5) contingency and spill response plans, and (6) final wellhead protection plan document. The project management

Exhibit 7
Cost of Wellhead Protection: Tumwater, WA
February 1993 to September 1995
($1994)

Item	City of Tumwater	Centennial Clean Water Fund	Total
WHPP Development			
Project Management			
Prepare monthly reports			
Provide status briefings			
SUBTOTAL:	$26,331	$26,331	$52,662
Establish Wellhead Protection Areas			
Review existing aquifer characterization data			
Review WSDOE databases on potential contaminant sources			
Develop a preliminary threat ranking			
Prepare work plan for field work			
Model preliminary wellhead protection areas			
Establish final wellhead protection areas			
SUBTOTAL:	$26,440	$26,440	$52,880
Wellhead Inventory/Test Well Construction			
Inventory contamination sources			
Identify private wells for water quality monitoring			
Develop data system			
Construct monitoring wells			
Sample ground water			
Incorporate sampling data into data system			
SUBTOTAL:	$56,693	$56,693	$113,386
Wellhead Protection Management Strategies			
Develop plan for public involvement			
Establish local wellhead protection committee			
Compile information on management strategies used by other PWSs			
Develop a pollution prevention plan			
SUBTOTAL:	$20,493	$20,493	$40,986
Contingency/Spill Response Plans			
Develop contingency/spill response plans			
SUBTOTAL:	$21,978	$21,978	$43,956
Final Wellhead Protection Plan Document			
Develop plan document			
Transmit to WSDOE			
SUBTOTAL:	$21,978	$21,978	$43,956
TOTAL COST:	$173,913	$173,913	$347,826

task, budgeted at $52,662, includes activities such as monthly reporting and preparing status briefings for the Tumwater City Council. The remaining tasks are described below:

- Task #2 includes activities such as reviewing existing aquifer characterization data, reviewing WSDOE databases on potential contaminant sources, developing a preliminary threat ranking, developing a work plan for field work, modeling preliminary wellhead protection areas, and establishing final wellhead protection areas. The budget calls for a total expenditure of $52,880.

- Task #3 consists of comprehensive inventories of contamination sources and private wells that could be used for water quality monitoring, development of a data system, construction of monitoring wells, ground water sampling, and incorporation of sampling data into the data system. According to the work plan, the cost of these activities is $113,385.

- Task #4 calls for developing a plan to involve the public, establishing a local wellhead protection committee, compiling information on management strategies used by other PWSs, and developing a pollution prevention plan. The work plan projects a total cost of $40,985.

- Task #5 calls for developing contingency and spill response plans; the total cost is estimated to be $17,645.

- Task #6 includes production of the final wellhead protection plan document and transmitting it to WSDOE and WSDOH. The work plan calls for a total expenditure of $23,165.

Implementation costs are difficult to determine, since the management plan has not been developed. Other cities in Thurston County have demonstrated a willingness to spend significant funds to implement their WHPPs. For example, the City of Lacey's draft WHPP calls for an annual expenditure of about $110,000. Thurston County officials expect that Tumwater's plan will be similar to Lacey's. Given that TWS is about half the size of the Lacey PWS, an annual expenditure of about $55,000 is probably realistic.

Because the Tumwater wellhead protection effort is just getting underway, it does not appear to have imposed any indirect costs on Tumwater residents. In contrast, Tumwater's aquifer protection ordinances have probably increased costs for proposed construction projects in the aquifer protection district. Since the ordinances largely restate other federal and state regulatory requirements, the costs are not attributable to wellhead protection.

8.0 CONCLUSIONS

As of September 1995 the cost of contamination at the Palermo wellfield is approximately $797,541; expected costs through September 2005 are approximately $914,899. Thus, the total cost of contamination is expected to exceed $1.7 million, or $570,000 per well.

The total cost to develop Tumwater's WHPP is approximately $347,826. Annual implementation costs are difficult to determine, but they are likely to be in the $55,000 range. Assuming that implementation begins in 1997, the net present value of wellhead protection activities through 2005 is approximately $328,400. Thus, total wellhead protection costs are approximately $676,226, or about $52,017 per well.

9.0 REFERENCES

Callison, Kathleen. Water Resources Specialist, City of Tumwater. Personal Interview, February 23, 1995.

City of Tumwater. *FY 1994 Budget.* (undated).

City of Tumwater. *Centennial Clean Water Fund Grant/Loan Application.* February 16, 1993.

City of Tumwater. Water Service Regulations. Chapter 13.04. August 1992.

Economic and Engineering Services, Inc. *City of Lacey Wellhead Protection Plan (Draft).* November 1994.

Hedges, Jane. Manager, Resources Protection Program, Thurston County Public Health and Social Services Department. Personal Interview, February 22, 1995.

Jennings, David. Director, Wellhead Protection Program, Washington State Department of Health. Personal Interview, February 22, 1995.

1990 Session Laws of the State of Washington. *Growth Management Act.*

1991 Session Laws of the State of Washington. *Growth Management Act.*

Pacific Groundwater Group. *Summary Report: Tricholoroethene Contamination at the Palermo Well Field, City of Tumwater.* September 1993.

Pacific Groundwater Group and Economic and Engineering Services, Inc. *Preliminary Characterization and Proposed Work Plan: Tumwater Wellhead Protection Program.* January 1995.

Post, Rusty. Washington Department of Ecology. Telephone Interview.

RH2 Engineering. *City of Tumwater Comprehensive Water System Plan.* September 1992.

Rolluda, Monica. Site Assessment Manager, Hazardous Waste Division, U.S. EPA Region 10. Personal Interview, February 24, 1995.

Roy F. Weston, Inc. *Field Operations Work Plan; Soil Gas, Groundwater, and Soil Sampling; Palermo Well Field Test; Tumwater, Washington.* October 1994.

Roy F. Weston, Inc. *Trip Report; Soil Gas, Groundwater, and Soil Sampling; Palermo Well Field ESI.* February 2, 1995.

Thurston County Health Department. *Northern Thurston County Ground Water Management Plan.* September 1992.

Washington State Department of Ecology. *Permit Handbook: Commonly Required Environmental Permits for Washington State.* November 1994.

Washington State Department of Health. Division of Drinking Water. *Pesticide Monitoring Waivers for Public Water Systems.* December 1994.

Washington State Department of Health. Division of Drinking Water. *Susceptibility Assessment Survey Packet.* April 1994.

Washington State Department of Health. Division of Drinking Water. *Group A Public Water Systems (Chapter 246-290 WAC).*

Washington State Department of Health. Wellhead Protection Program. *Washington State Wellhead Protection Program.* December 1993.

Washington State Department of Health. Wellhead Protection Program. *Inventory of Potential Contaminant Sources in Washington's Wellhead Protection Areas.* December 1993.

Contract No. 68-C4-0011
Work Assignment No. 1-14

Benefit/Cost Analysis of Preventing Contamination: City of Middletown, Ohio

September 30, 1995

Submitted to:

U.S. Environmental Protection Agency
Ground Water Protection Division
Technical and Information Management Branch

TABLE OF CONTENTS

LIST OF EXHIBITS

BENEFIT/COST ANALYSIS OF PREVENTING CONTAMINATION MIDDLETOWN, BUTLER AND WARREN COUNTIES, OHIO

In 1985 the City of Middletown, Ohio began monitoring its production wells for Volatile Organic Compounds (VOCs), as required by the Ohio Environmental Protection Agency (OEPA). In the initial round of sampling, VOCs were detected in four of the city's 16 wells. Since 1985, tetracholorethylene (PCE) has been detected continuously in three wells, and intermittently in two others. The City shut-down one well in 1985, and two more wells in 1988. Investigations by the City and OEPA traced the contamination to AEP Flexo, Inc., which manufactured flexographic printing plates between 1984 and 1990 in an industrial park near the wellfield. OEPA entered into a consent decree with AEP Flexo in July 1993. Pursuant to the decree, AEP Flexo is investigating the extent of the contamination and undertaking interim measures to halt the spread of contaminants.

Middletown began developing a wellhead protection program (WHPP) in 1991 as a result of the contamination incident and an OEPA requirement that water suppliers in vulnerable areas undertake wellhead protection (WHP) in order to gain approval for water system improvements. To date, the city has delineated its wellhead protection area (WHPA), developed a management plan and a public education campaign, conducted source identification, and prepared draft contingency and groundwater monitoring plans. The public education effort was funded in part by a $12,000 U.S. EPA demonstration grant. The City is in the process of establishing a WHP fee and plans to adopt an overlay zoning ordinance in 1996.

1.0 COMMUNITY DESCRIPTION

The City of Middletown is located in southwestern Ohio, about half way between Cincinnati and Dayton. The PWS is operated by the City of Middletown Department of Public Works (MDPW). Middletown has a population of approximately 50,000.

1.1 Land Use

Middletown contains a wide variety of land uses, including residential, light industrial, commercial, and heavy industrial. Several large industrial sites, including a steel mill and a paper manufacturer, operate in the vicinity of the wellfield.

1.2 Geology/Topography

Geology in southwestern Ohio is the result of glacial activity. At least two major episodes of glacial advance and retreat, and drainage from glacial rivers have deposited tills within the region. Valley fill sediments consist of sand and gravel glacial outwash. Lenses of ice-deposited clay tills also exist within the sediments underlying the region. Typical stratigraphy in Butler County consists of 25 to 50 feet of sand/gravel alluvium, underlain by 10 to 40 feet of clay, clay-till, or till. Beneath the till layer is up to 125 feet of outwash deposits (sand and gravel), which overlie the Ordovician-age shales and limestone bedrock. The City of Middletown is located on the floodplain of the Great Miami River.

1.3 Hydrology

Ground water resources in the region are dominated by the Great Miami Buried Valley Aquifer (MBVA) System. This highly productive aquifer system consists of sand and gravel interbedded with low-permeability tills, which effectively divide the aquifer into lower and upper producing zones.

At the wellfield, ground water in the shallow aquifer zone flows from north-northwest to south-southeast, roughly following the bedrock valley walls. In the deeper zone, groundwater movement is toward the south-southwest (this may be due to pumping from production wells at the Sorg Paper Company nearby). The upper aquifer is unconfined; the lower zone is semi-confined, due to the presence of the leaky confining till layer. Water levels in the aquifer system mimic the surface elevation. Precipitation recharge to the aquifer system in undeveloped areas is about 12 inches per year.

1.4 Climate

The average January temperature in southwestern Ohio is 27 degrees; average July temperature is 74 degrees. Average monthly precipitation ranges from a low of 1.9 inches (in October) to a high of 4.0 inches during the summer months.

2.0 PWS CHARACTERISTICS

The Middletown PWS serves the entire city of Middletown and parts of adjoining Madison, Lemon, Franklin, and Turtle Creek Townships. Treatment consists of lime softening (to reduce hardness), filtration, and chlorine disinfection. The PWS maintains about 318 miles of mains, ranging from 4 inches to 30 inches in diameter; a reservoir; and three elevated storage tanks. The wellfield, located along Carmody Boulevard between the municipal airport and the Great Miami River, has 13 operating wells.

2.1 Water Supply

Between 1992 and 1994, the PWS delivered an average of 10.6 million gallons per day (MGD) to its customers. Flow ranges from about 7.0 MGD in the winter to about 14.0 MGD during the summer months. Twenty-seven monitoring wells allow the city to monitor the quality of water entering the well field, including 14 at the periphery and 13 downgradient from the Middletown City Landfill.

Two industrial users operate wells downgradient from the wellfield. Sorg Paper Company operates four production wells about 1,000 feet to the south of the wellfield, and Armco Steel Company operates five production wells 1.5 miles south of the wellfield.

Middletown's 13 operating wells tap the MBVA, designated by U.S. EPA as a sole source aquifer system. In the vicinity of the wellfield, the till layer is 25 to 35 feet thick, dividing the aquifer into lower and upper producing zones. The 13 wells tap either the shallow or the deep zone, and have a combined rated capacity of 21,614 MGD. Water quality is generally good; however, the water is naturally hard and contains concentrations of iron and manganese. Substantial evidence indicates that wells CW-6, CW-7, CW-12, CW-14, and CW-16 recharge from the Great Miami River. Exhibit 1 summarizes Middletown's water source characteristics.

MDPW has identified a potential site for an additional well near the airport and has submitted pump test data to OEPA for approval. The City hopes that the well will be on-line by the end of 1995. The PWS's Master Plan calls for three additional wells by the year 2000.

EXHIBIT 1
Water Source Characteristics

Well	Average Depth (feet)	Aquifer	Well Capacity (gal/day)
CW-1	40	shallow	Disconnected
CW-2	180	deep	Abandoned
CW-3A	175	deep	1,200
CW-4/5	37	shallow	Disconnected
CW-6	178	deep	1,350
CW-7	181	deep	855
CW-8	199	deep	1,178
CW-10	43	shallow	1,075
CW-11	42	shallow	1,176
CW-12	43	shallow	1,044
CW-13	46	shallow	1,121
CW-14	42	shallow	1,183
CW-15	47	shallow	1,060
CW-16	51	shallow	1,103
CW-17	140	deep	1,548
CW-18	140	deep	1,119

2.2 Financial/Management Characteristics

MDPW maintains a separate enterprise fund for its water utility. The PWS's FY 1994 operating budget was approximately $3.1 million. In that year, the City undertook $0.9 million in capital improvements and retired $3.0 million in debt. Revenue included approximately $5.2 in customer payments and $3.0 million from bond sales. The fund had a cash balance of $3.2 million at the end of the year.

Middletown has a uniform water rate structure. The PWS raised water rates 5 percent in 1992, 1993, and 1994, and projects that another rate increase will be required in 1997. Water rates are relatively low compared to other southwest Ohio communities. Residential customers pay an average of $46.10 per quarter, compared to the regional average of $61.79.

2.3 Population Served

The PWS serves a population of approximately 60,000 persons in Middletown and parts of adjoining Madison Township. The PWS has approximately 20,400 service connections, of which 18,600 are residential, 1,700 are commercial, and 100 are industrial.

3.0 CONTAMINATION

In 1985 Middletown discovered chlorinated VOCs in four of its wells (CW-1, CW-2, CW-3A, and CW-4/5) during initial routine monitoring. Between 1985 and 1990, tetrachloroethene (PCE) has been detected consistently in three wells (CW-1, CW-2, and CW-4/5) and occasionally in two other wells (CW-14, CW-18). Exhibit 2 summarizes contaminant concentrations for the period.

EXHIBIT 2
Contaminant Concentrations

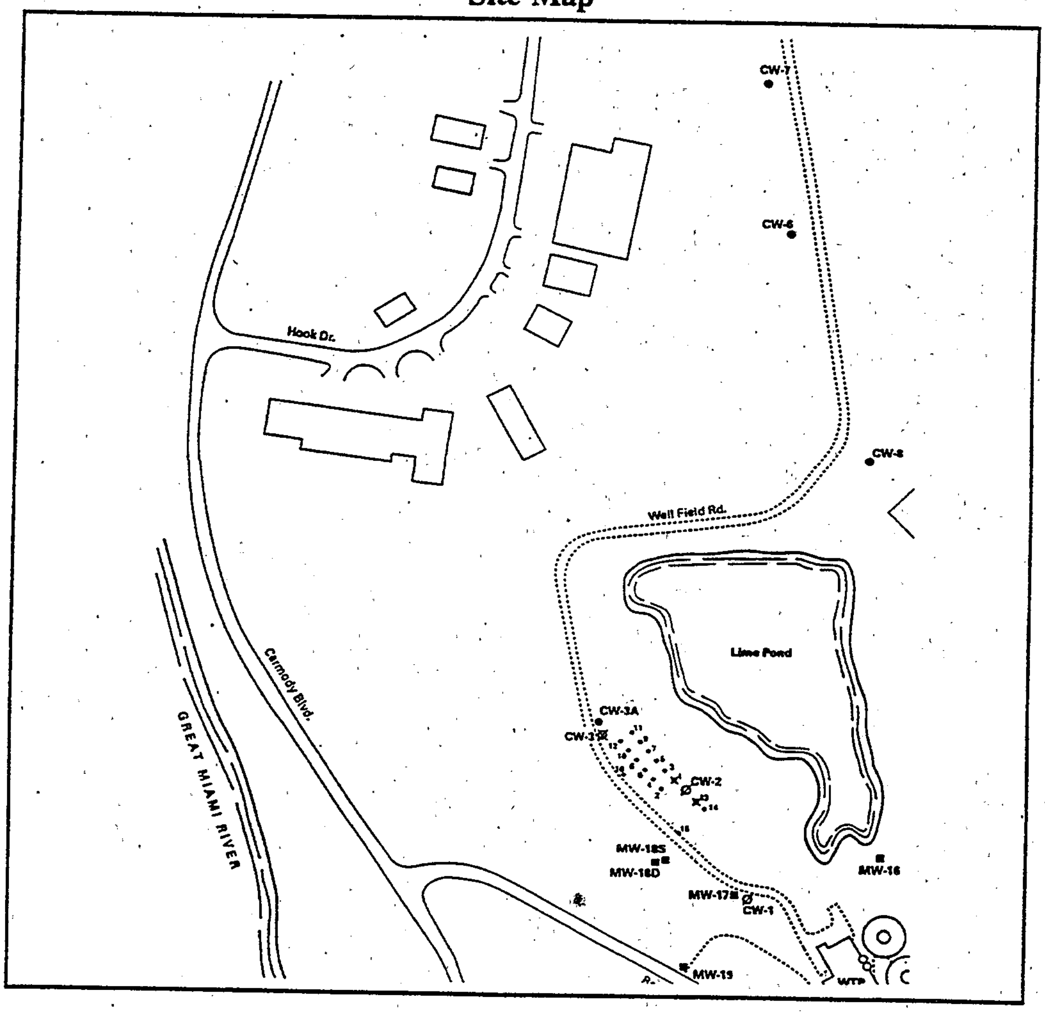
Constituent	Concentration (ug/l)				
	2/27/85	11/26/85	9/4/87	8/29/89	2/9/90
CW-1					
PCE	4.6		662.0		67.7
TCE	<1.0			9.97	
c-1,2-DCE				33.6	
CW-2					
PCE	3.4	103.0	102.0		104.0
CW-4/5					
PCE	30.4	314.0	192.6		64.6
TCE	5.3				
1,1,1-TCA	1.0				

3.1 Contamination Source

MDPW retained CH2M Hill, Inc. to characterize the contaminant plume. Sampling results identified three possible sources of contamination on Hook Drive: a business in the Hook Drive Industrial Park, the storm sewer, or the sanitary sewer. The storm sewer drains the Hook Drive area and discharges into a lime pond in the vicinity of the wellfield. The MDPW discharges effluent from is water softening operation to the lime pond, which is hydrologically connected to the upper aquifer.

CH2M Hill recommended that the city conduct a soil gas survey and install additional monitoring wells to further narrow the source of contamination. OEPA subsequently conducted a soil gas survey, and MDPW installed three additional monitoring wells. OEPA identified AEP Flexo, Inc., a manufacturer of flexographic printing plates located in the Industrial Park, as the source. Interviews with AEP Flexo employees revealed that numerous spills had occurred from a distillation unit onsite, and that the liquids were squegeed out a plant door. Exhibit 3 is a map of the wellfield area.

EXHIBIT 3
Site Map



3.2 Contaminants

CH2M Hill collected ground water samples in late 1990. PCE concentrations in the shallow aquifer ranged from 1.3 ug/l to 96.2 ug/l. In the deep aquifer, PCE was found only in the vicinity of CW-2. Two shallow borehole samples contained toluene at concentrations of 2 ug/l and 3.4 ug/l, but it was not detected in monitoring wells. PCE concentrations were higher in the northern part of the sampling area and decreased toward the south.

CH2M Hill suggested that the contamination in the deep aquifer could be related to a problem with the well casing in CW-2, and recommended further investigation. MDPW later determined that the well's casing was corroded.

3.3 Effects of Contamination

No evidence of health or ecological effects from the contamination exists. EPA has classified PCE as a probable human carcinogen. Fortunately, MDPW discovered the contamination before it entered the distribution system in concentrations above national drinking water standards.

4.0 RESPONSE ACTIVITIES

Middletown and AEP Flexo (under OEPA supervision) are conducting separate response activities. Under its consent decree, AEP Flexo is characterizing the contamination at the site, and has proposed several interim measures to halt the spread of contamination offsite. Middletown shut down three contaminated wells and has begun siting new wells.

4.1 Response to Contamination of the Water Supply

Upon discovering the contamination, the City shut down Well CW-4/5 in 1985, and Wells CW-1 and CW-2 in February 1988. MDPW disconnected both wells from the distribution system in March 1990. An investigation determined that CW-2 lacked mechanical integrity and had allowed contamination to flow from the upper to the lower aquifer, so MDPW abandoned it. The other two wells have not been abandoned to date.

MDPW is in the process of siting two new production wells, scheduled to come online before the end of 1997. In the meantime, MDPW has been operating its remaining 13 wells more frequently to compensate for the loss of the three wells. Some evidence exists that increased pumping is beginning to draw the contamination toward the other wells. MDPW is considering at least two options for reversing the plume's migration. One option is to construct one or two air strippers in the wellfield. A second option is to pump contaminated water from CW-1 to the Sorg Paper Company, where it would be used to cool equipment. The VOCs would be removed from the water during the cooling process.

4.2 Response to Aquifer Contamination

As discussed above, MDPW retained the services of CH2M Hill to assess potential sources of the VOC plume in 1990. In its investigation, CH2M Hill surveyed potential sources of contamination along Hook Drive, installed monitoring wells, reviewed aerial photographs of the area surrounding the wellfield, met with city personnel to discuss past activities that have occurred near the wellfield, and reviewed Ohio Department of Natural Resources records to identify other wells in the vicinity of the wellfield.

OEPA's soil gas investigation determined that the source of the contamination was AEP Flexo, Inc. OEPA entered into a consent decree with AEP Flexo in July 1993. Under the decree, AEP Flexo is conducting a Focused Site Characterization (FSC) to characterize the sources of contamination at the site, determine site physical characteristics, develop cleanup goals, and obtain all other data necessary to design and implement source control interim actions (SCIAs).

In June 1995, AEP Flexo submitted a draft report to OEPA. The report recommended soil vapor extraction (SVE) in combination with air sparging as the most appropriate technologies to remediate soil at the site. VOCs would be removed from air emissions from the soil treatments with carbon absorption units. The proposed SCIAs are currently being reviewed by OEPA. Cleanup of the aquifer itself does not appear to be under consideration at present. Because enforcement activities are continuing, the Cadmus project team was denied access to OEPA files in order to collect more information on the nature of the SCIAs under consideration.

5.0 COSTS OF CONTAMINATION

5.1 Tangible Costs

Middletown and AEP Flexo have incurred contamination-related costs. The City's costs include the costs of investigating the source of contamination, closing the contaminated wells, and modifying other wells to allow increased pumping. AEP Flexo's costs include the costs to investigate contamination, install and maintain SCIAs, and reimburse OEPA for its oversight costs. Exhibit 4 summarizes the costs of responding to contamination through September 1995, and Exhibit 5 presents expected future costs through September 2005.

Exhibit 4
Cost of Responding to Contamination: Middletown, OH
December 1990 to September 1995
($1994)

Item	City of Middletown	AEP Flexo, Inc.	Total
Provide Safe Drinking Water			
One-time costs			
Field investigation of contamination	342,000		$342,000
Well abandonment	51,000		$51,000
Monitoring well installation	114,000		$114,000
Upgrade other wells	204,000		$204,000
Increased monitoring	16,128		$16,128
Litigation	5,100		$5,100
TOTAL:	$732,228	$0	$732,228
Remediate Aquifer			
Pre-remediation			
Field investigation	0	45,861	$45,861
TOTAL:	$0	$45,861	$45,861
TOTAL COST:	$732,228	$45,861	$778,089

Exhibit 5
Future Cost of Responding to Contamination: Middletown, OH
October 1995 to September 2005
($1994)

Item	City of Middletown
Provide Safe Drinking Water	
One-time costs	
Well abandonment	70,093
Construction of two new wells	122,159
SUBTOTAL:	$192,253
Potential costs(1)	
Construction of air strippers	280,374
Electricity	210,707
Maintenance	14,047
SUBTOTAL:	$505,128
TOTAL COST:	$192,253-$697,381

Notes:
(1) If Middletown chooses air stripper option.

5.1.1 Costs to Provide Safe Drinking Water

The total cost of the city's response activities through September 1995 is approximately $655,000 ($732,228 in 1994 dollars). These costs include:

- $300,000 ($342,000 in 1994 dollars) for the field investigation of the contamination;
- $50,000 ($51,000 in 1994 dollars) for plugging well CW-2;
- $100,000 ($114,000 in 1994 dollars) for installation of monitoring wells;
- $200,000 ($204,000 in 1994 dollars) for contamination-related improvements to the remaining wells;
- $21,600 ($16,128 in 1994 dollars) for additional VOC monitoring[1]; and
- $5,000 ($5,100 in 1994 dollars) for litigation.

Between October 1995 and September 2005, MDPW expects to abandon wells CW-1 and CW-4/5 and construct two new production wells. If the contamination had not occurred, MDPW probably would not have to construct new wells until the year 2000. The net present value of these expected activities is $192,253, assuming a discount rate of 7 percent. The present value of the well abandonment is $70,093 and the net present value of incremental cost of well construction is $122,159.[2]

Middletown is considering at least two options to halt the spread of contamination toward its other wells. The net present value of the air stripper option is approximately $505,128. The largest component of the total, construction of the air strippers, is $280,374. Operating costs for the air stripper would consist primarily of electricity and periodic replacement of the media. The net present value of these items is $210,707 and $14,047, respectively.

[1]MDPW sampled its 13 operating wells for VOCs each quarter, rather than the one sample required by regulations.

[2]Defined as the difference between the present worth of the wells in 1996 and the present worth of the wells in 2000.

5.1.2 Costs to Remediate the Aquifer

Many of the costs associated with the investigation of the contamination at the AEP Flexo site cannot be determined. AEP Flexo is conducting a Focused Site Characterization according to the terms of its consent decree with OEPA. The firm would not provide Cadmus with information on the cost of these activities. As noted above, the City's investigation of the contamination cost $300,000 ($342,000 in 1994 dollars). It is reasonable to assume that AEP Flexo is spending a similar amount in its investigation. OEPA's oversight costs over the last three years total $44,821 ($45,861 in 1994 dollars). Under the terms of the consent decree, AEP Flexo is reimbursing the agency for its oversight costs.

5.2 Intangible Costs

In addition to forcing the closure of three public wells, the contamination has raised fears among business owners in the Hook Drive Industrial Park. For example, a business owner expressed concern that he would not be able to sell his building because the contaminant plume extended under his property.

6.0 WELLHEAD PROTECTION

Ohio EPA's Division of Drinking and Ground Waters is the lead agency for implementing wellhead protection in Ohio. Ohio EPA provides technical guidance and assistance to PWSs and is also responsible for reviewing local WHP plans. EPA approved Ohio's Wellhead Protection Program in May 1992.

Wellhead protection is voluntary in Ohio; however, OEPA is requiring WHP as a condition for approval of water system improvements. To promote interest among communities, the state offers incentives such as waivers from monitoring requirements to communities that adopt WHP. If communities demonstrate that there are no hazardous chemicals in use within a certain radius of the wellhead areas (the radius depends on the well's pumping capacity), Ohio EPA may issue monitoring waivers.

6.1 State Requirements for Wellhead Protection

Ohio's Ground Water Protection and Management Strategy is comprised of seven activities to protect ground water resources.

- **WHPA delineation.** Ohio recommends that communities delineate a five-year time of travel zone around each well or wellfield, in addition to a one-year time of travel inner management zone. Ohio's plan recognizes the variety of geologic settings and available technical and financial resources among communities, and allows a flexible approach to WHPA delineation methods. Depending on local geology, delineation methods ranging in complexity from a simple calculated fixed radius to computer models may be used.

- **Pollution source inventory.** Water purveyors must report an inventory of all potential contamination sources as part of their local WHP plans. Ohio EPA has developed standards and formats for reporting pollutant source data.

- **Management strategy.** Ohio EPA considers establishing and maintaining a comprehensive coordinated ground water management plan the most important element of an effective local WHP plan. Communities' management plans differ depending on the type of system and the population served. Ohio is developing a generic "check list" or "fill-in-the-blank" model management plan which could assist smaller systems in developing an appropriate WHP plan.

- **Ground water monitoring.** All systems must prepare a monitoring plan that assesses the need for ground water monitoring and, if needed, would provide early warning of ground water contamination. If purveyors can demonstrate that no major pollution sources may potentially contaminate groundwater, they may request a monitoring waiver.

- **Contingency planning.** Communities must provide evidence they are prepared for emergencies and can provide alternative sources of water. Ohio's WHPP expands upon the requirements of Ohio regulations for PWSs to develop and maintain contingency plans.

- **Public involvement/education program.** Communities must inform people who live and work near wellhead areas of the WHP plan and provide them opportunities for involvement in the WHP planning process.

- **Protection of new wellfields.** Ohio's wellhead protection program directs communities to protect proposed wells and wellfields. If new wells are needed, communities must take steps to secure and protect new sites from potential contamination. In the future, Ohio EPA may request that water purveyors submit an estimated WHPA and source inventory as part of new water source applications.

6.2 Local Wellhead Protection Plan

Middletown began its WHPP in 1991 in response to the contamination incident. OEPA made completion of Middletown's WHPP a condition for approval of $3.6 million in water system capital improvements in 1993. A key element of the effort was the creation in

June 1992 of a wellfield protection committee (WFPC) composed of representatives from the City of Middletown, and Butler and Warren Counties. The WFPC developed a public education campaign and a wellfield protection plan.

6.2.1 Wellhead Protection Area Delineation

CH2M Hill collected hydrogeological data for the area around the wellfield, developed a numerical model, and delineated one- and five-year time of travel zones using the MODFLOW code. The one-year time-of-travel zone is known as the Inner Management Zone (IMZ), and the five-year zone is known as the Wellfield Protection Area (WFPA). The WFPA extends into adjacent Madison Township.

6.2.2 Source Identification

City staff and CH2M Hill conducted a contaminant source inventory in late 1990 and early 1991. CH2M Hill consulted several databases of potential contaminant sources: a list of hazardous waste sites maintained by OEPA; the State Fire Marshal's list of USTs; the State Emergency Response Commission's SARA Title III Right-to-Know notifications; and aerial photographs of the city. City staff supplemented the database search with a windshield survey of major roads in the estimated capture area.

The source identification effort located approximately 80 actual and potential sources within the WFPA. These included several major industrial sites, such as Sorg Paper Company, Aeronca Aerospace, a former Diamond International Plant, Hook Drive Industrial Park, several aggregate mines, and the Middletown City Landfill. Commercial sites included several service stations, auto repair facilities, and dry cleaners; the City's vehicle maintenance area, and the municipal airport. Several major transportation routes cross the WHPA, including State Highways 4, 73, and 122; Carmody Boulevard; a CSX railroad line; the Great Miami River; and the Middletown Hydraulic Canal.

CH2M Hill staff divided the source list into high and moderate priority categories, based on the level of threat posed by the source. High priority sites consisted of confirmed sources of contamination and potential sources with liquid chemical storage exceeding 500 gallons. Three confirmed sources of contamination lie within the one- and five-year time-of-travel zones:

- ***Middletown city landfill***. Shallow groundwater in the shallow aquifer has been found to contain elevated dissolved solids, high alkalinity, heavy metals, and 1,1-dichloroethane (1,1-DCA). The landfill lies within the five-year time of travel zone.

- ***Sorg Paper Company.*** The paper company previously operated four USTs containing a variety of solvents, including methyl ethyl ketone, toluene, naptha, and lactol spirits. A groundwater sample collection from a monitoring well in the vicinity of the tanks had a toluene concentration of 0.13 mg/l. Part of the facility lies within the one-year time-of-travel zone.

- ***AEP Flexo, Inc.*** The Flexo site falls within the one-year time-of-travel zone.

The WFPA contains a total of 23 high priority sites and 61 medium priority sites. CH2M Hill noted that the Great Miami River is a potential source of contamination. Because the river is hydrologically connected to the shallow aquifer, any spill or discharge upstream from the wellfield has the potential to contaminate it.

As part of keeping the source inventory updated, Middletown is considering a proposal to forward copies of new building permits and chemical inventory information maintained by the fire department to the MDPW for sites located within the WHPA.

6.2.3 Ground Water Monitoring

CH2M Hill identified seven high priority areas for ground water monitoring. These sites have a high potential for contaminating the wellfield because of their close proximity or the types of chemicals used or stored on the site. They include the Hook Drive Industrial Park, the municipal airport, the city landfill, and Sorg Paper Company. CH2M Hill recommended constructing seven additional monitoring wells at five locations immediately downgradient from the priority source areas. Existing monitoring wells appeared sufficient to monitor water quality in the vicinity of the municipal landfill and Sorg Paper Company.

6.2.4 Management Plan

In December 1993 the WFPC completed a draft management plan which consists of the following components:

- ***Zoning overlays.*** Different zoning overlays would be created in the IMZ and in the WFPA. Within the IMZ, the City would adopt the "Intensity of Land Use Classification" approach developed by the City of Dayton. Each parcel of land would be assigned a rating on a scale from 1 to 9, based upon the maximum quantities and types of chemicals used or stored on the site. Data acquired through inventory forms submitted by the site and annual inspections would be used to determine the rating. No increase in the hazard ranking would be permitted. Any land owner wishing to undertake activities which would result in an increase in the site's ranking would be required to install additional engineering controls and adopt risk management measures so that the site remained at the original ranking. Within the WFPA, owners would be required to submit inventories of SARA Title III chemicals stored or used onsite. In addition, downgradient monitoring may be required. The City would establish a Risk Management Reserve Fund to provide grants or low-interest loans to individual businesses to improve or upgrade facilities as necessary to meet WHP requirements.

- ***Annual inspections***. All sources within both overlays would be inspected annually by the health and/or fire department. The purpose of the inspections would be to complete annual chemical inventory forms, to note engineering controls and risk management practices in use at the facility, and to monitor compliance with WFP ordinances.

- ***Transportation***. Trucks over 5 tons gross weight would be restricted from using Carmody Boulevard, which runs along the wellfield. In addition, the speed of trains running through the WFPA on the CSX line would be limited. Any railroad cars sitting on spurs for more than 72 hours would be considered "in storage" and fall under the storage facility requirements of the WFPP.

- ***Building permit review***. An interjurisdictional permit review committee would be established to review all building permits in the WFPA. The committee would consist of members from Middletown, Madison Township, and Franklin Township. The review would consider the types of activities to be conducted on the site, the types and quantities of chemicals to be used or stored, and the safeguards the owner proposed to implement. The committee would deny permits where the proposed activity would increase the site's hazard ranking. An increase of more than 5 percent or 25 gallons in chemical storage or use would constitute a permit modification and automatically trigger a permit review. The management plan recommends that additional requirements be developed for septic systems within the IMZ.

- ***Underground storage tank reporting/upgrading***. Operators of USTs must adhere to federal and state UST regulations. The State Fire Marshall is developing additional requirements for USTs located in WFPAs. The proposed management plan calls for additional coordination and sharing of information with the Fire Marshall's office.

- ***Surface water drainage***. The management plan recommends that dry wells be closed wherever storm sewers are available. NPDES permit holders will be requested to notify the WFPC whenever permit modifications, spills, or accidental releases occur. The plan recommends that owners of surface impoundments located within the WFPA be required to close them or monitor water quality downgradient from them.

- ***Storage facility requirements.*** Above-ground storage facilities would be required to install containment systems (e.g., concrete-liners, berms) within three years of adoption of the WHP ordinances.

- ***Wellfield protection area signs.*** Signs would be installed along roads and railroads crossing the WFPA.

- ***Public education.*** Middletown received a demonstration grant from the U.S. EPA to develop a public education program. In March 1993, the MDPW sent flyers to its customers. The WFPC held two public meetings and developed adult and elementary school educational materials.

- ***Regional cooperation.*** The plan calls for continued cooperation and coordination with other local jurisdictions, including Madison Township, Butler County, and Warren County.

- ***Household hazardous waste disposal program.*** The City would conduct semi-annual hazardous waste collection days for residents. The WFPC will attempt to identify corporate sponsors who could underwrite part of the cost.

The proposed management plan has been given preliminary approval by the Middletown City Council, although the final ordinances still must be approved.

6.2.5 Contingency Plan

CH2M Hill developed a framework for a contingency plan that would be activated if either:

- Substantial changes in groundwater quality are detected in routine monitoring; or

- An emergency that could adversely affect ground water quality occurs within the WFPA.

The first part of the plan would be triggered if MDPW detects contaminant concentrations above preventative action limits (PALs) in either monitoring wells or production wells. The PAL is defined as a percentage of the MCL for the constituent (10 percent of the MCL for VOCs and 50 percent of the MCL for inorganics).

The framework calls for Middletown to establish an emergency response team consisting of members from the police and fire departments and MDPW. CH2M Hill recommended evaluating existing emergency response plans to determine their adaptability to wellfield emergency response planning.

The City plans to establish an Emergency Response Fund to handle emergencies which could threaten the wellfield. The Fund will be capped at $500,000.

7.0 COST OF WELLHEAD PROTECTION

The MDPW has developed substantial data on the start-up and ongoing implementation costs of its WFPP. Exhibit 6 summarizes the costs of wellhead protection through September 1995, and Exhibit 7 summarizes expected future costs through September 2005.

7.1 Tangible Costs

Through September 1995, the City of Middletown spent $95,000 ($98,720 in 1994 dollars) to develop its WFPP, including $12,000 ($12,240 from a U.S. EPA demonstration grant). The delineation and source identification efforts cost approximately $40,000 ($45,600 in 1994 dollars). WFPC activities, including the management plan and the public education campaign, cost $36,000 ($36,720 in 1994 dollars). The City has spent $10,000 ($11,400 in 1994 dollars) on monitoring wells constructed so far. Miscellaneous WFP activities, including teacher in-service meetings and presentations, have cost another $5,000 (in 1994 dollars).

Between October 1995 and September 2005, the City plans to install additional monitoring wells, develop a monitoring database, and conduct sampling and laboratory analysis. The City also plans to make transfers into its Emergency Response and Risk Management Funds during the period. The net present value of these activities is approximately $1.28 million. Implementation activities, such as monitoring and laboratory analysis, account for $468,144 of the total. The reserve funds account for at least $810,000; the exact amount will depend on the level of payouts from them.

The WFPP will be financed through a $0.50 monthly service connection charge ($0.25 for senior citizens). Industrial users will pay a 5 percent usage surcharge. The fee is expected to raise approximately $240,000 per year, which will be used for operating expenses

Exhibit 6
Cost of Wellhead Protection: Middletown, OH
February 1985 to September 1995
($1994)

Item	City of Middletown	U.S. EPA	Total
Preparation of Initial WHPP			
WHPA delineation			
Source identification			
SUBTOTAL:	$45,600	$0	$45,600
Wellhead Protection Committee Activities			
Management plan development	11,220	0	$11,220
Public education plan development	13,260	12,240	$25,500
SUBTOTAL:	$24,480	$12,240	$36,720
Ground Water Monitoring Program			
Monitoring well installation	11,400		$11,400
SUBTOTAL:	$11,400	$0	$11,400
WHP Implementation			
Miscellaneous implementation activities	5,000		$5,000
SUBTOTAL:	$5,000	$0	$5,000
TOTAL COST:	$86,480	$12,240	$98,720

Exhibit 7
Future Cost of Wellhead Protection: Middletown, OH
October 1995 to September 2005
($1994)

Item	City of Middletown
WHP Implementation	
Monitoring/Laboratory Analysis	$468,144
Emergency Response Fund*	$405,624
Risk Management Fund*	$405,624
TOTAL COST:	**$1,279,392**

Notes:
(1) Approximate; actual expenditures depend upon payouts from Fund.

and the reserve funds. When the funds reach their caps, the fee will be reduced to cover only operating expenses.

7.2 Intangible Costs

With the exception of the proposed requirement that storage areas have containment structures, each of the elements in Middletown's management plan is a restatement of existing federal or state regulatory programs, such as the federal UST program. The City estimates that the number of businesses affected by the storage requirements is minimal, and could not provide an estimate of the cost to comply.

MDPW expects that businesses in the WFPP will incur a modest cost to compile and submit the annual SARA Title III chemical inventories.

8.0 CONCLUSIONS

Past and expected future costs (through September 2005) of responding to the contamination incident likely will range from approximately $970,000 to $1.48 million (in 1994 dollars), depending upon whether Middletown elects to construct the air strippers. This does not include costs incurred by AEP Flexo, aside from reimbursement of OEPA oversight costs. The total cost of the contamination incident probably is considerably higher than the costs reported in this report. The per-well cost ranges from $74,615 to $113,846.

Past and expected future costs (through September 2005) for wellhead protection will total approximately $1.38 million. This includes transfers into the Emergency Response and Risk Reduction funds. The per-well cost of these efforts is approximately $106,009.

The director of Middletown's WFPP believes that it would have prevented, or at least mitigated, the contamination incident. He feels that the proposed storage requirements would have prevented the release of contamination from the AEP Flexo site. If not, annual inspections or groundwater monitoring probably would have detected the contaminant release at the AEP Flexo site before contaminants migrated into the wellfield.

9.0 REFERENCES

City of Middletown. *City of Middletown Well Field Plume Study.* (draft document) Prepared by CH2M Hill. 1990.

Duritsch, David J. Jr. Assistant City Engineer, City of Middletown, Division of Engineering. Personal interview, June 29, 1995.

Martin, Stephen H. Group Leader, Ohio Environmental Protection Agency, Division of Emergency & Remedial Response. Personal interview, June 28, 1995.

Middletown Area Wellfield Protection Committee. *Draft Report.* 1993.

Middletown Department of Public Works. *Middletown Well Field Protection Report.* Prepared by CH2M Hill. 1991.

Ohio Environmental Protection Agency, Division of Drinking and Ground Waters. *Ohio Wellhead Protection Program.* 1992.

Ohio Environmental Protection Agency, Division of Drinking and Ground Waters. *Guidance For Conducting Potential Pollution Source Inventories In Wellhead Protection Areas.* (draft document) 1995.

Ohio Environmental Protection Agency. *Administrative Order on Consent -- AEP Flexo, Inc.* issued: July 28, 1993; effective: July 28,1993.

Ohio Environmental Protection Agency, Division of Emergency and Remedial Response. "AEP Flexo invoice for internal audit." April 13, 1995.

Saxe, Heather A. Hydrologist, CH2M Hill. Personal interview, June 29, 1995.

Sedoris, Helen. Geologist, Ohio Environmental Protection Agency, Division of Drinking and Ground Waters. Personal interview, June 29, 1995.

U.S. Environmental Protection Agency. *Middletown Wellhead Protection Public Education Program.* Prepared by City of Middletown and CH2M Hill. 1994.

Contract No. 68-C4-0011
Work Assignment No. 1-14

Benefit/Cost Analysis of Preventing Contamination: Town of Norway, Maine

September 30, 1995

Submitted to:

U.S. Environmental Protection Agency
Ground Water Protection Division
Technical and Information Management Branch

TABLE OF CONTENTS

LIST OF EXHIBITS

BENEFIT/COST ANALYSIS OF PREVENTING CONTAMINATION NORWAY, OXFORD COUNTY, MAINE

When the town of Norway installed its sole drinking water well in 1965, the Norway Water District (NWD) could not anticipate that the hayfields around the well would become a thriving commercial area with gasoline stations, restaurants and other facilities. Indeed, commercial development mushroomed during the 1970s and 1980s and, although the Norway water system superintendent expressed concern over this development, he was powerless to stop it. In 1988, Norway initiated a wellhead protection (WHP) study of its well area in an attempt to protect its drinking water supply.

In 1990, a gasoline leak from an Underground Storage Tank (UST) at Steve's Country Store, a gasoline station/variety store, contaminated the aquifer within 300 feet of Norway's well. Norway and Maine DEP benefitted from the prior wellhead protection area (WHPA) delineation and were able to quickly characterize the contamination, shut the well to contain the contaminant plume, and remediate the aquifer within 15 months.

1.0 COMMUNITY DESCRIPTION

Norway, Maine is located in Oxford County; the southern part of Norway is nestled between the towns of Oxford and South Paris. The three towns, generally referred to as "the tri-town area," are located in southwestern Maine approximately 15 miles northwest of the Auburn-Lewiston area. Exhibit 1 shows the study area.

1.1 Land Use

Norway is a predominantly residential town. Approximately 80 percent of Norway's land is used for residences, with the remainder for commercial and light industrial development. Commercial and industrial facilities in Norway include a small grocery store and a mill and shoe manufacturer. Little land in Norway remains available for further development and no expansion of town boundaries is predicted in the future.

Norway's well is located south of Norway within the town limits of Oxford in an area of heavy commercial development. The most common commercial facilities in that area, which is adjacent to State Route 26, are gasoline stations and other automotive facilities, shopping centers, and grocery and convenience stores.

1.2 Geology/Topography

In general, the geology of Maine is characterized by crystalline bedrock covered by a shallow layer of unconsolidated surface sediments, or overburden. The Norway Water District's lone well penetrates the Little Androscoggin River Valley aquifer, a glacial sand and gravel aquifer measuring approximately 15 square miles in area.

flank of an esker.[1] This topographic feature outcrops discontinuously along the entire north-south axis of the Little Androscoggin River Valley.

1.3 Hydrology/Climate

Ground water in Maine generally flows the same direction as surface water, from high to low elevations. These low areas are generally points of discharge into wetlands and other surface water bodies. The infiltration of precipitation is the most common source of recharge for Maine's aquifers. In general 10 to 30 percent of Maine's precipitation infiltrates into soil to become groundwater. At most locations in the Little Androscoggin River Valley, aquifer recharge is directed vertically downward except near the river.

Near the Norway well, groundwater generally flows from northwest to southeast while the well is in operation west to east while the well is dormant. As is the case with most aquifers near active pumping wells, groundwater flow can be significantly altered depending on pumping rates and well locations. This makes accurate predictions of groundwater flow in Maine difficult in such situations.The Little Androscoggin River Valley aquifer discharges into the Little Androscoggin River west of the tri-town area. Exhibit 2 presents a geologic cross-section of the aquifer in the vicinity of the Norway well.

Surface water in the tri-town area drains into the Little Androscoggin River, a part of the Androscoggin River Basin. The river originates approximately 13 miles to the northwest of Norway and Lake Pennessewassee. From there, it flows to the southeast between Norway and South Paris, passes Oxford on the eastern end of town, and drains into the Androscoggin River almost 15 miles further downstream near the Auburn-Lewiston area. The Androscoggin eventually flows into the Kennebec River which empties into Atlantic Ocean near Bath.

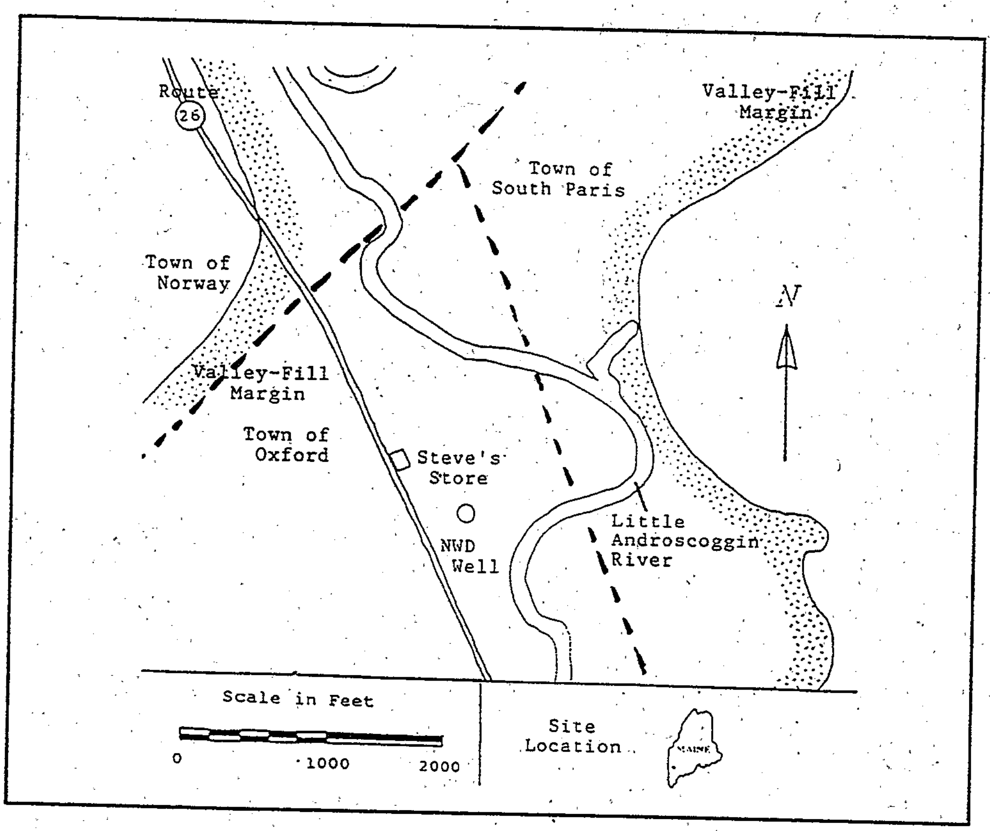
Temperatures near the tri-town area generally range from an average low of 11 degrees in January to an average high of 79 degrees in July. Maine experiences cooler weather then most of the United States and few hot summer days. Due to the cooling of warm Gulf Stream air by prevailing arctic air currents, winters in Maine are often colder than other areas of equal latitude. About 44 inches of precipitation fall annually with the most heavy period lasting from October to April.

---

[1] Geological term for a ridge of sand and gravel deposited by a stream flowing in or beneath the ice of a stagnant or retreating glacier.

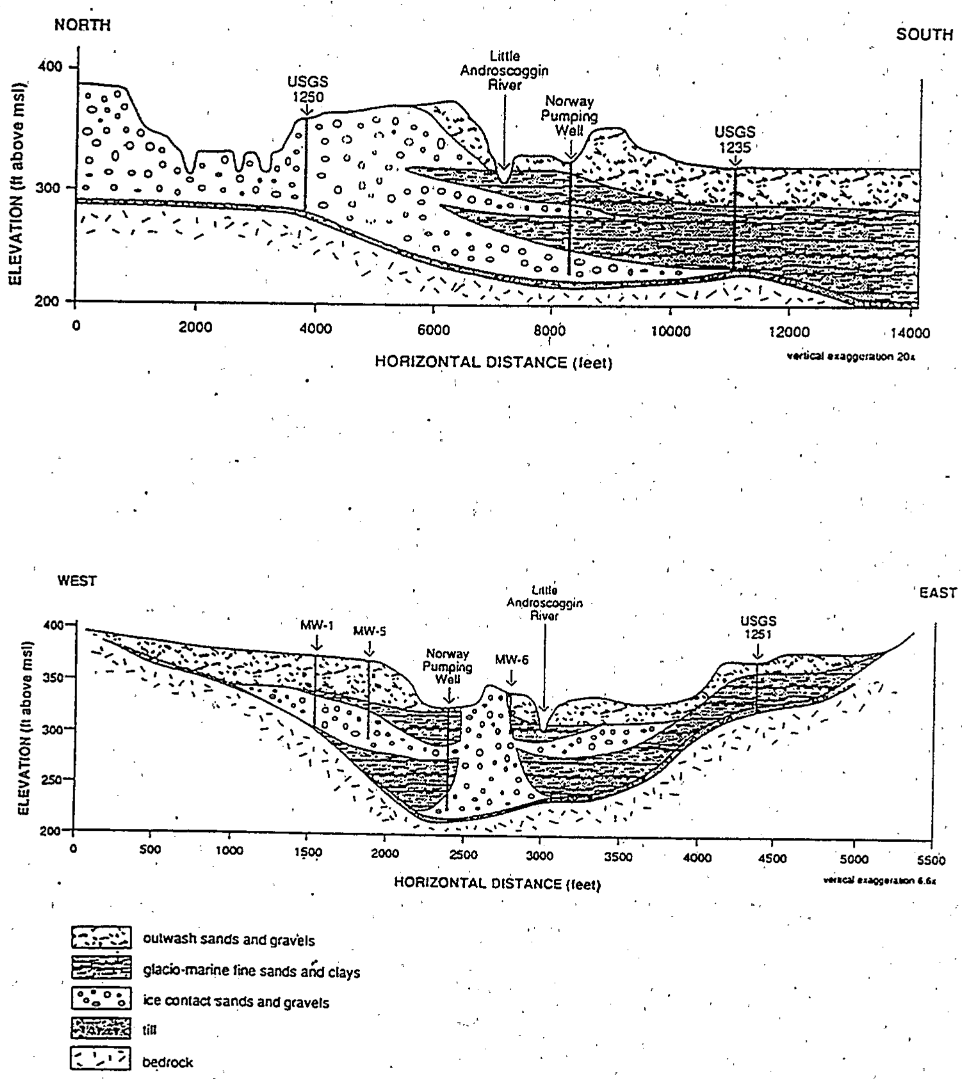
The Norway Water District's well is situated near the center of a glacially reworked sequence of sands and gravels with intermittent clay lenses. These sediments extend from the surface to depths between 125 to 130 feet. They were deposited during the Pleistocene (between 8,000 and three million years ago) when continental glaciers made their final advance and retreat. About half of the State was covered by glacial ice during this period.

EXHIBIT 1
Site Map



Maine's topography is dominated by glacially formed terrain, ranging from mountainous regions in the western, northwestern, and northern parts of the State to sea level along the Atlantic coast in the southeast. The towns of Norway, Oxford, and South Paris are located in the southwestern part of the State. The Norway well is situated on the western

EXHIBIT 2
Geologic Cross Section of the Area Near the Norway Well



2.0 PWS CHARACTERISTICS

The Norway Water District (NWD) supplies water to approximately 2,000 people, or 40 percent of Norway's population. NWD operates a single well which taps the Little Androscoggin River Valley aquifer. The well has been in operation since 1965.

2.1 Water Supply

NWD's well is located in the northern part of the adjacent Town of Oxford. The gravel-packed well is screened amidst the sand and gravel deposits of the Little Androscoggin River Valley aquifer. The well is 84 feet deep and encased with 24-inch diameter well casing. NWD pumps the well at a rate of 620 gallons per minute for eight to twelve hours each day; although, the well has a maximum safe capacity of 620 gallons per minute for 24 hours. The water system maintains approximately 30 miles of water mains, which range from 12-inch to one-inch cast ductile iron, asbestos, and galvanized copper lines.

The water produced by the Norway well is somewhat harder than optimum. NWD treats its raw water with potassium hydroxide to raise the pH; sodium silicate treatment is used to raise the pH and to coat the 100-year-old and older pipes in its distribution system to meet requirements of the Lead and Copper Rule (LCR). The water system also fluoridates and adds sodium hydrochloride. After treatment, NWD supplies its customers with water that meets all EPA and Maine Department of Environment Protection (DEP) standards.

The Norway Water District is connected to the water systems of both South Paris and Oxford. The three systems rely upon each other as emergency supply sources. For example, to provide fire flow, Oxford purchases water from NWD through a valve connecting the two systems. A similar connection with the South Paris Utility District allowed NWD to provide uninterrupted service to its customers during a contamination incident (see Section 3.0).

2.2 Financial/Management Characteristics

The Norway Water District's annual operating budget of $200,000 is sustained almost entirely by the water rates it charges it customers. The usage rate structure is based upon a minimum consumption charge of $29.80 per 1,200 cubic feet of water used.

To borrow funds or raise water rates, the Public Utility Commission requires that Norway first expend all of its available funding. The system last applied to adjust its water rates in February 1995. NWD is currently trying to borrow $500,000 from the Farmers' Home Administration (FmHA) to fund capital improvements, including an air stripper to treat for carbon dioxide and which would also reduce radon levels and correct pH without chemical treatment.

In addition its to normal operating procedures, NWD operates the Oxford Utility District's water system day-to-day.

2.3 Population Served

The Norway Water District serves approximately 2,000 of Norway's residents via approximately 800 service connections. The remaining residents are served by private wells. Residential customers account for about 80 percent of water users in Norway. The remainder is made up of 138 commercial and nine governmental customers.

3.0 CONTAMINATION

Contamination of Norway's well resulted from a gasoline leak in one of the pumps at Steve's Country Store, a gasoline station/convenience store located only 600 feet from the Norway well. Exhibit 3 is a map of the contamination site.

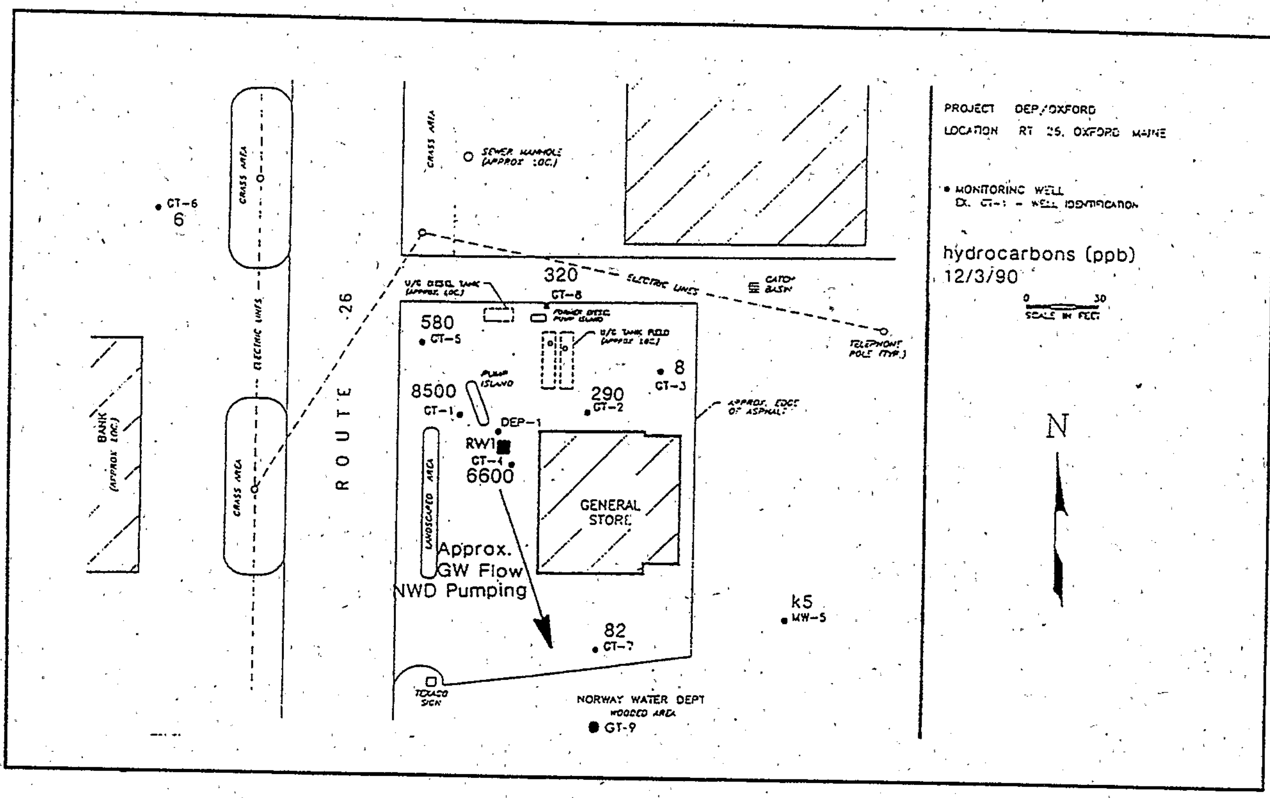
3.1 Contamination Source

In August 1990, a truck accidently hit and knocked over the diesel pump at Steve's Store. When the NWD operator expressed concern, the station owner assured him that the pump would be fixed.

Later that month, during a routine UST inspection by the Maine DEP, inspectors discovered that another pump at Steve's Store was leaking gasoline into the soil below and ordered the facility owner to install a monitoring well. Following installation of the monitoring well, DEP discovered evidence of groundwater contamination and ordered the facility to cease operation of its gasoline pumps and advised NWD to shut down its well. The well remained out of operation for over a year while the spill was remediated.

Prior to the incident, Steve's Country Store was identified among the nine major contaminant threat facilities in a wellhead protection study. NWD had asked all contaminant threat facility operators to consider Best Management Practices (BMPs), including upgrading single-wall underground gasoline storage tank to a safer dual-wall model. At that time, the owner of Steve's Store agreed to consider the upgrade.

EXHIBIT 3
Site Map of Contamination



3.2 Contaminants

DEP's laboratory analysis of the soil samples collected near the leaky pump indicated high concentrations of hydrocarbons. The concentrations were highest in those samples collected at a depth of about 25 feet. Groundwater samples collected from monitoring wells yielded evidence of a dissolved hydrocarbon plume beneath the leaky pump island extending at least 150 feet toward the Norway well. No methyl tertiary butyl ether (MTBE) was detected in the Norway well before it was shut down, and remediation instituted.

The soil vapor extraction (SVE) system installed to help remediate the spill originally yielded vapors very rich in MTBE. An anti-knock additive of gasoline, MTBE exhibits chemical and physical properties distinct from those of hydrocarbons. Because it is the most soluble component of gasoline, it is very difficult to remediate.

Initial concentrations of MTBE in a monitoring well at the gasoline pump island were 12,000 parts per million (ppm). The contaminant plume was contained to within a fifty-foot radius of the storage tank. It is believed that at least 600 gallons of gasoline spilled into the soil.

3.3 Effects of Contamination

Due to the fact that the NWD was in the process of delineating a wellhead protection area (WHPA), a great deal of data were available on groundwater flow and aquifer stratigraphy. This enabled DEP to respond quickly in shutting down the Norway well and beginning site assessment and remediation. A DEP official also credited the owner of Steve's Store with facilitating remediation through cooperation with State and local officials involved in the cleanup. As a result of this quick response, the customers of the Norway Water District were spared the potentially serious health effects associated with ingestion of MTBE and other components of gasoline.

The quick response also mitigated potentially serious ecological damage. According to a Maine Department of Human Services (DHS) official, nearly all streams in Maine are gaining (i.e., they are at least partially recharging from aquifers). In this case, the contamination incident occurred west of the Little Androscoggin River. Because ground water in the area generally flows west to east, the MTBE could have contacted and affected the river and its aquatic organisms.

4.0 RESPONSE ACTIVITIES

Because Norway had previously initiated a wellhead protection study, a great deal of data were available on groundwater flow and aquifer stratigraphy in the vicinity of the Norway well. This enabled DEP, DHS and the Norway Water District to respond quickly in shutting down the Norway well and beginning site assessment and remediation. Because of the quick response to the contamination incident, no contamination was detected in the Norway well.

4.1 Response to Contamination of the Water Supply

Upon receipt of confirmation that samples taken from the monitoring well were contaminated with MTBE, DEP advised the Norway Water District to shut down its well. The well remained out of operation for approximately 15 months. While the remedial operation took place, NWD supplied water to its customers by purchasing water through a preexisting connection with the Town of South Paris.

After DEP completed the remedy in 1992, NWD continued to collect samples from the monitoring wells. Under an agreement with the Water District, DEP continues to pay to analyze the samples. The NWD superintendent estimates that this practice will continue for at least another year.

4.2 Response to Ground Water Contamination

Upon discovery of the leaky gasoline pump at Steve's Store, DEP ordered the owner to install a monitoring well according to DEP specifications. The facility owner installed a well without geotechnical supervision from DEP on September 20. Samples from this monitoring well, sent to a laboratory for analysis, indicated gross gasoline contamination in the samples.

At the time of discovery, the contamination was only 350 feet from the Norway well. As part of NWD's ongoing WHP study, hydrogeologists had estimated that groundwater in the vicinity of Steve's Store would reach the Norway well in fewer than 200 days, based on conservative assumptions. DEP immediately began work on assessing the extent of the contamination and choosing a remediation technique, relying heavily on wellhead area delineation data provided by the NWD.

DEP chose pumping and treatment of the contaminated groundwater. The Department drilled a recovery well and installed a two-foot diameter packed tower air stripper. After treatment, water was passed through carbon prior to discharge to the Little Androscoggin River. A series of monitoring wells tracked the progress of the remedy. Additional monitoring wells and a second recovery well were drilled when it was discovered that the MTBE plume had migrated beyond the first recovery well.

The Norway well was judged safe to reopen in January 1992, and quarterly monitoring continued. DEP continues to pay for analyses and materials in conjunction with this monitoring. Due to the precarious nature of the Norway well, DEP, DHS, and the Water District decided to leave the remediation system on-site and off-line, but in a state of readiness should contamination be found in the future. NWD presently conducts routine quarterly sampling of the monitoring wells and continues to lobby for WHP in the tri-town area (see Section 6.2 below).

4.3 Response to Soil Contamination

DEP also employed soil vapor extraction (SVE) as a remedial technique. The agency installed three monitoring well/vapor points to remediate surface soils and soils near the depth of the water table. DEP activated the ground water and soil remediation systems in January 1991. DEP initiated monthly sampling of monitoring wells and tracking of remediation system influent and effluent at this time as well.

Initially, the amount of contaminant removed through SVE was rather high. As of August 1991, crude estimates of the amount of gasoline removed from the soil were in the range of a few hundred gallons. Over time, the rate of contaminant removal gradually decreased.

In August 1991, the USTs and piping at Steve's Store were removed and replaced wit a state-of-the-art double-walled gasoline storage system. The soil extracted during the tank excavation was stockpiled on impermeable plastic sheets, then disposed.

5.0 COSTS OF CONTAMINATION

The total cost of the contamination incident at Steve's Store was $526,453. This included $139,166[2] to provide replacement drinking water during the water emergency, and $396,703 for groundwater and soil remediation.

5.1 Tangible Costs

Exhibit 4 provides a detailed accounting of the cost to date of contamination associated with the 1990 incident. Exhibit 5 presents the estimated future cost of responding to contamination between 1995 and 2005.

5.1.1 Costs to Provide Safe Drinking Water

To protect the health and safety of its customers, the NWD began purchasing water from the Town of South Paris. The net cost of this water totaled $133,946. This figure represents the purchase price of the water minus the normal operating costs that the water district would have incurred to deliver water to its customers during the duration of the remedy. DEP asked the NWD to estimate the electrical and chemical costs associated with delivering water to its users over a 15-month period, and paid the incremental cost over this amount. This amount was funded through Maine's Third Party Damage Claim process, an insurance fund for cleanup of contamination incidents.

DEP continues to pay for quarterly monitoring to ensure that the Norway well remains contamination-free. The NWD plans to continue submitting samples for as long as DEP is willing to pay laboratory fees for analysis, probably for one more year. This cost, which as of September 1995 has totaled $5,220, is paid from a State Groundwater Oil Cleanup Fund,

[2]Unless otherwise specified, all costs are presented as 1994 dollars.

Exhibit 4
Cost of Responding to Contamination: Norway, ME
August 1990 to September 1995
($1994)

Item	Norway Water District	Maine DEP GW Oil Cleanup	Maine DEP Bond Fund	Maine DEP Third Party Damage Claim	Total
Provide Safe Drinking Water					
One-time costs					
Purchase Water from 9/90 to 1/93(1)				133,946	$133,946
SUBTOTAL:	$0	$0	$0	$133,946	$133,946
Incremental operating costs					
Post-Remedial Monitoring		5,220			$5,220
SUBTOTAL:	$0	$5,220	$0	$0	$5,220
TOTAL:	$0	$5,220	$0	$133,946	$139,166
Remediate Aquifer					
Pre-remediation					
Investigation of Spill			41,284		$41,284
Remediation					
Install Pump & Treat (P&T) System and Soil Vapor Extraction (SVE) System			153,735		$153,735
Operations and Maintenance			136,364		$136,364
WQ Monitoring Before/During Remediation (2)		22,104			$22,104
Oversight	10,000		33,215		$43,215
TOTAL:	$10,000	$22,104	$364,599	$0	$396,703
TOTAL COST:	$10,000	$27,324	$364,599	$133,946	$535,869

(1) Net cost of purchased water minus the operational costs saved due to closure of well for 15 months.
(2) Includes work with DEP on site investigation, remediation, and sample collection during and after remediation.

Exhibit 5
Future Cost of Responding to Contamination: Norway, ME
October 1995 to September 2005
($1994)

Item	Ground Water Oil Cleanup Fund	Town of Norway	Total
Provide Safe Drinking Water			
Incremental operating costs			
Post-remedial monitoring	3,096	6,939	$10,035
TOTAL COST:	$3,096	$6,939	$10,035

funded by a per-barrel import tax on gasoline and heating oil. Based on DEP and NWD estimates, the future cost of monitoring paid by DEP will total $3,096. After DEP discontinues paying for the monitoring, Norway anticipates that it will probably continue to (and perhaps be required to) monitor for MTBE on a semi-annual basis for several more years. This would cost Norway an additional $6,939 (Exhibit 5).

5.1.2 Costs to Remediate Aquifer

As of 1995, groundwater and soil remediation cost a total of $396,703. There are four components to the remedial process:

- DEP spent $41,284 to investigate the extent and severity of the spill and to select the appropriate remedy. This was funded by a bond fund set up by the State and administered by DEP for responding to contamination incidents.

- Installation of the ground water pump and treatment system and the soil venting system cost $153,735 and $136,364, respectively. Both were funded by the state bond fund.

- During the remedy, DEP monitored water quality at the recovery wells and within the monitoring well network on a monthly basis. This cost a total of $22,104, paid through Maine's Groundwater Oil Cleanup Fund.

- Oversight of the remedy by DEP staff totaled $33,215, funded by the bond fund. In addition, the NWD incurred approximately $10,000 in staff costs for consultations with DEP and to collect water samples for analysis.

5.2 Intangible Costs

There is no indication that the contamination incident at Steve's Country Store adversely affected property values or the salability of properties nearby. The greatest economic impact of the spill was to gasoline sales at the store. Steve's Store was unable to sell gasoline for almost 15 months while the site was being remediated. This likely reduced the customer traffic in the variety store as well.

6.0 WELLHEAD PROTECTION

Norway initiated its wellhead protection program in 1988, in response to the growing threat from commercial development around its water well. At that time, Norway also anticipate that the State of Maine was about to adopt mandatory wellhead protection.

6.1 State Requirements for Wellhead Protection

Interest in wellhead protection (WHP) in Maine began in 1987 in response to the requirements of the Federal Safe Drinking Water Act Amendments of 1986. At that time, a work group made up of State agency staff, water utility representatives, members of the Maine Municipal Association, and Regional Council representatives began writing a plan to implement WHP. Maine submitted the final draft of its plan to EPA in August 1989; EPA approved the plan in September 1990. Despite this early progress, the State Legislature defeated the bill to authorize the Maine Department of Human Services (DHS) to implement the Wellhead Protection Program (WHPP). A majority of legislators believed that the parties affected by the WHPP did not understand it or recognize its need.

The Legislature instructed DHS to redevelop the Program, and to seek more involvement of affected parties. Work on the new Program began in May 1992. DHS staff sought to involve all interest groups named by the Legislature by assembling a network of advisory committees to participate in drafting a WHP implementation plan. The latest draft was produced in November 1994 and is currently being revised based on comments from the advisory committees.

The main difference between the two plans is that participation in a WHPP would now be voluntary. To encourage participation, the DHS would consider waivers of Phase II and Phase V monitoring requirements for communities that have WHPPs. The revised version advised communities seeking to establish a WHPP to include the following elements:

- *Wellhead Protection Area (WHPA) Delineation.* Depending on the type and size of the water system, and calculated fixed radius delineation between 380 and 2,500 feet should be established around each well as a WHPA.

- *Inventory of Potential Contaminant Source Facilities.* Participating water systems should create a list of all potential contamination sources within their delineated WHPAs.

- *Management.* Participating public water suppliers should notify local governments of WHPAs. One or more of the following management techniques should be employed: information and education; use of existing regulatory tools; and capital intensive methods (e.g., extending sewer lines, or purchasing land in the WHPA).

- *Contingency Planning.* Water systems should develop a contingency plan specifying how, in the event of an emergency, they would supply water to their customers and contain a spill. This plan should be filed with local governments, DEP, and all other appropriate government agencies.

Throughout the implementation of WHP, DHS would serve as the lead agency in providing technical assistance and general guidance. By participating, water suppliers would save money through Phase II and Phase V monitoring waivers. A DHS official estimated that, so far, 50 WHP programs had been reviewed and approved statewide out of 300 submitted applications. The same official credited the incentive of monitoring waivers as the chief reason behind the level of interest in the program.

6.2 Local Wellhead Protection Plan

Interest in wellhead protection in Norway began as a result of concern over the rapid commercial development near the town's municipal water supply well during the 1970s and 1980s. Nearly all of the facilities now considered to be contamination threats to the well were established during this time period. In 1988, the Norway Water District, in order to better understand groundwater processes affecting the town's water supply, retained a consulting firm to perform a wellhead protection study. This study resulted in the delineation of a WHPA according to the State of Maine wellhead protection guidelines as they existed at the time.

Steve's Country Store was among the nine major contaminant threat facilities listed in the 1988 wellhead protection study. Early in 1990, NWD met with its consultants and representatives of all contaminant threat facilities, including Steve's Store, to inform them of their location with respect to the well and its recently-delineated wellhead protection area. When Norway requested voluntary cooperation with Best Management Practices (BMPs), many facility representatives cooperated by adopting modifications to lower the risk of contamination from their facilities.

The visible remedial activity at Steve's Store heightened public concern in Norway over the safety of the Town's water supply. During 1991, in order to continue funding WHP implementation and prevent future contamination incidents, NWD applied for and received a U.S. EPA Wellhead Protection Demonstration Grant.

With the grant funds, Norway, Oxford, and South Paris drafted a model WHP ordinance from which they could draft specific ordinances of their own. Management plans and contingency plans were also drafted. Norway and South Paris have both passed WHP Ordinances applying to all WHP areas within their town limits. At present, the Town of Oxford has passed a zoning ordinance which limits new development in WHPAs.

6.2.1 Wellhead Protection Area Delineation

Norway installed six monitoring wells to map groundwater flow patterns and delineated WHPAs for the well based on these findings. Norway delineated protective zones WHPA 1 and WHPA 2 based on 200-day and 1,000-day time of travel limits, respectively.

Norway also delineated an inner area of WHPA 1, defined by a 30-day time of travel limit. WHPA 3 is based on topography and the locations of watershed divides. It consists of areas of hillsides beyond the edge of the aquifer with the potential to contribute water to the aquifer via surface runoff or groundwater flow. Because its well and portions of the WHPA lie outside its jurisdictional limits, Norway recognizes that cooperation between the three towns is vital to effective implementation of wellhead protection practices.

6.2.2 Source Identification

The only contaminant threats in existence when the Norway well was sited in 1965 were two car dealerships with a combined total of six underground storage tanks (USTs) for motor fuel. There are presently more than ten contaminant threats within the 1,000-day time of travel limit for the well. They consist of a shopping center, an industrial park, and several gasoline stations and convenience stores, including the one at Steve's Store. Eight additional threats exist in sensitive areas beyond WHPA 3.

6.2.3 Management Plan

Due to the presence of a number of potential sources of contamination in the wellhead protection area in addition to Steve's Store, participants in Norway opted for fairly strict control and management through local ordinances.

A Wellhead Protection Ordinance is the primary element of the Management Plan for the Norway well. It was modeled after a generic wellhead protection ordinance developed as part of a Wellhead Demonstration Grant Project funded by the U.S. Environmental Protection Agency (EPA). The generic ordinance was modified to account for Norway's inability to include parts of the WHPA that lie within the towns of South Paris and Oxford. Town officials passed the ordinance in the hopes that Oxford and South Paris would adopt similar wellhead protection ordinances to protect the remainder of the Norway WHPA. Only South Paris has succeeded in doing so.

In 1995, Oxford passed a zoning ordinance that identifies wellhead areas in its protective zones. Oxford's fire department has instituted a plan to carry absorbent pads for hazardous waste on fire trucks to contain spills from fuel tanks associated with automobile accidents. The Oxford fire department also agreed to notify the NWD in the event of a spill near the well.

Norway's ordinance includes several items intended to protect portions of the wellhead protection area within town limits by providing for the regulation of certain land uses. The Ordinance also gives the Code Enforcement Officer certain inspection and monitoring powers and lists BMPs (to be phased in over time) for existing land uses and facilities. Specific procedures for appeals and variances are also provided.

Norway samples and analyzes water from the six monitoring wells around its water well. The town currently conducts this sampling every two years, although should NWD officials suspect that the well may be in danger of contamination, monitoring may be conducted at a greater frequency.

Recently, Norway has begun to focus on educating homeowners and businesses about the steps they can easily or inexpensively take to protect ground water. For example, residents were asked to store gas cans or other hazardous material containers in a safe place where they are unlikely to spill or corrode.

Areas outside Norway's town limits, wellhead protection areas for other public wells, and other groundwater aquifers are not covered by the Ordinance. Homeowner activities are also exempt, although they are urged to use BMPs. NWD is in the process of lobbying Oxford officials to institute mandatory BMPs at facilities in Norway's WHPA. Passage of a WHP ordinance in Oxford seems unlikely due to voter sentiment.

6.2.4 Contingency Plan

Because of budgetary constraints, no contingency plan was developed under the wellhead demonstration grant project. Several recommendations were made, however. In a contamination emergency, NWD can shut down its well and immediately begin purchasing water from either or both of the other two towns.

7.0 COSTS OF WELLHEAD PROTECTION

The total cost of developing Norway's wellhead protection plan was $100,588.[3] Additionally, the town has spent approximately $15,000 between 1988 and 1995 to implement wellhead protection. A detailed accounting of the cost of developing and implementing WHP for the Norway well can be found in Exhibit 6.

7.1 Tangible Costs

Norway spent $66,713 to delineate the WHPAs around its well; this figure includes the cost of drilling the six monitoring wells. Through the EPA Wellhead Demonstration Grant, Norway identified contaminant threats around its well, developed a management plan, and wrote its ordinance. The cost of these activities combined was $33,875. In addition to the $26,500 EPA grant (1993 dollars), this amount included the contribution of funds and in-kind resources from the Towns of Norway, Oxford, and South Paris in conjunction with the Androscoggin Valley Council of Governments (AVCOG).

[3] All costs are given in 1994 dollars unless otherwise specified.

Since 1988, Norway has spent $15,127 to implement its WHPP. The NWD Superintendent estimates that he spends approximately 50 to 60 hours per year maintaining contact with owners of businesses within the WHPA and with officials in South Paris and Oxford. The total cost of this labor is approximately $9,300. Additionally, Norway has conducted two rounds of sampling at the six monitoring wells. This requires two days of labor to collect the samples ($416) in addition to laboratory costs (approximately $2,500). The total cost of the two rounds of sampling are approximately $5,832. Between 1995 and 2005, Norway's WHPP implementation costs will total $22,588 (See Exhibit 7).

7.2 Intangible Costs

The indirect costs associated with Norway's WHPP include costs to businesses or residences affected by the ordinance. Because Norway is primarily a residential town and homeowners are exempt from the BMP requirements Norway imposes on business, there are no indirect costs associated with Norway's WHPP. It is unlikely that new businesses will move into Norway's WHPA zones, as the town has little land available for development.

8.0 CONCLUSION

Because of the contamination at the Norway well, DEP and Norway incurred costs of nearly $536,000. By contrast, the cost of developing the Norway wellhead protection program was $100,588.

Although Norway's wellhead protection was fairly costly (considering that only one well is protected), Norway has already realized a benefit associated with the rigorous delineation of the vulnerable areas around its well. Had the WHPA data not existed at the time of the incident, commencement of the cleanup would have been delayed, the plume would have expanded further, and would ultimately have required a much more extensive cleanup.

Exhibit 6
Cost of Wellhead Protection: Norway, ME
1988 to September 1995
($1994)

Item	Norway Water District	U.S. EPA (1)	Town of Oxford	Town of South Paris	Androscoggin Valley Council of Governments	Total
WHPP Development						
WHPA Delineation	66,713					
Study aquifer characteristics						$66,713
Construct monitoring wells						
WHP Development	1,575	27,825	1,050	1,050	2,375	$33,875
Source Identification						
Develop Management Plan						
Write Ordinance						
Recommendations for Future Activities						
SUBTOTAL:	**$68,288**	**$27,825**	**$1,050**	**$1,050**	**$2,375**	**$100,588**
WHPP Implementation						
NWD Oversight	$9,295					$9,295
Monitoring	$5,832					$5,832
TOTAL:	**$15,127**	**$0**	**$0**	**$0**	**$0**	**$15,127**
TOTAL COST:	**$83,415**	**$27,825**	**$1,050**	**$1,050**	**$2,375**	**$115,715**

(1) WHP Demonstration Grant# S001574-01-0

Exhibit 7
Future Cost of Wellhead Protection: Norway, ME
October 1995 to September 2005
($1994)

Item	Norway Water District
WHPP Implementation	
NWD oversight	$9,131
Monitoring	$13,457
TOTAL COST:	**$22,588**

9.0 REFERENCES

Barlow, John W. Manager, Paris Utility District. Personal interview, September 11, 1995.

Breale, David. Maine Department of Human Services, Division of Health Engineering, Drinking Water Program. Personal interview, September 12, 1995.

Bureau of Hazardous Materials and Solid Waste Control, Division of Technical Services. *Interim Report Aquifer Remediation, Steve's Store - Oxford.* October 1991.

MacDonald, David. Superintendent, Norway Water District. Personal interview, September 11, 1995.

Maine Department of Environmental Protection. *Status Report - January 1991, Steve's Store.* Prepared by Groundwater Technology, Inc. February 1991.

Maine Department of Environmental Protection. *Remediation of Gasoline Contamination In a Sand and Gravel Aquifer in Oxford, Maine: A Success Story for Wellhead Protection.* October 1991.

Maine Department of Human Services, Division of Health Engineering, Drinking Water Program. *Maine's Wellhead Protection Program.* November 1994.

Maine Department of Human Services. *The Costs of No Wellhead Protection in Maine, A Study of the Costs of Cure vs. Prevention: Volume 1.* November 1993.

Maine Department of Human Services. *The Costs of No Wellhead Protection in Maine, A Study of the Costs of Cure vs. Prevention: Volume 2.* November 1993.

Norway Water District. *Wellhead and Aquifer Protection Plan for Norway, Oxford and South Paris Water Districts, Phase I Report.* Prepared by BCI Geonetics, March 1989.

Smith, Rodney. Code Enforcement Officer, Building Inspector, and Plumbing Inspector, Towns of Oxford and Otisfield. Personal interview, September 11, 1995.

Steve's Store. *Oil and Hazardous Materials Report Form (with notes detailing contamination incident).* August 8, 1990.

Swain, Christopher. Environmental Services Specialist, Maine Department of Environmental Protection, Division of Technical Services, Bureau of Oil & Hazardous Materials Control. Personal interview, September 12, 1995.

Town of South Paris. *Wellhead Protection Ordinance.* June 1994.

United States Environmental Protection Agency. *Project Report - Norway, Maine.* Prepared by Hydrosource Associates, Inc. under U.S. EPA Wellhead Protection Demonstration Grant (Assistance #S001574-01-0). October 1993.

United States Environmental Protection Agency. *Final Project Report - Norway, Maine.* Prepared by Hydrosource Associates, Inc. under U.S. EPA Wellhead Protection Demonstration Grant (Assistance #S001574-01-0). November 1993.

PART TWO

LESSONS LEARNED

1.0 Introduction and Overview

The experiences of the study communities show that even the most modest WHPP has merit: communities pay closer attention to threats near their drinking water wells, citizens are educated on simple ways to protect water wells, and communities can work together to achieve real goals to protect the environment. As Chapter 3 indicates, well-for-well, WHP offers relatively inexpensive insurance compared to the rather significant cost of cleanup.

Aside from the cost-avoided benefits of WHP, certain trends appear across the case studies that can enlighten community leaders on the true threat to their water supplies and the importance of protecting them. For example, it is not news-making contamination incidents, but more everyday type sources such as dry cleaners and gas stations that most often threaten water quality. Furthermore, poor planning or inattention to rapid development can foil attempts to protect water supplies.

By studying local experiences with developing, implementing, and maintaining WHPPs, the project team observed those parts of a WHPP that provide the greatest protection for the resources spent and where communities often stumble. While every wellhead protection program produces either a financial, health, or environmental benefit, not every pitfall can be anticipated or prevented. Some communities have developed innovative approaches to wellhead protection, or have allowed other communities to benefit from their work.

1.1 Contamination Threats

Although extensive contamination incidents, such as Superfund sites, are often the subject of headlines in the news, everyday activities pose the most significant threat to drinking water supplies.

1.1.1 Risks from Various Types of Contamination

In two of the six contamination incidents, leaking gasoline storage tanks were at fault. In Gilbert, a gasoline leak from a UST at an abandoned gas station contaminated soil and ground water. The UST remained buried for three years after the gas station closed, and in the interim, the tanks leaked. Contamination in Norway resulted from gasoline leaking from a pump at a gas station.

Dry cleaners, found in nearly every community, also pose a substantial threat. In Gettysburg, the accidental failure of a drain at a dry cleaning facility contaminated one of GMA's wells. The dry cleaning facility had legally disposed of waste to the borough's sewer system until, in 1986, during State-required pre-operational monitoring, GMA discovered contamination at the well.

In Tumwater, the source of contamination has not been determined, but of the four sites that are the focus of the contamination investigation, two are current or former dry cleaners, and one is a gas station. In Middletown, poor housekeeping practices at a relatively small industrial facility were the source of contamination: staff at a flexographic printing plate manufacturer squeegeed leaks from a distillation unit out a doorway.

1.1.2 Potential Contamination Threats

While the case studies focus on the devastating effects of a single contamination incident, the contaminant source identification effort in the subject communities identified up to dozens of potential threats.

Contaminant source identification often enlightens communities on the multitude of threats to their drinking water supplies:

- In Lancaster County, the volunteers and contractors identified 119 contamination threats. The majority of these were underground storage tanks, and commercial or suspected hazardous waste storage facilities. In the rural county, the WHP committee chose not to include agricultural facilities in the search for threats, as the farms in the region were well known. The committee instead opted to focus on less obvious point sources.

- Gilbert's final contaminant source inventory identified 27 potential sources of contamination, 13 of which were current or former service stations or garages. Other sources included three cemeteries, two dry cleaners, a small airport, sewage lines and disposal ponds, and drainage canals.

- In Dartmouth, 16 potential sources of contamination were found to exist within the Zone I and II protection areas of the wells. These include propane storage tanks, an oil storage tank, diesel oil disposal sites, and gravel pits.

- Middletown located approximately 80 actual and potential sources of contamination within its WHPA. These included several industrial sites; commercial sites such as service stations, auto repair facilities, and dry cleaners; and major transportation routes, including State highways, a railroad line and the Great Miami River.

- Norway identified 18 threats to water quality within the zones of contribution or in the sensitive areas beyond this zone. The threats included gas stations, commercial facilities, automotive facilities, a dump, and a waste treatment plant.

Tumwater and Middletown identified actual contamination incidents during their contamination source identification processes. In Tumwater, the preliminary survey of contaminants identified several sites of particular concern. These include two leaking petroleum USTs within the five-year time-of-travel zone of the wellfield. Also identified were a bulk fuel storage depot, a fiberglass manufacturing facility, and a fisheries maintenance yard.

Three confirmed sources of contamination lie within the one- and five-year time-of-travel zones of Middletown's wells. They include a city landfill which lies within the five-year time of travel zone; a paper company within the one-year time-of-travel zone; and the printing plate manufacturer that is the subject of the case study within the one-year time-of-travel zone.

1.1.3 The Role of Siting

In the ideal case, the inner protective zones around each drinking water well would be free of potential contaminants. If the well is sited in a relatively developed area of the community, there is a significant potential for contamination.

Gettysburg sited its well in the middle of town, close to several potential sources of contamination, including dry cleaning facilities. A drain located inside a dry cleaners, through which the facility was legally discharging wastewater into the Gettysburg sewer system, was the source of the contaminated ground water. The drain failed and leaked wastewater into the soil. Had Gettysburg conducted a contaminant source identification around the proposed well site, the results may have discouraged the GMA from siting the well where it did.

Dartmouth had siting one of its wells, and it was a call from a concerned citizen which alerted officials of former dumping activity in an abandoned gravel pit. During the well design phase, a caller, noting the town's signs delineating a "Water Supply Area," identified the area as an old dump site. If the town had performed a preliminary inventory of potential contamination sources before initiating the siting process, they may have chosen to site that well elsewhere.

The majority of drinking water wells in Gilbert, Tumwater, Middletown, and Norway were sited before WHP. For decades, no safeguards were in place to stop the encroachment of potential threats to the wellfield area. As the communities grew, so did the contamination threat.

Often, water suppliers who sited wells in the 1950's and 1960's could not have anticipated the development near their wellfields. The wellfields of Gilbert, Tumwater, Middletown, and

Norway lie along state roads or interstate highways, which are natural locations for industrial or commercial development. For example, Gilbert's wells were located in the center of the Village, near a state highway dotted with gas stations. In Middletown, development encroached on a wellfield which had existed for over 50 years. As development encroached on Norway's well, sited in 1965 in a hay field, the water district superintendent was powerless to act upon his concern that the new gas stations would threaten the town's drinking water supply.

Another aspect of effective well siting is the importance of geographically separating wells as much as possible. By spreading wells over large distances, communities can lessen the possibility that one contaminant plume can affect a large percentage of its wells. Gilbert, Tumwater, and Middletown each lost multiple wells as a result of a single contamination incident. In fact, Tumwater's wells were sited so close together that the city was unable to pump both wells at the same time. Had the contamination incident in Middletown been slightly north of where it was, for example, in the Great Miami River, Middletown could potentially lose its entire wellfield.

Siting wells far from each other and from a central treatment plant can be very expensive: transmission lines connecting outlying wells to treatment facilities can be very costly, especially in areas of rough terrain. A widely dispersed wellfield can serve as effective insurance against loss of multiple wells from a single contamination incident, however.

1.2 Wellhead Protection

The six study communities are in various stages of completing their WHPPs. Every community has delineated its WHPAs, and conducted at least a preliminary contaminant source identification.[1] Three communities (Gilbert, Dartmouth, and Norway) have enacted WHP ordinances; the other three (Lancaster County, Tumwater, and Middletown) are in the process of developing them. Three communities (Gilbert, Dartmouth, and Norway) have developed contingency plans.

1.2.1 Effectiveness of WHPPs

A key step in assessing the benefits of WHP is determining whether the WHPP in place or under development in each community would prevent a similar contamination incident, or at least mitigate the effects of contamination on the water system. Whether or not a community has completed all of the required WHP elements, it is possible to make some observations about the likely effectiveness of its WHP efforts. As noted in Section 1.0, for purposes of quantifying potential benefits, the WHPPs are assumed to be 100 percent effective, although the programs cannot warrant or guarantee such results. In reality, several of the WHPPs have limitations which could

[1]Dartmouth did not have a distinct source identification effort, but compiled existing data on potential sources.

reduce their effectiveness in certain circumstances.

Despite some limitations, all of the WHPPs studied offer some level of protection to ground water resources. Moreover, they provide other types of benefits to the community. In Dartmouth, for example, some local officials believe that the most important benefit of WHP is increased awareness of the need to protect ground water supplies. The identification of potential sources of contamination alone is of substantial benefit in that it heightens citizen awareness of the vulnerability of ground water supplies. Further, at least two study communities (Tumwater, Middletown) have listed confirmed sources of groundwater contamination in their source inventories.

Lancaster County's WHPP, though not complete, appears likely to be effective at preventing contamination. The proposed plan includes performance and design standards, and inspections of potential sources of contamination. In addition, the communities plan to develop a public education program for agriculture, the most common source of groundwater contamination in the county.

Gilbert's management ordinance focuses on preventing high risk activities (e.g., dry cleaners, facilities with USTs) from locating within 1,000 feet of its wells. The ordinance does not address the 27 potential threats currently located in the WHPA, or potential sources of contamination that may locate outside the 1,000 foot radius, but still within the WHPA. Essentially, the ordinance protects the Village from certain new contamination sources within the 1,000 foot radius, but still leaves the community somewhat vulnerable to groundwater contamination.

The leaking UST that caused Gilbert's contamination incident was located about 150 feet from the village's wells. Gilbert's ordinance would prohibit the construction of a new gasoline station at the site, but would not affect an existing gas station. Federal UST regulations provide Gilbert with some protection against threats from existing USTs. The UST in Gilbert leaked prior to the promulgation of federal regulations, however.

If a UST leak occurred within the WHPA, Gilbert's WHPP probably would not provide the village with advance warning of the spreading contaminant plume. Gilbert does not have any monitoring wells in the vicinity of its wellfield. Thus, once a contamination plume begins migrating toward the wellfield, it might not be discovered until it enters a well.

In Dartmouth, contamination of one well was caused by illegal drum storage at a warehouse, and contamination of a second well was the result of clandestine dumping. A thorough contaminant source identification effort might identify a clandestine dump, or an illegal drum storage site. Without routine inspections, however, contamination could develop and not be discovered before it is too late. Dartmouth does not inspect potentially threatening facilities, other than septic systems.

Because the source of contamination in Tumwater has not been determined and the final

WHPP has not been developed, it is difficult to ascertain whether Tumwater's WHPP would prevent a similar contamination incident. The city's monitoring well network should provide it with early warning of an advancing contaminant plume, giving officials time to respond.

Middletown's WHPP appears likely to prevent a contamination incident similar to the one that shut down three of its wells. The printing plate manufacturing plant would have been required to install a containment structure to prevent a release of contaminants from an above-ground storage unit. Further, annual inspections probably would have identified the improper housekeeping practices at the plant. In the event that both containment structures and inspections failed to prevent the release of contaminants, groundwater monitoring likely would have picked up the contamination plume moving toward the wellfield.

Norway has adopted a WHPP that includes monitoring, permit reviews, land use restrictions, performance and design standards, and impervious cover restrictions. As part of its WHPP, Norway monitors water quality bi-annually. Although a regular DEP inspection, rather than WHP-related monitoring, detected the contamination incident, the availability of the in-place monitoring well network expedited the remedial process.

Norway's WHPA extends into the nearby town of Oxford, where many potential sources of contamination are located, including the gas station that caused the contamination incident. Norway officials have been unable to convince their counterparts in Oxford to adopt an ordinance requiring Best Management Practices (BMPs), however.

1.2.2 Other Factors

Even with an ideal WHPP, factors beyond the control of local officials may leave a community's wells vulnerable to contamination. The Gilbert, Dartmouth, and Norway case studies offer three examples.

The Louisiana Department of Environmental Quality (LDEQ) has been unable to secure funding for cleanup of the aquifer in Gilbert. This leads to the observation that communities are likely to identify existing contamination problems through their contaminant source identification efforts. If funding is not available to address them, a community will realize little benefit. One LDEQ official pointed out that wellhead protection may identify more potential sources of contamination than were initially perceived. This observation may also reflect the need to concentrate on high risk contamination sources first, especially in resource-constrained circumstances.

As Dartmouth's experience shows, illegal activity may contaminate ground water supplies. No WHPP can be expected to fully safeguard a community against contamination caused by illegal actions. A WHPP can provide an early warning to local officials before the contamination reaches the wellfield, however.

Frequently, WHPAs cross political boundaries into other jurisdictions. If the other jurisdictions do not adopt source controls or other management approaches, the WHPP may not be effective. Most of the potential threats in Norway's WHPA are located in nearby Oxford. Although Norway has enacted a fairly comprehensive management ordinance, Norway officials have been unable to convince their counterparts in Oxford follow suit.

1.2.3 Key WHP Elements

Two of the most important elements in determining the effectiveness of WHPPs appear to be inspections and groundwater monitoring. Even the most comprehensive management ordinance can fail if communities do not have the ability to verify that potential sources of contamination are in compliance. Inspections can identify potential problems before they become groundwater contamination incidents. In addition, they may serve as a deterrent to illegal activity, such as illegal storage of hazardous materials.

Monitoring wells located immediately downgradient of potential sources of contamination and upgradient from PWS wells serve as an early warning in the event contaminants are released into ground water. If the case study communities had monitoring well networks in place, they might have discovered the contaminant plumes before they entered the wellfields. With warning time, the communities could have taken steps to prevent or mitigate the contamination incidents.

Gettysburg, Tumwater, and Middletown provide cases in point. Pumping from PWS wells altered the course of contaminant plumes, drawing contamination toward those wells. With advance warning, local officials may have been able to alter pumping regimes or construct interceptor wells to prevent the contamination of the wellfields. If not, they might have constructed treatment facilities before contaminants reached the wells, possibly reducing the impact on the community.

The importance of monitoring is acutely demonstrated in Norway, even though regular WHP-related monitoring did not detect the contamination. Because the town discovered contamination early and reacted immediately, the well was shut down and contamination removed before it spread beyond the immediate vicinity of the gasoline station. Officials at Maine DEP agree that, had contamination spread, cleanup would have been far more costly and probably would not have yet begun.

1.2.4 Information Exchange

Communities developing WHPPs commonly look toward one another for advice, information, and technical assistance. Several of the case study communities borrowed approaches and ideas from other communities, or served as models for their counterparts.

- Dartmouth was the first community in Massachusetts, and one of the first in the country, to develop a WHPP. Other communities in Massachusetts have looked toward Dartmouth as a source of information and expertise.[2] Dartmouth's ordinance served as a model for other communities that have subsequently adopted WHP.

- Tumwater is likely to adopt a final WHP plan very similar to the one under development in nearby Lacey, Washington. To a large extent, this reflects Thurston County's efforts to promote WHP. Tumwater and Lacey have designed their WHPPs to be consistent with the county's ground water management plan. Tumwater's WHP budget includes funds to study implementation strategies of other communities.

- The centerpiece of Middletown's source management effort, the "Intensity of Land Use Classification" approach, was borrowed from nearby Dayton. Dayton is widely regarded as a WHP innovator in Ohio.

The Pennsylvania Department of Environmental Resources (PADER) has recognized the value of exchanging information among communities. The agency has begun to develop a program to match communities that have implemented WHPPs with those that are interested in developing one.

1.2.5 Role of Community Sparkplugs

The WHP efforts of several case study communities are led by dynamic, energetic individuals who are totally committed to their success. In Dartmouth, Tumwater, Middletown, and Norway, these "sparkplugs" have been key participants since the beginning of the WHP efforts, and were, in fact, crucial to getting the effort underway. These individuals have contributed many long hours to developing their WHPPs, sometimes at their own expense. Their continued commitment has been especially important over the long run, since it often takes several years to build the community support necessary to adopt a WHPP. These individuals recognize the importance of public education and public participation in developing a successful WHPP, and have worked hard to "get the word out" in their communities. It is difficult to imagine that the WHP efforts would have come as far without their participation.

---

[2] Upon hearing about Dartmouth's WHPP, Tumwater asked the project team to provide the name and telephone number of Dartmouth's WHPP coordinator.

1.2.6 Approaches to Contaminant Source Management

The case study communities have adopted or are considering varied approaches to managing their contamination sources, reflecting differences in state WHP requirements, contamination threats, resource availability, and institutional capabilities.

The most common management approaches include site plan reviews, land use restrictions, performance standards, and design standards. Site plan reviews focus on catching a potential for contamination before a proposed project is built in the WHPA. Land use restrictions generally focus on preventing high risk land uses from locating near wells. Performance and design standards generally restate requirements in federal and state environmental regulations. They target facilities such as septic systems, stormwater collection facilities, and underground and above-ground storage tanks.

Dartmouth, Tumwater, and Middletown appear to favor a more comprehensive, proactive approach toward WHP. Generally, these communities have more resources available, and more potential threats to their wells. The existence of a State requirement to undertake WHP probably also plays a role. Massachusetts and Washington require water systems to develop WHPPs. Ohio does not have a formal requirement, but the Ohio EPA requires WHP as a condition for approval of water system improvements. Other factors contribute to the character of their WHPPs. For example, concerns over the city's rapid growth rate and a general pro-environment attitude among citizens have spurred Tumwater's interest in WHP.

Gilbert and Norway have adopted more modest approaches, reflecting their smaller size, regional attitudes about the role of government, fewer resources, fewer potential sources of contamination, and a lack of a state requirement to undertake WHP. Both communities are located in undeveloped areas, and generally have fewer potential contamination sources. The Norway ordinance contains land use restrictions, impervious cover restrictions, and performance standards. However, the part of the WHPA located in Norway is mostly residential. The Town of Oxford, which contains most of the sources of potential contamination, has not enacted a management ordinance. Exhibit 1 summarizes the management tools which have been adopted or are under consideration in the communities.

EXHIBIT 1
Management Tools Adopted or Under Consideration

	Site Plan Review	Source Prohibitions	Minimum Lot Sizes	Impervious Cover Re-strictions	Performance Standards	Design Standards	Inspections	Public Education
Lancaster					X	X	X	X
Gilbert		X						
Dartmouth	X		X	X		X		
Tumwater	X*	X*	X*		X*	X*	X*	X*
Middletown	X	X	X		X	X	X	X
Norway	X	X		X	X			

*Recommended by the Thurston County Groundwater Management Plan.

The communities of Lancaster County appear to be an exception to the rule. They plan to adopt a relatively proactive WHPP, despite their similarity to Gilbert and Norway. The proposed WHPP, includes inspections, performance standards, design standards, and a public education program that focuses on agriculture. It is interesting to note that none of the communities has enacted the ordinance, perhaps indicating public sentiment for a more modest WHP approach.

1.2.7 Difficulty of Adopting WHP Ordinances

Aside from Dartmouth, none of the communities has had much experience implementing WHP ordinances. Building support for WHP ordinances can be a long, difficult process. The communities of Lancaster County and the City of Middletown have been working on WHP for several years, but have yet to adopt management ordinances.

Communities must educate citizens about the need to protect their ground water sources. In addition, they may have to overcome opposition among various groups in the community. In Lancaster County, for example, some farmers are opposed to the WHP ordinance because they fear it may limit their ability to develop their land in the future. In Middletown, it has taken over a year to convince the City Council to grant preliminary approval for WHPP, despite the contamination incident. Final approval for a WHP ordinance may not occur until sometime in 1996.

1.2.8 Transferability of Innovative WHP Strategies

Two study communities have included relatively unique elements in their WHPPs. Dartmouth's contingency plan goes beyond typical contingency plans; Middletown's management strategy is similarly innovative.

The Dartmouth contingency plan addresses automobile accidents, which pose the most common threat to groundwater. Fire departments respond to the scene of an accident with absorbent pads, which are kept on fire trucks. At each pump house, a supply of absorbent pads is kept in stock in case a spill should occur near the well. The town is investigating the possibility of equipping police officers with similar kits, since they frequently are the first responders to accidents.

Although it borrowed the concept from nearby Dayton, Middletown plans to adopt the innovative "Intensity of Land Use Classification" approach to managing potential contamination sources with the WHPA. Each source is given a rank based on: (1) the type and quantity of hazardous chemicals stored or used onsite and (2) engineering controls or risk reduction strategies in use. Businesses cannot increase their scores. If a business wishes to store or use a higher quantity of chemicals onsite, it must take steps to mitigate the additional risk. Middletown has created a Risk Reduction Fund to provide businesses within the WHPA with low interest loans and grants for the construction of engineering controls to prevent contaminant releases.

1.3 Who Pays?

Whether faced with contamination or considering WHP, local governments often look to regional, state or federal agencies for financial assistance. Communities often pay the cost of protecting their wells from a contamination incident, although state or federal agencies step in to address aquifer cleanups. Communities often avail themselves of state or federal grants to assist them in developing their WHPPs.

1.3.1 Financial Impacts of Contamination

When contamination is discovered, two parallel sets of responses take place: first, the PWS acts to protect the safety of its customers; second, the responding agency (usually the state or federal government) steps in to select, design and implement the aquifer remedy.

Water suppliers usually pay the cost of responding to contamination in the wells to continue providing safe drinking water to their customers. Gettysburg and Dartmouth paid capital and O&M costs associated with installing and operating air strippers on their supply wells. Middletown will likely pay to construct air strippers within the next two years. Gilbert paid the cost of purchased water, but has been unable to recoup these costs from its customers. The Tumwater Water System paid for all of the costs associated with PWS contamination.

When a water supply well is lost to contamination, communities may be forced to purchase water from neighboring water systems. Often, this water must be purchased at the highest usage rates charges by the new supplier.

- The Village of Gilbert purchased water from two nearby communities at a higher rate than it normally charged its customers. The village did not raise its water usage rates to compensate for the higher purchase price during the 18-month water emergency.

- Dartmouth increased the portion of its water supplied by New Bedford, for which it has historically paid the same rate that city charges its commercial users. With the closure of one well, the town lost the source of 81 million gallons of drinking water per year.

- Norway was also forced to purchase water. Although the Town of South Paris offered to adjust its rates during the emergency, the Public Utility Commission would not approve the change.

The communities of Dartmouth and Norway fortunately were able to access the purchased water fairly easily. Dartmouth had historically purchased a portion of its water from New Bedford; Norway used to supply water to South Paris, and the two utilities sell each other water during water emergencies such as fires. In contrast, the Gilbert Water System was forced to build transmission lines in order to connect to the neighboring water systems.

State or Federal agencies, and ultimately taxpayers, usually pay the cost of aquifer characterization. In four of the six contamination incidents studied (Gettysburg, Gilbert, Tumwater, and Norway[3]), the State paid all or part of the contamination assessment costs. In Middletown, the PWS paid for initial investigation of the contaminant plume. The owner of the facility responsible for the contamination is paying for additional investigation of the plume and interim source control measures. Dartmouth was unique among the case studies in that the town paid all groundwater cleanup-related expenses.

The bill for aquifer remediation, usually the most costly element, is often paid by state or federal agencies. In Gettysburg, PADER will pay to install and operate an air stripper and soil vapor extraction system, a remedial effort which may last up to thirty years. This cleanup will be funded by Pennsylvania's Hazardous Sites Cleanup Program (HSCP).

Federal and State reserve funds exist to address the relatively common problem of leaking underground storage tanks. Gilbert and Norway benefitted from the availability of these funds. Gilbert received funds from the Federal LUST Trust fund, FmHA, and HUD's Urban Community Development Block Grant for response to PWS contamination. LDEQ has been unable to secure LUST Trust funds to clean up the aquifer, however. State monies funded soil vapor extraction and groundwater pumping/treatment in Norway, as well. Maine's Groundwater Oil Cleanup Fund (from a per-barrel import tax on gasoline and heating oil), financed DEP's cleanup of contamination in Norway.

Responsible parties often do not pay the costs of responding to contamination at the well or the aquifer; if they do pay, it is usually a small portion of the total cleanup costs. The reason for this is that most of the responsible parties are small businesses: a gas station and attached variety store or a small dry cleaners. These types of businesses do not have the funds to pay for million-dollar cleanups, and are rarely insured against this type of liability. Even if legal action is taken against responsible parties, little money is recovered, and much time and money are spent on litigation.

Some States have funding mechanisms in place to provide money for responding to

---

[3]Norway's wellhead protection report, funded by an EPA Wellhead Protection Demonstration Grant and funds from Norway, Oxford, South Paris, and the Androscoggin Valley Council of Governments, was instrumental in expediting the aquifer characterization.

groundwater contamination. Gettysburg, Tumwater, and Norway benefitted from the availability of these funds. For example, the J.C. Cleaners site in Gettysburg has been listed on the Pennsylvania Priority List of Hazardous Sites for Remedial Response (PAPL), the state equivalent of the CERCLA National Priorities List (NPL).

1.3.2 Role of Outside Funding for WHP

The case studies show that outside funding can provide a critical boost to WHP efforts, sparking community interest, leveraging local resources, and increasing the scope of feasible WHP activities. The challenge for communities is in implementing WHP over the long term, since funding is generally not available for implementation activities. Communities that choose to implement proactive WHPPs must adopt funding mechanisms, such as permit fees, water use surcharges, and connection fees.

The communities of Lancaster County benefitted from a $30,000 grant from EPA Region 3 to delineate WHPAs using fracture trace analysis, and a $20,000 State grant to develop a contaminant source management ordinance. Without the grants, the communities probably would not have undertaken WHP. Even if they had, the EPA grant probably allowed them to use a more sophisticated, more accurate delineation method than they might have otherwise chosen.

Although the cost of Gilbert's WHPP is relatively modest, the contribution of staff time by LDEQ was crucial to its development. The PWS is a one-person operation, and the village probably would not have undertaken a WHP effort without State assistance. LDEQ staff spent numerous hours delineating the WHPA, identifying potential sources of contamination, preparing maps, and providing technical assistance in the development of Gilbert's contingency plan and management ordinance.

Tumwater received a $170,000 grant from Washington's Centennial Clean Water Fund, and provided a 100 percent match. Although the community would have undertaken WHP to fulfill State requirements, the grant allowed Tumwater to have a more comprehensive WHP than it might have otherwise. For example, Tumwater is implementing an ambitious ground water monitoring effort.

Middletown received a $12,000 EPA WHP Demonstration Grant to develop a public education program. Although the grant was a relatively small part of the WHP budget, it likely spurred Middletown to develop a more comprehensive and formal public education plan. Middletown is the only community in the study to develop a WHP curriculum for its schools.

Norway received a $26,500 EPA WHP Demonstration Grant to develop a WHP ordinance and comprehensive land use plans. The grant spurred two neighboring towns and the local council of governments to contribute small financial or in-kind assistance. More importantly than the financial value of the contributions, the grant sparked interest in two communities that otherwise would have little incentive to implement WHP.

2. CONCLUSIONS

The case studies suggest steps to improve the effectiveness of WHPPs and to encourage local communities to undertake a WHP effort in the first place.

- **Encourage communities to review PWS well construction and identify conduits for contamination within WHPAs.** In Middletown, Gilbert, and Gettysburg, casing failures in PWS wells or faulty construction in nearby private wells allowed contamination to migrate from surficial aquifers to confined or semi-confined deep aquifers tapped by PWS wells. This suggests that communities should evaluate the physical conditions of their wells during the WHP effort. In addition, WHPAs could be analogous to the "Area of Review" concept in the Underground Injection Control program. Local communities would identify wells in their WHPAs which could serve as conduits for contamination. This review could be conducted during the contaminant source identification effort.

- **Facilitate the exchange of information and ideas among communities.** Mechanisms to consider include a WHP document clearinghouse, a World Wide Web site, or an electronic bulletin board. EPA currently is developing a Community Empowerment Kit for WHP. The kit will contain sample management ordinances and contingency plans, and case studies of successful WHPPs. The kit could serve as a starting point for these activities. Some states are initiating programs to promote information exchange among local communities. For example, the Pennsylvania Department of Environmental Resources is developing a WHP peer matching program for communities interested in starting a WHPP. State officials hope that communities that have experience with WHP will share their observations and "lessons learned" with target communities.

- **Recognize innovative WHPPs.** Several state and local officials contacted during the study stressed the value of formally recognizing innovative or especially successful WHPPs. Community recognition can encourage local officials to make the sometimes difficult decisions necessary to protect WHPAs. State officials in Louisiana, for example, present a Certificate of Completion to community officials when they have completed all of the WHP elements. LDEQ staff publicly recognize local officials for their efforts in establishing WHPPs. They encourage local media to cover each event.

- **Encourage communities to conduct a simple delineation and preliminary**

contaminant source identification early in their WHP efforts. Several state and local officials contacted during the case studies advocated conducting a simple delineation and contaminant source identification effort to identify the biggest threats to the groundwater supply. Local officials can use this information to build support for WHP in their communities. If actual contamination sources are identified in the preliminary contaminant source identification effort, communities can address them during the course of their WHP efforts. Once the wellhead protection effort is underway, communities can conduct a more complex delineation and comprehensive contaminant source identification effort.

BIBLIOGRAPHY

Adding Flexibility to Socioeconomic Criteria. Memorandum from ICF, Inc. to OGWP, September 10, 1987.

Ground Water Valuation Program. *Ground Water Valuation Case Studies.*

League of Women Voters Education Fund. *Protect Your Ground Water: Educating for Action.* 1994.

National Rural Water Association. *Wellhead Protection Program: Case Studies.* (GWTG-01), 1992.

Options for Revising the Economic Tests of the Ground-water Classification Guidelines. Memorandum from ICF, Inc. to OGWDW and OPPE, August 24, 1987.

Raucher, Robert S. *Estimating Replacement Costs as an Eligibility Criterion for Critical Aquifer Protection Areas: Issues and Evidence from the Estimation of Household Water Costs.* Prepared for U.S. EPA Office of Groundwater Protection and Office of Policy Analysis, March 25, 1987.

U.S. General Accounting Office. *Drinking Water: Stronger Efforts Needed to Protect Areas Around Public Wells from Contamination.* (GAO/RCED-93-96), April 1993.

U.S. Environmental Protection Agency, Office of The Administrator. *Final Comprehensive State Groundwater Protection Program Guidance.* (EPA 100-R-93-001), December 1992.

U.S. General Accounting Office. *Groundwater Protection: The Use of Drinking Water Standards by the States* (GAO/PEMD-89-1), December 1988.

U.S. General Accounting Office. *Groundwater Quality: State Activities to Guard Against Contaminants.* (GAO/PEMD-88-5), February 1988.

U.S. Environmental Protection Agency, Office of Water. *Definitions of the Minimum Set of Data Elements for Ground Water Quality.* (EPA 813/B-92-002), July 1992.

U.S. Environmental Protection Agency, Office of Water. *Developing a State Wellhead Protection Program: A User's Guide to Assist State Agencies Under the Safe Drinking Water Act.* (EPA 440/6-88-003), July 1988.

U.S. Environmental Protection Agency, Office of Water. *Protecting Local Ground-Water Supplies Through Wellhead Protection.* (EPA 570/09/91-007), May 1991.

U.S. Environmental Protection Agency, Office of Water. *Guide for Conducting Contaminant Source Inventories for Public Drinking Water Supplies, Technical Assistance Document.* (570/9-91-014), December 1991.

U.S. Environmental Protection Agency, Office of Water. *A Guide for Cost-Effectiveness and Cost-Benefit Analysis of State and Local Ground Water Protection Programs.* (EPA 813-R-93-001), April 1993.

U.S. Environmental Protection Agency, Office of Water. *Wellhead Protection Programs: Tools for Local Governments.* (EPA 440/6-89-002), April, 1989.

U.S. Environmental Protection Agency, Office of Water. *Wellhead Protection: A Decision Maker's Guide.* (EPA 440/6-87-009), May 1992.

U.S. Environmental Protection Agency. *Minimum Set of Data Elements for Ground Water Quality.* (EPA Order 7500.1A), October 29, 1992.

U.S. Environmental Protection Agency, Office of Water. *Case Studies in Wellhead Protection: Ten Examples of Innovative Wellhead Protection Programs.* (EPA 813-R-92-002), December 1992.

Virginia Ground Water Protection Steering Committee. *Wellhead Protection: A Handbook for Local Governments in Virginio*

Virginia Ground Water Protection Steering Committee. *Wellhead Protection: Case Studies of Six Local Governments in Virginia.* Fall 1993.