813B95005

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, DC 20460

ACKNOWLEDGEMENTS

This project and report were completed under Environmental Protection Agency (EPA) Contract No. 68-C4-0011, Work Assignment 1-14, by the CADMUS Group, Ron Bergman, EPA Work Assignment Manager. Charles Job provided technical direction and expanded the final report to incorporate detailed analysis and reporting of individual community costs and funding sources separate from the detailed case studies in Volume 2. EPA wishes to express its appreciation to the officials who participated in this project 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, for their cooperation that made this study possible.

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EXECUTIVE SUMMARY

Introduction

The benefits of avoiding contamination of community drinking water sources are greater than the costs of implementing a local prevention program for wellhead protection. Wellhead protection (WHP) offers community leaders a less expensive approach to protect public health and avoid the costs of future contamination of their ground water sources of drinking water. This analysis of seven communities shows that, on average, dealing with contamination of their ground water supply may be 30 to 40 times more costly than to prevent it in the first place. The Wellhead Protection Program is designed under the Safe Drinking Water Act (Section 1428) to prevent contamination from entering the ground waters supplying public water wells, but is not a guarantee. At this time, forty States and Territories have adopted wellhead protection programs under this law, but in most States, communities decide on the direction of implementation. The "basic" steps of a wellhead protection program include forming a team of local stakeholders, delineating the protection area around public wells, identifying potential contamination sources, and developing and implementing a local management plan. In most States, the type of plan and its implementation are determined at the community level. The results of this study suggest that the ratio of contamination costs to basic prevention costs may be as large as 200:1.

Six of the seven communities in this study identified below had experienced actual or immiment contamination of the ground waters supplying their public water systems. These experiences were motivating factors in their decisions to implement local wellhead protection programs. A seventh community area, a portion of an eastern Pennsylvania county comprised of four small adjacent communities, not currently affected by contamination but near one of the others, decided to implement a wellhead protection program jointly on their own. The responses of the leaders of these seven locations to contamination and prevention provide the data for this study. These data include the documented costs of responding to contamination affecting their ground water sources of drinking water and the documented costs of subsequently establishing a wellhead protection program to prevent future contamination incidents. The study identifies the contamination costs as being avoidable in communities that implement prevention activities through wellhead protection programs. Since contamination costs could be avoided through prevention, the avoided costs are benefits (referred to as "avoided-cost benefits) for communities implementing wellhead protection programs because future funds would not have to be spent on contaminant remediation. The avoided-cost benefits are compared to WHP costs to obtain benefit-cost ratios for the seven communities, assuming that their contamination costs would not have occurred if wellhead protection had been implemented earlier.

Communities Selected

The communities selected for this case study, their estimated populations, and settings are:

Communities	Population	Setting
1) Gilbert, Louisiana	700	Rural
2) Norway, Maine	4,000	Rural
3) Tumwater, Washington	13,000	Suburban
4) Gettysburg, Pennsylvania	12,000	Suburban
5) Eastern Lancaster County (4 adjacent towns), Pennsylvania	20,000	Rural
(Gettysburg and Eastern Lancaster County serve as a "community pair")		
6) Dartmouth, Massachusetts	24,000	Suburban
7) Middletown, Ohio	60,000	Central City

Benefit-Cost Analysis

The case studies demonstrate that in the long run, the cost of responding to a contamination incident significantly exceeds the cost of developing and implementing a WHP program. In the six case study communities that experienced contamination and developed a WHP program, the ratio of avoided- cost benefits to WHP development and implementation costs ranged from 5:1 to 200:1, on a per-well basis. Exhibit ES-1 presents a summary of the results for each community. Past costs were adjusted to 1994 dollars (U.S.) using the Consumer Price Index. Future costs to 2005 were discounted at 7 percent. The analyis of undiscounted costs provided similar results and ratios.

A number of factors affect the interpretation and magnitude of the study's results. This report is addressed to community officials, and not to national decision makers, to provide examples of potential costs of contamination and WHP implementation and to assist in planning and decision making at the community level. Thus, the accounting perspective of this report is at the community level and not State or national levels. Furthermore, this analysis assumes that the probability of contamination is 100 percent since six of these communities did have a contamination incident. This assumption would overestimate the probability of contamination for many communities. This analysis does not quantify or estimate the risk or probability of contamination to a ground water source of drinking water for any particular location or nationally to weight the case study results for application to other communities. Should contamination occur, however, the communities would face the full cost of cleanup and not a cost weighted by a probability or average cost across the State or country. The opportunity costs of volunteers' time is included for two communities that used volunteers to identify potential contaminant sources. Most costs that were easily identified and documented were for local, State, and Federal government expenditures. Business or private sector costs that could be easily identified and documented are included in this analysis. Costs for contaminant remediation that could not be documented include: health related costs, lost production of individuals and businesses, interruption of fire protection, loss of economic development opportunities, and loss of property value or tax revenue. From a prevention standpoint, business

EXHIBIT ES-1
SUMMARY COMPARISON OF TOTAL AND PER WELL CONTAMINATION AND BASIC WELLHEAD PROTECTION COSTS
(All costs adjusted to 1994 Dollars)

COMMUNITY (POPULATION)	TOTAL CONTAMINATION COST*	PER WELL CONTAMINATION COST	BASIC WHP COST	PER WELL BASIC WHP COST	RATIO OF CONTAM. TO BASIC WHP COST	RATIO OF PER WELL CONTAM. TO BASIC WHP
GILBERT Louisiana (700)	$1,094,645	$547,323	$5,487	$2,744	200 : 1	200 : 1
NORWAY Maine (4,000)	$545,904	$545,904	$101,014	$101,014	5: 1	5 : 1
TUMWATER Washington (13,000)	$1,712,440	$570,813	$286,954**	$22,073	6 : 1	26 : 1
GETTYSBURG/LANCASTER CO. Pennsylvania (12,000/20,000)	$4,015,351 (Gettysburg)	$4,015,357	$248,370** (Lancaster Co.)	$22,579	16 : 1	178 : 1
DARTMOUTH Massachusetts (24,000)	$2,353,291	$1,176,646	$693,365	$99,052	3 : 1	12 : 1
MIDDLETOWN Ohio (60,000)	$970,342 - $1,475,470	$323,447 - $491,823	$295,892	$22,761	3-5 : 1	14-22 : 1
TOTAL	$11,197,101	$933,092***	$1,631,087	$34,704***	7 : 1	27 : 1***

* Includes costs of alternative water suplies, water treatment, and contaminant source removal or remediation.
** Includes opportunity cost of volunteers' time for potential contaminant source identification.
*** Weighted by number of wells either contaminated or protected in each community.

costs associated with changes in processes, activities or facilities beyond those already planned or required by current law were not documented.

Smaller towns do not necessarily have small contamination problems; the contamination can be just as extensive or serious as in larger cities. For example, the contaminating incident in Gilbert involving two wells serving 700 people is nearly as costly as Middletown's remediation of ground water supplying three wells and 60,000 people. In addition, the costs of prevention do not have to correspond to community size. Because of particular protection concerns, both large and small communities may desire to implement prevention measures, such as ground water monitoring or detailed facility inspections, beyond the basic steps identified above. These additional protection measures are referred to as "special protection" in this report. Three communities - Norway,

Tumwater, and Middletown - are spending significant funds for ground water monitoring to provide early warning of future contamination. If ground water is the only reliable, high quality drinking water source, expenditures for special protection are probably warranted.

While the probability that all the wells in a community would be closed because of actual or imminent contamination (which did happen in the two smallest communities, Gilbert and Norway) may not be 100 percent, a community may desire to consider the costs of responding to such a problem in estimating total avoided-cost benefits in comparison to prevention costs. If all the protected wells in this study were to become contaminated (using the locally developed costs reflecting the respective areas' hydrogeologic settings) contaminant remediation of the ground water sources of drinking water in these locations may cost as much as $68 million. The combined costs for the 47 wells to receive special protection is $4.9 million and for basic protection is $1.6 million. The respective avoided-cost benefit to prevention cost ratios are 14:1 and 42:1. Even if the probability of contamination were 50%, and the contamination costs in this analysis were considered to be 50% too high, the combined average avoided-cost benefit to basic WHP cost ratio would still be 10:1 (see Exhibit ES-2).

EXHIBIT ES-2

Ratios of
Avoided-Cost Benefit to Wellhead Protection Costs
Assuming All Wells Are Contaminated (100% Probability of Contamination)

Community	Population	No. of Protected Wells	With Basic Protection	With Special Protection	Sensitivity Analysis: Assuming 50% Probabilityof Contamination and 50% of Contamination Costs/Basic Prot. Costs
Gilbert	700	2	200 : 1	200 : 1	50 : 1
Norway	4,000	1	5 : 1	4 : 1	1 : 1
Tumwater	13,000	13	26 : 1	11 : 1	7 : 1
Lancaster Co.	20,000	11	178 : 1	104 : 1	44 : 1
Dartmouth	24,000	7	12 : 1	4 : 1	3 : 1
Middletown	60,000	13	22 : 1	5 : 1	5 : 1
TOTAL		**47**	**42 : 1**	**14 : 1**	**10 : 1**

Comparison of Funding Sources for Contaminant Remediation and Prevention

Larger communities in this study funded most of their remedial and WHP costs themselves, whereas smaller communities relied on assistance from State and Federal sources. Overall, sources of funding for the contaminant remediation of the six communities' ground water supplies were: Community, 50%; State, 38%; Federal, 12%; and private, <0.5%. For the wellhead protection costs, Gilbert funded 80 percent of its basic WHP program through assistance from State programs. The other communities all funded most of their basic WHP and special protection activities themselves.

Overall, for the six basic WHP programs, the communities funded 84 percent of the cost themselves, States funded 6 percent, Federal programs 4 percent, and private sources 7 percent. Ninety-four percent of all special protection activities were funded by communities and 6 percent by States. This analysis of funding sources suggests that small communities will need support for both remedial and prevention activities. However, it also gives an indication that considerably less State and Federal money would be spent assisting any particular small community in preventing contamination of its drinking water source rather than remediating the contamination after it occurs.

Conclusions

Considering the cost of contamination - much of which could not be monetized for the purpose of this study - the cost of prevention is worth the investment. The benefits, expressed as possible avoided costs of contamination in this report, are substantial. For the smallest community, Gilbert, LA (population, 700, with 2 wells and 250 water connections), the benefit-cost ratio is 200:1. For Gilbert, the expenditure of $5,487 for prevention is very small in comparison to its cost of a new water supply - nearly $400,000 - and subsequent cleanup of the contamination to reduce future risk, a projected additional cost of $700,000.

For the larger communities, the benefits (possible avoided costs) are also significant. Their possible benefit-cost ratios range from 5 to 178 : 1. The combined average per well benefit-cost ratio for a basic prevention program considering the results of all seven communities is 27:1. These larger communities decided to incorporate other factors and concerns that raised their program development and future implementation costs, such as recent contamination and resulting desire for detailed delineation and management plans. Even so, the combined average possible per well benefit-cost ratio for all special program development and implementation is nearly 9:1, almost an order of magnitude difference, with a range of 4:1 to 104:1. Unquantifiable contamination costs would make the benefit-cost ratios larger (i.e., larger avoided-cost benefits).

While this analysis is based on a limited number of communities, the benefits of preventing contamination of drinking water supplies are evident. Further analysis of costs for a larger number of systems should occur to obtain a better distribution of communities. In particular, more analysis of smaller communities should be conducted to establish the range of costs consistent with their needs for protecting their drinking water sources and the high costs of contamination. Prevention costs for three of this study's communities were within or near the ranges calculated by Washington State for its communities that are developing and implementing WHP programs. For the larger communities that decided to invest considerably more in their wellhead protection programs, the steps they took indicate a strong desire to protect their water supply from contamination and service interruption, and, in some cases, protecting their only water source. Protecting public health through drinking water supply protection is a priority in these communities, even though they have had problems. The experience of these communities should benefit communities that currently have safe drinking water and desire to keep it that way.

1. INTRODUCTION

The benefits of avoiding contamination of community drinking water sources are greater than the costs of implementing a local prevention program for wellhead protection. Wellhead protection offers community leaders a less expensive approach to protect public health and avoid the costs of future contamination of their ground water sources of drinking water. This analysis of seven communities shows that, on average, dealing with contamination of their ground water supply may be 30 to 40 times more costly than to prevent it in the first place. In this ananysis, benefits are considered to be the possible avoided costs of remediating contamination, which six of these communities, not previously having a wellhead protection program, were not able to avoid. Wellhead protection is designed under the Safe Drinking Water Act (Section 1428) to prevent contamination from entering the ground waters supplying public water wells, but is not a guarantee. At this time, forty States and Territories have adopted wellhead protection programs under this law, but in most States, communities decide on the direction of implementation. The "basic" steps of a wellhead protection program include forming a team of local stakeholders, delineating the protection area around public wells, identifying potential contamination sources, and developing and implementing a local management plan. In most States, the type of plan and its implementation are determined at the community level.

The six case studies provide a starting point for future analyses of the avoided-cost benefits of prevention programs for wellhead protection. For the 43,000 communities out of 48,000 nationally which rely on ground water sources and have not started a wellhead protection program or are only partly implementing such a program, this report offers economic results showing that wellhead protection is an excellent investment. In particular, for small communities, the cost of contamination is so large in comparison to implementing a locally tailored prevention program that an avoided contamination cost to prevention cost ratio may be as large as 200:1.

The seven community experiences documented in this report show the wide array of activities that have already impaired or pose future threats to the quality their ground water sources of drinking water. Past and present hazardous waste sites, commercial and industrial operations, underground storage tanks, and chemical spills are the contaminant sources in these communities. This groundwater contamination has imposed or has the potential to impose significant costs on these communities and their residents. Treatment and/or replacement of the water supply has required these local governmental units to make substantial capital outlays and to increase user charges. Only after experiencing contamination of their ground water supplies of drinking water did six of these communities initiate a wellhead protection program from which basic and special protection costs were determined.

Substantial information exists on the direct costs of remediating, treating, or replacing contaminated drinking water. 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, such as health or economic development costs. These various types of data have not been systematically compiled, analyzed, and compared, however.

The purpose of this study is to compare the cost of local wellhead protection to the cost of contamination which could potentially be avoided by implementing a WHP program. Additionally, the information in this study is intended to assist local decisionmakers assess the value, cost and feasibility of implementing wellhead protection in their communties. 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.

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 benefit is called a *resource* benefit. This type includes 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 WHP program, 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 WHP program; and
- The probability that the WHP program will prevent contamination.

For purposes of calculating benefits and costs in this report, a contamination incident has a 100 percent probability of occurring and a WHPP will be completely effective.

This report encompasses the results of case studies of communities which have experienced contamination of ground water sources and have implemented WHP programs.[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 WHP program.

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 WHP program 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 WHP program).

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).

[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.

1.2.1 Pilot Study

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 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. 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 WHP program. The larger municipality of Gettysburg and the group of four 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 may result in differences in approach and associated 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 WHP program.

1.2.2 Case Study Selection

In attempting to make the project as representative as possible of the nation as a whole, the project team made an effort to include case studies in several geographic regions of the country. Several EPA Regional offices recommended points of contact in state environmental agencies. Because state staff often work closely with 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 affecting community water systems is underway and the cost has been sufficiently documented;
- WHP program 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 the key factor in the selection of case studies: Locations in which litigation constrained available information or where WHP programs were too recently initiated to allow reasonable estimates of future costs were not included.

The communities selected, their estimated population, and settings are:

Communities	Population	Setting
1) Gilbert, Louisiana	700	Rural
2) Norway, Maine	4,000	Rural
3) Tumwater, Washington	13,000	Suburban
4) Gettysburg, Pennsylvania	12,000	Suburban
5) Eastern Lancaster County, (4 adjacent communities), Pennsylvania	20,000	Rural
(Gettysburg and Eastern Lancaster County serve as a "community pair")		
6) Dartmouth, Massachusetts	24,000	Suburban
7) Middletown, Ohio	60,000	Central City

Figure 1 is a map showing the general locations of these communities.

1.2.3 Site Visits

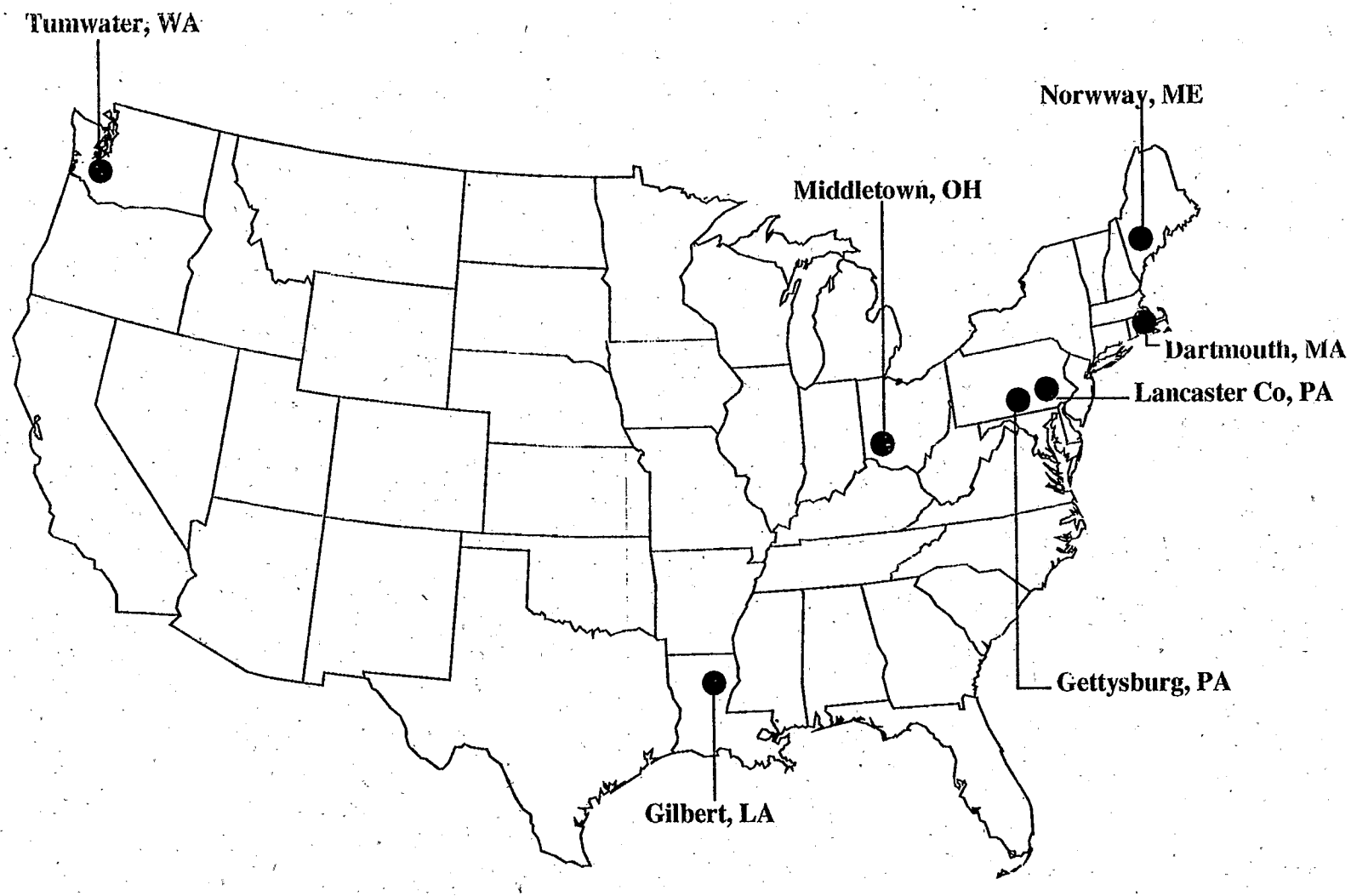
After selecting a community as a case study, the project team contacted the PWS operator to schedule a visit, and to inquire about other appropriate contacts. The team set up interviews with local, state, or EPA Regional staff involved with either responding to the contamination or developing the WHP program. People interviewed 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 and obtain information from decision documents and project files.

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 WHP program. The study team consulted decision documents, consultant reports, WHP program documents, PWS budgets, equipment invoices, and contract information.

Because many communities are in the early stages of responding to contamination or developing their WHP programs, 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

FIGURE 1
MAP OF CASE STUDY COMMUNITY LOCATIONS



implementation, such as an inspection or a round of monitoring. Using this information, the team projected annual WHP program implementation costs.

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

1.3 Major Assumptions and Premises

Several major assumptions and premises are consolidated and stated here to facilitate understanding the results of the rest of this report:

(1) The costs of contamination to ground water sources of drinking water supply can be avoided through community actions in a wellhead protection program. WHP is not a guarantee of avoiding all future contamination, but very significantly reduces future possibilities of contamination to ground water sources of drinking water.

(2) These avoided costs of contamination become benefits to communities' residents, businesses and governments, since funds would not need to be expended in the future to deal with contamination, assuming prevention activities for wellhead protection are completely successful.

(3) This report is addressed to community officials, and not to national decision makers, to provide examples of potential costs of contamination and WHP implementation and to assist in planning and decision making at the community level. Thus, the accounting perspective of this report is at the community level and not State or national levels. The results of this report should not be extrapolated to the national level. Averages and ranges reported are for comparison and summary purposes for the communities as a group in this report only. The number of communities is too small to represent a statistically significant sample. In particular, a greater proportion of smaller communities would be needed to be representative of the distribution of community water systems' sizes.

(4) While the probability of any particular well becoming contaminated is not known with certainty, any public well has some probability of being contaminated because of the complex nature of the subsurface and the variable but widespread use of chemicals in manufacturing, agriculture and residential applications. One factor increasing the probability of contamination is that most of the surficial aquifers of the United States are highly to moderately vulnerable to contamination. (US EPA, 1991) Another factor is the increasing observation of microbial contamination of ground water surces of drinking water. While

the expected value of the probability of contamination may be low in a particular location, once contamination occurs (even in a low probability situation), the community must face the full cost of contamination (e.g., an unlikely chemical spill occurs in a recharge zone or near a well), and, therefore, should consider the probability to be 100 percent for planning purposes. This full cost of contamination would not then be weighted by a probability, or by an average derived for all communities of that size, of occurrence, as it would be from a national planning perspective. NOTE: This analysis does not quantify or estimate the risk or probability of contamination to a ground water source of drinking water for any particular location or nationally to weight the case study results for application to other communities.

(5) The communities which are the case studies in this report did not have fully implemented WHP programs early on and, therefore, obviously did not receive the benefits of such prevention efforts. These communities are now or will soon be protecting their public wells through wellhead protection. The costs of contamination that they were not able to avoid serve as a "benchmark" for other communities to evaluate against and are referred to in this report as "avoided-cost benefits" (as described in more detail above). Other communities would need to evaluate the extent of such benefits in their particular situations. These case study communities serve as starting points and examples of the magnitude and range of such benefits. With respect to water supply protection, the worst case (as exemplified in some of the communities which lost all their wells to contamination) should be used for planning purposes, since any well has some probability of becoming contaminated.

(6) The costs of contamination could be significantly higher or lower than reported here. An earlier EPA analysis (EPA, 1992) found that past contamination of public water supply wells for a range of 51 small to large communities resulted in actual and projected remedial costs of from $380,000 to over $37,000,000 (in 1991 dollars).

(7) The costs of wellhead protection could be higher or lower as also documented by the State of Washington (Washington Department of Health, 1995). The needs of each community will be different, with some communities having only one source of water supply which may require substantial attention for protection. Other communities will have simpler needs for protection because of few but still significant contaminant sources.

(8) Basic wellhead protection, while not a guarantee, is sufficient for preventing contamination to public water supplies. This assumption is important in providing the benefit-cost results that follow in this report. Because of local conditions, some communities may desire to implement additional measures to provide further assurance of protection that would also increase their costs.

(9) The analysis assumes that the readily documentable costs for both contamination response and wellhead protection are sufficient. In some cases, private sector costs are included where

documented. Many contamination costs could not be developed because they were not documented, including health related costs, lost production of individuals and businesses, interruption of fire protection capabilities, loss of economic development opportunities, and loss of property value or tax revenue. Prevention costs that could not be documented include business costs associated with changes in processes, activities or facilities beyond those already planned or required by current local, State or Federal law or regulation. These remedial and prevention costs should be evaluated further in future analyses.

1.4 Organization of this Report

The remainder of this report is organized as follows:

- ***Chapter 2: Overview of the Case Studies*** contains a brief summary of the seven case studies.

- ***Chapter 3: Analysis of Benefits and Costs*** compares the costs of groundwater contamination to the cost of WHP. This chapter also analyses the sources of funding for contamination response and wellhead protection.

2. OVERVIEW OF THE CASE STUDIES

2.1 Comparison of Case Studies

The seven small to medium-sized communities in this study represent a variety of economic and geologic settings. Exhibit 1 presents an overview of community and PWS characteristics, contamination information, and WHP activities and status for the communities.

Two of the communities are located in the Northeast, two are in the Mid-Atlantic, one is in the Midwest, one in the South, and one is in the Pacific Northwest. The PWSs serve from less than 1,000 to over 50,000 residents. Four of the seven serve populations between 12,000 and 24,000 people. Three communities are rural (Lancaster County, Gilbert, and Norway); three are suburban (Gettysburg, Dartmouth, and Tumwater); and Middletown is a small industrial city. Four of the communities (Gettysburg, Lancaster County, Dartmouth, and Tumwater) are facing pressure from rapid development.

Three of the communities (Tumwater, Middletown, and Norway) are situated on glacially-deposited sediments. One (Dartmouth) is located over bedrock; Gilbert is located on alluvial sediment; and Gettysburg and Lancaster County are situated in rolling hills underlain by sedimentary rock.

Six of the seven communities studied experienced a contamination incident. Contamination in two communities (Gilbert and Norway) is due to leaking storage tanks at gas stations; dry cleaners contaminated the well in Gettysburg. Both dry cleaners and gas stations are on the list of the most likely sources of contamination in Tumwater, but the exact source has not been determined. In each contamination incident, the community responded to protect the quality of the water provided to its residents, either by purchasing drinking water, treating water at its affected wells, or developing new water sources. In all but Dartmouth, state or federal agencies stepped in to remediate the aquifer and soils.

Six of the seven communities studied have WHP programs. Of these six communities, three have reached the implementation stage (Gilbert, Dartmouth, and Norway). The three communities that are still developing their WHP programs have delineated WHP areas (or WHPAs) and conducted source inventories, and are currently working on management and contingency plans.

EXHIBIT 1
Comparison of the Case Studies

	Gettysburg, PA	Lancaster County, PA	Gilbert, LA	Dartmouth, MA	Tumwater, WA	Middletown, OH	Norway, ME
Response Activities							
Response to Water Supply Contamination	Constructed air stripper on affected well	N/A	Closed wells; drilled two new wells	Purchased water; installed air stripper	Closed 3 wells; drilled 2 replacement wells; considering air stripper	Closed 3 wells	Purchased water
Response to Aquifer Contamination	Soil vapor extraction; air stripping [planned]	N/A	Hydrocarbon removal; soil vapor extraction; air sparging [planned]	Removed sources of contamination	Undetermined	Soil vapor extraction; air sparging [proposed]	Air stripping; soil venting
Wellhead Protection							
Status of Wellhead Protection Program	Held preliminary discussions with State	Delineated WHPA; identified sources; developed management plan and ordinances; plan not yet implemented	Delineated WHPA; identified sources; passed zoning ordinance; developed contingency plan	Delineated WHPA; passed zoning ordinance; implemented contingency and management plans	Delineated WHPA; conducted source identification; conducting baseline water quality monitoring; developing management plan—completion expected mid 1996	Delineated WHPA; consulted several databases; conducted source identification; developed management plan	Delineated WHPA; identified contaminant sources; developed and adopted management plan
Management Tools	N/A	Performance & design standards; inspections; public education	Source prohibitions	Site plan reviews; minimum lot sizes; impervious cover restrictions; design standards	Site plan reviews; source prohibitions; minimum lot sizes; performance & design standards; inspections; public education	Site plan reviews; source prohibitions; minimum lot sizes; performance & design standards; inspections; public education	Site plan reviews; source prohibitions; impervious cover restrictions; performance standards

EXHIBIT 1
Comparison of the Case Studies

	Gettysburg, PA	Lancaster County, PA	Gilbert, LA	Dartmouth, MA	Tumwater, WA	Middletown, OH	Norway, ME
PWS Characteristics							
Population Served	12,200	20,000	700	24,000	13,000	60,000	4,000
Number of Wells	8 (6 active, 2 inactive)	11	4 (2 active, 2 inactive)	9 (7 active, 2 inactive)	15 (12 active, 3 inactive)	16 (13 active, 3 inactive)	1
Community Type	Suburban	Rural	Rural	Suburban	Suburban	Central city	Rural
Aquifer Type	Fractured sandstone and shale	Fractured conglomerates, dolomite	Alluvium	Alluvium	Alluvium, undifferentiated deposits, and glacial outwash	Sand and gravel	Sand and gravel
Contamination							
Source of Contamination	Dry cleaners	N/A	Leaking UST	Clandestine dumping	Four possible sources - WA DOT regional office, gas station, suspected former dry cleaners, and dry cleaners	Three possible sources - a business in the industrial park, the storm sewer, or the sanitary sewer	Gas station
Contaminants	VOCs [1 well]	N/A	Benzene [2 wells]	VOCs [2 wells]	VOCs [3 wells]	VOCs [3 wells]	MTBE [1 well]

All six communities began wellhead protection at least partially in response to the contamination incidents they experienced. Communities also responded to increasing development by adopting WHP. Gilbert, Dartmouth, and Tumwater adopted WHP to comply with state requirements. Norway began WHP in anticipation of Maine's statewide WHP program, which was subsequently defeated in the State legislature. Middletown is adopting a WHP program partially in response to a state requirement for them as a condition of approval for PWS improvements. Four of the communities are undertaking a regional approach to wellhead protection, recognizing that ground water quality can be affected by activities beyond jurisdictional boundaries.

To manage their WHPAs, the communities have adopted combinations of management tools. These include: site plan reviews; source prohibitions; minimum lot size requirements; impervious cover restrictions; design and performance standards; inspections; and public education programs. Three communities (Tumwater, Middletown, and Norway) periodically monitor water quality around their supply wells.

2.2 Case Study Summaries

In the sections below, each case study is presented in a brief synopsis. More detailed case study reports appear in "Benefits and Costs of Prevention: Case Studies of Community Wellhead Protection; Volume II; Detailed Case Studies of Seven Communities." These case studies in Volume II provide a thorough description of the contamination incident, its effects, the community's response, and associated costs, and WHP activities and costs.

Special Note on contamination response and remedial costs: The contamination response and remedial costs are only the documented costs for this expensive, and typically long term, effort. These costs may be borne by local, State and/or Federal governments. The potential costs that could not be documented include:

- Health related costs associated with illnesses that were not documented but may have been associated with contaminated water supply and lost production
- Interruption of drinking water supply until alternate sources are procured
- Loss of fire protection capabiliaties and insufficient water pressure to put out fires
- Interruption to commercial and industrial processes and lost production
- Loss of economic development opportunities because of contaminated water resource and drinking water being unattractive to relocating, expanding or new companies and businesses
- Loss of property value and tax revenue

While all of these undocumented costs associated with contamination may not have occurred in every community examined in these case studies, several did occur and would significantly increase the contamination costs described. For communities that have not experienced contamination of

their source waters, the documented remedial and undocumented community response costs are indicative of the magnitude and range of potential "avoided contamination costs" or "benefits."

Special Note on Prevention Costs: The total prevention program costs for wellhead protection documented in these case studies are high since most of the communities were faced with existing contamination problems. These communities desired to reduce the prospect of having to deal with further contamination of their source water in the future by implementing wellhead protection programs. In response to the contamination of their drinking water source, these communities implemented significant efforts that communities without such problems may not decide to do. Specifically, ambient monitoring around the wellfield, detailed inspections, public school curriculum, and other efforts directed specifically at responding to potential chemical and biological threats may be beyond the needs or the affordability of many communities. In particular, smaller communities with fewer potential contaminant threats can implement basic wellhead protection programs that respond to their needs at lower cost. Prevention program expenditures may be funded by local, State and/or Federal governments. The costs presented below for the local wellhead protection programs are separately stated for "basic protection elements" and then the incremental costs for additional "special protection elements" deemed necessary by the respective communities. The "basic protection elements" include forming a team of local stakeholders, delineating the protection area around public wells, identifying potential contamination sources, and developing and implementing a local management plan. In most States, the type of plan and its implementation are determined at the community level. "Special protection" includes (but is not limited to) use of complex methods for delineating protection areas, ground water monitoring, detailed facility inspections, and spill remediation.

Also, certain prevention (wellhead protection implementation) costs could not be easily documented and were not estimated. These costs include the incremental cost to businesses to modify processes, activities or facilities beyond those costs incurred to be in compliance with other local, State or Federal laws and regulations, or already planned. The documented costs are mainly for local, State or Federal expenditures for wellhead protection. Private sector costs were included where readily identified and available. A previous EPA report indicates that businesses in some locally-managed wellhead protection areas have incurred costs to modify processes or facilities earlier than originally planned. (EPA, 1995) These costs were not quantified by the businesses. However, these costs were planned to reduce business costs and future business liability for possible ground water contamination incidents due to chemical handling, storage or use. These latter costs somewhat offset the process or facility modification costs (although the extent of offset is not known). These costs should be examined further in future studies.

Total and "Per Well" Costs: Costs presented below are for both total and "per well" costs for contamination and/or remediation (that could be quantified within the scope of this analysis) and wellhead protection (or prevention). Total costs are those that could be easily quantified as

discussed above, based on interviews with local and State officials and on file reviews. "Per well" costs are given to allow comparison across the communities and to determine if economies of scale exist. Per well analysis is also appropriate since any and all wells could be contaminated or protected. In one case, Dartmouth had two separate wells contaminated by different incidents. Gilbert had both of its two wells contaminated by one incident. Middletown had three of its 16 wells contaminated by one contamination source, with other sources being examined for threats to other wells. Costs per well give a perspective on projecting remediation and potentially avoidable costs per well for the respective locations. If all wells were contaminated over time, hopefully an avoidable scenario through wellhead protection, the ratio of avoided-cost benefits to prevention costs would be much larger than shown in the case studies below, and could be estimated.

2.2.1 Gilbert, Louisiana

Gilbert is located in northeastern Louisiana. The village is almost exclusively rural, with land used mainly for agricultural and residential purposes. Gilbert's two wells, which tap the same aquifer, provide water for about 700 people.

In 1990, Gilbert residents began to complain that their water smelled of gasoline, and the PWS operator called the Louisiana Department of Health and Hospitals (LDHH) to report the problem. DHH tested samples from Gilbert's wells and notified the Louisiana Department of Environmental Quality (LDEQ) that the wells were contaminated with benzene. LDHH instructed Gilbert to stop using the wells. Gilbert connected to nearby water supplies on a temporary basis, plugged the old wells, and then drilled replacement wells. Soon after starting the new wells, Gilbert found excessive levels of manganese in one of the wells and shut it down. The remaining well is sufficient to meet current needs.

Contaminant source identification studies concluded that the benzene had leaked from an underground storage tank at an abandoned gas station 150 feet from one of Gilbert's wells. The tank had been removed in 1987, but had left behind enough benzene to make the soil near the site flammable. LDEQ conducted an investigation to characterize the contamination in preparation for the development of a corrective action plan, and proposed remedial alternatives, which have yet to be implemented.

As of 1995, the total cost of responding to the contamination was approximately $426,000. Gilbert paid approximately $95,000 of this total, using grants from the Farmers Home Administration, the Leaking Underground Storage Tank (LUST) Trust Fund, and the Department of Housing and Urban Development's Community Development Block Grant program. In addition, the Gilbert Water System lost 10 to 12 customers, who opted to drill private wells. Between 1995 and 2005, remedial costs will total $648,000. Aquifer remediation has not yet begun, as LDEQ has been unable to secure funding.

When LDEQ staff came to Gilbert for a WHP program meeting they found that, because of the contamination, the village was without a source of water. LDEQ assisted Gilbert in compiling an inventory of 27 potential contamination sources and siting new wells away from the sources. After Gilbert constructed the wells, LDEQ delineated a WHPA using a fixed radius around the wells. The village, aided by LDEQ, wrote and adopted a management ordinance and contingency plan, based on models provided by LDEQ. Gilbert implemented its WHP program in 1993.

Given the small area and relatively few sources of potential contamination, Gilbert utilized a basic approach to wellhead protection with the State's assistance. Gilbert's WHP program cost approximately $4,666. Most of these costs are salary costs for LDEQ and LDHH personnel. Gilbert also spends about $125 per year for informal inspections of potential sources. A summary of Gilbert's contamination response and remediation costs compared to program implementation costs is (past costs adjusted using the Consumers' Price Index; projected costs discounted using a 7 percent rate):

Contamination Costs:	$1,094,645
Wellhead Protection	
Basic Costs:	$5,487
Special Protection Costs:	0
Contamination Costs per well:	$547,323
Basic Wellhead Protection Costs per well:	$2,744
Potential Per Well Contamination to Basic Prevention Costs Ratio:	200 : 1

2.2.2 Norway, Maine

Norway is located in southwestern Maine. The town is predominantly residential, with some commercial and light industrial development. Norway's well, which taps the Little Androscoggin River Valley aquifer, serves about 2,000 of its 5,000 residents.

1990, during a routine UST inspection, Maine Department of Environmental Protection (DEP) personnel discovered a leaking pipe supplying a pump at Steve's Country Store, a gas station/variety store. Samples from a monitoring well installed under a DEP order provided evidence that the leak had contaminated soil and ground water around the site with hydrocarbons and methyl tertiary butyl ether (MTBE). DEP ordered the gas pumps and the drinking water well shut down.

Aquifer studies conducted for the WHP program in 1988 provided valuable information on ground water flow in the vicinity of Steve's Store, allowing DEP to respond quickly to prevent the

gasoline from migrating into the well. DEP installed an air stripper to treat the contaminated water, a soil venting system to treat the contaminated soil, and a series of monitoring wells to track the remediation. The well was reopened in 1992 after a 16-month remedy. During the time the well was shut down, Norway purchased water from the Town of South Paris. DEP continues to pay laboratory costs for monitoring water quality near the well.

The total cost of responding to the contamination was about $536,000. Norway paid about $10,000 in staff costs. The remainder was funded through DEP funds. Between 1995 and 2005, the ongoing costs for post-remedial monitoring will total $10,000.

Interest in WHP began as a result of concern over the rapid commercial development near Norway's well during the 1970s and 1980s. Because of the recent development and ground water contamination, Norway decided to obtain a detailed delineation and management plan for its protection area and to continue to monitor ground water quality which expanded its wellhead protection approach beyond a basic program to address local concerns. In 1988, Norway retained a consulting firm to perform a wellhead protection study. Using this study, the town delineated a WHPA based on ground water flow patterns and identified eighteen potential sources of contamination within the WHPA. Norway passed an ordinance to protect its WHPA and conducts bi-annual monitoring. Parts of this WHPA extended into the neighboring towns of South Paris and Oxford and many of the potential contamination sources were located in Oxford. Therefore, Norway encouraged the participation of these two towns in the WHP effort. In 1994, Norway and South Paris passed Wellhead Protection Ordinances to manage their sources. Oxford has yet to do so.

As of 1995, the total cost of Norway's WHP program was about $115,715. Norway paid about $83,400 of this total. The remainder was funded through a U.S. EPA Wellhead Protection Demonstration Grant and contributions from Oxford, South Paris, and a regional council of governments. From 1995 to 2005, monitoring and oversight of the WHPA will cost Norway $22,000. A summary of Norway's contamination response and remediation costs compared to prevention program implementation costs is:

Contamination Costs:	$545,904
Wellhead Protection	
Basic Costs:	$101,014
Special Protection Costs:	$37,289
Contamination Costs per well:	$545,904
Basic Wellhead Protection Costs per well:	$101,014
Potential Per Well Contamination to Basic Prevention Costs Ratio:	5 : 1

2.2.3 Tumwater, Washington

Tumwater is located in southwest Washington, near the state capital, Olympia. The city is mainly residential, with some industrial and commercial areas. Tumwater is experiencing a great deal of growth pressures. Tumwater's sixteen wells tap three aquifers to serve its 13,000 residents.

In August 1993, while conducting routine monitoring, Tumwater detected trichloroethylene (TCE) in three of its wells. The city shut the wells and increased pumping from its other wells. The city also received expedited approval on a pending water rights application to develop new wells.

The Washington Department of Ecology, EPA Region 10, and the city conducted field investigations to determine the source of the contamination. By the end of 1994, they narrowed the list of potential sources down to four, including two current or former dry cleaners and a gas station. They also conducted studies to characterize the contaminant plume, and found that the pumping of the wells had drawn the contamination to the wells.

As of September 1995, the total cost of responding to the contamination was $787,541. Tumwater has paid about half of these costs. Over the next ten years, contamination costs will total $914,899.

Tumwater began its WHP effort in 1993, when it received a state grant to develop a WHPP. The city decided on a detailed delineation of its WHP area in response to existing contamination of its ground water supply and potential contamination sources, and to monitor ground water quality. To date, Tumwater has passed three aquifer protection ordinances, developed a preliminary list of potential sources, and ranked the sources according to the threat they pose to the wells. During its contaminant source inventory, Tumwater identified five confirmed contamination incidents. The city's WHPP includes development of a ground water monitoring network. The wells will be located either upgradient of wells or immediately downgradient of known contaminant sites. Tumwater expects to complete its WHP program development by mid 1996.

Costs as of 1995 for developing and implementing Tumwater's WHP program total about $348,000, half of which will be paid by Washington through the grant awarded in 1993. A summary of Tumwater's contamination response and remediation costs compared to prevention program implementation costs is:

Contamination Costs:	$1,712,440
Wellhead Protection	
Basic Costs:	$286,954
Special Protection Costs:	$397,322

Contamination Costs per well:	$570,813
Basic Wellhead Protection Costs per well:	$22,073
Potential Per Well Contamination to Basic Prevention Costs Ratio:	26 : 1

2.2.4 Gettysburg, Pennsylvania

Historic Gettysburg is located in south-central Pennsylvania. The borough has evolved into a relatively busy commercial, institutional, and residential center. Gettysburg is characterized by its tourist attractions, the Gettysburg National Military Park and Eisenhower National Historic Site. Gettysburg relies upon eight wells tapping the Gettysburg Formation and nearby Marsh Creek to serve about 12,000 people.

Gettysburg first discovered volatile organic chemical (VOC) contamination of its Well #6, located in the center of town, during State-required pre-operational monitoring. The primary VOCs present were tetrachloroethene (PCE), trichloroethylene (TCE), and 1,2-dichloroethenes (1,2-DCE). The Pennsylvania Department of Environmental Resources (PADER) conducted a preliminary search for the source of the contamination in late 1986. It focused on nearby dry cleaners because PCE is a solvent commonly used in dry cleaning processes. PADER identified J.C. Cleaners as the likely contamination source, and subsequently determined that a drain located within the building was the source. For undetermined reasons, the drain failed and leaked wastewater into the soil. Pumping appears to have drawn contamination into Well #6.

Soil and ground water in the vicinity of the site were contaminated with VOCs, and a former private well on the J.C. Cleaners site may have caused contamination to move into the water-bearing zone of the well. Gettysburg has been treating the water at its well with an air stripper since 1987. PADER intends to install a ground water collection and treatment system to remediate the contamination plume, and is currently assessing two remedial scenarios, which may last either five or 30 years.

The total cost of the contamination incident to date is $1.7 million. Gettysburg has incurred approximately $349,000 of this cost. Over the ten year period from 1995 to 2005, remedial costs will range from $2.3 million to $2.9 million; over thirty years, the costs may exceed $3.9 million. A summary of Gettysburg's contamination response and remediation costs is (comparision to prevention program implementation costs appears below in 2.2.5 Lancaster County, Pennsylvania):

Contamination Costs:	$4,015,351
Wellhead Protection Costs: (See Lancaster County below)	

Contamination Costs per well: $4,015,351
Basic Wellhead Protection Costs per well: (See Lancaster County below)

Potential Per Well Contamination to Prevention Costs Ratio: (Combined under Lancaster County below)

2.2.5 Lancaster County, Pennsylvania

Lancaster County is located in southeastern Pennsylvania and is approximately 55 to 60 miles east of Gettysburg. Agriculture is the primary land use: the county is the most agriculturally productive non-irrigated county in the United States. Four communities in the eastern part of the county—Terre Hill, New Holland, Earl Township, and East Earl Township—are the subject of the case study. The region is almost completely dependent on ground water: eleven wells tap the Hammer Creek Formation and the Elbrook-Zooks Corner dolomite to serve approximately 19,000 people. The four communities are co-developing a regional WHP program. Interest in wellhead protection for Lancaster County began around 1990, when EPA Region 3 wanted to pilot test a WHPA delineation method for fractured bedrock aquifers using a geological method known as fracture trace analysis.

Three protective zones have been delineated around each of the four communities' wells using fracture trace analysis. Consultants to the communities searched EPA and PADER databases for potential contamination sources. Local officials and other volunteers conducted door-to-door surveys of potential contamination sources, and developed a list of 119 potential sources of contamination.

The four communities are joining together to develop a single comprehensive ordinance to impose active zoning controls within the WHPAs. Work on this ordinance has begun. Plans for the ordinance include imposing permit fees, design and performance standards, as well as initiating a public education program focusing on farmers. Contingency plans have been discussed but not developed.

The cost as of September 1995 of developing the WHP program is $66,000. The WHP program was financed by grants from EPA Region 3 and PADER, and community matches. Once the WHP program is implemented, permitting fees will fund the program. From 1995 to 2005, these costs may total $351,000, principally for a detailed facility inspection program, which will be a major factor affecting its future program implementation costs. These eastern Lancaster County towns and Gettysburg serve as a "community pair" for this study, comparing the contamination remedial costs of Gettysburg to the wellhead protection costs in nearby Lancaster County.

Contamination Costs:	(Refer to Gettysburg above)
Wellhead Protection	
Basic Costs:	$248,370
Special Protection Costs:	$175,589
Contamination Costs per well:	(Refer to Gettyburg above)
Wellhead Protection Costs per well:	$22,579

Potential Per Well Contamination (Gettyburg)
to Basic Prevention (Lancaster Co.) Costs Ratio: 178 : 1

2.2.6 Dartmouth, Massachusetts

Dartmouth is located in southeastern Massachusetts, along the coast of the Atlantic Ocean. The town is mainly residential, but has commercial, industrial, and manufacturing areas. Dartmouth relies upon seven sand/gravel wells tapping two aquifers to serve 24,000 of its 27,000 residents. To meet its total demand, the town annually purchases 20 percent of its water from the neighboring city of New Bedford.

In 1978, responding to calls from concerned citizens, Dartmouth found organic and VOC contamination from a hazardous waste dumping operation in its Route 6 well. As a result, the town lost the well and has been forced to purchase replacement water. In the early 1980s, the town discovered VOC and hydrocarbon contamination from an old town dump site while siting its Chase Road well. The town responded by installing an air stripper/greensand filtration plant at the well.

As of September 1995, the total costs of discovery, characterization, cleanup, and water replacement at Dartmouth's two wells is $1,380,694. Since the closure of the Route 6 well, the town has lost revenue from the sale of water netting $513,687. From 1995 to 2005, Dartmouth will pay over $389,000 to purchase replacement water. At the Chase Road well, the town paid a total of $777,247 to study the contamination and install and operate an air stripper/greensand filtration plant. Between 1995 and 2005, O&M costs will total approximately $583,000.

Contamination of its drinking water supply prompted Dartmouth to voluntarily undertake an innovative wellhead protection program in 1980. Dartmouth was one of the first communities in the nation, and the first in Massachusetts, to adopt WHP.

Dartmouth's WHP program, developed in response to the contamination its wells experienced from uncontrolled and illegal dumping of hazardous waste in two water supply areas, is highly protective of its wellfields. The largest WHP expense is for a daily detailed on-site inspection of the wells and wellfields, which is nearly 90 percent of the total program cost. The WHPAs are managed through close cooperation among several departments of local government:

the Water Department has responsibility for day-to-day management of the WHPAs. The Planning Commission proposes bylaws for aquifer protection and mandates best management practices within WHPAs, and the Building Commission implements zoning bylaws. The Department of Health inspects septic systems. Fire Departments carry spill response kits to respond to fuel spills associated with traffic accidents. Dartmouth is considering equipping police cars with similar kits, as police officers usually arrive first to the scene of traffic accidents.

To date, development of Dartmouth's bylaw and the delineation process have totaled $183,510, or $26,215 per well. The annual costs of WHP in Dartmouth are $154,052, or $22,000 per well. Between 1995 and 2005, WHP implementation will cost Dartmouth approximately $1.1 million. A summary of Dartmouth's contamination response and remediation costs compared to prevention program implementation costs is:

Contamination Costs:	$2,353,291
Wellhead Protection	
Basic Costs:	$693,364
Special Protection Costs:	$1,614,256
Contamination Costs per well:	$1,176,646
Basic Wellhead Protection Costs per well:	$99,052
Potential Per Well Contamination to Basic Prevention Costs Ratio:	12 : 1

2.2.7 Middletown, Ohio

Middletown is located in southwestern Ohio, about half-way between Cincinnati and Dayton. The city supports a wide variety of land uses, including residential, commercial, and light and heavy industrial. Middletown depends on thirteen wells, tapping the Great Miami Buried Valley Aquifer System, to serve its 60,000 customers.

In the five years since Middletown discovered VOCs in its wells, monitoring detected PCE consistently in three wells and occasionally in two other wells. Upon discovering the contamination, Middletown shut down three wells. The Ohio Environmental Protection Agency (OEPA) identified AEP Flexo, Inc., a manufacturer of flexographic printing plates as the source. The facility used PCE in its process and had spilled and disposed of the chemical improperly for years. OEPA entered into a consent decree with AEP Flexo in July 1993. Under the decree, AEP Flexo is investigating the contamination and preparing for remediation.

Responding to the contamination incident has cost Middletown $732,000 as of September 1995. AEP Flexo's investigation costs were not provided; however, under the terms of the consent decree, AEP Flexo will reimburse OEPA's oversight costs, which total about $46,000 to date. Between 1995 and 2005, Middletown will spend between $192,000 and $697,000 to provide safe drinking water to its residents, depending on whether the city decides to construct air strippers.

In 1991, partly in response to the contamination incident, Middletown began developing a WHP program. The city's consultant delineated WHPAs for the wells; city staff and the consultant conducted a contaminant source inventory by consulting databases of potential contaminant sources and then supplementing this information with a windshield survey. They identified approximately 80 potential and three confirmed sources of contamination. The consultant then prioritized the potential sources based upon the risks they posed to the wells and identified seven high priority areas for ground water monitoring. In December 1993, Middletown completed a draft management plan.

Middletown borrowed Dayton's "Intensity of Land Use Classification" management approach. Under the approach, every parcel of land is assigned a rating, based on the amount and types of chemicals used or stored onsite. No increase in the hazard ranking is permitted; land owners must adopt engineering controls or risk management measures to maintain the site ranking should they wish to store more chemicals onsite. The city also developed a framework for a contingency plan.

To date, Middletown has spent $98,000 to develop its WHP program, including $12,000 from a U.S. EPA Wellhead Protection Demonstration Grant. By 2005, the city expects to have spent approximately $1.3 million on the program, to be funded through a $0.50 monthly connection fee and a 5 percent usage surcharge on industrial customers. Part of this expense will be the creation of a Risk Reduction Fund to financially assist businesses in adopting measures to prevent contamination, and an Emergency Response Fund. Other than ground water quality monitoring in the wellfield, these funds represent the largest expense of the Middletown WHP program, going beyond a basic approach to respond to local concerns. A summary of Middletown's contamination response and remediation costs compared to prevention program implementation costs is:

Contamination Costs:	$970,342 - $1,475,470
Wellhead Protection	
Basic Costs:	$295,892
Special Protection Costs:	$1,082,220
Contamination Costs per well:	$323,447 - $491,823
Basic Wellhead Protection Costs per well:	$22,761
Potential Per Well Contamination to Basic Prevention Costs Ratio:	14 - 22 : 1

3. ANALYSIS OF BENEFITS AND COSTS

As discussed in Chapter 1, the primary goal of this study was to demonstrate that over the long run, the cost of responding to contamination (a potential avoidable cost) exceeds the cost of developing and implementing a wellhead protection program. Sections 3.1 and 3.2 summarize the costs of contamination (which could potentially be avoided by other communities through implementing a WHP program, and therefore counted as "benefits" in this study) and WHP, respectively. Section 3.3 presents the resulting benefit/cost ratios. Section 3.4 addresses a comparison of funding sources. Section 3.5 presents a discussion of intangible contamination costs. Section 3.6 covers the commodity value of the contaminated water in the case study communities.

3.1 Contamination Costs Avoided (Benefit)

Contamination costs consist of the costs associated with two parallel courses of action in response to groundwater contamination. First, communities affected by contamination must protect their water supplies. Second, an aquifer remedy must be selected, installed, and implemented, usually by state or federal agencies. In responding to PWS and aquifer contamination, the communities, state and federal agencies, and responsible parties will pay between $500,000 and $4 million per well.[2] Exhibits 2 and 3 compare remedial costs in each community and present the organizations that will pay those costs. A previous analysis by EPA in 1992 indicated that for a selection of 51 communities with contaminated or threatened drinking water systems, the cost of remediation averaged $5.9 million per community water system, with most costing between $1 million and $10 million. (EPA, 1992)

3.1.1 Response to PWS Contamination

When contamination is discovered, communities must react to prevent the contaminants from reaching their customers. Each community faced with contamination acted either to treat water entering the distribution system, or to provide an alternative water supply in the short-term (by purchasing water) or in the long-term (by siting new wells).

Treatment of PWS Wells

If it is feasible and cost-effective, communities may opt to apply treatment to their water supply wells and continue using those wells. Gettysburg and Dartmouth chose to install air strippers on their contaminated wells. Treatment at the well imposes both capital costs and increased operation and maintenance (O&M) costs on the PWSs.

Capital costs usually include expenses for purchasing and installing treatment equipment.

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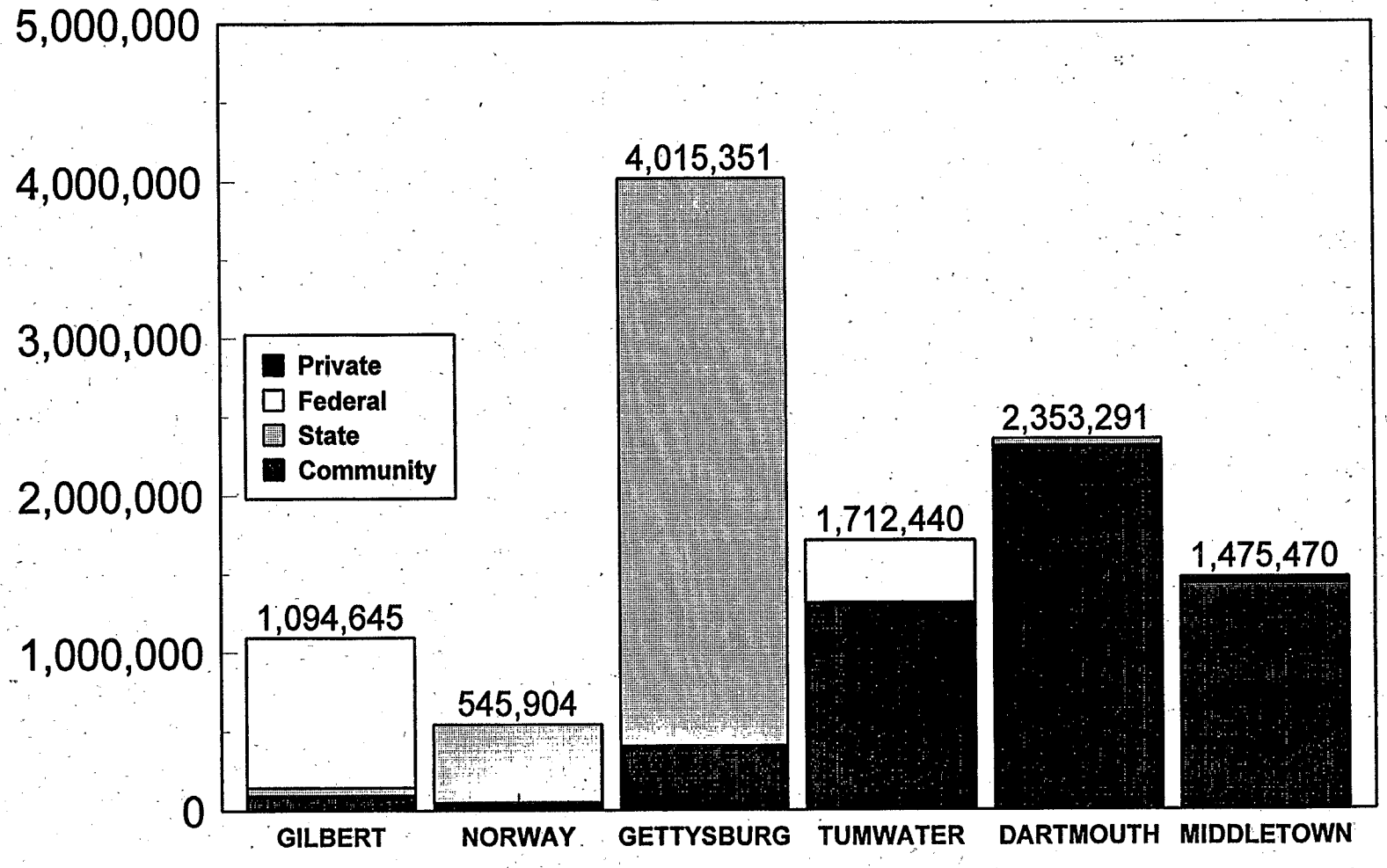
[2]All costs are presented as constant 1994 dollars, unless otherwise noted.

EXHIBIT 2
COST OF CONTAMINATION
BY FUNDING SOURCE
($1994)

FUNDING SOURCE	GILBERT	NORWAY	TUMWATER	GETTYSBURG	DARTMOUTH	MIDDLETOWN	TOTAL
LOCAL	$95,122	$16,939	$1,306,040	$407,730	$2,337,821	$924,481-1,429,609	$5,088,133-5,593,261
STATE	51,531	528,965	5,000	3,607,621	15,470		4,208,587
FEDERAL	947,992		401,400				1,349,392
PRIVATE						45,861	45,861
TOTAL	$1,094,645	$545,904	$1,712,440	$4,015,351	$2,353,291	$970,342-1,475,470	$10,691,973-11,197,101
COST OF CONTAMINATION SUBTOTAL FOR PROVISION OF SAFE DRINKING WATER							
LOCAL	$90,122	$6,939	$1,180,480	$406,927	$2,337,821	$924,481-1,429,609	$4,946,330-5,451,458
STATE	4,633	142,262					162,365
FEDERAL	299,998				15,470		299,998
SUBTOTAL	$394,753	$149,201	$1,180,040	$406,927	$2,353,291	$324,481-1,429,609	$5,408,693-5,913,821

EXHIBIT 3
WHO PAYS FOR CONTAMINANT REMEDIATION?
($1994)



Population :	700	4,000	12,000	13,000	24,000	60,000

These costs can be significant one-time expenditures for a PWS. Gettysburg paid $321,117 to acquire land for and to construct an air stripper on its well. Dartmouth paid $81,250 for an air stripper tower and greensand filtration plant at its Chase Road Well. O&M costs for treatment plants such as air strippers include the additional electrical, maintenance, and supply costs associated with the added treatment. In addition, PWSs may have to conduct additional monitoring to ensure the quality of the water entering the distribution system. Gettysburg's annual O&M costs total $13,280 for additional monitoring and electricity. As of 1995, the Gettysburg Municipal Authority (GMA) paid $27,500 in O&M costs; between 1995 and 2005 GMA will incur incremental monitoring and electrical costs of $58,000 to $100,000. Dartmouth pays $76,300 annually for the incremental electricity, chemical treatment, and maintenance of the air stripper/greensand filtration at the Chase Road Well.

Emergency Replacement of Water

Purchasing water is an option for affected communities if an adjacent water system has a surplus water supply and is able to sell its water. Communities may purchase water either in the short-term, until remediation is complete, or in the long-term to permanently replace a lost well. Water often must be purchased at the highest rates charged by the new supplier. Gilbert, Dartmouth, and Norway incurred costs between $50,000 and $200,000 annually to purchase replacement water.

Gilbert purchased water from two nearby communities at a higher rate than it normally charged its customers: the village paid $75,500 for replacement water over an 18 month period. Additionally, Gilbert paid $26,300 for transmission lines to tie into the neighboring PWSs.

Although Dartmouth has historically purchased a portion of its water from the City of New Bedford, loss of the Route 6 well forced the town to increase its dependence on New Bedford's water system. Paying commercial water rates (the highest New Bedford charges), Dartmouth spends an additional $55,000 annually to replace the 81 million gallons the well once supplied.

During its 15-month water emergency, Norway purchased water from the Town of South Paris at a total cost of $133,000. Maine DEP paid the cost of the purchased water above Norway's usual production cost via the State's Third Party Damage Claim process.

Development of New Sources

Searching for and developing new ground water sources appears to be the most expensive response to loss of a well. Gilbert, Tumwater, and Middletown were forced to develop new drinking water sources. The Village of Gilbert spent almost $280,000 to plug its two contaminated wells and to acquire land for and construct two replacement wells. This accounted for over 70 percent of the total cost associated with the contamination incident.

Tumwater spent $76,000 per well to replace three of its wells. Although Tumwater planned to eventually site one of these wells to meet growing water demand, the city was forced to incur substantial costs to site the wells away from contamination; this figure represents the incremental siting costs. Middletown is forced to incur substantial water supply development costs several years earlier than anticipated at an incremental cost of $17,000 per well, on a present value basis.

Indirect Costs to PWSs

Gilbert appears to be the only water system that has experienced documented indirect costs due to contamination of its water supply. Initially, the Gilbert Water System (GWS) did not raise water rates to compensate for the incremental costs associated with purchasing water. As a condition to receiving its FmHA grant, Gilbert was required to raise its water rates. In response to both the contamination and the higher water rates, approximately 10-12 residents abandoned public water and drilled private wells.

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.

3.1.2 Aquifer Clean-up

Cleanup of the contaminated aquifer typically involves a much more costly response effort than the PWSs can usually undertake. Groundwater cleanup costs can exceed several million dollars, so State or Federal assistance is sought to pay to remove contamination, especially if it is now or considered to be a potential continuing or future contamination source.

Capital Costs

Capital costs refer to the up-front expenditures response agencies incur to assess the extent and severity of contamination, select an appropriate response action, and procure the necessary equipment. Capital costs include direct costs (e.g., purchased equipment and construction materials, equipment and material installation, and health and safety equipment) and indirect costs (e.g., surveying, construction inspection, engineering/design, and administrative activities).

Assessing Contamination

Assessing the scope of the contaminant plume and selecting a remedy are the first steps to aquifer cleanup. In the case studies, these costs totaled from $28,330 to $1.4 million per well.

- In Gilbert, LDEQ performed a preliminary contamination assessment and developed a corrective action plan, spending $23,500 per well in contractor and staff effort. LDEQ anticipates conducting additional delineation of the contamination before treatment is installed, at an estimated cost of $4,830 per well.

- Tumwater, WSDOE, and EPA Region 10 conducted two investigations of the wellfield contamination, at a cost of approximately $69,000 per well. The City spent $42,000 per well and WSDOE spent $1,700 per well for their joint initial investigation. EPA's Expanded Site Investigation cost approximately $133,800 per well.

- In Gettysburg, PADER has spent at least $1.4 million (as of September 1995) for the contamination assessment and to assess remedial alternatives for cleaning the ground water and soil around the J.C. Cleaners site.

- Dartmouth spent $89,760 to study contamination at the Route 6 well and the surrounding aquifer. At the Chase Road site, Dartmouth performed a Phase II assessment of contamination (at a cost of $89,250), and a Risk Assessment (at a cost of $15,470).

- Middletown's investigation of its contamination incident cost $114,000 per well. The responsible party is likely spending a similar amount in its investigation. OEPA's oversight costs from 1992 to 1995 total $15,300 per well.

Constructing Treatment Operations

Once a remedy is selected, the responding agency must build a treatment plant or otherwise execute the remedy. Remediation is complete only in Dartmouth and Norway. In several of the other case studies, decision documents or knowledgeable staff have indicated what response costs likely will be.

- In Gilbert, LDEQ anticipates spending approximately $96,000 per well to construct an air sparging and soil vapor extraction systems. This estimate assumes that the preferred remedial alternative is implemented.

- Norway is the only community studied that has constructed, implemented, and completed a treatment operation. Maine DEP drilled two production wells, and constructed an air stripper. The total up-front costs associated with the remedy in Norway were approximately $322,000.

- In Gettysburg, PADER is currently examining two alternative scenarios for

groundwater treatment and soil vapor extraction. The agency projects that remediation of soil and ground water will require approximately $820,000 in capital expenditures. PADER will fund the cost of remediation through its Hazardous Sites Cleanup Program (HSCP).

Operation and Maintenance Costs

O&M costs are the ongoing expenses of implementing a remedy over several years. O&M costs include electricity, maintenance, materials, administration, insurance, taxes, licenses, equipment replacement, and sample analysis.

As indicated above, Norway is the only community for which ongoing aquifer remediation costs are known for certain, although reasonable estimates of remedial costs in Gettysburg and Gilbert are available.

- In Gilbert, O&M costs associated with remediation will probably total $223,000 per well between 1995 and 2005. This figure includes $89,762 per well for the hydrocarbon recovery system, $87,795 per well for soil vapor extraction, and $3,850 per well for the proposed air sparging system.

- In Norway, Maine DEP pumped and treated ground water for 18 months. The total O&M cost of the remedy from 1990 to 1995 was $22,100. Additional monitoring of water quality will probably total $10,000 between 1995 and 2005.

- In Gettysburg, the net present value of O&M costs for the years 1995 to 2005 will be from $2.3 million to $2.8 million, depending on the duration of the remedy. If remediation takes 30 years, total O&M costs could exceed $3.9 million.

3.1.3 Comparison of Costs for Providing Safe Drinking Water and Total Projected Remedial Costs

Comparison of costs for providing safe drinking water and total projected remedial costs indicates that for the six communities, providing safe drinking water was a significant cost. These costs for providing safe drinking water include connecting to alternative sources of supply, installing new wells, or water treatment. Total projected contaminant remedial costs include the provision of safe drinking water and aquifer remediation. As Exhibit 4 shows, overall 53 percent of the remedial costs were for safe drinking water supply. In Dartmouth, 100 percent of the remedial costs were for safe drinking water. In Gettysburg, only 10 percent were for safe drinking water, while in Gilbert, the smallest community in the study, 36 percent of remedial funds went for drinking water supply.

Since providing long-term safe drinking water supply is the major concern of communties

with wellhead protection, these alternative water sources or treatment may be considered the principal costs to be avoided by wellhead protection. Averaging over all the communities, the ratio of the avoided cost of an alternative safe drinking water supply to basic wellhead protection is 4:1. For Gilbert, serving 700 people, this ratio is 72:1. These ratios vary considerably among communities and also suggest that small communities may proportionally have substantially higher costs for water supply alternatives in comparison to wellhead protection. Additionally, the ratios are higher when evaluating total projected remedial costs of contamination since the drinking water supply costs may not take into account long term supply requirements and other factors affected by contaminated ground water. Typically, removing any source that could continue to contaminate or threaten the drinking water supply is also a priority and must be included. Both provision of a safe drinking water supply and contaminant remediation are included in Total Projected Clean-up Costs in the Exhibit 4, below. Long-term public health costs are not included in these evaluations.

EXHIBIT 4

Remedial Costs
For
Safe Drinking Water and Total Projected Clean-up
($1994)

Community	Subtotal for Providing Safe Drinking Water Supply	Total Projected Drinking Water And Clean-up	Percent Drinking Water of Total	Ratio of Remedial Drinking Water Costs to Basic Prevention Costs
Gilbert	$394,733	$1,094,645	36%	72
Norway	$149,201	$545,904	27%	2
Tumwater	$1,180,040	$1,712,440	69%	4
Gettysburg	$406,927	$4,015,351	10%	2*
Dartmouth	$2,353,291	$2,353,291	100%	3
Middletown	$924,481- $1,429,609	$970,342- $1,475,470	95%- 97%	3-5
TOTAL	$5,408,673- $5,913,801	$10,691,973- $11,197,101	53%	3-4

* Ratio is for Gettysburg's remedial costs for safe drinking water supply divided by Lancaster Co.'s basic wellhead protection program costs.

3.1.4 Extent of Outside Funding for Contaminant Remediation

The smaller communities relied on outside sources of funding - State and Federal programs -for contaminant remediation. Exhibit 3, Who Pays for Contaminant Remediation?, shows the amount of remedial costs and the source of funding by community. State and Federal programs funded 91 percent of the remedial activities in Gilbert, 97 percent in Norway, and 90 percent in Gettysburg, the three smaller communities in the study. In Tumwater, 25 percent was funded by State and Federal programs. Dartmouth funded 99 percent and Middletown funded 97 percent of the contaminant remediation costs themselves. Overall, 50 percent of the remedial costs of the six communities were funded by State and Federal sources.

3.2 Wellhead Protection Costs

The case study communities are at different stages in the development of their WHPPs. Three communities (Gilbert, Dartmouth, and Norway) have completed all of the WHP elements, and their programs are in the implementation stage. Middletown and the communities of Lancaster County have developed, but not yet adopted, source management strategies. Tumwater currently is developing its source management plan.

This section summarizes WHP costs as of September 1995, as well as projected expenditures through September 2005. To account for size differences among the case study communities, costs are reported as per-well costs, except where otherwise noted. Most costs that were readily identified and easily documentable were for local, State and Federal government expenditures. Private sector expenditures are included where available and documented. Exhibit 5 presents the Basic and Total Wellhead Protection Program Costs to 2005.

3.2.1 Cost Determinants

Total WHP costs as of September 1995 vary widely among the case study communities, ranging from $2,700 to $329,700 per well. For Tumwater, Middletown, and Lancaster County communities, costs as of September 1995 largely represent WHPP development. In Gilbert, Dartmouth, and Norway, these costs include both development and implementation activities.

WHPP Development

Gilbert, the smallest and most rural of the communities, has the lowest WHP cost to date. Total expenditures are approximately $2,300 per well. Lancaster County and Middletown have similar per-well basic protection costs of approximately $6,000 and $4,800, respectively. Dartmouth's per well basic development costs are five times as high as Middletown's, Lancaster County's, and Tumwater's, at $99,000. Norway's $101,000 per-well basic plan cost is the highest.

EXHIBIT 5
BASIC AND TOTAL WELLHEAD PROTECTION PROGRAM COST TO 2005
($1994)

	Middletown, OH	Dartmouth, MA	Lancaster, PA	Tumwater, WA	Norway, ME	Gilbert, LA
Population Served	60,000	24,000	20,000	13,000	4,000	700
Community Setting	Central City	Suburban	Rural	Suburban	Rural	Rural
Number of CWS Wells	13	7	11	13	1	2
PROGRAM DEVELOPMENT						
Delineation	$45,000 (Includes cont. source id.)	$64,905	$45,780 (Includes cont. source id.)	$52,880	$48,713	$3,347 (includes cont. source id.)
Contaminant Source Identification			6,600[6]	18,910[8]		
Management Plan	11,220		20,400	40,986	33,875	571
Contingency Plan				21,978		231
New Well Protection						
PROGRAM IMPLEMENTATION						
Unspecified				152,200		
Overlay Zoning/Ordinance		53,700 (includes contaminated source identification and contingency plan				36
Well(s)/Wellfield Inspection		516,450[4]				1,071 (incl. cont. source Admin)

	Middletown, OH	Dartmouth, MA	Lancaster, PA	Tumwater, WA	Norway, ME	Gilbert, LA
Contam. Source Self-Audit/Report						
Contam. Source Admin/Inspections	239,072	58,310	175,590		18,426	
Sign Installation						231
Public Information						
Subtotal Basic WHP Cost	$295,892	$693,365	$248,370	$286,954	$101,014	$5,487
Other Administration (reporting/briefing/ documentation				96,618[9]		
Delineation (detailed)		64,905[5]				
Wells Operation/Inspection		1,549,350[4]				
Permitted Facility Inspection			175,589[7]			
Education	25,500[1]					
Monitoring in WHPA	245,472[2]			278,726[10]	37,289[12]	
Spill Response/Risk Mgmt.	811,248[3]			21,978[11]		
Subtotal Special WHP Cost	$1,082,220	$1,614,255	$175,589	$397,322	$37,289	$0
TOTAL WHP COST	$1,378,112	$2,307,620	$423,959	$684,276	$138,303	$5,487

Notes to Exhibit 5 are on the following page.

NOTES TO EXHIBIT 5

1. A public School Education program on ground water protection.

2. Wellhead protection area (WHPA) monitoring reflecting concern for other potential specific contaminant sources in WHPA.

3. Spill Response and Risk Management funds to remediate contamination and provide loans to business to implement best management practices.

4. Assumes that the incremental cost of implementing WHP immediately around the wellheads is 25 percent of Wells and Wellfield inspection costs, since well operation must be checked regularly whether or not a WHP program is in place ; in a more basic program with no previous contamination incidents, the duration and frequency of inspection may be less.

5. Half of the total delineation costs considered to reflect special local concerns for more precise boundaries.

6. Includes the opportunity cost of local government officials working after hours to identify potential contaminant sources; evaluated at 120 hours (estimated) multiplied by $55.00 per hour, an estimated hourly rate if a consultant had been retained, equaling $6,600.00. As a practical matter, these costs were not incurred by the community.

7. Half of Permitted Facility Inspection considered to be additional local cost of detailed facility inspections beyond a basic WHP program.

8. Includes the opportunity cost of community volunteers (senior citizens) to identify potential contaminant sources; evaluated at 315 hours (estimated) multiplied by $4.25 (1994 minimum wage) and by a factor of 1.2 to include benefits, etc, equaling $1,610.00. As a practical matter, these costs were not incurred by the community.

9. Additional reporting and briefings reflecting additional local concerns; also includes reporting and documentation to State.

10. WHPA monitoring reflecting concerns for other potential specific contaminant sources in WHPA.

11. Includes spill response costs beyond basic WHP program.

12. WHPA monitoring reflecting concern for other potential specific contaminant sources in WHPA.

Given the small sample size, it is difficult to identify any general factors that appear to influence the cost of developing a WHPP. However, the experience with contamination did cause several of these communities to take additional efforts to assist them in protecting their wellfields from future contamination, such as the early warning that monitoring wells might provide. One can assume that, in certain circumstances, economies of scale are present. Delineation and source identification costs may be affected by the number of unique WHPAs that must be delineated; they are also sensitive to the number of wells and distance between wells in the wellfield, as well as the pumping rates which affect the size of the protection areas. A community with three wells in separate wellfields could be expected to have higher per-well costs than a community with three wells in one wellfield. The costs of developing management and contingency plans for alternate water supplies probably are not significantly affected by the number of WHPAs, since, presumably, the plans are not entirely WHPA-specific. Thus, economies of scale may occur.

Factors unique to each case study community appear to exert the biggest influence on WHPP development costs. For example:

- Gilbert's low cost can be attributed to LDEQ's use of the fixed radius delineation method. Further, Gilbert used a "fill in the bank" contingency plan and modelled its ordinance on examples provided by LDEQ.

- Norway's high per-well cost can be attributed to a lack of economies of scale. The town undertook a relatively complex delineation and aquifer characterization effort for its sole well.

- Tumwater's relatively high development cost can be attributed to its extensive groundwater monitoring effort and its heavy reliance on consultants to develop its management and contingency plans, and to conduct the preliminary source identification effort.

- Middletown relied extensively on its volunteer Wellfield Protection Committee to develop several elements of the WHPP, keeping costs lower than they might have been otherwise.

Implementation Costs

WHP costs between October 1995 and September 2005 appear to reflect the communities' implementation approaches, more than anything else. Expected per-well basic protection costs range from $411 in Gilbert to $41,000 in Dartmouth. It is interesting to note that the other communities

have similar per well implementation costs. Future costs in Tumwater[3] and Lancaster County are $11,700 and 16,000, respectively. Middletown's expected $18,400 basic protection cost per well is one-third that of Dartmouth's. Note that during the next few years, Middletown will be building reserves in its Risk Reduction and Emergency Response Funds. If spending on the two funds is included, Middletown's per-well cost increases to $80,700. Implementation costs cover the following activities:

- Gilbert's PWS operator conducts informal inspections of potential contaminant sources.
- Norway's primary activities are informal patrols of the WHPA and periodic ground water monitoring.
- The Lancaster County communities plan to focus on inspections of potential contamination sources.
- Dartmouth conducts permit reviews and patrols of the WHPAs.
- Middletown plans to inspect potential contaminant sources and conduct ground water monitoring. In addition, Middletown plans to accumulate funds in its Risk Reduction and Emergency Response Funds.

None of the communities could provide costs to business of complying with WHPPs. Many of the performance and design standards that communities have incorporated into their WHP ordinances are restatements of existing federal or state environmental requirements. Thus, their compliance costs cannot be attributed to WHP. For example, Middletown and Tumwater require new USTs to have double walls, a current requirement under RCRA UST regulations.

3.2.2 Extent of Outside Funding for Wellhead Protection

None of the case study communities paid the entire cost of developing its WHPP. Each community benefitted from financial or in-kind contributions from EPA, states, or private organizations. These outside sources of assistance accounted for between 12 percent and 92 percent of the total cost of WHPP development:

[3]Although Tumwater has not yet developed a management plan, it is likely to be similar in approach to that of neighboring Lacey. Implementation costs in Lacey are projected to be about $110,000 per year. Given that the Tumwater PWS is about half the size of the Lacey PWS, it is reasonable to assume that annual implementation costs would be approximately half Lacey's, or about $55,000, with $20,000 for basic program implementation and $25,000 for ground water quality monitoring.

- Gilbert obtained approximately $4,300 in staff assistance from LDEQ (92 percent).
- Norway benefitted from a $26,500 ($27,030 in 1994 dollars) EPA WHP Demonstration Grant for WHPP development (23 percent).
- Tumwater received a $170,500 ($173,913 in 1994 dollars) grant from the Washington State Centennial Clean Water Fund (50 percent).
- Lancaster County communities received a $30,000 ($32,700 in 1994 dollars) grant from EPA Region 3 for delineation and a $20,000 ($20,400 in 1994 dollars) grant from PADER for developing a management plan (47 percent of the cost of WHPP development).
- Dartmouth received two wells from Dartmouth Power Associates; the value of the associated WHPA delineation was approximately $88,000 (73 percent).
- Middletown was awarded a $12,000 ($12,240 in 1994 dollars) EPA WHP Demonstration Grant to develop a WHP curriculum for public schools (12 percent).

Exhibits 6, 7 and 8 compare the sources of funding for wellhead protection. Notably, 88 percent of all wellhead protection program costs for the six communities combined were paid for or provided in kind by local sources (e.g., city/town, water district, local company, adjacent town).

3.2.3 Costs by WHP Element

The Wellhead Protection Program, as described in Section 1428 of the Safe Drinking Water Act and in program guidance, includes the basic elements of:

(1) Forming a local team, including the water purveyor;
(2) Delineating the area below which the ground water supplies the well and/or wellfield;
(3) Identifying potential contaminant sources;
(4) Developing a contaminant source management strategy or plan, including public information and education;
(5) Preparing a contingency plan for alternate water supplies; and
(6) Developing a plan for protecting areas supplying new wells.

As conditions warrant, a WHP program may be expanded and tailored to special protection needs of the community. This tailored special protection may include detailed hydrogeologic investigations and modeling, ground water monitoring, expanded public education, detailed site inspections, remedial spill response and other management activities.

The study communities provided information on the cost of various WHP elements, although certain elements are combined in some cases. These are described in the following sections.

EXHIBIT 6
WHO PAYS FOR WELLHEAD PROTECTION ?
($1994; Cost for Basic Prevention Program)

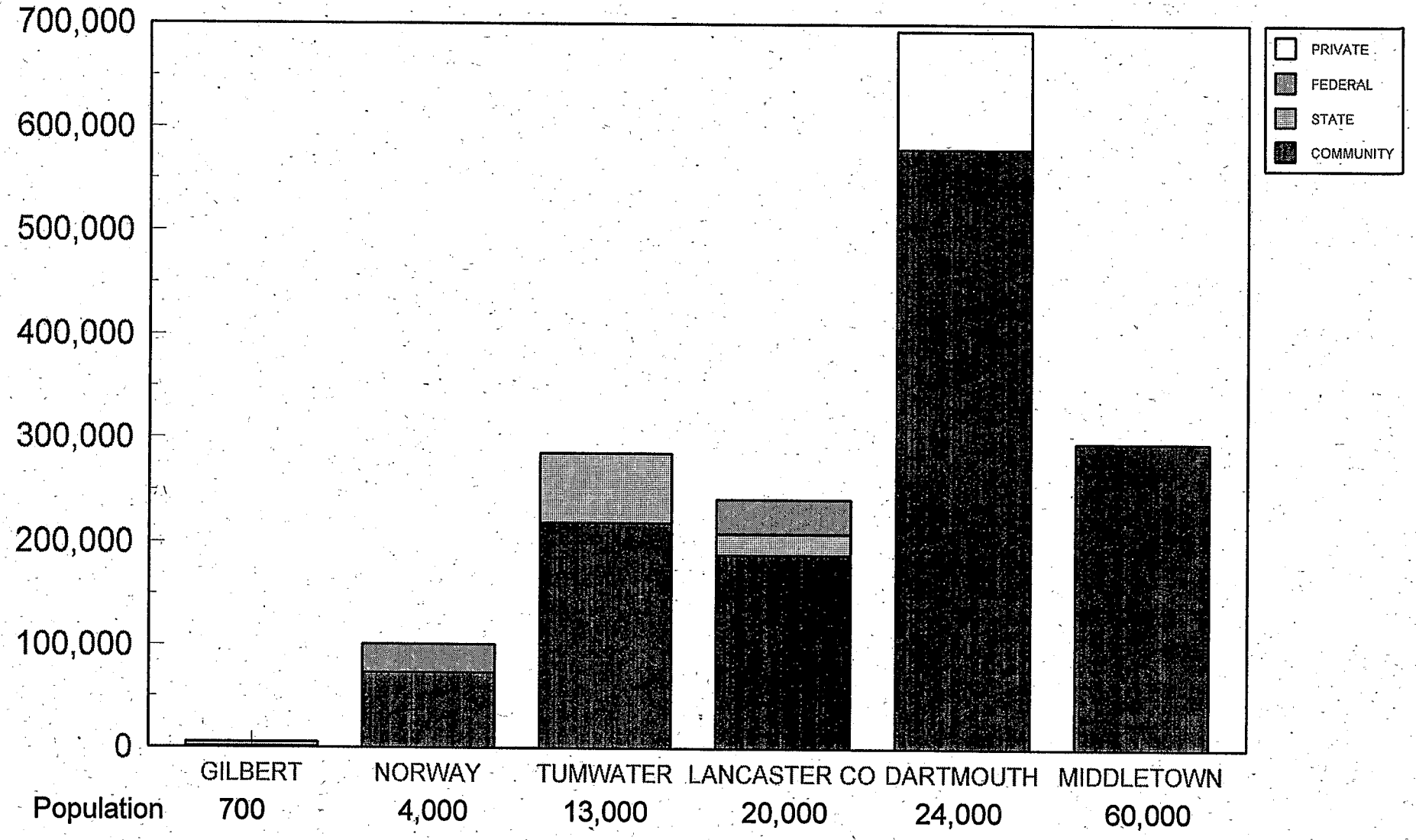


EXHIBIT 7
BASIC WELLHEAD PROTECTION COSTS BY FUNDING SOURCE
($1994)

FUNDING SOURCE	GILBERT	NORWAY	TUMWATER	LANCASTER	DARTMOUTH	MIDDLETOWN	TOTAL
LOCAL	$1,071	$73,189	$220,382	$195,270	$579,365	$295,892	$1,365,169
STATE	4,416		66,572	20,400			91,388
FEDERAL		27,825		32,700			60,525
PRIVATE					114,000		114,000
TOTAL	$5,487	$101,014	$286,954	$248,370	$693,365	$295,892	$1,631,082
SPECIAL PROTECTION							
LOCAL		$37,289	$198,661	$175,589	$1,614,255	$1,069,980	$3,095,744
STATE			198,661			12,240	210,901
FEDERAL							
PRIVATE							
SUBTOTAL	$0	$37,289	$397,322	$175,589	$1,614,255	$1,082,220	$3,306,675
TOTAL	$5,487	$138,303	$684,276	$423,959	$2,307,620	$1,378,112	$4,937,757

EXHIBIT 8
PERCENTAGE OF BASIC WELLHEAD PROTECTION COSTS BY FUNDING SOURCE

FUNDING SOURCE	GILBERT	NORWAY	TUMWATER	LANCASTER	DARTMOUTH	MIDDLETOWN
LOCAL	20%	72%	77%	79%	84%	100%
STATE	80%		23%	8%		
FEDERAL		28%		13%		
PRIVATE					16%	
BASIC TOTAL	100%	100%	100%	100%	100%	100%
BASIC WHP COSTS AS A PERCENT OF TOTAL WHP COSTS	100%	73%	42%	59%	30%	21%
POPULATION SERVED	700	4,000	13,000	20,000	24,000	60,000

Delineation/Contaminant Source Identification

In several communities delineation costs could not be separated from source identification costs, so costs should be interpreted with caution. Per well delineation costs range from $1,674 in Gilbert to $66,713 in Norway. The complexity of the delineation method used appears to be the driving factor in determining cost. Generally, the more extensive the modelling effort required, the higher the cost. Gilbert is the only community where the WHPA was delineated using a fixed radius; the other five employed groundwater modelling techniques. Norway's relatively high delineation costs are attributable to a lack of economies of scale. All the communities (except eastern Lancaster County) required detailed delineation of their wellhead protection areas because of contamination at or moving toward their wells.

Information available for communities not included in this study but having currently safe drinking water supplies indicates that delineation costs for a basic wellhead protection can range from $100 if community has resident or volunteer hydrogeological expertise and obtains public software for WHP delineation, to $3,000 for a similar approach but desiring more hydrogeologic interpretation through a State or local agency expert or a consultant. Obtaining the services of the State Geologist's Office may cost more or less than this latter figure, depending on the hydrogeologic interpretation needed; it may even be free to a community in some circumstances or States. Of course, the simplest approach for very small systems wanting to get started with WHP is to use an arbitrary fixed radius for the distance set by the State for wellhead protection areas around PWS well(s). As long as the location of the well(s) is (are) known and can be mapped, the protection areas can be delineated on a geologic map within an hour and determined in the field within a day. Usually, these fixed radii are typically about 1/4 mile for the smallest systems. In this report's analysis, the costs described in this paragraph are categorized as part of "Basic" wellhead protection.

Basic contaminant source identification can be obtained relatively inexpensively. Two communities in this study, Tumwater and eastern Lancster County, used volunteers to identify potential contaminant sources. Tumwater's volunteers were principally organized retired senior citizens, who spent about 315 hours doing a detailed contaminant source survey. Evaluated at a minimum wage ($4.25/hour multiplied by a 1.2 overhead factor), the opportunity cost of this time is $1,610. In eastern Lancaster County, local community officials and other volunteers worked after hours to conduct their contaminant source inventory. The opportunity cost of this time is estimated to be $6,600 for 120 hours (evaluated at a consultant's hourly rate of $55/hour). From a practical standpoint, communities would not actually incur these costs, but these estimates give an idea of the costs without volunteers. By comparison, costs in twelve other communities (not part of this study) around the country for volunteers to go door-to-door has averaged $5,000 per community, regardless of community size. This cost includes insurance for the volunteers, mileage reimbursement (if necessary) and the time of a coordinator. The cost to a local government for coordinating such an activity may be considerably less than $1,000, depending on the size of the community.

Source Management Strategy Development

Compared to delineation and contaminant source identification, development of source management strategies and plans are a relatively small contributor to WHP costs. However, source management plans rely heavily on these first two major steps of delineation and contaminant source identification. In most cases, these costs include developing a plan document and ordinance language. Development costs in the study communities ranged from $18 per well in Gilbert to $33,875 in Norway.[4] The other four communities had costs of between $863 and $6,713 per well.

A major factor that communities are concerned with is the cost of getting a WHP plan in place to guide implementation of wellhead protection. Exhibit 9 addresses the cost of developing a wellhead protection program through the management plan. The basic WHP costs incurred by the six communties show that on average 29 percent of the costs from program inception through ten or more years of implementation are used for delineation, contaminant source identification and management plan development. Although not a statistically significant sample, the smaller communities spent a larger proportion of their first 12 to 15 years of WHP funds on management

EXHIBIT 9

Development and Implementation Costs
For A
Basic Wellhead Protection Program
($1994)

Community	Subtotal for Basic WHP Program Through Management Plan Development	Total for Basic WHP Program Incl. Implement'n Through 2005	Percent Basic Management Plan Development of Total Basic WHPP Impl'n
Gilbert	$4,666	$5,487	85%
Norway	$82,588	$101,014	81%
Tumwater	$134,754	$286,954	47%
Lancaster Co.	$79,780	$248,370	32%
Dartmouth	$118,605	$693,365	17%
Middletown	$56,820	$295,892	19%
TOTAL	$469,003	$1,622,872	29%

[4]In Norway, source identification costs cannot be separated from management plan development costs.

plan development, and therefore a smaller portion for implementation. This result makes sense when considering that smaller communities have fewer contaminant sources to track or work with to protect their wellhead protection areas as they move into the implementation phase of their program.

Ground Water Monitoring

Tumwater, Middletown and Norway monitor ground water quality downgradient from high-risk potential contaminant sources, and upgradient from their wellfields. Tumwater's monitoring plan appears to be the most comprehensive; it is also the most expensive element in Tumwater's WHP effort. The total cost of $8,462 per production well includes the cost of siting wells and developing a data system. Norway's monitoring activities total about $5,800. Middletown has spent $877 per production well on ground water monitoring so far, and plans to construct additional monitoring wells in 1996. Ground water monitoring is treated as a special protection effort in this report.

Contingency Planning

Only two communities provided costs of developing contingency plans. The cost of plan development varies widely, depending on the scope of the effort. Gilbert used a "fill-in-the-blank" contingency plan provided by LDEQ, at a cost of only $116 per well. In contrast, Tumwater is developing a comprehensive contingency/spill response plan at a projected cost of $3,382 per well.

Public Education/Outreach

Public education and outreach generally account for a small fraction of WHP costs. Middletown is the only study community that developed a formal public education campaign. The other communities have used or plan to use previously prepared outreach materials.

The availability of an EPA WHP Demonstration Grant played a significant role in Middletown's decision to develop educational curricula for elementary and high school students. The total cost, including the city's match, was approximately $2,000 per well.

3.2.4 Comparison With Other Reported WHP Costs

This analysis shows that communities can take very simple or very complex and tailored approaches to wellhead protection. Based on the experience of Gilbert, LA, small communities can complete a wellhead protection plan for under $5,000, with ongoing implementation costs under $200 per year to make regular checks of the protection area for any irregularities. Anecdotal information for communities not included in this study indicates that larger communities (5,000 to 60,000 or more) that do not have an experience with contamination can also implement a basic prevention program for under $50,000, and perhaps as little as $20,000, depending on the level of

volunteerism and cooperation of business. Regular follow-up, such as checking the protection area by foot or car, and other management may cost as much as $10,000 to $20,000 per year. These costs are comparable to those for the communities covered in this report.

The State of Illinois Environmental Protection Agency has provided communities with delineations and contaminant source identifications for fixed radius WHPAs of 1,000 feet for all community water systems. Additionally, for communities utilizing shallow unconfined aquifers and desiring more detailed delineations for greater protection, the State EPA will use computer models and its hydrogeologic expertise to delineate more accurate protection areas. Along with the delineation, the State provides potential contaminant source identifications. The State estimates that these detailed delineations, using a simple computer model such as the WHPA Code, and contaminant source identifications for small systems with one or two wells costs $6,000 (about $3,000 per well). For larger systems serving one community with 5 to 20 wells and an area of less than 50 square miles, the delineation, using more complex computer models such as MODFLOW and interpreting hundreds of well records, and source identifications costs about $35,000, or about $1,750 to $7,000 per well. For areas covering over 50 square miles and serving several community water systems using 25 to 30 wells, this cost is about $70,000, or $2,300 to $2,800 per well. (Communication, R.P. Cobb, Illinois EPA, November, 1995)

The State of Washington Department of Health (DOH) has prepared its estimate of WHP program implementation costs based on results from State WHP grant awards to communities, input from a technical advisory panel and professional experience. The State estimated the following costs based on system size as measured by the number of connections:

Number of Connections	Estimated 5-Year Cost Per System
15-49	$500
50-99	$2,000
100-500	$5,000
500-999	$5,000
1,000-2,499	$7,500-40,000
2,500-9,999	$10,000-60,000
10,000 or more	$15,000-100,000

These cost estimates include delineation, contaminant source inventory, initial management plan development, contingency water supply and spill response planning. The State notes that direct costs to a water supplier could be as high as $450,000 or more depending on the number of connections, hydrogeologic setting, vulnerability to contamination, accuracy of the delineation desired, and the

extent and type of planning needed in a particular community. (Washington DOH, 1995) The costs of these two States' experiences are confirmed by the analysis of the seven communities in this study.

A similar breakdown of WHP costs as that for the State of Washington for the six communities in this study that have implemented wellhead protection showing the number of years of WHPP development and implementation and system size (by number of connections) provides the results in Exhibit 10.

EXHIBIT 10

BASIC PROGRAM DEVELOPMENT COSTS AND TIMING OF EXPENDITURES FOR WELLHEAD PROTECTION
($1994; previous costs adjusted using CPI; future costs discounted at 7%)

Community	Years of WHP Development/ Implement'n	No. of Connections (approximate)	Cost of Basic Prog. Development through 1995	Cost of Basic Prog. Implement'n through 1995	Cost of Basic Prog. Implement'n 1996 through 2005
Gilbert	1992-1995	250	$ 4,666		$ 821
Norway	1990-1995	800	91,883		9,131
Tumwater	1993-1995	4,800	134,754		152,200
Lancaster	1990-1995	7,400	72,780		175,590
Dartmouth	1988-1995	8,900	183,510	$229,533	286,917
Middletown	1985-1995	20,400	61,820		239,072

This table shows that in comparison to the cost estimates by system size (i.e., number of connections) for the State of Washington, Gilbert (population, 700), Lancaster (pop., 20,000), and Middletown (pop., 60,000) had costs for basic WHP program development within or near the ranges suggested for Washington communities of similar size. The other three communities, Norway (4,000), Tumwater (13,000), and Dartmouth (24,000), all had needs for detailed delineations and spent the additional funds to do so. These latter three communities also had additional expenditures for developing more detailed management plans or ordinances that they required. It should be noted that because the Wellhead Protection Program is constantly evolving and each community takes its own initiative to improve and shape the program to meet its needs, such ranges as reported above in program development costs are expected.

3.3 Comparison of Benefits and Costs

The case studies demonstrate that, in the long run, the cost of responding to a contamination incident **significantly exceeds** the cost of developing and implementing a WHP program. Exhibits 11 and 12 compare total and per-well contamination and WHP costs (i.e., costs to date plus expected costs through September 2005). In the six case study communities that experienced contamination and developed a WHPP, the ratio of contamination costs to WHP development and implementation costs ranged from 5:1 to 200:1, on a per-well basis. The average per well ratio for all the case study communities of contamination costs to WHP costs is 27:1. Exhibit 11 provides these costs as undiscounted values, not taking into account the time value of money. The analyis of undiscounted costs provided similar results and ratios.

As discussed in Sections 1.1 and 1.3, this analysis assumes that (1) the probability of contamination is 100 percent, and (2) the WHP program will be 100 percent effective. In reality, contamination is not a certainty, and the WHP program will not always be completely effective, so the actual ratio of benefits to costs may be different.

Exhibit 13 summarizes uncertainties in the cost calculations which could bias the ratio of benefits to costs upward or downward. In Gilbert, Tumwater, and Middletown, aquifer remediation costs are uncertain or incomplete. In the latter two communities, it is likely that the addition of aquifer remediation costs would push the ratio of benefits to costs significantly higher. In Gilbert, the direction of the bias is uncertain, because the duration of remediation may be either longer or shorter than the ten years estimated in the case study. As noted previously, many costs associated with ground water contamination and the response of residents, business, and local and State governments to it could not be quantified or monetized in this study. These potentially large costs could make the avoided-contamination-cost benefits much larger. On the WHP side, costs for implementation and/or business compliance probably are understated in several communities; thus, the ratio probably is overstated. In any case, it is unlikely that elimination of the uncertainties would cause WHP costs to exceed contamination costs, on a per-well basis.

In looking at the contamination costs across the communities, the contaminating incident in Gilbert involving two wells serving 700 people is about costly as Middletown's remediation of ground water supplying three wells and 60,000 people. One conclusion that can be drawn from this comparison is that smaller towns do not necessarily have small contamination problems; the contamination can be just as extensive or serious as in larger cities. Both larger and smaller communities can spend large amounts of funds on wellhead protection if they want to ensure a protected water supply without interrupted service from contamination. Norway (population, 4,000) is spending significant funds for ground water monitoring to provide early warning of contamination, as is Tumwater (pop., 13,000) and Middletown (pop., 60,000). If ground water is the only reliable, high quality drinking water source, expenditures for monitoring and special protection are probably warranted. Middletown is within the area designated under Section 1424(e) of the Safe Drinking

EXHIBIT 11
SUMMARY OF DISCOUNTED COSTS AND RATIOS TO 2005

	Middletown, OH	Dartmouth, MA	Gettysburg/ Lancaster Co. PA	Tumwater, WA	Norway, MA	Gilbert, LA	Total
COST COMPARISON							
Contamination Cost (poss. avoided cost)	$970,342-$1,475,470	$2,353,291	$4,015,357 (Gettysburg)	$1,712,440	$545,904	$1,094,645	$11,197,101
Total Special WHP Costs	$1,378,112	$2,307,620	$423,959 (Lancaster)	$684,276	$138,303	$5,487	$4,937,757
Contam. to Special Prot. Ratio	1:1	1:1	9:1	3:1	4:1	200:1	2:1
Basic WHP Cost	$295,892	$693,365	$248,370	$286,954	$101,014	$5,487	$1,631,082
Total Contam. to Basic WHP Ratio	3-5:1	3:1	16:1	6:1	5:1	200:1	7:1
PER WELL COST COMPARISON							
Contam. Drinking Water Wells	3	2	1 (Gettysburg)	3	1	2	12
Protected Drinking Water Wells	13	7	11 (Lancaster)	13	1	2	47
Total Contam. Cost/Well	$323,447-$491,823	$1,176,646	$4,015,351 (Gettysburg)	$570,813	$545,904	$547,323	$933,092

	Middletown, OH	Dartmouth, MA	Gettysburg/ Lancaster Co. PA	Tumwater, WA	Norway, MA	Gilbert, LA	Total
Total Special WHP Cost/Well	$106,009	$329,660	$38, 542	$52,637	$138,303	$2,744	$105,059
Contamination to Special Protection Ratio	3-5:1	4:1	104:1	11:1	4:1	200:1	9:1
Basic WHP Cost/Well	$22,761	$99,052	$22,579	$22,073	$101,014	$2,744	$34,704
Contamination to Basic WHP Ratio	14-22:1	12:1	178:1	26:1	5:1	200:1	27:1

Continuation of Exhibit 11

EXHIBIT 12
SUMMARY OF UNDISCOUNTED COSTS AND RATIOS
TO 2005

	Middletown, OH	Dartmouth, MA	Gettysburg/ Lancaster Co. PA	Tumwater, WA	Norway, MA	Gilbert, LA	Total
UNDISCOUNTED COST COMPARISON							
Contamination Cost (poss. avoided cost)	$996,421-$1,616,421	$4,310,348	$4,000,906 (Gettysburg)	$2,174,082	$562,382	$1,261,484	$13,305,623-13,925,623
Total Special WHP Costs	$1,741,000	$2,815,583	$562,000 (Lancaster)	$775,848	$150,492	$5,830	$6,050,753
Contam. to Special Prot. Ratio	1:1	5:1	7:1	3:1	4:1	216:1	2:1
Basic WHP Cost	$381,000	$875,286	$312,000	$311,166	$125,500	$5,830	$2,010,782
Total Contam. to Basic WHP Ratio	3-4:1	5:1	13:1	7:1	5:1	216:1	7:1

	Middletown, OH	Dartmouth, MA	Gettysburg/ Lancaster Co. PA	Tumwater, WA	Norway, MA	Gilbert, LA	Total
EXHIBIT 12 (CONTINUED) UNDISCOUNTED PER WELL COST COMPARISON							
Contam. Drinking Water Wells	3	2	1 (Gettysburg)	3	1	2	12
Protected Drinking Water Wells	13	7	11 (Lancaster)	13	1	2	47
Total Contam. Cost/Well	$332,140-$538,807	$2,155,174	$4,000,906 (Gettysburg)	$724,694	$562,382	$630,742	$1,180,802-1,161,469
Total WHP Cost/Well	$133,923	$402,226	$51,091	$59,681	$150,492	$2,915	$128,739
Contamination to Special Protection Ratio	3-4:1	5:1	78:1	12:1	4:1	216:1	9:1
Basic WHP Cost/Well	$29,308	$125,041	$28,364	$23,936	$125,500	$5,830	$42,783
Contamination to Basic WHP Ratio	11-18:1	17:1	141:1	30:1	5:1	216:1	27:1

EXHIBIT 13
SUMMARY COMPARISON OF PER WELL CONTAMINATION AND BASIC WHP COST
($1994)

COMMUNITY	CONTAMINATION COST	BASIC WHP COST	RATIO OF CONTAMINATION TO WHP	COMMENTS/ UNCERTAINTIES
GILBERT	$547,323	$2,744	200:1	**Contamination:** Overestimated-some routine maintenance cost may have been attributed to contamination; duration of aquifer remedy unknown. **WHP:** Underestimated-community officials' time has value, but is not quantified; implementation cost are estimated **Conclusion:** Uncertain
NORWAY	$545,904	$101,014	5:1	**Contamination:** Slightly underestimated-cost of lost business at Steve's Store unavailable **WHP:** Underestimated-oversight costs are probably low **Conclusion:** Ratio is accurate
TUMWATER	$570,813	$22,073	26:1	**Contamination:** Underestimated-remedy has not been selected, so costs unavailable; costs to business not available **WHP:** Overestimated-implementation costs are estimated based nearby communities' experiences **Conclusion:** Ratio may be underestimated
GETTYSBURG/ LANCASTER COUNTY	$4,015,351	$22,579	178:1	**Contamination:** (Gettysburg) Underestimated-cost associated with length of clean up uncertain **WHP:** (Lancaster, County) Overestimated-Extent of inspections needs to be determined. **Conclusion:** Ratio is underestimated.
DARTMOUTH	$1,176,646	$99,052	12:1	**Contamination:** Underestimated-cost of removal and analysis of drums unavailable, but probably not significant **WHP:** Underestimated-cost associated with upgraded septic systems, impervious cover are unavailable **Conclusion:** Ratio may be underestimated.
MIDDLETOWN	$491,823	$22,761	22:1	**Contamination:** Underestimated-remedial costs are uncertain companies characterization costs to date are unavailable **WHP:** Underestimated-cost to businesses unavailable **Conclusion:** Ratio is underestimated

Water Act as the Sole Source Miami Valley Buried Aquifer System, indicating that no other sources of water are reasonably or economically available. Thus, the potentially unquantifiable and/or unmonetized benefits of avoiding future contamination in such communities may be high regardless of WHP program implementation costs.

While the probability that all the wells in a community would be closed because of actual or imminent contamination (which did happen in the two smallest communities in this study, Gilbert and Norway) may not be 100 percent, a community may desire to consider the costs of responding to such a problem in estimating total avoided-cost benefits in comparison to prevention costs. If all the protected wells in this study were to become contaminated, using the locally developed costs reflecting the respective areas' hydrogeologic settings, contaminant remediation of the ground water sources of drinking water in these locations may cost as much as $68 million. Exhibit 14 displays details of this analysis. The combined cost for the 47 wells to receive special protection is $4.9 million and for basic protection is $1.6 million. The respective combined avoided-cost benefit to prevention cost ratios are 14:1 to 42:1. (The ratios for each community in Exhibit 14 are similar to the per well ratios previously presented. The combined average, or "Total," ratios below are larger

EXHIBIT 14

Ratios of
Avoided-Cost Benefit to Wellhead Protection
Assuming All Wells Are Contaminated (100% Probability of Contamination)*

Community	Population	No. of Protected Wells	With Basic Protection	With Special Protection	Sensitivity Analysis*: Assuming 50% Probability of Contamination and 50% of Contamination Costs/Basic Prot. Costs
Gilbert	700	2	200 : 1	200 : 1	50 : 1
Norway	4,000	1	5 : 1	4 : 1	1 : 1
Tumwater	13,000	13	26 : 1	11 : 1	7 : 1
Lancaster Co.	20,000	11	178 : 1	104 : 1	44 : 1
Dartmouth	24,000	7	12 : 1	4 : 1	3 : 1
Middletown	60,000	13	22 : 1	5 : 1	5 : 1
TOTAL		**47**	**42 : 1**	**14 : 1**	**10 : 1**

*** Calculations for Sensitivity Analysis assuming (a) 100% probability of contamination of all wells for "With Basic Protection" and "With Special Protection" and (b) 50% probability of contamination of wells and 50% of contamination costs reported in this study:**

(a) [number of protected wells X per well contamination costs] / [number of protected wells X Basic WHP cost per well]

(b) [(number of protected wells X .5) X (per well contamination costs X .5)] / [number of protected wells X Basic WHP cost per well]

because contamination costs are projected for all protected wells, not just for those that are currently contaminated or imminently threatened.) In doing this computation in the future, a community may desire to evaluate the probability of ground water supplying its wells becoming contaminated and then decide whether to use the worst case estimates for planning to protect public health or modify the estimates to some other expected value for avoided-cost benefits. Even if the probability of contamination were 50% (rather the 100% assumed in the worst case) and the costs in this report were considered to be 50% too high, the average or expected avoided-cost benefit to basic WHP cost ratio would still be 10 : 1, assuming the basic WHP costs were appropriate. Higher ratios would likely apply to smaller communities.

3.4 Qualitative Analysis of Benefits and Costs

In addition to the quantifiable benefits which have been described and compared in the previous sections, there are certain unquantifiable or *intangible* costs associated with contamination. Compilation of these costs is based on anecdotal evidence from knowledgeable people in the communities.

The most commonly noted intangible cost of contamination concerns the potential marketability of properties near affected sites. Property owners, real estate agents, or tax assessors in Gettysburg, Tumwater, and Middletown noted the possibility that contamination may affect property sales.

- A realtor in Gettysburg indicated that neither the value nor salability of properties near J.C. Cleaners have been affected by the contamination. She notes that contamination incident is not well known in the community. She did speculate that, in general, contaminated sites tend to limit the market for adjacent and/or affected properties, however. Anecdotal evidence suggests that federal Superfund sites in the county may have had limited effects on the market for adjacent properties. The realtor attributed the lack of quantitative evidence to the small number of property transactions in the area.

- In Tumwater, 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 the wellfield recently asked the City for reassurance that the incident would not affect his chances of selling the property at a fair price.

- The contamination in Middletown has caused concern among business owners in the

Hook Drive Industrial Park. One business owner expressed concern that he would not be able to sell his building because the contaminant plume extended under his property.

Community contacts noted other unquantifiable costs:

- In Gilbert, benzene concentrations in the distribution system exceeded the Maximum Contaminant Level for several months. Benzene is a human carcinogen and has been associated with numerous other health effects. Although no health effects have appeared in Gilbert yet, they may appear over time.

- In Tumwater, between the closure of the three contaminated wells and construction of the replacement well a year later, 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 and loss of property.

3.5 Comparison of Funding Sources for Remediation and Prevention

Examining the funding sources for both the possibly avoided contaminant remediation costs and WHP program costs, results show that larger communities fund most of the remedial and WHP costs, whereas smaller communities rely on assistance from State and Federal sources. Exhibits 4, 6 and 7 provide details of the funding sources. The results show that the the two smaller communities, Gilbert (population, 700) and Norway (pop., 4000) relied on Federal funding sources for 87 and 97 percent of their remedial costs, respectively. Additionally, Gilbert obtained another 5 percent of its remedial assistance from the State of Louisiana. The remainder of their contaminant remediation has been or will be funded by the communities. The larger communities, Middletown (pop., 60,000) and Dartmouth (pop., 24,000), funded 97 and 99 percent, respectively, of their remedial costs themselves. Overall, the combined sources of funding for the contaminant remediation of the six communities' ground water supplies are: Community, 50%; State, 38%; Federal, 12%; and private, <0.5%.

For the wellhead protection costs, Gilbert funded 80 percent of its basic WHP program through assistance from State programs. The other communities all funded from 72 to 100 percent of their basic WHP programs and in most cases 100 percent of their special protection activities themselves. Overall, for the combined six basic WHP programs, the funding sources are: Community, 84 %; States, 6 %; Federal, 4 %; and private, 7 %. Ninety-four percent of all special protection activities were funded by communities and 6 percent by States.

This analysis of funding sources suggests that small communities will need support for both remedial and prevention activities. However, it also gives an indication that considerably less State

and Federal money would be spent assisting any particular small community in preventing contamination of its drinking water source rather than remediating the contamination after it occurs. Dollar for dollar, the benefits (measured as avoided costs) far exceed the costs of WHP program development and implementation, as indicated in the analysis of this study's smaller communities. Larger communities appear to fund their remediation of contamination problems and prevention needs themselves for the most part.

3.6 Approximate Value of Contaminated Water

Another approach to measure benefits is to determine the commodity value of the contaminated ground water that could have been produced but was not or will not be used for public water supply. Uncontaminated ground water has value to the PWS, determined by the price of water its customers are willing to pay. Once ground water becomes contaminated, it loses value because it cannot be sold to customers, or it must be treated prior to being sold. Three communities (Gilbert, Dartmouth, and Norway) were forced to purchase replacement water from other communities. The other communities (Gettysburg, and Tumwater) added treatment, tapped new sources, or increased pumpage from existing sources. Exhibit 15 presents estimates of the value of the contaminated ground water in each community. The estimates are based on the approximate quantity of water that would have been pumped from the affected wells in the absence of contamination and the unit price of the water.

Exhibit 15 shows that the value of the contaminated water for these six communities may approach $111 million. This estimate may be overstated for three reasons. In Tumwater and Middletown, actual pumpage from the affected wells could not be determined, so the calculations are based on the maximum safe yield of the wells. Second, where a community has a block rate structure, the unit cost of the water is based on the highest block rate. Third, some wells may have sufficiently clean water available to them earlier than 2005; however, contaminated water may still reside in the aquifer and not be usable. The estimates assume that the water could have been produced through 2005, the planning horizon of the study. The value of this water far outways the cost of its protection. In these case studies, the cost of all special and basic protection measures is estimated to be $4.9million, with the basic protection portion being $1.6 million.

EXHIBIT 15

Approximate Value of Contaminated Water
($1994)

Community	Time Period	Water Not Pumped	Unit Price	Value
Gilbert*	4/92-12/05	523,656,000 gal.	$1.50 /1000 gal.	$ 785,000
Norway	9/90-12/05	93,587,000 cu.ft.	$2.48 /100 cu.ft.	$ 2,321,000
Tumwater#	8/93-12/05	233,767,000 cu.ft.	$1.15 /100 cu.ft.	$ 2,688,000
Gettysburg*	8/86-12/05	10,799,446,000 gal.	$2.87 /1000 gal.	$ 30,994,000
Dartmouth*	6/78-12/05	1,752,816,000 gal.	$1.36 /1000 gal.	$ 2,384,000
Middletown#	2/88-12/05	44,902,517,000 gal.	$1.60 /1000 gal.	$71,844,000
TOTAL				$111,016,000

* Based on estimated pumpage from contaminated wells.
# Based on maximum safe yield of the contaminated wells.
NOTE: 1 cu.ft. = 7.4805 gal.

4.0 CONCLUSIONS

Considering the cost of contamination - much of which could not be monetized for the purpose of this study, the cost of prevention is worth the investment. The benefits, expressed as possible avoided costs of contamination in this report, are substantial. Exhibit 16 provides a summary graphical comparison of the avoided-cost benefits and WHP costs per well for each community. For the smallest community, Gilbert, LA (population, 700, with 2 wells and 250 water connections), the benefit-cost ratio is 200:1. For Gilbert, the expenditure of $4,666 for prevention is very small in comparison to its cost of a new water supply - nearly $400,000 - and subsequent cleanup of the contamination to reduce future risk, a projected additional cost of $700,000.

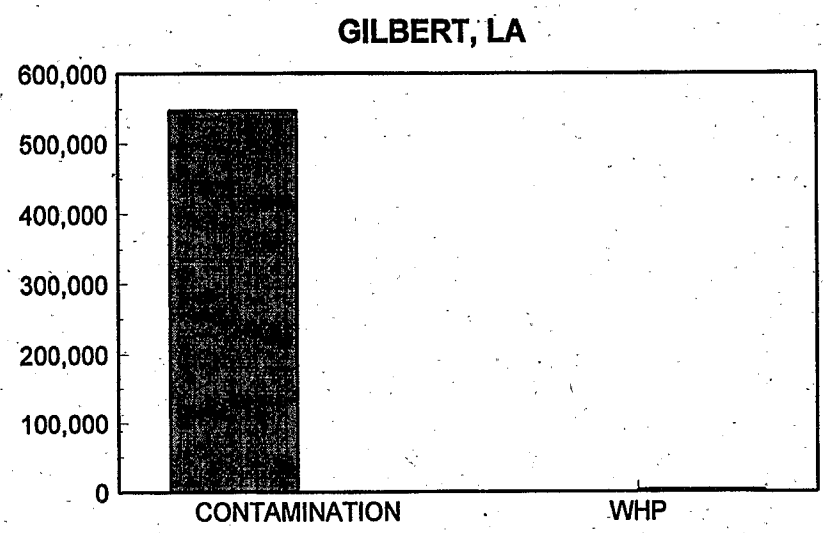
For the larger communities, the benefits (possible avoided costs) are also significant. Their possible benefit-cost ratios range from 5 to 178 : 1, on a per well basis. The combined average per well benefit-cost ratio for a basic prevention program considering the results of all seven communities is 27:1. These larger communities decided to incorporate other factors and concerns, such as recent contamination and resulting desire for detailed delineation and management plans, that raised their program development and future implementation costs. Even so, the combined average possible per well benefit-cost ratio for all special program development and implementation is nearly 9:1, almost an order of magnitude difference, with a range of 4:1 to 104:1. Unquantifiable contamination costs would make the benefit-cost ratios larger (i.e., larger avoided-cost benefits). To apply these results to other communities or nationally, additional analyses are needed to determine the risk and probability of contamination to ground water sources of drinking water across a statistically representative set of communities. The derived probabilities could then be used to weight the avoided-cost benefits for application in other locations.

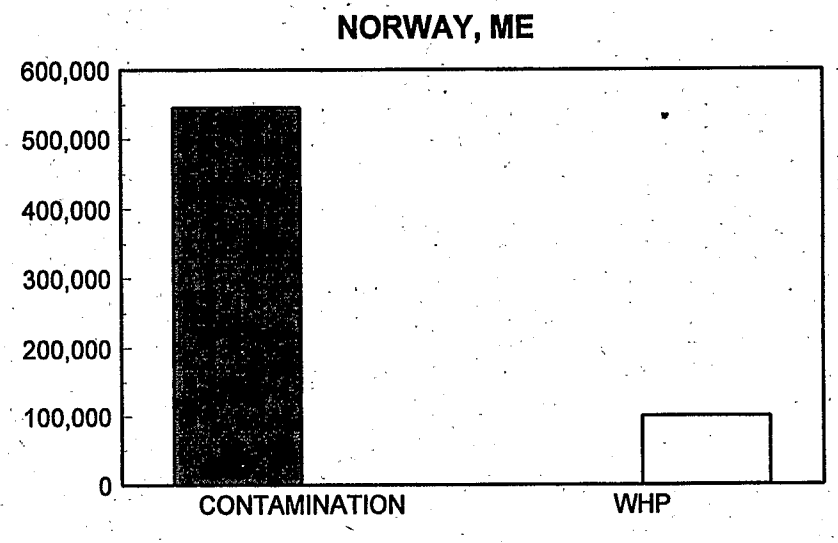
While this analysis is based on a limited number of communities, the benefits of preventing contamination of drinking water supplies are evident. Further analysis of costs for a larger number of systems should occur to obtain a better distribution of communities. In particular, more analysis of smaller communities should be conducted to establish the range of costs consistent with their needs for protecting their drinking water sources and the high costs of contamination to them. Half of the communities investigated in this study had prevention costs that were within or near the ranges calculated by Washington State for its communities that are developing and implementating WHP programs. For the larger communities that decided to invest considerably more in their wellhead protection programs, the steps they took indicate a strong desire to protect their water supply from contamination and service interruption, protecting their only water source, in some cases. Protecting public health through drinking water supply protection is a priority in these communities, even though they have had problems. The experience of these communities should benefit communities that currently have safe drinking water and desire to keep it that way.

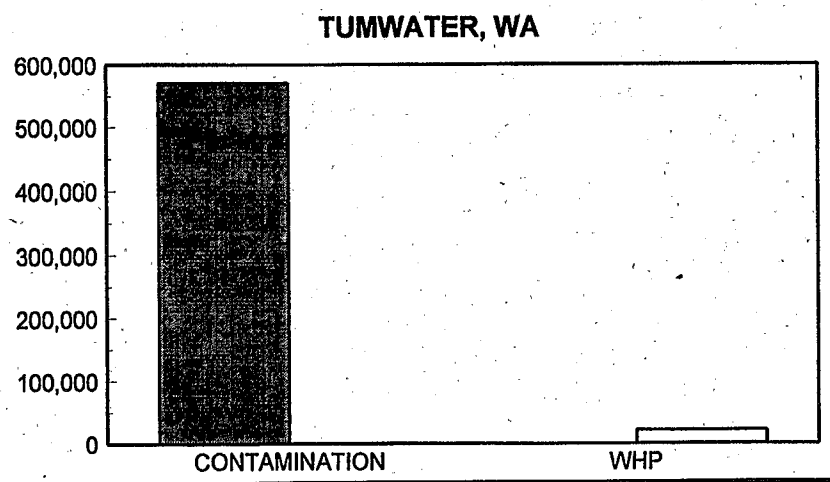
In terms of the extent and priority for local funding, small communities will need support for prevention activities. While this study includes a small selection of communities, it appears that

substantially fewer State and Federal funds would be needed to assist any particular small community in preventing contamination of its drinking water source rather than remediating the contamination after it occurs. While future cases would need to be evaluated individually, larger communities seem to have most of the funding capability to take care of their contamination problems and prevention needs themselves, based on these results.

EXHIBIT 16
COST PER WELL OF CONTAMINATION AND BASIC WELLHEAD PROTECTION
($1994)







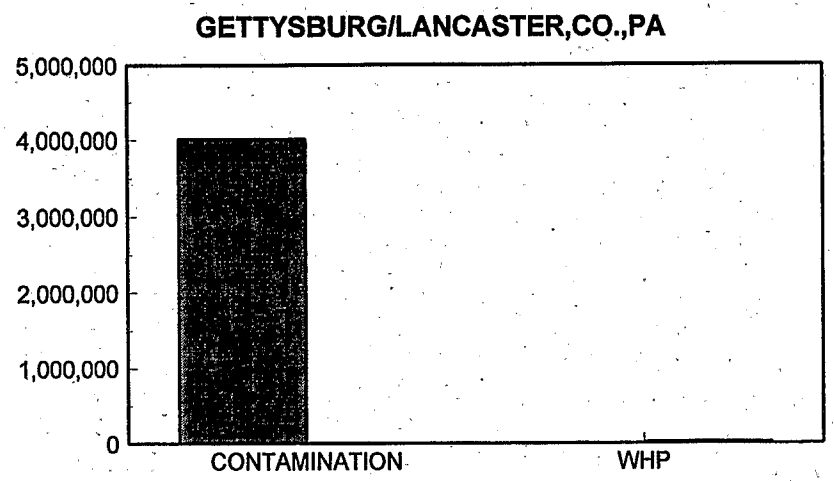
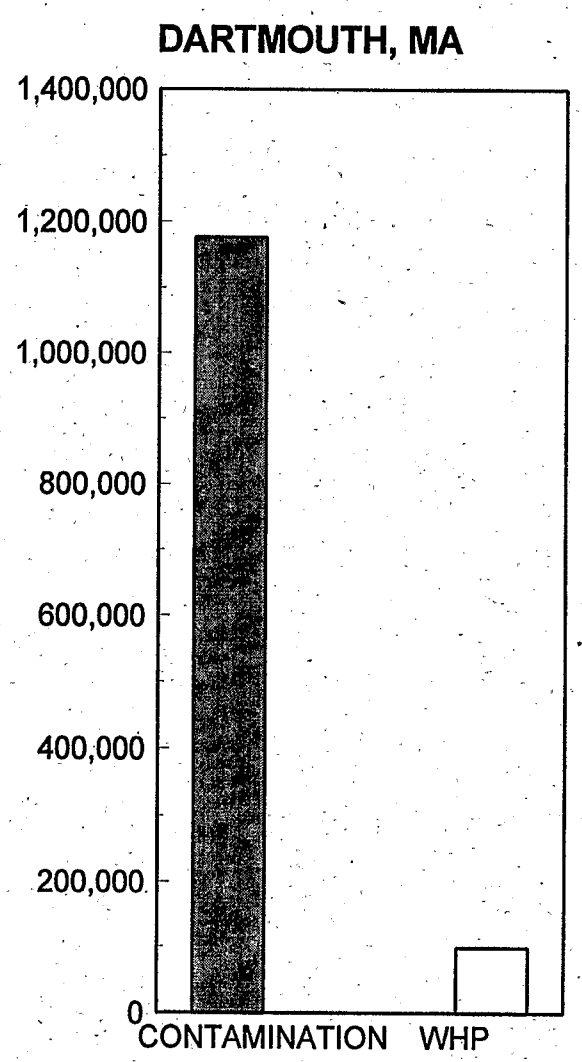
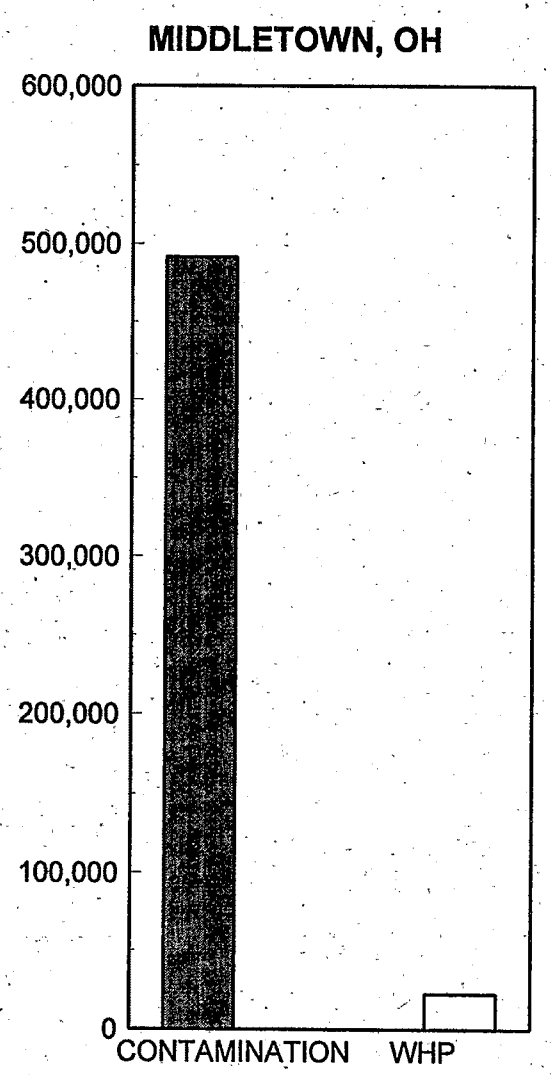


EXHIBIT 16 (CONT.)
COST PER WELL OF CONTAMINATION AND BASIC WELLHEAD PROTECTION
($1994)





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