

THE WALKERTON INQUIRY

Commissioned Paper 14

**THE ECONOMIC COSTS
OF THE WALKERTON WATER CRISIS**

By
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Abstract

The water contamination in Walkerton, Ontario, in May 2000 took seven lives, caused 2,300 illnesses, and cost millions of dollars. It is important to understand how costly that crisis was in order to determine the value of investing public resources in water treatment and safety practices to prevent or reduce similar crises.

This paper presents the results of a study undertaken in 2001 to assess the tangible economic costs of the Walkerton water crisis. Through interviews with Walkerton residents and business owners and with representatives of the various local, municipal, and provincial authorities, the study tried to capture all the relevant tangible costs attributable to the water contamination crisis. Exact costs were determined where possible and, where expenses were ongoing, conservative estimates were derived.

The author conservatively estimates the tangible economic impact of the Walkerton water crisis at more than \$64.5 million.

(This study specifically does not attempt to determine the intangible value of the actual lives lost or illnesses caused, since any such valuation is impossible. But, in a companion study, Walkerton Inquiry Commissioned Paper 15, *Value-of-Life Estimates in an Economic Cost Assessment*, the author presents a statistical estimation of the benefits of preventing illness and future loss of life, and incorporates those values into the results of his 2001 study to give an overall estimate of the benefits of reducing municipal water contamination.)

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1 Introduction and Overview

This report presents the results of a study commissioned by the Walkerton Inquiry to assess the magnitude of the tangible economic costs of the municipal water contamination crisis that arose in Walkerton, Ontario, in May 2000.¹ Many segments of society were affected by the crisis. Seven people lost their lives. More than two thousand suffered illnesses. Households and businesses were unable to use municipal water for eight months. Every component of the municipal water supply system, from wells to kitchen taps, had to be disinfected. The influence of the crisis extended beyond Walkerton itself, into the nearby towns and countryside. Extreme demands were placed on health units dealing with overwhelming case loads, and on investigative units charged with the task of determining the cause of the outbreak and understanding its transmission.

Assigning costs to these and the many other impacts of the water crisis is a daunting undertaking. Why is it important? Simply put, knowing how costly a water contamination crisis is helps to determine the value of investing public resources in water treatment and safety practices to prevent or reduce the probability of further crises. At a deeper level, as governments face future resource allocation decisions, knowing the cost of a water contamination crisis helps decision makers approach the problem from a more informed position. The resource allocation problem is that investing more public resources in water treatment and safety practices necessarily means that fewer resources are available to allocate to other public services, such as health care and education. Therefore, the real costs of allocating more resources to water treatment and safety practices are the forgone values of the other public services that could have been provided. The benefits of having safer water may nevertheless exceed the costs. But what are the benefits? The benefits are the avoidance (or reduced probability of occurrence) of the costs of a water crisis. Thus the value of estimating the costs of a water crisis is that this exercise provides information that makes it possible to weigh the benefits and the costs of investing in safer water.

John Livernois is a professor in the Department of Economics, University of Guelph. This paper has been prepared for discussion purposes only and does not represent the findings or recommendations of the Commissioner.

¹ Walkerton is a town of about 5,000 inhabitants, situated in the Municipality of Brockton, Bruce County, in a picturesque, rural area of southwestern Ontario. For detailed information about the contamination of the municipal water supply system with *Escherichia coli* O157:H7, see Ontario, Walkerton Inquiry, 2002, *Report of the Walkerton Inquiry, Part 1: The Events of May 2000 and Related Issues*, Commissioner: Dennis R. O'Connor (Toronto: Ontario Ministry of the Attorney General).

Although the impact of the water crisis was clearly most severe on those that became ill and their families, the economic effects extend much further. In fact, the full breadth of the impact is staggering. However, identifying every individual, public agency, and business that was affected by the water crisis is an impossible task. While we have made every effort to identify the affected parties, we will undoubtedly have missed some. At the same time, assessing the economic impact of the crisis on every identifiable party inevitably involves making various assumptions and in some cases making the best estimate possible given the information available. For example, calculating the cost of the hospital resources used because of the crisis inevitably requires making assumptions about the capacity utilization rates of the hospitals employed, the value of the supplies used, the amount of staff time devoted to Walkerton patients, the types of treatments required, and so on. Although we made every effort to assess the costs accurately, in cases where some estimation was required, I have chosen to estimate on the conservative side. Because I tried consistently to be conservative, and because we likely missed some affected parties, the assessment of the economic cost presented in this report errs on the low side.

In addition to the limits on the identifiable breadth of the impacts, there are limits on their measurable depth. In particular, considerable suffering, trauma, and deaths resulted directly from the water crisis. Although I regard such intangible impacts as significant costs, I make no attempt to assign a value to them here. Instead, I limit the assessment in this report to the tangible costs that have been incurred.²

The intent in this report is to capture all the relevant tangible costs that are attributable to the water crisis. Many of these have been incurred already, and some are ongoing. For those that are ongoing, I make conservative estimates using whatever data are available. Whenever costs are assessed, I count only the true resource costs. For example, some expenditures, such as insurance claims and compensation payments, should not be counted generally as resource costs because they are just transfer payments made to reimburse the real costs that will already have been counted. By contrast, some activities, such as volunteered time

² Nevertheless, there is clearly a value to preventing future loss of life and future illnesses from water contamination. Therefore, I briefly discuss in a companion report – John Livernois, 2002, *Value-of-Life Estimates in an Economic Cost Assessment* (Toronto: Ontario Ministry of the Attorney General), Walkerton Inquiry Commissioned Paper 15, Walkerton Inquiry CD-ROM <www.walkertoninquiry.com> – how the benefits of preventing future loss of life and illness could be incorporated with the results of this study to arrive at an overall estimate of the benefits of reducing the risk of municipal water contamination.

or public staff time diverted from normal activities, may not be associated with actual expenditures but nevertheless should be counted as real resource costs.

Given these qualifications, I estimate the tangible economic impact of the Walkerton water crisis at more than \$64.5 million. Table 1-1 summarizes the breakdown. It shows the section of this report in which further details about the estimate can be found, the category of each cost estimated, and that estimated cost.

In the remainder of this report, I outline the methods by which these estimates were obtained. In section 2, I report on the economic impact of the crisis on

Table 1-1 Summary of Cost Estimates

Section	Category	Cost estimate, \$
2.1	Households (Walkerton)	\$6,876,452
2.4	Households (non-Walkerton)	40,497
2.5	Household property values	1,106,136
3.1	Walkerton business costs	1,460,139
4.1	Lost productivity	1,234,296
4.2	Drinking water	4,167,179
4.3	Hospital stays	437,872
4.4	Opportunity cost of time spent in hospital	50,824
4.5	Physician's visits	99,239
4.6	Long-term health costs	2,497,932
4.7	Epidemiology costs	212,160
4.8	Helicopter ambulance cost	159,546
4.9	Local public health unit	2,775,000
4.10	Assistance to BGOSHU ^a	375,000
4.11	Chief Coroner	509,000
4.12	Walkerton health study	5,000,000
4.13	Water testing, laboratory, and auditing costs	645,000
4.14	OCWA ^b costs of remediation and repair	9,222,215
4.15	Other Brockton costs	6,548,523
4.16	Walkerton Inquiry	9,000,000
4.17	Private legal expenses	1,000,000
4.18	Other agency costs	11,110,184
Total		\$64,527,194

Notes: ^aBruce-Grey Owen Sound Health Unit. ^bOntario Clean Water Agency

Sources: See the sections in this report, as numbered in column 1, for details.

households. In section 3, I report on the impact on Walkerton businesses. In section 4, I report first on the productivity losses incurred in the economy that were due to water-related illnesses and then on the economic costs ultimately borne by taxpayers because of the public resources consumed in dealing with the water crisis. Section 5 contains my concluding remarks.

2 The Economic Impact on Households

To estimate the economic costs to Walkerton households I used the results of a random survey of 282 households conducted during May 2001. We conducted personal interviews with a representative of each household, who answered detailed questions about the economic impact on household members.

2.1 Overview of Results

On the basis of the survey results, I estimate that a total cost of \$6,876,452 was incurred by Walkerton households, with an average of approximately \$3,764 per household.³ Further details follow. But this estimate, it bears repeating, does not include any estimate of the cost of the loss of life or the psychological costs associated with the crisis. I explain in my brief companion piece to this report how modern economics deals with the value of loss of life, and discuss how to incorporate it into a study of this type.

2.2 Method

The sampling frame for the survey was an address list provided by the Ontario Clean Water Agency (OCWA) in late April 2001.⁴ The list included all the addresses connected to the municipal water supply. Deleting business addresses from the list left 1,952 addresses, representing households, from which we drew a random sample of 390 household addresses. We contacted these households

³Some households received compensation from the provincial government for some of these costs incurred, but compensation received has not been netted out in arriving at the household cost. Thus, the household cost reported here will have been partly borne by the household and partly by provincial taxpayers. Compensation payments in and of themselves do not generally represent a true cost; they are instead just a transfer payment.

⁴Faxed by OCWA to the Inquiry's offices on my behalf.

initially by telephone to set up an interview time. Of the 390, we ultimately interviewed households at 282 addresses. The remaining 108 households were not interviewed for the following reasons: 27 refused to participate, 34 telephone numbers were out of service or unlisted, 10 could not be reached by telephone (we made ten attempts for each), 13 addresses were owned by non-residents of Walkerton and were not occupied, 3 householders were deceased, 1 household had a private well so was excluded, 3 were business properties with no tenants, 1 building was no longer present, 4 were vacant rental properties, and 12 were unaccounted for.

Although there are 1,952 household addresses in our sampling frame, I estimate that only approximately 1,827 of these were occupied and connected to the municipal water supply, assuming that the fraction of households that were unoccupied or not connected to the municipal water supply is the same as in our random sample. There were 25 such households in our sample, which represents 6.41% of the sample. Subtracting 6.41% of 1,952 from 1,952 leaves 1,826.9 as the estimated number of households. I use this number to scale household averages obtained from the household survey up to the population level. Details of the 25 households in the sample that were unoccupied or unconnected to municipal water are as follows:

Households	# of households in sample
Owned by non-residents and unoccupied	13
Occupants were deceased	3
With a private well	1
Vacant business properties	3
Building no longer present	1
Vacant rental properties	4

A team of three interviewers carried out the 282 interviews during May 2001. Interviewers met with a household representative who answered questions about (1) health-related impacts of the crisis on each adult member of the household, (2) health-related impacts of the crisis on each child member of the household, (3) expenses and activities in the household related to obtaining safe water supplies, (4) other household costs, (5) impacts on schooling, and (6) any other impacts.⁵

⁵ See the full questionnaire in appendix A2.

2.3 Results

The average household included 1.95 adults and 0.67 children. The average household income was estimated to be \$56,653; 61% of the households reported two or more incomes. We found that 65.4% of the households reported having at least one person who became ill as a result of *E. coli* contamination. On the basis of the number of adults and children reported as having become ill, I estimate that a total of 1,646 adults and 551 children in the town of Walkerton became ill as a result of contaminated water. The resulting total number of ill individuals, 2,196, is considerably higher than the estimate of 1,286 obtained by the Bruce-Grey Owen Sound Health Unit (BGOSHU) survey.⁶ A possible explanation of the difference is that the BGOSHU survey question defined illness very clearly as having three or more loose stools within a 24-hour period, whereas our survey question asked whether or not household members had become ill as a result of the *E. coli* contaminated water, thereby leaving it up to the respondents to use their own definition of illness. This discrepancy does not affect the results of the assessed costs in this study since no cost is being attributed to illness per se; this study records only tangible costs, such as expenditures on medication and days spent in hospital.

The percentage of households that reported at least one hospital night was 4.26%. The average length of a hospital stay was 13 nights for adults and 14.7 nights for children.

Table 2-1 summarizes the results of the survey. It shows the average cost per household by category for all households and for those households that reported at least one illness.

The estimates in table 2-1 were calculated from the survey responses. Before providing details about how each entry was calculated, it is worth noting that the average costs per household are considerably higher for households reporting an illness. There are at least two reasons for this. The first is that in households with an illness people would obviously make more trips to seek medical care. The second is that households reporting an illness tended to be larger on average (more children and more adults) so that household expenditures would naturally tend to be higher.

⁶ Bruce-Grey Owen Sound Health Unit (BGOSHU), 2000, *The Investigative Report of the Walkerton Outbreak of Waterborne Gastroenteritis, May-June 2000*, October 10, 2000 [online], [cited November 13, 2001], <www.publichealthgreybruce.on.ca/_private/Report/SPReport.htm>.

The following sections explain each entry in table 2-1.

2.3.1 Travel Cost for Treatment

The survey provided information about the number of trips made to a hospital or local doctor or emergency room by adults and children in each household. In addition, the survey asked which hospitals were visited. From this information, I estimated the distance travelled per household (over a 12-month period) and, assuming a travel cost of \$0.32 per kilometre, calculated the travel cost per household. The assumed travel cost of \$0.32 per km is a crude estimate of the fuel and depreciation costs of personal vehicles, since most householders drove their own vehicles for their visits. I have not included an opportunity cost of time spent travelling or receiving treatment because of the likelihood that this time has already been reported as days of work missed. The cost of days of work missed is counted as productivity costs (discussed more fully in section 4).

Table 2-1 Average Direct Cost per Household

Cost category	Average cost, \$	
	For all households	For households reporting illness
Travel cost for treatment	\$53.04	\$78.86
Over-the-counter medication cost	26.06	23.82
Total boiling cost	7.99	6.96
Water pickup cost	148.11	183.88
Cost of contaminated food wasted	56.92	77.89
Extra grocery cost	160.24	224.82
Cost of damaged clothing	667.94	851.02
Cost of takeout or restaurant meals	784.19	993.60
Cost of transporting children	40.81	56.60
Travel cost for supplies, services	915.57	1,092.46
Other costs	902.91	1,175.87
Total average cost to household	\$3,763.79	\$4,765.78

Source: Calculations from the responses to the household questionnaire, see appendix A2.

2.3.2 Over-the-Counter Medication Cost

The representative of each household was asked to estimate the household expenditures on over-the-counter medications.

2.3.3 Total Boiling Cost

We estimated the total time spent boiling water during the 28-week boil water advisory period. The electricity cost was then estimated assuming an average cost of \$0.10 per kilowatt hour.

2.3.4 Water Pickup Cost

We estimated the total time spent picking up drinking water over the 28-week period of the boil water advisory . The opportunity cost of the time spent was estimated assuming that the hourly time cost was that of the lowest-paid member of the household, to a minimum of \$6 per hour. However, the hourly opportunity cost of time was then adjusted to reflect the fact that the water was probably picked up during what would otherwise be leisure time. The basic adjustment factor used was 0.5, meaning that only half of the hourly wage cost was counted as the opportunity cost of leisure time. We used a range of adjustment factors from 0.3 to 1.0, however, to test the sensitivity of the final results to this assumption. The sensitivity is discussed in section 2.3.11 below.

2.3.5 Cost of Contaminated Food Wasted

The estimate for the cost of contaminated food wasted comes directly from the survey, in which the household representative was asked to estimate the value of the food that had been disposed of, at the time the *E. coli* outbreak first became known, because of the fear that it had come in contact with contaminated water.

2.3.6 Extra Grocery Cost

The extra grocery cost was calculated from the survey responses. The household representative was asked to estimate the additional grocery cost (per week, over 28 weeks) incurred by the household to purchase ready-to-cook meals that required minimum preparation and little cleanup involving the use of water. In addition, the household was asked to estimate the distance travelled per week to purchase the groceries. The travel cost, at \$0.32 per km, was then calculated and added to the grocery cost.

2.3.7 Cost of Damaged Clothing

The cost of damaged clothing also comes directly from the survey. The household representative was asked to estimate the value of clothing damaged from washing in the superchlorinated municipal water following the outbreak.

2.3.8 Cost of Takeout and Restaurant Meals

This figure is calculated from the survey results. The household representative was asked to estimate the additional expenditures per week on restaurant and takeout meals made by the household over the 28-week period.

2.3.9 Cost of Transporting Children

Households were asked to estimate the average distance travelled per week and the average time spent per week transporting children to their alternative school or daycare facilities. We calculated the travel cost assuming \$0.32 per km, and the time cost using the method described in section 2.3.4 above.

2.3.10 Travel Cost for Supplies and Services

Households were asked to estimate the average distance travelled per week to other towns to avoid using services in Walkerton because of concerns about contaminated water (for example, to take showers or baths, or to do laundry) during the 28-week period of the boil water advisory. The cost was then calculated assuming \$0.32 per km.

2.3.11 Other Costs

This category contains relatively minor costs in various categories, such as veterinary costs, prescription drug costs, and such other household costs as damage to carpets or structures (which were high for some individual households but low on average).

2.3.12 Sensitivity of the Estimates

I tested the sensitivity of the estimates in table 2-1 to the assumption made about the opportunity cost of leisure time. Economic theory provides little concrete assistance in this regard beyond saying that the opportunity cost can be lower or higher than the wage cost depending on the existing constraints on hours of work. In this study, I have tested the sensitivity of the results to the assumption by calculating the total household cost for three estimates of the opportunity cost of leisure time: a low estimate (at 30% of the wage cost); an intermediate estimate (at 50% of the wage cost), which is the estimate used in table 2-1; and a high estimate (at 100% of the wage cost). At the low end the total cost per household is approximately \$3,696, and at the high end the total cost per household is \$3,934. I conclude that the estimates presented here are not particularly sensitive to the assumption regarding the opportunity cost of leisure time.

2.4 Non-Walkerton Households

The Bruce-Grey Owen Sound Health Unit, in its October 10, 2000 report,⁷ estimates that 1,035 individuals living outside Walkerton became ill as a direct result of contact with Walkerton water. Assuming that the number of individuals per non-Walkerton household is the same as for Walkerton households, this implies that approximately 394 (394.4 for statistical purposes) non-Walkerton households had an illness caused by contaminated Walkerton water. To estimate the cost to these households, I assume the costs obtained from the survey of Walkerton residents can be applied to non-Walkerton residents. However, most of the categories of household costs that apply in Walkerton would not apply to non-Walkerton residents. In particular, none of the costs incurred because municipal water was unavailable for many weeks would apply outside Walkerton. Thus, I assume that only travel costs to receive medical treatment

⁷ BGOSHU, cited above.

and costs for medications apply to non-Walkerton households (productivity costs are calculated in the next section). This gives a total cost of \$40,497 incurred by non-Walkerton households.

2.5 Residential Property Values

One would expect a substantial decline in the demand for properties in a town that had experienced a water contamination crisis of the magnitude of Walkerton's. Along with this decline in demand, one would expect to see a decline in the selling prices of properties, a decrease in the selling rate of listed properties, and a decrease in the supply of properties listed, as potential sellers are discouraged by the poor market conditions. The latter two effects will tend to dampen the extent to which selling prices decline.

To measure the loss of property values due to the water crisis, I restrict my estimate to the losses incurred by properties that actually sold. In doing this, I underestimate the true cost to some extent because I do not capture completely the opportunities forgone by those who wanted to sell their properties but were unable to do so. On the other hand, at least some of those forgone opportunities have been picked up and estimated from the responses to the household survey. For example, at least some respondents reported the additional expenses they had to incur to travel to their places of employment because they had been unable to sell their properties.

To estimate whether losses had been incurred on those properties that sold, I used a statistical technique called a hedonic price regression. Data were collected on more than 1,000 real estate property transactions covering the period of January 1, 1996 to July 31, 2001 in the towns of Walkerton, Hanover, Port Elgin, and Kincardine.⁸ The first objective of this technique is to test the hypothesis that the water contamination crisis had no statistically significant impact on Walkerton property values. If this hypothesis can be rejected, indicating that there was an impact, the second objective is to estimate the size of the impact.

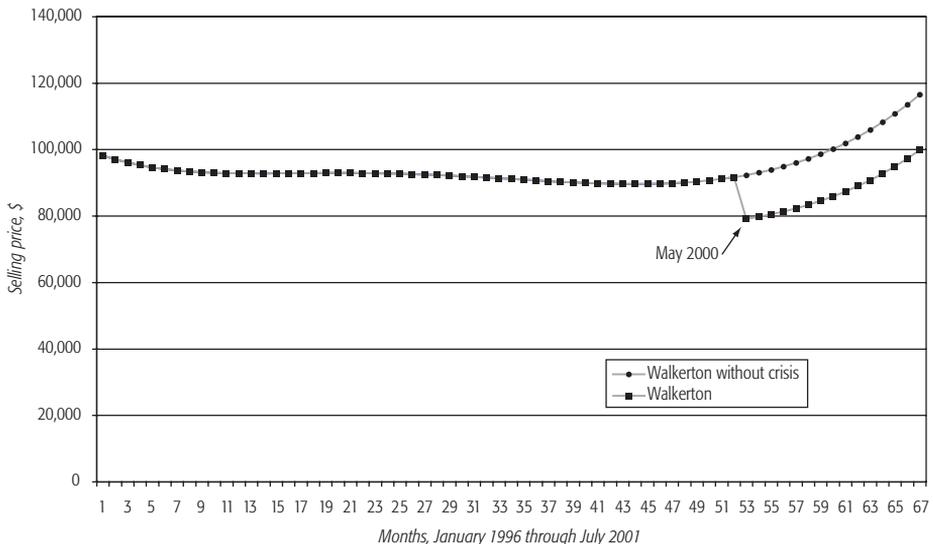
A large data set was necessary in order to obtain greater precision and confidence in the results. A hedonic regression model was specified in which the logarithm of the selling price was the dependent variable, and a vector of property

⁸I am indebted to Michael McIntee of McIntee Real Estate Limited, Walkerton, for his assistance in arranging my access to these real estate records.

characteristics such as town, a polynomial function of selling date, age of structure, property taxes, number of bedrooms, number of bathrooms, and other characteristics formed the independent variables. Appendix A4 provides details of the specification.

The results indicate that we can reject with a very high degree of confidence the hypothesis that the water crisis had no impact on property values. In fact, the data suggest that property values in Walkerton declined by about 15.4% on average because of the water crisis. Figure 2-1 shows the estimated index of property values for Walkerton over the period January 1996 to July 2001. This index can be interpreted as showing the price at which the same house with characteristics equal to the average characteristics in the sample would have sold in each month of the sample period. Figure 2-1 shows a modest declining trend in prices in the early part of the sample period that started to turn modestly upward in about month 44 (August 1999). The price index then shows the substantial decline that occurred beginning in May 2000. In addition, Figure 2-1 shows that, although property values rose somewhat during the crisis period, the overall level continued to be well below the level predicted to have occurred had there not been a water crisis.

Figure 2-1 Estimated Property Value Index for Walkerton, January 1996 through July 2001



A total of 72 residential properties with Walkerton addresses sold between May 1, 2000 and July 31, 2001, at an average price of \$99,759. The results then indicate that the average capital loss experienced by sellers was approximately \$15,363. The total property value loss then attributable to the water crisis is estimated to be \$1,106,136.⁹

3 The Economic Impact on Walkerton Businesses

The economic impact of the water crisis on business establishments in Walkerton was estimated using the results of a survey of most businesses. An interviewer met with business owners or representatives to obtain this information, using a questionnaire developed for the purpose.¹⁰

3.1 Overview of Results

From the responses to the business questionnaires, I estimate that all businesses combined in Walkerton incurred additional costs of \$651,422 because their normal water supply was contaminated. They also experienced a loss of business revenues from May 1, 2000 to April 30, 2001 of approximately \$2,695,722. Not all of these lost revenues represent an economic cost, however. Only the portion that represents reduced profits should be counted as an economic cost. Since some part of the reduced revenues would have been accompanied by a reduction in operating costs, the loss of profits is smaller than the loss of revenues.

A complication is that most of the lost business revenues and, hence, profits in Walkerton probably were matched by increased revenues and, hence, profits for businesses in neighbouring towns. The implication is that the cost to Walkerton businesses is matched by a benefit to non-Walkerton businesses so that, in aggregate, there is neither a cost nor a benefit.¹¹ But to the extent that Walkerton businesses have been financially compensated for their losses, there is clearly a net loss of resources. For example, suppose a \$1 loss to Walkerton businesses is

⁹ Commercial properties were not included in this statistical exercise and are not counted as part of property value losses. The reason is that any reduction in commercial property values reflects the expected decline in profits from the commercial enterprise, and such losses are being captured in the business survey.

¹⁰ See the questionnaire in appendix A3.

¹¹ The aggregate cost would actually be the increased travel cost incurred by customers purchasing goods and services in a neighbouring town. These costs are captured in the household survey.

matched by a \$1 gain in Hanover because shoppers just shift to the nearest town. The gain would cancel the loss. However, suppose that the \$1 loss in Walkerton is compensated by a \$1 transfer from the provincial government to Walkerton businesses. In the end, there has been a net loss of resources of exactly \$1, and the full burden of the original loss, in this example, falls on taxpayers.

The best way to deal with these complications would be to use information on the amount of compensation paid for lost business as a measure of the cost of lost profits. At the time of writing, this information was unavailable from government sources. Therefore, I assume that only a portion of the lost revenues (an assumed profit margin) equal to 30% represents the lost profits and is therefore a cost. This amounts to \$808,717.

The total economic costs we attribute to businesses then comes to \$651,422 plus \$808,717, or \$1,460,139.

3.2 Methods

We tried to contact every business establishment with a Walkerton address (using a list provided by the Chamber of Commerce). To give businesses time to prepare accurate responses, we made initial contact by telephone and followed with a fax, or in some cases a hand-delivered outline, of the questions that would be asked during the interview. Finally, we conducted a personal interview at the place of business, using the questionnaire developed for that purpose.

A total of 134 businesses with Walkerton addresses were interviewed in May 2001; 18 business establishments declined to be interviewed; and another 30 establishments could not be reached or were otherwise unavailable. Thus, about 73% of the business establishments in Walkerton were interviewed. Businesses near to but outside Walkerton were not interviewed because of the limited resources available for conducting the survey.

To ensure anonymity, I have classified the businesses into sectors using the North American Industrial Classification Structure (NAICS).¹² I chose the level of sectoral aggregation used for presenting the results in this report so that

¹² Canada, Statistics Canada, 1998, *North American Industrial Classification Structure*, catalogue 12-501-XPE.

no sector contained fewer than four establishments. Table 3-1 shows the sector classifications chosen, the number interviewed, and the number that could not be interviewed.

The interviews focused on two central questions. The first was designed to determine how the water crisis affected the cost of running the businesses from May 1, 2000 to April 30, 2001. The interviewers asked about expenditures on equipment and drinking water, and staff time devoted to picking up water or otherwise doing work caused by the water contamination problem. The second was designed to determine how the water crisis affected the revenues of the businesses during the period. The interviewers asked for specific reasons and dates associated with each reported revenue decline in order to improve the credibility and accuracy of the responses.

Table 3-1 Number of Businesses Interviewed and Not Interviewed, by Sector

Sector	Number interviewed	Number not interviewed
Construction	10	8
Manufacturing	8	0
Wholesale trade	5	0
Retail trade	40	17
Finance and insurance	11	0
Professional, scientific, and technical services	9	0
Health care and social assistance	14	8
Accommodation services	4	0
Food services and drinking places	12	3
Other services ^a	14	8
Other ^b	7	4
Total	134	48

Notes: ^a "Other services" includes repair and maintenance, personal care and laundry services, and religious, grant-making, civic and professional, and similar organizations.

^b "Other" includes transportation and warehousing; real estate, rental and leasing; administrative and support services; waste management; educational services; arts, entertainment, and recreation.

3.3 Results

The businesses interviewed reported three types of additional costs caused by the water crisis: obtaining safe drinking water, replacing and disinfecting equipment, and diverting human resources away from their normal activities to deal with the water crisis. The first two types of additional costs appear to have been mostly provided for by the government or its agencies, primarily the Ontario Clean Water Agency (OCWA), and are therefore captured elsewhere in this report. The focus here then is on the third type of cost. The most common activity of this type was staff time devoted to picking up and handling water supplies and cleaning and disinfectant supplies.

Each business was asked to estimate the additional number of hours of staff time per week directly related to managing or dealing with the water crisis and to indicate the hourly wage cost of the employees performing these tasks. We calculated the total additional staff cost within each sector. We then scaled up this total by the ratio of the total number of businesses in Walkerton to the number actually surveyed. This yields, within each sector, an estimate of the total staff time costs for all businesses in Walkerton, including those businesses not interviewed. The results are shown in table 3-2 and figure 3-1. Food services

Table 3-2 Estimated Costs to Walkerton Businesses, by Sector

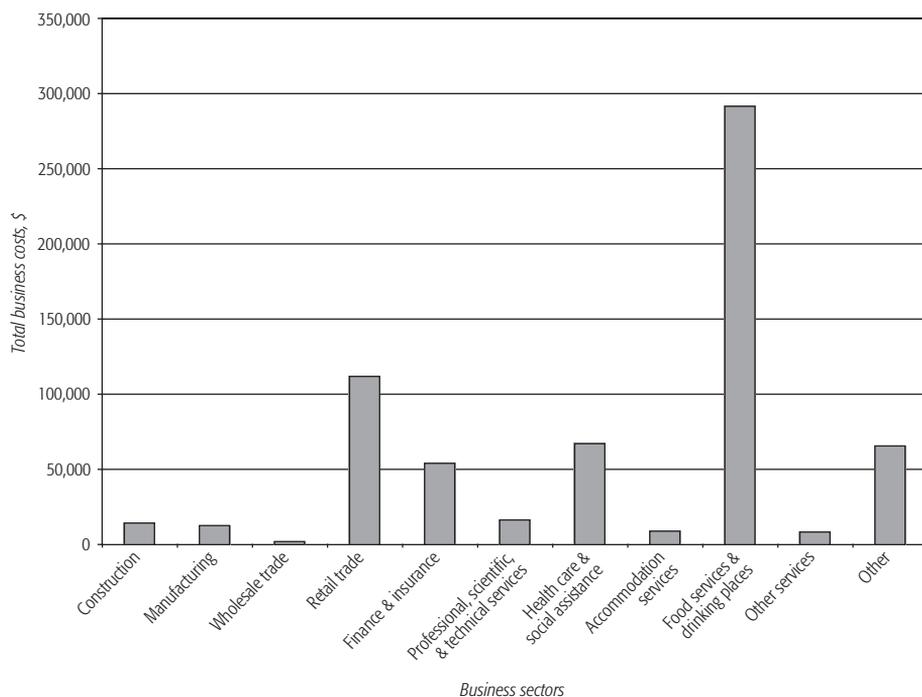
Sector	Estimated business costs for staff time diverted, \$	
	Total	Per establishment ^a
Construction	\$14,166	8
Manufacturing	12,571	1,571
Wholesale trade	1,818	364
Retail trade	111,726	1,960
Finance and insurance	53,856	4,896
Professional, scientific, and technical services	16,308	1,812
Health care and social assistance	67,041	3,047
Accommodation services	8,769	2,192
Food services and drinking places	291,413	19,428
Other services ^a	8,291	377
Other ^b	65,462	5,951
Totals	\$651,422	\$3,579

Notes: ^aCalculated as the total cost divided by the number of businesses including those not interviewed.

and drinking places were clearly the hardest hit, having to divert staff time to washing food, dishes, glasses, and utensils, and to ensuring a safe supply of drinking water to customers; the table shows that sector with an estimated total cost of \$291,413, an average cost of \$19,428 per establishment, over the one-year period. Businesses in retail trade and in health services were second and third in rank, respectively, in terms of total costs (although not on average).

The total additional cost incurred by all Walkerton businesses combined is estimated to be \$651,422.¹³

Figure 3-1 Estimated Business Costs for Staff Time Diverted, May 1, 2000 to April 30, 2001



¹³The critical assumption in this determination is that the staff time that was diverted from normal activities would otherwise have been functioning at full capacity producing valuable goods and services. Assuming also that workers are paid the value of their marginal product and that there are constant returns to scale, the value of those goods and services forgone because of the water crisis equals the wage cost. That workers are paid the value of their marginal product is fundamental in neoclassical economics for perfectly competitive labour markets. Whether constant returns to scale is accurate is an empirical question but is likely to be quite reasonable for the scale of the output changes and labour diversions associated with the water crisis.

4 Economic Impact on Productivity and Public Sector Resources

In this section, I report my estimate of the lost productivity due to illness caused by the water crisis and the costs incurred by the public sector in dealing with patients, investigations, remediation of contaminated water distribution facilities, and other activities.

4.1 Lost Productivity Due to Illness

As reported in table 1-1, I estimate the cost of lost production due to days of work missed to be \$1,234,296 in total. This includes \$920,776 for days of work missed in Walkerton households and \$313,520 for days of work missed by households outside Walkerton in which there were illnesses caused by Walkerton water. Productivity costs are not borne by the households themselves, but rather they represent a cost to Ontario society as a whole.

The productivity cost per household is calculated by multiplying the days of work reported lost by the hourly earnings (to a minimum of \$6 per hour) multiplied by seven hours per day. Hourly earnings for each adult are calculated from the data obtained in the household survey on annual income for each adult in the household. Carrying out this calculation for each household in the sample (including those with no illnesses) yields an average of \$504.01 as the productivity cost per household in Walkerton. Therefore the total productivity cost for the town of Walkerton as a whole is the number of households, 1,826.9, times \$504.01, or approximately \$920,776.

To estimate the productivity cost for non-Walkerton households that had an illness, I first calculate the productivity cost per household in Walkerton in households that had an illness. This calculation is as described above except that it is done only for those households reporting an illness. These calculations yield an average of \$794.93 for households reporting an illness. I assume that this estimate can be applied to non-Walkerton households that had an illness. Using the estimated number of non-Walkerton households with an illness, 394.4 (see section 2.4), the productivity cost for non-Walkerton households is then \$313,520.

Using hourly earnings to estimate the value of lost production due to illness is common and relies on the assumption of competitive labour and output markets. Under these conditions, theory predicts that workers are paid the

value of their marginal product. For the purposes of this study of Walkerton, these assumptions seem reasonable.

4.2 Cost of Drinking Water

Bottled water was supplied by the Ontario government to residents and businesses of Walkerton. The survey responses indicated that the average household consumed 384.97 litres of bottled water per month during the 12-month period following the initial outbreak. The Culligan water company estimates that consumption rates for a typical household for drinking water range from 75 litres per month to about 230 litres per month. However, it is reasonable to expect the consumption rate to have been abnormally high in Walkerton during this period, since bottled water was used not only for drinking but also for cooking, bathing, and dish washing. I assume a cost of \$0.32 per litre, plus a monthly rental cost for water coolers of \$13.95 per household. This gives a total cost of \$3,006,529 for bottled water provision to households over 12 months. The business survey indicates that businesses consumed a total of 3,627,031 litres of bottled water over the 12-month period that would not otherwise have been consumed. At a cost of \$0.32 per litre, the total then comes to \$1,160,650. The total estimated cost of bottled water provision for households and businesses then comes to \$4,167,179.

4.3 Cost of Hospital Stays

On the basis of the survey responses, I estimate that a total of 1,043 patient-days in hospitals resulted from illness among Walkerton residents (not counting non-residents). I assume an average of \$419.82 as the marginal cost of a hospital day.¹⁴ This gives a total cost for hospital resources of \$437,872.

4.4 Opportunity Cost of Adult Hospital Days

I estimate the opportunity cost of adult hospital days due to the water crisis to be \$50,824 in total. The cost per household is calculated as the reported number

¹⁴ See appendix A1 for the source of this estimate. Some of the hospital stays were in teaching hospitals, which tend to cost more than other hospitals, so the assumed marginal cost is meant to be an average over all hospitals.

of days spent in hospital in excess of days of work lost multiplied by the opportunity cost of leisure time¹⁵ multiplied by seven hours. The average per household is \$27.82. Therefore the total for the town of Walkerton as a whole is 1,826.9 times \$27.82, or \$50,824.

4.5 Physicians' Visits

I estimate the cost of visits to physicians to be \$99,239. This estimate is based on an assumed resource cost of \$24.51 per visit¹⁶ and an estimated number of 4,048.9 visits to physicians by Walkerton residents, which is derived from the household survey responses.

4.6 Long-Term Health Costs

It is impossible to predict accurately the long-term health consequences of the *Escherichia coli* infections. We can, however, generate a conservative estimate based on the information available. The BGOSHU report indicates that 27 cases of hemolytic-uremic syndrome (HUS) were confirmed. The report also indicates that, on average, about a third of HUS cases develop long-term renal problems. The cost of treating renal disease is high. An Internet search revealed various estimates from the United States and Canada. I use the estimates produced by Goeree et al.¹⁷ because they are conservative relative to others, they are supported by a substantive research paper, and they are estimates for Canada. Their estimates range from \$32,570 to \$88,585 per year, depending on the type of treatment. I use the mid-point of this range, approximately \$60,600 per year, and assume an average of five years of treatment per case. Assuming a 3% real discount rate, this gives a present-valued cost of approximately \$2,497,932.

4.7 Epidemiology Costs

Health Canada provided a team of epidemiologists led by Dr. Andrea Ellis to determine the source and extent of the contamination. The direct costs to Health Canada, including the cost of staff time devoted to the Walkerton crisis, amounted

¹⁵ See appendix A1 for an explanation of the opportunity cost of leisure time.

¹⁶ See appendix A1 for details about the source of information.

¹⁷ Ron Goeree et al., 1995, "Cost Analyses of Dialysis Treatments for End-Stage Renal Disease," *Clinical and Investigative Medicine*, vol. 18, no. 6.

to \$189,200.¹⁸ In addition, the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) provided the participation of Dr. David Alves in the epidemiological investigation for 20 days at a resource cost of \$850 per day. Dr. Alves also travelled approximately 2,400 km, which, at \$0.32 per km, amounts to \$768, and he was assisted by a staff member located in the Walkerton area who worked for 30 days for a cost of \$5,192. The total for the OMAFRA involvement then is \$22,960.¹⁹ The total cost for epidemiology studies is thus \$212,160.²⁰

4.8 Helicopter Ambulance Cost

The cost of air ambulance services, paid out of the budget of the Ministry of Health and Long-Term Care, is estimated to be \$159,546.²¹

4.9 Ministry of Health and Long-Term Care, Local Public Health Unit

The estimated cost of the resources expended by the Ministry of Health and Long-Term Care at the local public health unit on the Walkerton crisis between May 2000 and August 2001 is \$2,775,000.²² Approximately \$1.4 million of this amount was to cover the costs incurred at the Bruce-Grey Owen Sound health unit (BGOSHU). The BGOSHU costs were replacement salaries for three full-time positions including that of Dr. Murray McQuigge, chief medical officer, additional staff hired by the health unit, transportation, benefits, equipment, and legal expenses (which alone account for nearly 33% of the total). Indications are that legal expenses there could add another \$125,000 to the total; salary

¹⁸ Andrea Ellis, Health Canada, personal communication by email September 27, 2001.

¹⁹ David Alves, provincial veterinarian of Ontario, manager Veterinary Science Group, Ministry of Agriculture, Food and Rural Affairs, personal communication by telephone, September 2001.

²⁰ An important conceptual issue arises about whether or not to count the cost of the epidemiological staff since their purpose, in large part, is to respond to emergency situations. I include this cost because, from a long-run perspective, the cost of maintaining emergency response teams relates directly to the risk of emergencies like water contamination. Since expenditures on improved water safety could reduce those risks, it is appropriate to view the cost of an emergency response as one of the long-run costs of not reducing risks.

²¹ Kevin French, director, Issues Management, and committee liaison, Environmental Health and Safety Project, Cabinet Office, Government of Ontario, personal communication by fax March 30, 2001.

²² This estimate was obtained from interviews in September 2001 with Fred Ruf, senior policy analyst, Public Health Branch, Ministry of Health and Long-Term Care. Telephone interviews in September 2001 with Dr. Murray McQuigge, chief medical officer, and Joan Tod, finance director, of BGOSHU helped to confirm the details of this amount.

replacements could add another \$25,000; and increased insurance premiums could add an undetermined amount, though these additional amounts are not included in my estimate. The estimate of the costs incurred at BGOSHU also does not include the likely long-term costs that may arise in the health unit as a result of the extreme stress under which the staff have worked during and since the crisis. The remainder of the total costs were incurred at 27 other health units in the province for enriched staffing to deal with public concerns and requests for information about water quality, other legal fees, mailing, and extra staff costs related to the interim adverse water reporting system.

4.10 Informal Assistance to BGOSHU by Other Health Units

Approximately 45 health professionals from many other health units informally assisted BGOSHU, for an average of two months per person, at an average annual salary of \$50,000.²³ The salaries continued to be paid by their home health units so their actions will not show up as an additional cost in the Ministry of Health and Long Term Care's accounting records. But their time was clearly diverted to dealing with the Walkerton crisis and therefore is a direct and legitimate cost of the crisis. I estimate the cost of these resources used at \$375,000.²⁴

4.11 Chief Coroner's Report

The Chief Coroner of Ontario, Dr. Jim Young, attended the Inquiry hearings and produced a lengthy report containing 57 recommendations. He estimates that the staff time, legal expenses, and expert costs borne by his office come to a total of \$509,000.

4.12 Walkerton Health Study

Though it had not yet begun at the time of writing, the Ontario government has committed \$5 million to finance a Walkerton health study.

²³ Murray McQuigge, personal communication, September 2001.

²⁴ Here and in other categories, some of the costs are reported as the cost of staff time diverted to dealing with the Walkerton crisis. The true cost of this diversion is the value of the services that were forgone because staff was unable to provide them. Since these services are not "sold" at market prices, I do not have data with which to estimate the forgone values. Instead, I assume throughout this report that the value of the services can be approximated by the cost of providing the services.

4.13 Water Testing, Laboratory, and Auditing Costs

The Ministry of the Environment reports costs of \$645,000 for testing water samples.

4.14 OCWA Costs of Remediation and Repair

The Ontario Clean Water Agency assumed the role of restoring and disinfecting the water distribution system for the municipality of Walkerton. Using information from the invoice OCWA submitted to the municipality, I estimate a cost of \$9,222,215 for the services performed, as follows:²⁵

Services	Cost, \$
Emergency response and remediation, and installation of a system to deliver potable water, May 25 to December 5, 2000	\$7,395,595
Long-term water supply study	98,828
Well rehabilitation	25,000
Interim water treatment facility	745,979
Watermain replacement (depreciated value)	831,770
Operations and maintenance for period ending December 31, 2000	125,043
Total	<u>\$9,222,215</u>

4.15 Other Brockton Municipality Costs

The municipality continues to incur ongoing expenses, not all of which will ultimately be the responsibility of the municipality itself. I include expenses in the following categories in the total cost of the Walkerton water crisis:²⁶

²⁵ These numbers are taken directly from the OWCA invoice except for the amount for watermain replacement. On the invoice, that cost is given as \$2,118,484, the total cost for replacing the watermains, but I use a depreciated value in tabulating the cost actually due to the contaminated water crisis, as explained in detail in appendix A5.

²⁶ The information on which this section is based was provided through the kind assistance of Richard Radford, chief administrative officer of the Municipality of Brockton, by telephone, September 2001.

- Class environmental action: \$405,000 projected
- Well remediation and well-head protection: \$1,282,000 projected
- Lease for filtration system: \$346,680 per year on-going
- Development of a long-term secure water supply: \$2 million to \$6 million projected
- Legal fees and disbursements: \$1,526,456 projected
- Legal representation of former public utilities commission and its commissioners: \$212,180
- Severance pay: \$54,313

I exclude other expenditures, such as the cost of upgrading the small-diameter water lines in Walkerton, projected to cost \$3.7 million; this expense is not directly attributable to the contamination problem. I also exclude a projected expenditure of over \$645,000 for proposed studies into the effectiveness of ultraviolet light as a contaminant barrier as well as a biofilm study, because such expenditures might well have been made – though not necessarily in Walkerton itself – even without the contamination crisis.

The filtration system has been in use since May 2000 and will remain in use until an alternative long-term water source is established. If the long-term solution is determined to be pipeline from Georgian Bay (the \$6 million option), it will likely be many years before such a project could be finished, and the water filtration lease will continue until then. If, however, the long-term solution is determined to be the upgrading of the existing well field (the \$2 million option), that could possibly be completed by the end of 2003. Thus, at the low end of the cost estimate, there would be a lease from May 2000 to the end of 2003 plus a \$2 million development of a water supply. Assuming a 3% real discount rate, the present-valued total is \$3,068,574. This is the conservative estimate I adopt. We must nevertheless recognize that, at the high end, the cost could exceed \$10 million.

The conservative estimate of the costs incurred by Brockton Municipality is therefore \$6,548,523.

4.16 The Walkerton Inquiry

At the time of writing, the Inquiry's expenses were a total of \$5.98 million. An additional \$3 million of expenses is projected. Thus the total cost attributed to the Inquiry process itself is approximately \$9 million.

4.17 Private Legal Expenses

It is difficult to determine the extent of the legal costs incurred by private citizens. I use as an estimate, however, the expenses paid out by the Office of the Attorney General of Ontario to cover the legal expenses for many of the private citizens who participated in the Inquiry. As of June 30, 2001, those billings totalled \$564,000 but are expected to rise to approximately \$1 million.

4.18 Other Agency Costs

I estimate the total cost to various Government of Ontario public agencies to be \$11,110,184.²⁷ Table 4-1 gives details of the agencies and the reasons for

Table 4-1 Costs Borne by Other Government Agencies

Agency	Explanation	Costs, \$
MMAH/MCSS	Additional costs associated with ambulances, home for the aged, and public health unit	\$1,000,000
EDU	Assistance to school boards to enable completion of 1999–2000 school year	300,000
EDU	Cost of providing separate water supply for schools to enable their opening in September 2000	595,700
MMAH/FIN	Interest-free loan to allow Brockton Municipality to postpone property tax installments – assume 6 months on \$1.825 million @ 7%	63,875
MMAH/FIN	Interest-free loan to Brockton to pay for legal and technical consulting – assume 6 months on \$1.6 million @ 7%	56,000
MMAH	Administrative costs for the Ontario Support Centre	800,000
MMAH/MOE	Cost of supplying water to institutions	1,510,000
MOE/MAG*	Legal costs – Government of Ontario	3,450,000
MOE/MAG/ Cabinet Office*	Walkerton response team	3,200,000
MOE	Incineration of biosolids and pumping septic tanks	134,609
Total		\$11,110,184

Note: MMAH is the Ministry of Municipal Affairs and Housing; MCSS is the Ministry of Community and Social Services; EDU is the Ministry of Education; FIN is the Ministry of Finance; MOE is the Ministry of the Environment; and MAG is the Ministry of the Attorney General.

Sources: Government of Ontario, Cabinet Office. *Estimated from secondary sources. At time of writing, awaiting direct estimates from government sources.

²⁷ Kevin French, director, Issues Management, and committee liaison, Environmental Health and Safety Project, Cabinet Office, Government of Ontario, personal communication, fax September 20, 2001.

the expenditures. Most of the estimates are taken directly from the information provided by the government. In the case of interest-free loans, however, I use only an estimate of the interest cost forgone as a result of the loan.

5 Concluding Remarks

The terms of reference for this study were to estimate the tangible costs of the Walkerton crisis. I present a conservative estimate of these costs of approximately \$64.5 million. The actual tangible costs could well turn out to be higher, since I attempt to be conservative whenever it is necessary to make assumptions.

The conclusion to be drawn from this study is that approximately \$64.5 million in tangible costs are at risk from any future water contamination incident of a magnitude similar to Walkerton's.²⁸ Knowing the probability of such an event would help us to predict the likelihood of incurring such a cost. Similarly, knowing the extent to which an appropriate public expenditure program could reduce that probability would help us to predict the expected benefits (cost avoidance) of the program. Such knowledge is, however, well beyond the scope of this project.

²⁸The terms of reference for this study do not include attempting to place a value on the intangible costs – the lives that might be lost or the illnesses that might result if a similar incident were to occur in the future. It is possible and appropriate to attempt such a valuation but the issues are complex. I therefore address those issues in a separate brief report in this series (Livernois, cited above).

Appendix A1: Critical Parameter Assumptions

Appendix A1 shows the assumed values for a number of critical parameters required to estimate some of the costs of the water crisis as well as the sources for those values.

A1.1 Marginal Cost of a Hospital Day

The marginal cost of a hospital day for the problems resulting from the Walkerton water crisis is \$419.82.²⁹ This is the average cost over 11 kidney-related procedures, ranging from the highest at \$567, for “admit for renal dialysis with class B cc,” to the lowest at \$328, for “kidney and urinary tract infections with class C cc.” The estimates are based on surveys over the 1993–95 period. The estimates are not inflated to bring them up to year 2001, however, because I lack a reliable cost-inflator; thus, as throughout the study, these estimates err on the conservative side. Although the hospitals used in the Walkerton crisis ranged from high-cost teaching hospitals to lower-cost rural hospitals, I believe that this estimate is the best available as an average.

A1.2 Marginal Cost of a Physician Consultation

The marginal cost of a physician consultation is \$24.51 per visit.³⁰ This a conservative estimate of the full cost of a physician visit and the best one available at the time of writing.

A1.3 Opportunity Cost of Leisure Time

Elementary economic theory suggests that the opportunity cost of leisure time is equal to the income that could have been earned at work if the hours of work desired are unconstrained. But when hours of work are constrained to be above or below what a worker would choose, economic theory provides little concrete

²⁹Manitoba Centre for Health and Policy Information, *Manitoba Cost List* [online], [cited November 7, 2001], <www.umanitoba.ca/academic/centres/mchp/concept/dict/costing.concept.html>.

³⁰Robert B. Coombs et al., 2001, “Asthma and Once-per Day Inhaled Corticosteroids: Potential for Improved Compliance and Reduced Health Costs,” University of Guelph Working Paper, photocopy.

assistance beyond saying that the opportunity cost could be lower or higher than the wage cost, depending on the constraints that exist on hours of work. In this report, I settle for the middle ground by assuming in the base case that the opportunity cost of leisure time equals 50% of the hourly earnings rate. To test the sensitivity of the results to this assumption, I calculate the total household costs under the assumption that leisure time cost is as low as 30% and as high as 100% of the hourly earnings rate. I find that the results are not very sensitive to these large differences, thus the middle-ground assumption of 50% seems satisfactory.

A1.4 Average Treatment Cost per Patient-Year for End-Stage Renal Disease

The estimate I use is based on the estimates produced by Goeree et al. These range from \$32,570 to \$88,585 per year, depending on the type of treatment (ranging from home hemodialysis to hospital hemodialysis).³¹ I use the mid-point of this range, approximately \$60,600 per year, and assume an average of five years of treatment per case.

A1.5 Number of Patients Developing End-Stage Renal Disease

According to one journal article,³² approximately 85% of children with classic hemolytic-uremic syndrome (HUS) recover completely, and 80% of adults with HUS will ultimately require long-term dialysis or renal transplantation. BGOSHU states that fewer than 10% of infection cases typically develop HUS and only about a third of those with HUS develop long-term renal problems.³³ In the actual event, there were 27 recorded cases of HUS, a relatively low incidence. To be conservative, I use the BGOSHU estimate of a one-third rate of renal disease among HUS cases and assume 9 of the 27 HUS cases may develop long-term renal problems.

³¹ Goeree et al., cited above.

³² Malvinder S. Parmer, 2001, "Hemolytic-Uremic Syndrome," *eMedicine Journal*, vol. 2, no. 5.

³³ BGOSHU, cited above.

Appendix A2: Household Survey Instrument

Estimating the Economic Cost of the Walkerton Water Crisis, Household Survey

Interviewers – Note:

- This survey is being conducted for the Walkerton Inquiry by researchers from the University of Guelph.
- The Inquiry wishes to estimate the economic cost of the water crisis. Although psychological costs and suffering may be significant, this survey will not be about these costs. The survey is about tangible expenditures that were incurred as a direct result of the water crisis.
- The researchers are taking the following extreme measures to safeguard the privacy and anonymity of respondents:
 - no names or addresses will appear on the questionnaire
 - the household will be assigned a random number for data-entry purposes but no code book or key of any kind will be created that matches names or addresses to the survey-assigned number
 - no one will know the identity of the respondents
 - all information gathered for the Household Survey will be anonymous
 - only aggregate and summary data will be reported
 - once the data are summarized the questionnaires will be destroyed
 - once the report is finalized, all raw data will be destroyed
- If there are any questions about the survey, respondents can call Dr. John Livernois at ----- (office) or ----- (home) or ----- (cell)
- Respondents must sign the “Written Consent” form BEFORE completing the interview.
- The time frame of the water crisis is from about April 15, 2000 to the present. The peak of the crisis occurred from April 15, 2000 to June 27, 2000 (10 ½ weeks).

Definition of a Household for the purpose of this survey is all persons living in the same household on a permanent basis. (Boarding houses will be excluded. Family members that were NOT living in this house during the water crisis are not considered members of this household.)

Critical Dates in the Walkerton Water Crisis

May 12: storm.

May 21 to Dec. 5: (28 weeks) Boil water advisory.

Onset of illnesses occurred from April 15–June 27.

Reported illnesses peaked May 17–19 and May 22–24.

Date of this interview: _____

Household # _____ **Interviewer #** _____

1. Demographic Questions

1.1 Did you live in Walkerton at any time from April 15, 2000 to December 5, 2000?

YES or NO (If NO, do not include in survey).

1.2 How many adults (18 years old or older as of April 15, 2000) were living in this household on April 15, 2000? _____

1.3 How many children (less than 18 years old as of April 15, 2000) were living in this household on April 15, 2000? _____

1.4 For each adult living in the household at any time during the water crisis (April 15 to Dec. 5; 33 weeks) please answer the following: *(use matrix - NO NAMES; if more than 4 adults, use space at end of questionnaire).*

Adults in the Household

	Adult #1	Adult #2	Adult #3	Adult #4
Year of birth				
Male or female				
# of weeks actually worked during the crisis				
# of days living away from Walkerton during crisis				
Income for year 2000 (use codes)				

- 1.5 For each child living in the household at any time during the water crisis (April 15 to Dec. 5; 33 weeks) please answer the following (*use matrix – NO NAMES; if more than 5 children, use space at end of questionnaire*).

Children in the Household

	Child #1	Child #2	Child #3	Child #4
Year of birth				
Male or female				
Grade in school in April 2000				
# of days living away from Walkerton during crisis				

Read these instructions: The following questions are about the economic impact of the water crisis on the household. Many of the questions will ask you about costs to the household. For the purpose of this household survey, costs are defined as all costs incurred by the household regardless of whether or not they were reimbursed, but not including any business-related costs if a business is run out of the home.

2. Health Related Costs to *Adults* as a Result of the Water Crisis.

- 2.1 Did any adults in this household become ill as a result of the water contamination? YES or NO.

If YES, please answer the following questions for *each* adult in the household. (Use the same adult # as in matrix.) If NO, proceed to question 3.

- 2.2 Approximately how many days of illness were experienced by each adult, including recurrences of the illness?

*Adult 1:*_____ *Adult 2:*_____ *Adult 3:*_____ *Adult 4:*_____

- 2.3 What were the dates approximately?

*Adult 1:*_____ *Adult 2:*_____ *Adult 3:*_____ *Adult 4:*_____

- 2.4 (a) In the past year, how many visits were made to a hospital by adults of the household for treatment of the illness caused by contaminated water? (Please list the location of the hospital – e.g., Owen Sound, London, Hanover, Toronto, Walkerton.)

Location 1: *Adult 1:*____ *Adult 2:*____ *Adult 3:*____ *Adult 4:*____

Location 2: *Adult 1:*____ *Adult 2:*____ *Adult 3:*____ *Adult 4:*____

- (b) How many nights in total were spent in hospital (or all hospitals combined if more than one) by adults of the household in the past year for treatment of the illness caused by contaminated water?

*Adult 1:*_____ *Adult 2:*_____ *Adult 3:*_____ *Adult 4:*_____

- (c) Please estimate how many trips were made by adults in the household in the past 12 months to visit or accompany family or friends that were in a hospital or were being treated in a hospital for an illness caused by contaminated water?

*Adult 1:*_____ *Adult 2:*_____ *Adult 3:*_____ *Adult 4:*_____

- (d) For the adults in (c) above, please indicate the usual method of transportation. For example, did they drive alone or car-pool with others?

- (e) If there were any overnight stays for adults in the household who accompanied an ill friend or family member to the hospital, please answer the following:

Total number of overnight rooms in a hotel/motel/B&B that were purchased in past year: _____

Average cost per night of the accommodation, not including food:

Average cost of meals: _____

- 2.5 If any visits were made in the past year to see a local doctor or emergency room for treatment of an illness caused by contaminated water that have not already been reported above, please indicate the number of visits.

*Adult 1:*_____ *Adult 2:*_____ *Adult 3:*_____ *Adult 4:*_____

2.6 Are any adults in the household making ongoing visits to see a doctor for treatment of the illness caused by contaminated water? YES or NO and HOW OFTEN?

Adult 1: _____ Adult 2: _____ Adult 3: _____ Adult 4: _____

2.7 How many days of work did each adult miss as a result of illness due to the water crisis?

Adult 1: _____ Adult 2: _____ Adult 3: _____ Adult 4: _____

2.8 How many days of work did each adult miss because of the illness of a child or family member?

Adult 1: _____ Adult 2: _____ Adult 3: _____ Adult 4: _____

2.9 If medications were necessary, please indicate for each the total cost to the household and, if there was drug plan coverage, also indicate the total cost if known (if not known, indicate the number of days taken for prescriptions).

Note to interviewer – the cost of medications in the table below should be the amounts for the household adults and children combined.

	Cost to household	Total cost if different from household cost (e.g., if covered by drug plan. If not known, indicate number of days taken)
Over-the-counter medications		
Prescription medications		

3. Health Related Costs to *Children* as a Result of the Water Crisis

3.1 Did any children in this household become ill as a result of the water contamination? YES or NO.

If YES, please answer the following questions for *each* child in the household. (Use the same child # as in matrix) If NO, proceed to question 4.

3.2 Approximately how many days of illness were experienced by each child, including recurrences of the illness?

*Child 1:*_____ *Child 2:*_____ *Child 3:*_____ *Child 4:*_____

3.3 What were the dates approximately?

*Child 1:*_____ *Child 2:*_____ *Child 3:*_____ *Child 4:*_____

3.4 (a) In the past year, how many visits for treatment of the illness caused by contaminated water have been made by children of the household? (Please list the location of the hospital – e.g., Owen Sound, London, Hanover, Toronto, Walkerton.)

Location 1: *Child 1:*____ *Child 2:*____ *Child 3:*____ *Child 4:*____

Location 2: *Child 1:*____ *Child 2:*____ *Child 3:*____ *Child 4:*____

(b) How many nights in total were spent in hospital (or all hospitals combined if more than one) by children of the household in the past year for treatment of the illness caused by using contaminated water?

*Child 1:*_____ *Child 2:*_____ *Child 3:*_____ *Child 4:*_____

3.5 If any visits were made in the past year to see a local doctor or emergency room for treatment of an illness caused by using contaminated water that have not already been reported above, please indicate the number of visits.

*Child 1:*_____ *Child 2:*_____ *Child 3:*_____ *Child 4:*_____

3.6 Are any children in the household making ongoing visits to see a doctor for treatment of the illness caused by contaminated water? YES or NO and HOW OFTEN?

*Child 1:*_____ *Child 2:*_____ *Child 3:*_____ *Child 4:*_____

3.7 How many days of school did each child miss as a result of personal illness due to the water crisis?

*Child 1:*_____ *Child 2:*_____ *Child 3:*_____ *Child 4:*_____

3.8 How many days of school did each child miss because of the illness of a family member?

Child 1: _____ *Child 2:* _____ *Child 3:* _____ *Child 4:* _____

4. Household Water Supplies

4.1 Did members of this household boil water for preparing food? (Do not include boiling for cooking that would normally be done.) YES or NO

(a) If yes, for how many weeks was water boiled for preparing food in this household? _____

(Note that the boil water advisory lasted 28 weeks.)

(b) If yes, in the weeks that water was being boiled, how many hours per day on average did members of the household boil water for preparing food? _____

4.2 Did members of this household use more bottled water than normal because of the water crisis? YES or NO

(a) If yes, for how many weeks was bottled water used? _____

(b) If yes, in the weeks that bottled water was used, approximately how many litres of bottled water per week would you say were used in this household? _____

(c) If yes, approximately how many hours per week were spent picking up and transporting the bottled water to the household? _____

4.3 If water was boiled in this household, please estimate the average amount by which each electricity or gas bill was higher in the period in which water was boiled. _____

4.4 Did members of this household sterilize (e.g., bleach or boil) water for bathing? YES or NO

(a) If yes, how many times per week on average? _____

6. Impact on Schooling

(If there are children in this household ask the following)

- 6.1 Please estimate the additional expenses incurred in the household per week to transport the children to and from the school or daycare centres they attended during the water crisis (from May 21, 2000 to end of June 2000).
- 6.2 Please estimate the additional time spent (in hours per week) by adults in the household transporting them to and from school during this period.
- 6.3 Please estimate any additional daycare costs. _____
- 6.4 Was the children's education adversely affected by school disruptions due to the water crisis? YES or NO? If YES, please explain briefly.
- 6.5 Were the children's extra-curricular activities adversely affected by school disruptions due to the water crisis? YES or NO? If YES, please explain briefly.

7. Other Impacts

- 7.1 During the boil water advisory period, how many trips per week would you say were made to shops outside of Walkerton (e.g., for groceries), which would normally have been made to shops located in Walkerton, because of concerns about contaminated water?

Please indicate the number of trips per week and to what town or city they were usually made.

___ trips per week to _____

___ trips per week to _____

(add more towns if necessary)

- 7.2 (a) About how many times in the past year did members of the household purchase takeout or restaurant meals because of concerns about contaminated water? _____
- (b) What was the average cost of these meals? _____

Appendix A3: Business Survey Instrument

Estimating the Economic Cost of the Walkerton Water Crisis, Business Survey

Interviewers – Note:

- This survey is being conducted for the Walkerton Inquiry by researchers from the University of Guelph.
- The Inquiry wishes to estimate the economic cost of the water crisis. Although psychological costs and suffering may be significant, this survey will not be about these costs. The survey is about tangible expenditures that were incurred as a direct result of the water crisis.
- The researchers are taking the following extreme measures to safeguard the privacy and anonymity of respondents:
 - no names or addresses will appear on the questionnaire
 - the business will be assigned a random number for data-entry purposes but no code book or key of any kind will be created that matches names or addresses to the survey-assigned number
 - no one will know the identity of the respondents
 - all information gathered for the Business Survey will be anonymous
 - only aggregate and summary data will be reported
 - once the data are summarized the questionnaires will be destroyed
 - once the report is finalized, all raw data will be destroyed
- If there are any questions about the survey, respondents can call Dr. John Livernois at ----- (office) or ----- (home) or ----- (cell)
- Respondents must sign the “Written Consent” form BEFORE completing the interview.
- The time frame of the water crisis is April 15, 2000 to December 5, 2000 (33 weeks) with the peak of the crisis occurring from April 15, 2000 to June 27, 2000 (10 1/2 weeks).
- The interview should take about 45 minutes.

Critical Dates in the Walkerton Water Crisis:

May 12: storm.

May 21 to Dec. 5: (28 weeks) Boil water advisory.

Onset of illnesses occurred from April 15–June 27.

Reported illnesses peaked May 17–19 and May 22–24.

Date of this interview: _____

Survey number: _____

A. Description of the Business Establishment

1. Has this business been operating at this location since May 2000?

Yes _____ No _____

If not please provide details. _____

2. Please indicate the classification code for this business. _____

3. Please indicate the number of full-time and part-time employees. _____

Note to interviewer: "Costs" are defined as the costs regardless of whether or not reimbursement was received.

B. Cost-Related Impacts – In this section, we are interested in identifying the extra costs incurred by the business because of contaminated municipal water

1. During the past 12 months, did the business provide staff and customers with bottled, tanker, or boiled water? YES or NO? If NO, go to next question. If YES:

(a) Please estimate the quantity of water per month provided (number of bottles, and size, or number of tankers)

(b) Please estimate how this affected the cost of operating the business. For example:

Was water purchased? (If so, indicate average monthly cost.)

Was water boiled? (If so, indicate the average hours per day or per month, whichever is easier.)

Appendix A4: The Hedonic Price Regression Model

Data were collected for 1,070 real estate sales made between January 1, 1996 and July 31, 2001. Of this total, 385 sales occurred in Walkerton. The others were in the towns of Hanover, Port Elgin, and Kincardine, which have real estate markets comparable to Walkerton's.³⁴ I used the sales records from these neighbouring towns to help control for price effects before and after the *E. coli* outbreak in Walkerton.

I used the standard hedonic model of real estate prices. In this model, the market price of a property is viewed as a function of the property's characteristics. The regression model estimated is represented as the following:

$$\ln(p_j) = \alpha_0 + \alpha_1 HAN_j + \alpha_2 PE_j + \alpha_3 KIN_j + g(T_j) \\ + \beta_1 CRISIS_{Wj} + \beta_2 CRISIS_{Hj} + \beta_3 CRISIS_{PEj} \\ + \sum \gamma_i x_{ij} + u_i$$

where

- $j = 1, \dots, 1,070$ is the index for properties in the data set;
- $\ln(p)$ is the natural logarithm of the selling price for property j ;
- HAN_j is a dummy variable that equals one if property j sold in Hanover but is zero otherwise;
- PE_j is a similar dummy variable but for the town of Port Elgin;
- KIN_j is a similar dummy variable but for the town of Kincardine;
- $g(T)$ is a polynomial function of time; more details are provided below;
- $CRISIS_{Wj}$ is a dummy variable that takes on the value one if property j sold after April 30, 2000 in the town of Walkerton but is zero otherwise;
- $CRISIS_{Hj}$ is a dummy variable that takes on the value one if property j sold after April 30, 2000 in the town of Hanover but is zero otherwise;
- $CRISIS_{PEj}$ is a dummy variable that takes on the value one if property j sold after April 30, 2000 in the town of Port Elgin but is zero otherwise;
- x_{ij} is the i th characteristic of property j ; a list of the characteristics used in the regression is provided below;
- u_j is the error term; and
- the α , β , and γ parameters are to be statistically estimated.

³⁴ Michael McIntee, 2001, McIntee Real Estate Limited, Walkerton, personal communication, May 2001.

The variable T for time was constructed using the selling month of the property. The month of January 1996 is designated month 1 and subsequent months are numbered sequentially up to July 2001, which is month 67. A 5th-order polynomial function of T was constructed to capture possible non-linear price movements over time. A separate polynomial function was estimated for each of the four towns to test the hypothesis that the time trends differed by town. However, none of the coefficients on the polynomials is statistically different from the others at even a 10% confidence level. Thus, in the results presented, the polynomial is forced to be the same for each town.

The dummy variables for the towns allow for the possibility of differences in average prices across towns. This is captured as shifts in the constant term.

The dummy variables called *CRISIS* are used to test the hypothesis that prices were statistically different in the months following April 2000. For completeness, I have tested the hypothesis that there were price effects due to the crisis, not only in Walkerton, but also in the surrounding towns.

A4.1 Results

Table A4-1 presents the results of the hedonic price model. Estimated coefficients that are significantly different from zero are indicated by an asterisk and are also shown in a bold font. Note that the estimated coefficients should be interpreted as showing marginal effects on property values. This, combined with the fact that the dependent variable is the logarithm of property value, means that, holding all else constant, an increase in one characteristic is predicted to affect the property value by the proportionate amount shown by the value of the coefficient.

The key result for this study is that the dummy variable for the crisis period in Walkerton is statistically significant (the t -statistic is larger than 3.0, indicating a very high level of significance). The estimated coefficient indicates that a decrease in property values of about 15.42% on average occurred after April 30, 2000, which cannot be explained by the characteristics or features of the sales of hundreds of properties in the four towns of Walkerton, Hanover, Port Elgin, or Kincardine.³⁵ I conclude that the decrease can be explained only by the depressed market conditions in Walkerton resulting from the water

³⁵The 95% confidence interval is 6.1% to 24.7%, meaning that the results of this statistical analysis allow us to conclude that the true impact of the water crisis will lie in this interval 95% of the time.

contamination crisis. This result appears to be quite robust to alternative specifications of the hedonic regression model.

Table A4-1 Hedonic Price Regression for 1,070 Real Estate Sales in Walkerton and Nearby Towns, January 1, 1996 to July 31, 2001

Variable name	Estimated coefficient	t-statistic	Variable meaning	Defaults for dummy variables
C	10.72*	97.04	Constant	
TAX	2.28E-04*	16.84	Property taxes	
AGE	-1.22E-03*	-3.82	Age of house	
CRISIS1	-0.15428	-3.24	Dummy	
CRISIS2	-0.0414	-0.77	Dummy	
CRISIS3	0.07197	1.57	Dummy	
TIME	-0.01523	-0.67	Month	
TIME2	1.18E-03	0.64	Month raised to power of 2	
TIME3	-3.9E-05	-0.62	Month raised to power of 3	
TIME4	5.49E-07	0.55	Month raised to power of 4	
TIME5	-2.39E-09	-0.42	Month raised to power of 5	
TOWN2	0.05643*	2.01	Hanover dummy	The default is Walkerton
TOWN3	0.03491	1.25	Port Elgin dummy	
TOWN4	-0.03212	-1.28	Kincardine dummy	
STYLE2	-0.09388	-0.36	Split-level dummy	The default is single-storey
STYLE3	0.06711*	3.39	Two-storey dummy	
STYLE4	-2.88E-03	-0.12	Three-storey dummy	
EXT2	-0.08188*	-2.1	Brick exterior dummy	The default is aluminum/vinyl exterior
EXT3	0.02679	0.7	Brick/alum./vinyl exterior dummy	
EXT4	-0.01986	-0.52	Brick/wood exterior dummy	
EXT5	0.06348	1.19	Wood exterior dummy	
EXT6	0.05729	1.22	Other exterior dummy	
BSMT2	-8.23E-03	-0.35	Partly finished basement dummy	The default is unfinished basement
BSMT3	-1.17E-03	-0.05	Finished basement dummy	
GARAGE2	0.1041*	5.37	Single attached garage dummy	The default is no garage.
GARAGE3	0.2052*	6.56	Double attached garage dummy	
GARAGE4	0.06845*	2.14	Single detached garage dummy	
GARAGE5	0.196*	4.53	Other garage dummy	
BATHS	0.07664*	5.36	Number of bathrooms	
BDRMS	0.06869*	5.99	Number of bedrooms	
RENT	-19E-04	-1.88	Rental income	
AC	0.09094*	3.71	Central air conditioning dummy	
BEACH2	-0.03987	-0.87	Near beach dummy	The default is not near beach
BEACH 3	0.04849	0.36	On beach dummy	

Note: Asterisk* and bold font indicate estimated coefficients that are significantly different from zero.

The other results shown in table A4-1 indicate that property taxes are significantly related to the price of a house. This is unsurprising given that the taxes are based on assessments meant to reflect property values. The age of a house significantly reduces the selling price by about 0.1% on average for each additional year of age. Property prices in towns other than Walkerton did not experience a statistically significant price effect during the crisis period, though Kincardine comes close to showing a significant price increase. The dummy variables for towns indicate that property prices in Hanover are higher than in Walkerton on average by 5.6% but that prices in Port Elgin and Kincardine are no higher on average than in Walkerton. Two-storey homes are higher in price than bungalows by 6.7% on average. One of the perhaps surprising results is that homes with a brick exterior are 8.2% cheaper than homes with a vinyl/aluminum exterior. The dummy variables for garage types are all statistically significant, indicating that homes with garages sell for higher prices than homes with no garages. For example, a house with a double attached garage sells for 20.5% more on average than a house with no garage. This is a surprisingly large effect and probably captures more than the effect of just the garage. In particular, it probably also picks up the effect of size of house. Since data for size of house (in square footage) were not collected by the real estate agents consistently, I was unable to control directly for the effect of the size of the house on the price of the house. For this reason, I believe that the dummy variable for garage type as well as the variables for numbers of bathrooms and bedrooms are picking up the effects of house size. The results show that the numbers of bedrooms and bathrooms have statistically significant effects on property values. In particular, the results show that an additional bathroom adds about 7.7% to the property value, while an additional bedroom adds about 6.9% on average to the property value. The final statistically significant variable is the dummy for the presence of central air conditioning, a feature that adds about 9.1% to the property value on average.

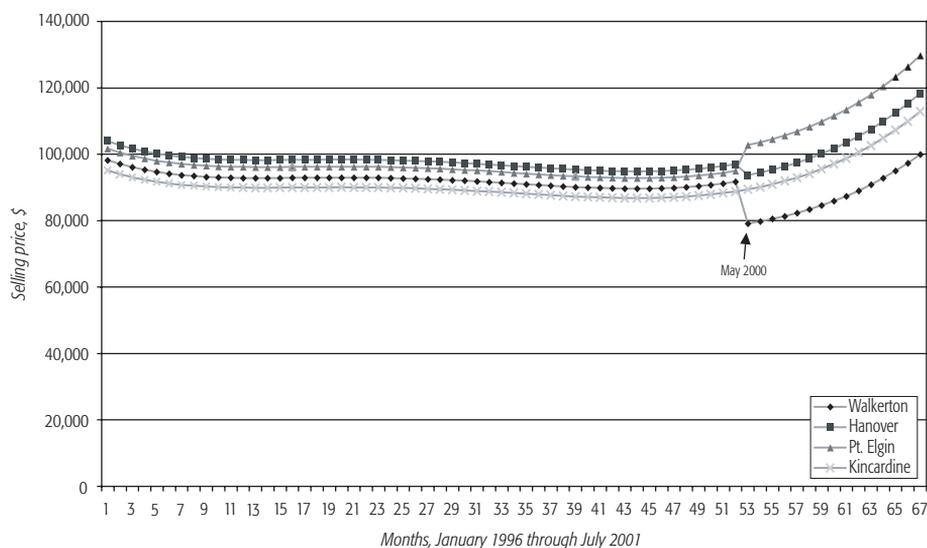
Again, I emphasize that the effects on property values of many of these “characteristics” variables, such as the presence of a double attached garage or the presence of air conditioning, are probably being overestimated because of the lack of statistical controls for house size and perhaps location in the data set. Nevertheless, the fact that some of these variables may also be acting as proxy variable for house size and perhaps location is unlikely to weaken the key result that property prices declined in Walkerton, and in Walkerton alone, during the crisis period in a way that cannot be explained by the controls available.

Figure A4-1 depicts the monthly statistical price indices implied by the regression model for property values in the four towns. Most price indices published for

real estate values are simple average selling prices over time. Such an index does not control for changes in the types of houses that are sold in a time period, so they can show price increases or decreases that are simply due to changes in the types of house sold and not necessarily due to changes in market conditions. The index derived here and shown in figure A4-1 does not suffer from this weakness. Instead, it shows how the price of the same average house, as predicted by the regression results, changed over time. In other words, controlling for property characteristics, the index shows the pure price movements due to market conditions.

Figure A4-1 shows that all towns experienced a modest downward trend in property values over the first three quarters of 1996, followed by steady prices until about early 1998, when a modest downward trend resumed. This bottomed out in 1999, and a modest upward trend in prices began. In Walkerton, this was abruptly interrupted by the water crisis. In the other three towns, however, the upward trend continued.³⁶ These results show that, although Walkerton prices appear to have climbed during the crisis period, they were nevertheless a good 15% below the level they would have reached had the crisis not occurred.

Figure A4-1 Predicted Time Path of Real Estate Prices for an “Average” Property, Walkerton and Nearby Towns, January 1996 through July 2001



³⁶The graph for Kincardine shows the upward price effect during the crisis period because the dummy variable was included in the regression equation to generate the price index. As the text indicates, however, this is not a statistically significant effect.

Appendix A5: Depreciation of the Cost of Watermain Replacement

The total cost of watermain replacement that appears on the OCWA invoice is \$2,118,484. Some of these watermains were very old, however, and would have been due for replacement anyway. Therefore, it would be incorrect to count the full amount of the replacement cost as an economic cost attributable to the water contamination crisis. Instead, only the undepreciated part of the watermains that were replaced should be counted.

To calculate depreciation, I assume that watermains are due for replacement approximately every 100 years. Suppose that a 50-year-old watermain must be replaced (50 years prematurely) because of contamination. What is the economic cost? Let the actual amount of money spent, in real (inflation adjusted) dollars, be denoted by K_{50} , and assume that this same amount (in real or constant dollars) applies regardless of whether the watermain is replaced now or at age 100. If replaced at age 100 (50 years in the future), the present discounted value of the expenditure is

$$\frac{K_{50}}{(1+r)^{50}}$$

where r denotes the real (inflation adjusted) rate of discount (assumed to be 3% in this report). If replaced at age 50 (that is, now), the expenditure is simply K_{50} . The economic cost incurred by having to replace the watermain 50 years prematurely is the difference between the expenditure now, K_{50} , and the present discounted value of the expenditure made 50 years in the future, shown above. This difference is the imputed economic cost and is given by

$$K_{50} \left[1 - \frac{1}{(1+r)^{50}} \right]$$

I refer to the term in square brackets as the “difference factor.” I calculate the difference factor for premature replacements ranging from 5 years prematurely to 95 years prematurely in 5-year increments. Table A5-1 shows the results.

The percentage of the watermains in each age group is taken from two sources. The first is the Municipality of Brockton, “Report on Cause,” which presents the age distribution of watermains in Walkerton. In that report, the percentages of the length of watermains installed in the decades 1950–59, 1960–69,

1970–79, 1980–89, and 1990–2000 are 2.1%, 5.3%, 10.8%, 5.7%, and 12.6%, respectively. These percentages are used in table A5-1, and the age for each age group is taken as the mid-point of the decade.

The report indicates that 63.6% of the watermains are of unknown age. Therefore, I use a second source of data to estimate the age distribution of this portion of the watermains – data on the age distribution of real estate properties sold in Walkerton over the period 1996 to 2001. (See section 2.5, on property values, in this report for more information about these data.) I assume that the age distribution of the houses sold reflects the age distribution of the watermains.³⁷ These data provide the remaining percentage figures in table A5-1 for ages beginning at 55 years and running up to 95 years. This leaves 52.5% of the

Table A5-1 Calculations of the Cost of Prematurely Replacing Watermains

Age of water main, years	Years to replacement	% of water mains	Expenditure, \$	Difference factor	Economic cost, \$
5	95	12.6	\$266,929	0.940	\$250,913
15	85	5.7	120,754	0.919	110,973
25	75	10.8	228,796	0.891	203,857
35	65	5.3	112,280	0.854	95,887
45	55	2.1	44,488	0.803	35,724
55	45	5.0	105,924	0.736	77,960
65	35	2.0	42,370	0.645	27,328
75	25	1.0	21,185	0.522	11,058
85	15	2.0	42,370	0.358	15,168
95	5	1.0	21,185	0.137	2,902
>100	0	52.5	1,112,204	0.000	0
Total			\$2,112,204		\$831,770

Note: Dollar values have been rounded off to the nearest dollar.

Sources: Municipality of Brockton, “Report on Cause” (May 2000) [online], [Cited November 13, 2001], <www.newswire.ca/releases/October2000/20/c5205.html>. Data collected (with the assistance of McIntee Real Estate Limited, Walkerton) on more than 1,000 real estate property transactions covering the period January 1, 1996 to July 31, 2001 in the towns of Walkerton, Hanover, Port Elgin, and Kincardine, Ontario.

³⁷This is a conservative assumption. Watermains are probably younger, on average, than the houses they serve because some will have been repaired or replaced. As is the case throughout this study, this conservative assumption leads to estimates that err on the low side.

watermains that are of unknown age, presumably because they are very old. I assume this percentage is older than 100 years of age. Therefore, I assume that 52.5% of the watermains that were replaced were due for immediate replacement anyway, and I impute no economic cost to their replacement.

The dollar amounts shown in the column marked “Expenditure” are calculated by multiplying the actual total expenditure (\$2,118,484) by the fraction of watermains in each age group. For example, the expenditure of \$266,929 on replacing 5-year-old watermains is 12.6% of \$2,118,484.

Finally, the economic cost in the last column is calculated by multiplying the expenditure by the difference factor. We can interpret this intuitively. For example, almost all (94%) of the \$266,929 spent replacing 5-year-old watermains is counted as an economic cost because these mains were not due for replacement for another 95 years. On the other hand, only a small share (13.7%) of the \$21,185 spent replacing 95-year-old watermains is counted as an economic cost because they would have been due for replacement in 5 years anyway.

Adding the numbers in the final column gives the total economic cost of replacing watermains – \$831,770.

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