A P P E N D I C E S

REGULATORY IMPACT ANALYSIS FOR PROPOSED TECHNICAL STANDARDS FOR UNDERGROUND STORAGE TANKS

MARCH 30, 1987

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A P P E N D I X A

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SUMMARY OF THE UST MODEL

INTRODUCTION

The underground storage tank (UST) failure model is a computerized Monte Carlo model which simulates the failure of an underground facility and the transport of any product released, as a result of the facility failure, through the unsaturated zone. The major outputs of the model include release characteristics, floating plume characteristics, and costs. Cost outputs include facility installation and maintenance costs, facility replacement and repair costs and remedial and corrective action costs.

Another major output of the model is a measure of the effectiveness of leak detection and tank monitoring devices. The model is particularly useful for comparing the effectiveness of different detection options for a particular tank or for comparing the effectiveness of one detection option in combination with several different tank types. Effectiveness may be measured in gallons of product released (or gallons avoided), the number and area of plumes formed (or avoided) and cost.

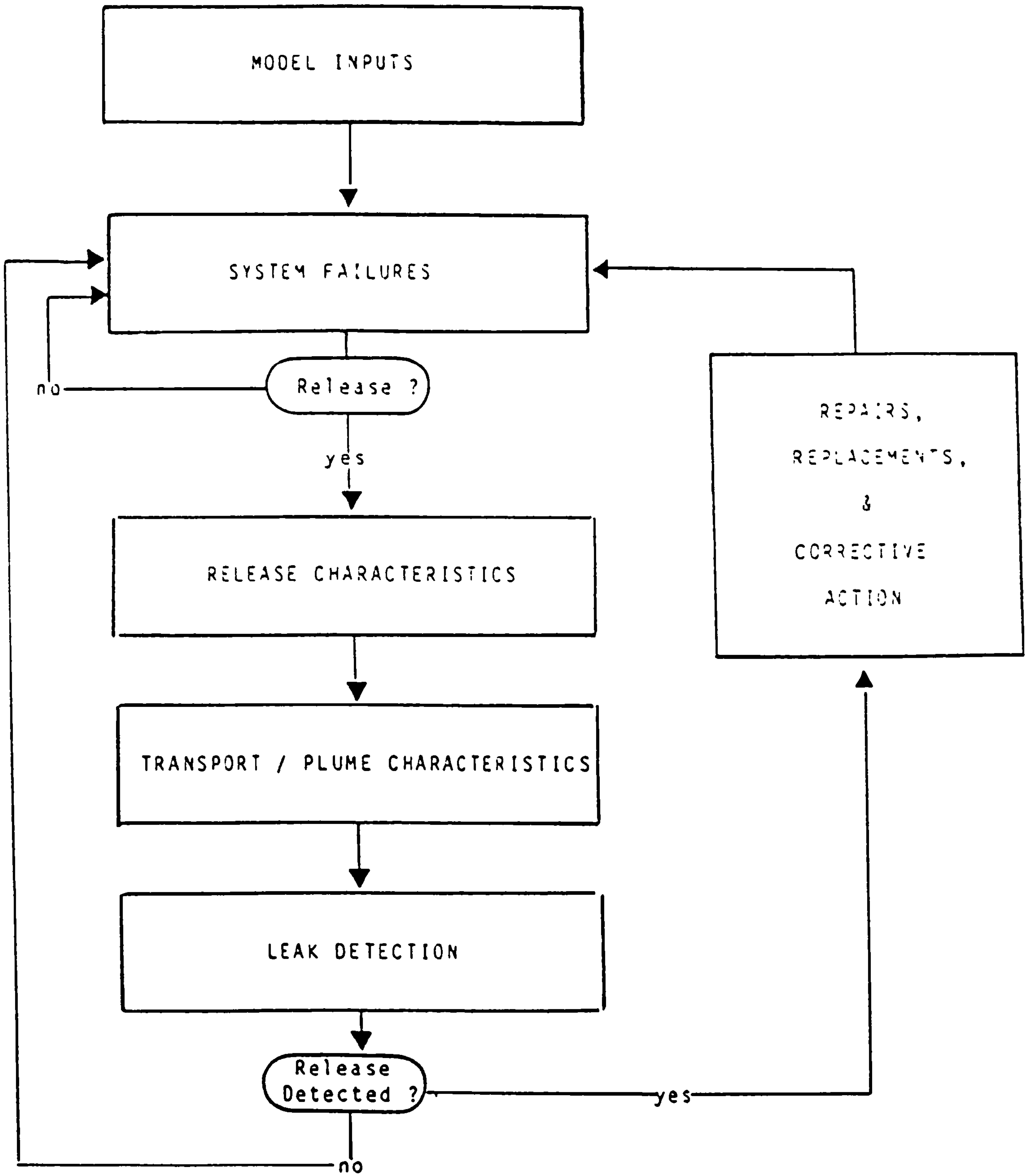
The model can simulate the life of a facility, or estimate the probability of a facility failing over a specific period of time, for many different types of underground tank facilities in many different environments. The model first accepts tank type and design information and soil and hydrogeological information as user inputs. The model feeds this information into several routines, or "sub-models". These routines then estimate the probability of the facility failing, determine the type and location of any failures, calculate the total volume of product released to the environment, determine the area of the plume that forms if the release meets the groundwater, and calculate the cost of repairs, tank replacements and cleanup. The inputs that must be read into the model include:

- Facility/tank type and tank design characteristics,
- Detection and/or monitoring devices and their sensitivity or detection threshold,
- Frequency of monitor or detection devices,
- Product type (gasoline, diesel fuel or other chemical), and
- Soil type and hydro-geological characteristics.

The model has three major "sub-models" or routines: a failure routine, a release routine and a transport routine. The first routine, the failure routine, estimates the probability and the time of failure and determines the location of the failure. Then the release routine calculates the time to detection of the release, the total volume of product released, and the cost of replacing or retiring the facility. The transport routine calculates the travel time of the release volume in the unsaturated zone and determines the area of the floating plume.

The following is a summary of each of the three major routines in the model. The reader may refer to the simple flowchart of the model presented in Chapter 2 and reprinted here.

SIMPLE FLOWCHART OF UST SIMULATION MODEL



FAILURE ROUTINE

Each facility[1/] begins each year with the failure routine. If a tank survives the year with no failures, it continues to the next year (returns to the failure routine) without entering the release and transport routines.

The failure routine estimates the probability of a failure occuring at a facility, and using this probability (in conjunction with a random number generator) determines whether the failure occurs.[2/] This routine also determines the type of failure, the time of failure and the location of the failure (i.e.: within the tank or within the piping). The types of failures simulated by the the model include ruptures, equipment and structural deficiencies, and corrosion leaks.

At the start of each year, the model determines the type of failures and the number of failures that will occur at a facility in the current year for every facility in the population. The model then chooses, or samples, a failure time randomly from a distribution of possible failure times for each failure that will occur in the year.

After the time of failure is determined, the model determines the location of each failure. Rupture, corrosion and deficiency failures can be located in the tank, fill pipe, piping connections or the discharge pipe. The only exceptions are that pipe welds cannot fail because of corrosion, and pipe gaskets cannot fail due to rupture.

The model repeats the time to failure sampling, and then the location sampling, at the beginning of each year for each tank (in the case of existing tanks, for each remaining tank) until the end of the run. If a failure occurs and product is released, the tank enters the release routine of the model. The type, time and the location of each failure are outputs from the failure routine and inputs to the release routine.

RELEASE ROUTINE

The release routine calculates the time to detection of the release, the total volume of product released, and the cost of repairing or replacing the facility.

The inputs to the routine are the type of failure, the time of failure and the location of the failure. All of these inputs are outputs determined by the failure routine.

[1/] A facility is defined as a single tank and its piping network. Facility and tank are used interchangeably throughout the text.

[2/] The probability of failure in conjunction with a random number generator determines when the failure actually occurs. For example, the failure routine may assign a ten percent chance of failure. A routine known as a random number generator then selects randomly a number between 0 and 1. If this number is less than the probability, then the failure is considered to have occured. If this process is repeated many times, the failure would occur approximately ten percent of the time.

The release routine first determines what type of failure has entered the routine, and when the release began. If the failure is a catastrophic failure, the release is detected immediately. For catastrophic releases, the routine samples, or chooses from a distribution of possible volumes, the volume of product released. Whenever a failure is detected in the tank (as is the case for a catastrophic failure), the tank is replaced or retired. If the run is a run of new facilities, the routine computes the replacement cost for the facility. If the run consists of existing tanks, the facility is retired and the run ends for that facility. The release volume then continues as an input to the transport routine.

If the failure type is not catastrophic, it may not be detected immediately. A release is detected when the cumulative volume from all leaks at the facility is great enough to surpass the detection threshold of the monitoring, or leak detection device. The amount of product which accumulates over a period of time, and therefore the detection time, will depend upon the leak rate. [1/]

In the case of a rupture or a deficiency, the leak rate is constant for the duration of the leak. In the case of corrosion leaks, the leak rate is dependent upon the initial hole size and the rate of corrosion. The initial hole size of a corrosion leak is randomly selected from a distribution containing the range of possible values for the parameter. The rate of corrosion is calculated independent of the hole size. The recalculation of the size of the hole, which grows linearly, is performed monthly (the size of the hole remains constant for any one particular month). The leak rate changes monthly when the diameter of the hole changes. The release volume is calculated by multiplying the leak rate by the time since the leak began.

Whenever the total release volume from all leaks at a single facility becomes greater than the volume threshold of the detection option, or whenever enough volume accumulates so that the sensitivity of the monitoring device is surpassed, the release is detected.

If the release is detected, the model records the time to detection, computes the repair or replacement cost of the facility, and calculates the discounted cost of the product lost. The tank is retired or replaced only if the tank itself has failed; if the failure is in the piping, the pipes are repaired and the facility remains in the run. The release volume is an input to the transport routine.

When the model has identified all failures which occur in a particular month and has calculated the total release volume for that month for each tank, the model moves on to the next month. The release volume which has not been detected at the end of the month is carried into the next month. The model continues to calculate the volume released from all leaks at a facility in each month until the calculated volume reaches a detection threshold. After a release is detected, or at the end of the run, the total volume released from each tank enters the transport routine. The transport routine will calculate

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[1/] The time to detection is also dependent upon the distance from the location of the leak to the detection or monitoring device and/or the amount of product accumulation needed to surpass the threshold of the device.

the travel time of the plume through the unsaturated zone and compute the area of the floating plume if the release reaches the ground water.

TRANSPORT ROUTINE

After the released product leaks from the facility it travels through the unsaturated zone to the groundwater. If the release is not detected before it penetrates the unsaturated zone, the release intercepts the groundwater and a plume is formed.

The transport routine uses the release characteristics determined in the release routine and traces the release through the unsaturated zone. This routine determines the travel time of the release from the facility to its point of detection or the groundwater. The transport routine calculates the area of the floating plume which results if the release reaches the groundwater and computes the discounted cost of any remedial or corrective action that is necessary to clean up the release and the plume.

Any release which has not been detected by the end of the run is assumed to be detected, is cleaned up and the discounted cost of remedial and corrective action is calculated.

APPENDIX B

ZIP CODE ANALYSIS OF UST LOCATION AND POPULATION DENSITY

APPENDIX B

ZIP CODE ANALYSIS OF UST AND WELL LOCATIONS AND POPULATION DENSITY

A. General Approach

To make accurate estimates of the risks presented by leaking USTs, and to measure the effectiveness of various proposed policies, we need to have a way to estimate the distribution of wells near USTs on a nationwide basis.

The crudest approach might be to assume that all private and public wells are spread evenly across the country. This would yield approximately 15 million private wells and 48,000 public systems in the 3 million square miles of the U.S., or one private well per 130 acres and one public system per 40,000 acres. This approach would probably be wide of the mark. It ignores the fact that most USTs are concentrated into the small areas of the country that are densely populated; the well densities in these areas are more representative of density in the vicinity of the typical UST than is the well density nationwide.

To allow for the uneven distribution of USTs and wells, we obtained 1980 Census data on well and tank populations at the smallest geographic level available: the zip code. By examining a large representative set of zip codes to calculate the number of private wells per square mile, and weighting the results by the number of service stations in each zip code, we obtained a nationwide average density of private wells in the vicinity of USTs. (Service stations provide the most important single group of USTs, constituting 48% of the tanks in the OTS Survey and 75% of the release incidents in the Release Incident Survey.) This data can also be used to show how USTs are distributed across areas of differing private well densities--that is, how many are in places where wells are likely to be close to USTs and how many are in places where wells are very unlikely to be located.

The data on well and UST location can be used not only to estimate the expected distance from a leaking tank to the nearest well, but also the expected distance from a given well to the nearest UST facility. This makes it possible to cross-check the predictions of the analysis with data on the proportion of wells that have been contaminated. We estimated only the distance to the nearest service station UST, then adjusted for the existence of other types of USTs on the assumption they are distributed similarly to service stations.

B. The Sample

A random sample of 2000 of the approximately 35,000 zip codes was selected, and data were obtained from Census tapes, EPA's FRDS data base on public water supplies and other sources concerning the locations and areas of the zip codes; their populations; the number of private and public water wells in each; and the number of service stations and other UST-using establishments. The sample size is large enough to ensure that sampling error is minimal for nationwide statistics, and reasonably small even for regions. The ability to analyze the data regionally allows cross-tabulation of regions of high hydrogeological hazard (shallow, fast-flowing ground water, for example) with regions where high well densities are common--that is, to find the extent to which these risk factors are correlated. Of the sample of 2000 zip codes, 1185 zip codes had at least one service station.

C. Relationship of Population Densities to Service Station Densities

An initial examination of the data in Exhibit 1 confirms the expectation that USTs are found where people are found: service stations are set up where there are customers to serve. (In some instances, such as service areas along heavily traveled highways, service stations are in areas of low resident population densities.) The relationship is, in a statistical sense, very strong: zip code populations explain over two-thirds of the variation in service station populations. In a given zip code, there tends to be one service station (with roughly three USTs) for each 2200 persons. Some of the most important exceptions to this relationship, as for the circled points on the graph, can be explained by the "Manhattan" effect. Where urban densities are extremely high, fewer stations are needed to serve the population adequately: gasoline usage will be lower per person, and the distance to the nearest station will be small in spite of the low ratio of stations to population.

Statistical tests show that higher population density is definitely related to lower ratios of stations per person, though this relationship explains only a small degree of the variation in numbers of stations per zip code.

D. Relationship of Population Density and UST Density to Well Locations

Population density is an important determinant not only of service stations, but also of private well usage. Exhibit 2 shows the distribution of wells, population, and service stations across groups of zip codes with distinctly different population densities. The horizontal axis shows population density classes in population per acre, while the vertical axis shows percent of the total population, service stations, and private water wells in each class out of the 1185 zip codes with service stations.

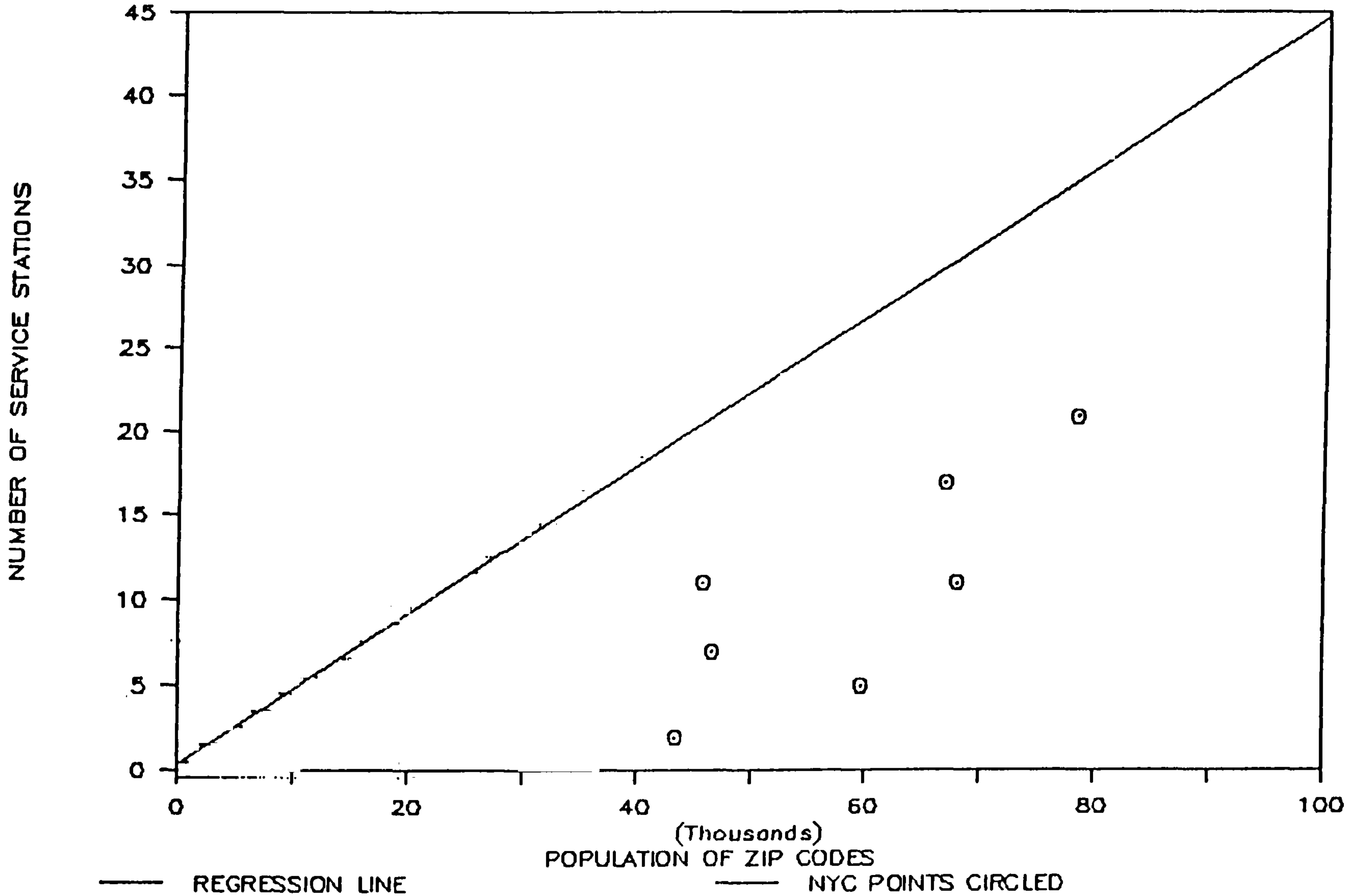
Most of the population and most of the service stations are concentrated in regions of high population density. Their distributions track one another closely, as would be expected on the basis of the close relationship noted above between stations and population. The graph also shows a subtle but persistent tendency for service stations to be less common relative to population at high population densities, and more common relative to population at low densities. This is more evidence of the "Manhattan" effect.

Private wells, however, are distributed very differently. The bulk of private wells are found in regions of moderately low population density, with a very small proportion found in the zip codes that have urban or suburban population density. The best explanation for this is economic: once the population of water users reaches a certain density, it becomes less costly to connect them all to a single, centralized source of water than to invest in an individual well for each household.

This can be seen more clearly in Exhibit 3, which displays the percentage of households using private wells, according to the same density classes as in the previous exhibit. The percentage starts extremely low, and rises steadily over a very wide range of densities. It reaches a plateau at forty percent for densities of fewer than one person per ten acres (60 persons per square mile).

Exhibit 1

PLOT OF SERVICE STATIONS AND POPULATION

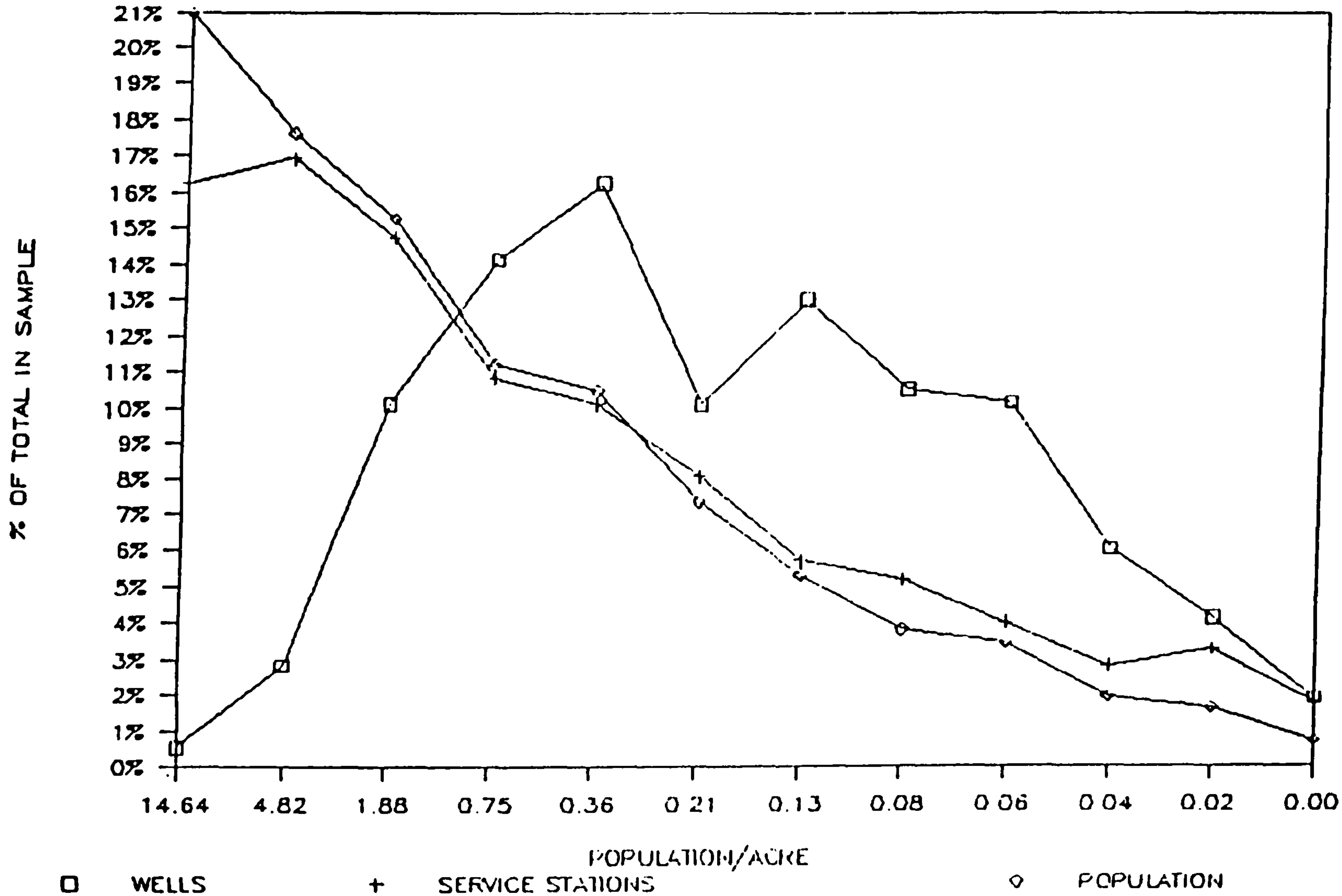


Source: SCI estimate from 1980 census data.

Exhibit 2

DISTRIBUTION OF WELLS, STATIONS, POP.

ACROSS AREAS OF DIFFERING POP DENSITY



Source: SCI and PRA Estimates Using UST Model

Exhibit 3
PRIVATE WELL USE BY POP/ACRE

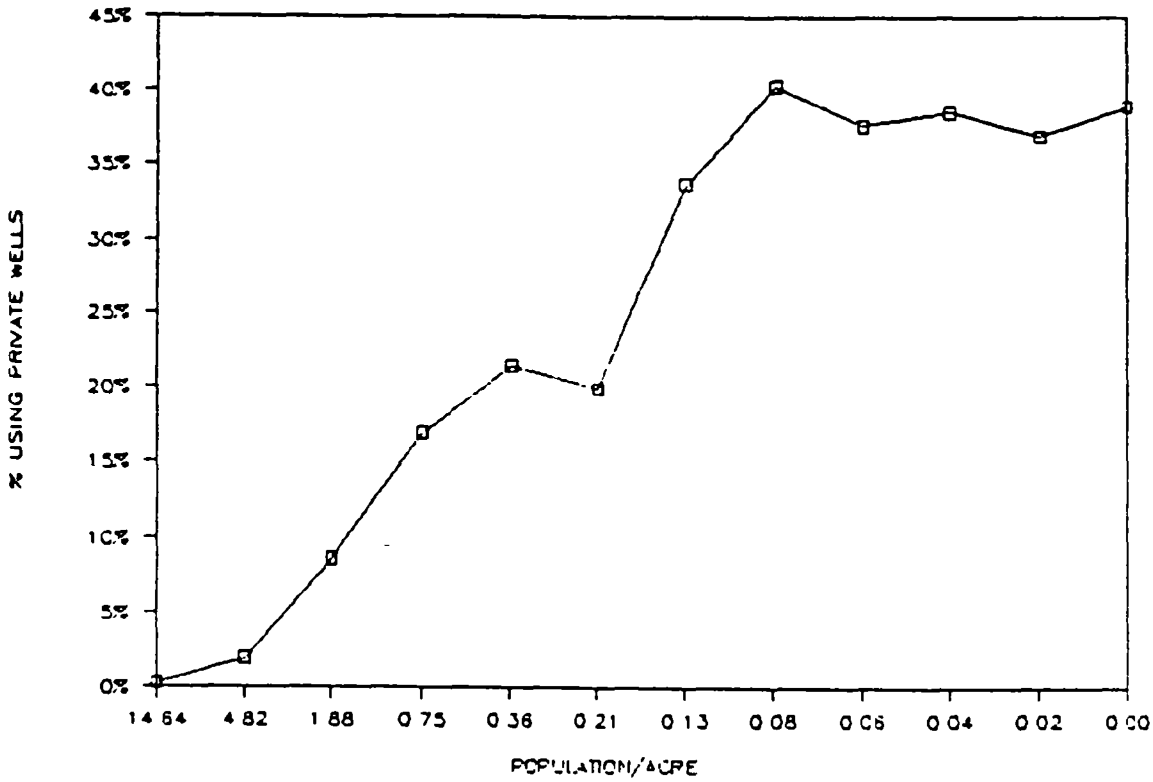
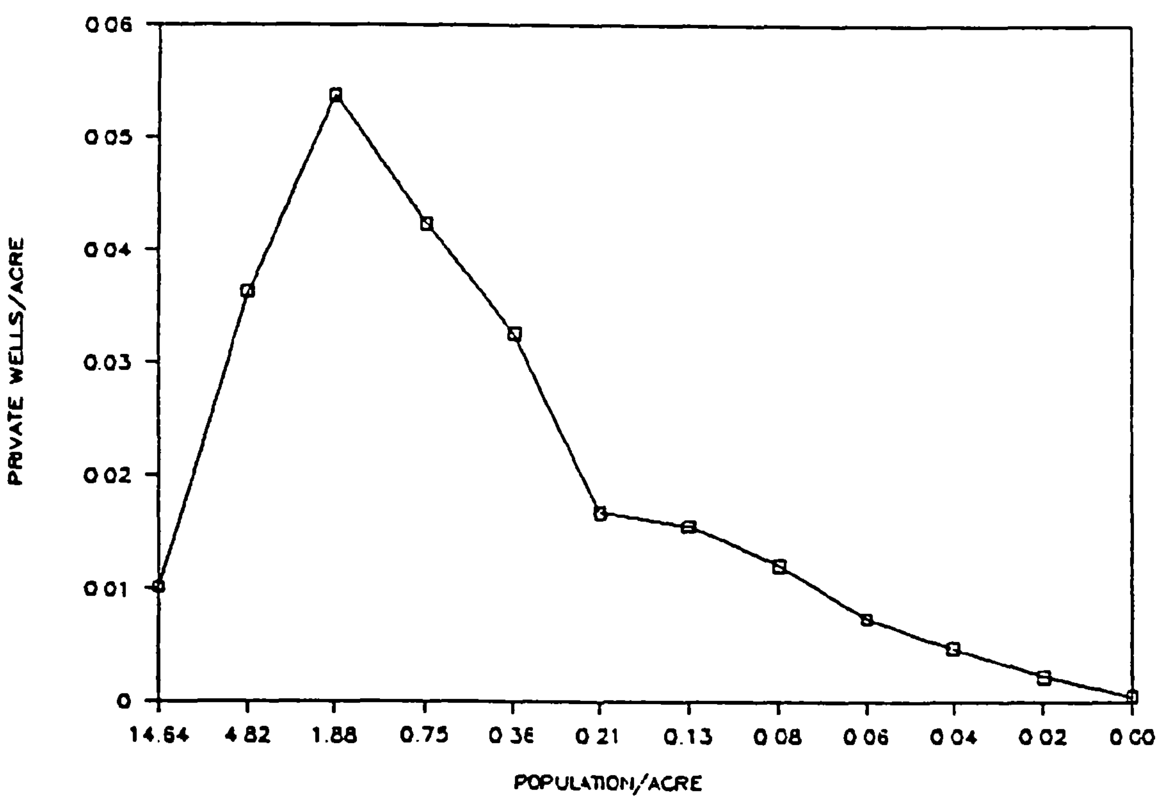


Exhibit 4
PRIVATE WELL DENSITIES, BY POP/ACRE



One possible conclusion from this data, that UST problems will be more severe at lower population densities because that is where higher proportions of the residents use private wells, is overly simplistic. The likelihood that a given plume will contaminate a well is a function not strictly of the proportion of people using individual wells in the area, but of the density of wells: this is influenced both by the fraction of the population using private wells and by the population density. Combining these two influences yields well density per acre, by population density group, as shown on Exhibit 4.

Private well densities may be seen to peak not at low population densities where private wells are commonly used, nor at high population densities, but at moderately low suburban densities. Well densities per acre average no higher than one well per twenty acres for any group (though in individual zip codes, the densities are occasionally much higher.) The mean density is about .025 wells per acre, or one well per forty acres, and it can be seen that a very large portion of the population density groups are within a factor of two of this mean.

Exhibit 5 displays the distribution of service stations across well density classes. It shows that about thirty percent of service stations are in areas where well densities are extremely low--one per 500 acres (just under a square mile) or less. Toward the opposite extreme, only about fifteen percent of service stations are in areas with densities as great as one well per eight acres, and almost none show densities greater than one well per three acres.

E. Public Well Distributions

Densities of public wells are much lower than the densities of private wells because each public well serves a large population. In the vicinity of service stations, there is an average of one public well per three thousand acres. This is on the order of one percent of the density of private wells.

F. Investigating our Assumption of a Random Distribution of Wells Relative to USTs Within a Zip Code

Even though zip codes are small geographical units (the median area in the sample was 20 square miles), we can expect that there will be clumping of population, service stations, and private wells within most zip codes. That is, there will be some parts of the area with greater-than-average concentrations of wells, service stations, and population, and other parts with lower-than-average densities. So long as we can assume that the clumps of service stations have no tendency to coincide with the clumps of private wells, this will not affect the average density of wells near service stations. There is no guarantee, however, that the clumps of wells and service stations do not indeed coincide to some extent. In a zip code with large tracts of uninhabited land and a few towns, the only service stations and the only wells might be much closer together than we would expect on the basis of average densities in the entire zip code. (This is the same problem, of course, that we have with looking at average densities nationwide, and which we have attacked by examining the country in small units.) Of course, the clusters of service stations and wells might also have some tendency to "avoid" one another, since service stations will cluster along busy, commercial strips and wells will be found in residential areas at least some distance away.

DISTRIBUTION OF SERVICE STATIONS

BY PRIVATE WELL DENSITY CLASS

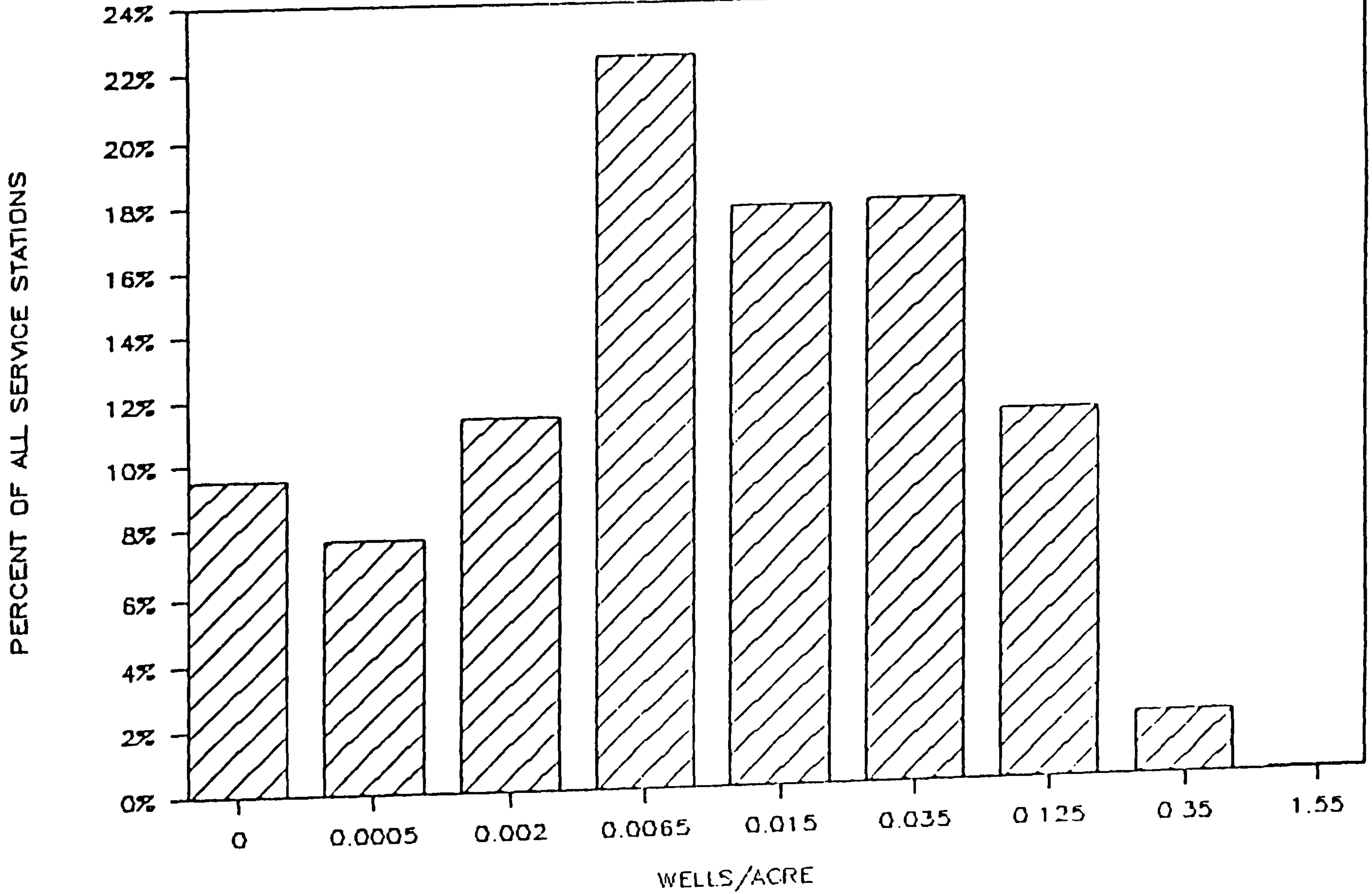


Exhibit 5

We investigated this problem by selecting for analysis only the smallest zip codes, averaging only about two square miles. Regions this small are unlikely to contain much empty space (unless the remaining area is so densely packed that private well use itself is unlikely). Analysis of small zip codes does show well densities near service stations, for given population densities, to be about 60% greater than for the whole sample of zip codes. We believe this increase in average density to be an upper bound. Our assumption of a random distribution of wells relative to USTs within a zip code appears to be only slightly inaccurate.

A P P E N D I X C

UST MODEL SPECIFICATIONS

APPENDIX C

UST MODEL SPECIFICATIONS

This appendix contains an explanation of the UST model inputs specified in order to simulate the base case and five regulatory options discussed in the RIA. The discussion of each model parameter is followed by tables summarizing the model inputs.

Population Characteristics

For each option we modeled a population of 500 tanks. Initially we ran the model using the same run specifications for three tank populations. We compared model runs of 2,000 tanks, 1,000 tanks, and 500 tanks. We found that all three model runs produced very similar statistics. We therefore are confident that a population of 500 tanks can accurately reflect the range of variables in a given run.

We modeled the existing tank population as consisting of bare steel and fiberglass tank types over a period of thirty years and modeled all replacement tanks as cathodically protected tanks in accordance with the Interim Prohibition (HSWA 9003(g)).

We ran the UST model using the DRI bare steel tank and fiberglass age distributions for existing tanks.1/ Because fiberglass tanks were introduced more recently than bare steel tanks, the age distributions are different. The age distributions for bare steel and fiberglass tanks are given below.

	Bare Steel Tanks	Fiberglass Tanks
Tanks 5 years old or less:	4%	50%
Tanks 10 years old or less:	8%	30%
Tanks 15 years old or less:	28%	20%
Tanks 20 years old or less:	24%	0%
Tanks over 20 years old:	36%	0%

Existing bare steel tanks are assumed to have a capacity of 4,000 gallons and fiberglass and new tanks are assumed to have a capacity of 10,000 gallons. This reflects the tank universe as we understand it through current data. We assume that the yearly throughput or the cumulative volume of petroleum stored in a tank over the course of a year, is 91,000 gallons for all tanks.

Inventory control

Another set of inputs relates to EPA's assumptions regarding manual inventory control. The daily, weekly, and monthly inventory limits indicate at what threshold a loss of product can be detected. In the base case we assume that loss of product (i.e., by way of a leak) can be detected if 10% of tank capacity is lost over a period of a day, if 10% of tank capacity is lost over a period of a week, or if 3% of monthly throughput is lost over a period of a month. We

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1/ DRI, Underground Storage Tanks, Technical/Financial/Economic Data Collection, October 2, 1985.

assume that with better inventory control practices the monthly inventory limit can be lowered to 0.5% (0.5% of monthly throughput can be detected within a month). Based on EPA's understanding of current inventory practices at existing facilities, we assume inventory control is undertaken at only 25% of facilities.

Water inventory limits set thresholds on a daily and monthly basis for detection of water entering an underground storage tank. We assume water entering a tank can be detected if it makes up 10% of the daily tank capacity or 3% of the monthly throughput.

Leak Detection

We specify what monitoring device, if any, will be used by a facility to detect a leak, the rate of failure of the device, and what year it is installed. We can model several types of monitoring devices. A summary of these devices is included in Chapter 4. However, the options require us only to model tightness tests and vapor wells. Based on EPA's confidence in leak detection and best engineering judgement, we assume that tightness tests fail at 10% of facilities and that vapor wells fail at 30% of facilities. In the base case we assume that no monitoring devices are used. For existing bare steel tanks, tightness tests are required to be performed once every three years. For fiberglass tanks and cathodically protected tanks, tightness tests are required to be performed less frequently, once every five years, because both fiberglass and cathodically protected tanks generally have a lower number of releases associated with them.

We also specify whether line leak detectors are used and how effective they are. In Options I and II we assume that replacement tanks are fitted with inexpensive line leak detectors which have the ability to detect a loss of product if the leak rate is three gallons/hour or greater.

Hydrosetting

We modeled bare steel tanks, which make up the majority of the tank population, in three hydrosettings: sand, sandstone, and clay. Because fiberglass tanks make up a small percentage of the tank population we modeled them in one hydrosetting: sand. The hydrosetting includes a description of the unsaturated as well as the saturated zone where the UST is located. The ground water depth distribution for facilities in a given hydrosetting is also specified.

Weighting the results

The results of all model runs are weighted by tank type, detection type, and hydrosetting. Bare steel tanks make up 89% of the total tank population and fiberglass tanks make up 11% of the population. In cases where two types of monitoring is employed for existing tanks, 50% use tightness tests and the other 50% use vapor wells. We weight the results by hydrosetting assuming that 40% of the tank population is in a sand hydrosetting, 39% of the population is in a clay hydrosetting, and 21% of the population is in a sandstone hydrosetting.

Tables C-1 through C-6 summarize the run specifications for the base case and the five options considered in the RIA.

Table C-1

OPTION:	BASE CASE EXISTING				BASE CASE REPLACEMENT			
TITLE	1A	2A	3A	4A	1B	2B	3B	4B
NUMBER OF FACILITIES	500	500	500	500	500	500	500	500
AGE DISTRIBUTION OF BARE STEEL TANKS:								
% OF TANKS THAT ARE 5 YEARS OLD OR LESS	4	4	4	50	NA	NA	NA	NA
% OF TANKS THAT ARE 10 YEARS OLD OR LESS	8	8	8	30	NA	NA	NA	NA
% OF TANKS THAT ARE 15 YEARS OLD OR LESS	28	28	28	20	NA	NA	NA	NA
% OF TANKS THAT ARE 20 YEARS OLD OR LESS	24	24	24	0	NA	NA	NA	NA
% OF TANKS THAT ARE OVER 20 YRS OLD	36	36	36	0	NA	NA	NA	NA
NUMBER OF YEARS TANK POPULATION IS MODELED	30	30	30	30	30	30	30	30
TANK TYPE: (DW,TK PI)(LINR)(BARE)(IP)(FG) [1]	BARE	BARE	BARE	FG	IP	IP	IP	IP
CAPACITY (GALLONS)	4,000	4,000	4,000	10,000	10,000	10,000	10,000	10,000
YEARLY THROUGHPUT (GALLONS)	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
MONTHLY INVENTORY LIMITS (DAILY, WEEKLY = 10%) [2]	3%	3%	3%	3%	3%	3%	3%	3%
MONTHLY INVENTORY LIMITS (IF MORE STRINGENT REQUIREMENTS)	3%	3%	3%	3%	3%	3%	3%	3%
INVENTORY CONTROL FAILURE (% OF FACILITIES)	NA	NA	NA	NA	NA	NA	NA	NA
WATER INVENTORY LIMITS (DAILY, MONTHLY) [3]	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%
1ST MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW) [4]	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
MON. FAIL. PROB.; TT-10%, VW-30%	NA	NA	NA	NA	NA	NA	NA	NA
2ND MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW) [4]	NA	NA	NA	NA	NA	NA	NA	NA
YEAR THAT MONITORING IS BEING RETROFITTED	NA	NA	NA	NA	NA	NA	NA	NA
LINE LEAD DETECTION THRESHOLD IF USED (0.05, 0.2, 3.0 GAL/HR)	NA	NA	NA	NA	NA	NA	NA	NA
YEAR TANK IS CATHODICALLY PROTECTED	NA	NA	NA	NA	NA	NA	NA	NA
YEAR OF MANDATORY RETIREMENT	NA	NA	NA	NA	NA	NA	NA	NA
HYDROSETTING IS: SANDSTONE (SS), SAND, CLAY	SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND
GW DEPTH DISTRIBUTION OF FACILITIES BY HYDROSETTING								
1 M	7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%
3.5 M	5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%
7.5 M	50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%
15 M	29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%
20 M	6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%

Footnotes:

[1] DW = Double wall tank
LINR = Tank with liner
BARE = Bare steel tank
IP = Interim Prohibition (cathodically protected tank)
FG = Fiberglass tank

[2] Daily -- a loss of product can be detected in a day if 10% of the tank capacity is lost
Weekly -- a loss of product can be detected in a week if 10% of the tank capacity is lost
Monthly -- a loss of product can be detected in a month if 3% of monthly throughput is lost

[3] Daily -- water entering an UST can be detected in a day if the amount of water in the tank is 10% of the tank capacity
Monthly -- water entering an UST can be detected in a month if the volume of water entering the tank is 3% of the monthly throughput

[4] VW-CONT = Vapor well with a continuous sensor
VW-PER = Periodic vapor well
POLL = Pollulert
PS/BA = Paste stick bailer
TT = Tightness test
GW = Ground water monitoring well

Table C-2

OPTION:		OPTION I (BASELINE) EXISTING								REPLACEMENT							
TITLE		1A	2A	3A	4A	5A	6A	7A	8A	1B	2B	3B	4B	5B	6B	7B	8B
NUMBER OF FACILITIES		500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
AGE DISTRIBUTION OF BARE STEEL TANKS:																	
% OF TANKS THAT ARE 5 YEARS OLD OR LESS		4	4	4	50	4	4	4	50	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 10 YEARS OLD OR LESS		8	8	8	30	8	8	8	30	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 15 YEARS OLD OR LESS		28	28	28	20	28	28	28	20	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 20 YEARS OLD OR LESS		24	24	24	0	24	24	24	0	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE OVER 20 YRS OLD		36	36	36	0	36	36	36	0	NA	NA	NA	NA	NA	NA	NA	NA
NUMBER OF YEARS TANK POPULATION IS MODELED		30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
TANK TYPE: (DW,TK PI)(LINR)(BARE)(IP)(FG)	[1]	BARE	BARE	BARE	FG	BARE	BARE	BARE	FG	IP	IP	IP	IP	IP	IP	IP	IP
CAPACITY (GALLONS)		4,000	4,000	4,000	10,000	4,000	4,000	4,000	10,000	4,000	4,000	4,000	10,000	4,000	4,000	4,000	10,000
YEARLY THROUGHPUT (GALLONS)		91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
MONTHLY INVENTORY LIMITS (DAILY, WEEKLY = 10%)	[2]	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
MONTHLY INVENTORY LIMITS (IF MORE STRINGENT REQUIREMENTS)		.5%	.5%	.5%	.5%	.5%	.5%	.5%	.5%	NA	NA	NA	NA	NA	NA	NA	NA
INVENTORY CONTROL FAILURE (% OF FACILITIES)		75%	75%	75%	75%	75%	75%	75%	75%	NA	NA	NA	NA	NA	NA	NA	NA
WATER INVENTORY LIMITS (DAILY, MONTHLY)	[3]	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%
1ST MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW)	[4]	3YR TT	3YR TT	3YR TT	5YR TT	QVW	QVW	QVW	QVW	5YR TT	5YR TT	5YR TT	5YR TT	QVW	QVW	QVW	QVW
MON. FAIL. PROB.; TT-10%, VW-30%		10%	10%	10%	10%	30%	30%	30%	30%	10%	10%	10%	10%	30%	30%	30%	30%
2ND MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW)	[4]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
YEAR THAT MONITORING IS BEING RETROFITTED		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LINE LEAD DETECTION THRESHOLD IF USED (0.05, 0.2, 3.0 GAL/HR)		NA	NA	NA	NA	NA	NA	NA	NA	3	3	3	3	3	3	3	3
YEAR TANK IS CATHODICALLY PROTECTED		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
YEAR OF MANDATORY RETIREMENT		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HYDROSETTING IS: SANDSTONE (SS), SAND, CLAY		SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND
GW DEPTH DISTRIBUTION OF FACILITIES BY HYDROSETTING																	
1 M		7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%
3.5 M		5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%
7.5 M		50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%
15 M		29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%
20 M		6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%

Footnotes:

[1] DW = Double wall tank
LINR = Tank with liner
BARE = Bare steel tank
IP = Interim Prohibition (cathodically protected tank)
FG = Fiberglass tank

[2] Daily -- a loss of product can be detected in a day if 10% of the tank capacity is lost
Weekly -- a loss of product can be detected in a week if 10% of the tank capacity is lost
Monthly -- a loss of product can be detected in a month if 3% of monthly throughput is lost

[3] Daily -- water entering an UST can be detected in a day if the amount of water in the tank is 10% of the tank capacity
Monthly -- water entering an UST can be detected in a month if the volume of water entering the tank is 3% of the monthly throughput

[4] VW-CONT = Vapor well with a continuous sensor
VW-PER = Periodic vapor well
POLL = Pollulert
PS/BA = Paste stick bailer
TT = Tightness test
GW = Ground water monitoring well

Table C-3

OPTION:		OPTION II (PROPOSAL)															
		EXISTING								REPLACEMENT							
TITLE		1A	2A	3A	4A	5A	6A	7A	8A	1B	2B	3B	4B	5B	6B	7B	8B
NUMBER OF FACILITIES		500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
AGE DISTRIBUTION OF BARE STEEL TANKS:																	
% OF TANKS THAT ARE 5 YEARS OLD OR LESS		4	4	4	50	4	4	4	50	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 10 YEARS OLD OR LESS		8	8	8	30	8	8	8	30	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 15 YEARS OLD OR LESS		28	28	28	20	28	28	28	20	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 20 YEARS OLD OR LESS		24	24	24	0	24	24	24	0	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE OVER 20 YRS OLD		36	36	36	0	36	36	36	0	NA	NA	NA	NA	NA	NA	NA	NA
NUMBER OF YEARS TANK POPULATION IS MODELED		30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
TANK TYPE: (DW,TK PI)(LINR)(BARE)(IP)(FG)	[1]	BARE	BARE	BARE	FG	BARE	BARE	BARE	FG	IP	IP	IP	IP	IP	IP	IP	IP
CAPACITY (GALLONS)		4,000	4,000	4,000	10,000	4,000	4,000	4,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
YEARLY THROUGHPUT (GALLONS)		91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
MONTHLY INVENTORY LIMITS (DAILY, WEEKLY = 10%)	[2]	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
MONTHLY INVENTORY LIMITS (IF MORE STRINGENT REQUIREMENTS)		0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	NA	NA	NA	NA	NA	NA	NA	NA
INVENTORY CONTROL FAILURE (% OF FACILITIES)		75%	75%	75%	75%	75%	75%	75%	75%	NA	NA	NA	NA	NA	NA	NA	NA
WATER INVENTORY LIMITS (DAILY, MONTHLY)	[3]	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%
1ST MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW)	[4]	3YR TT	3YR TT	3YR TT	5YR TT	MVW	MVW	MVW	MVW	MVW	MVW	MVW	MVW	MVW	MVW	MVW	MVW
MON. FAIL. PROB.; TT-10%, VW-30%		10%	10%	10%	10%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2ND MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW)	[4]	MVW	MVW	MVW	MVW	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
YEAR THAT MONITORING IS BEING RETROFITTED		8	8	8	8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LINE LEAD DETECTION THRESHOLD IF USED (0.05, 0.2, 3.0 GAL/HR)		NA	NA	NA	NA	NA	NA	NA	NA	3	3	3	3	3	3	3	3
YEAR TANK IS CATHODICALLY PROTECTED		8	8	8	8	8	8	8	8	NA	NA	NA	NA	NA	NA	NA	NA
YEAR OF MANDATORY RETIREMENT		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HYDROSETTING IS: SANDSTONE (SS), SAND, CLAY		SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND
GW DEPTH DISTRIBUTION OF FACILITIES BY HYDROSETTING																	
1 M		7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%
3.5 M		5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%
7.5 M		50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%
15 M		29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%
20 M		6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%

Footnotes:

[1] DW = Double wall tank
LINR = Tank with liner
BARE = Bare steel tank
IP = Interim Prohibition (cathodically protected tank)
FG = Fiberglass tank

[2] Daily -- a loss of product can be detected in a day if 10% of the tank capacity is lost
Weekly -- a loss of product can be detected in a week if 10% of the tank capacity is lost
Monthly -- a loss of product can be detected in a month if 3% of monthly throughput is lost

[3] Daily -- water entering an UST can be detected in a day if the amount of water in the tank is 10% of the tank capacity
Monthly -- water entering an UST can be detected in a month if the volume of water entering the tank is 3% of the monthly throughput

[4] VW-CONT = Vapor well with a continuous sensor
VW-PER = Periodic vapor well
POLL = Pollulert
PS/BA = Paste stick bailer
TT = Tightness test
GW = Ground water monitoring well

Table C-4

OPTION: OPTION III (SECONDARY CONTAINMENT)

EXISTING

TITLE		1A	2A	3A	4A	5A	6A	7A	8A
NUMBER OF FACILITIES		500	500	500	500	500	500	500	500
AGE DISTRIBUTION OF BARE STEEL TANKS:									
% OF TANKS THAT ARE 5 YEARS OLD OR LESS		4	4	4	50	4	4	4	50
% OF TANKS THAT ARE 10 YEARS OLD OR LESS		8	8	8	30	8	8	8	30
% OF TANKS THAT ARE 15 YEARS OLD OR LESS		28	28	28	20	28	28	28	20
% OF TANKS THAT ARE 20 YEARS OLD OR LESS		24	24	24	0	24	24	24	0
% OF TANKS THAT ARE OVER 20 YRS OLD		36	36	36	0	36	36	36	0
NUMBER OF YEARS TANK POPULATION IS MODELED		30	30	30	30	30	30	30	30
TANK TYPE: (DW,TK PI)(LINR)(BARE)(IP)(FG)	[1]	BARE	BARE	BARE	FG	BARE	BARE	BARE	FG
CAPACITY (GALLONS)		4,000	4,000	4,000	10,000	4,000	4,000	4,000	10,000
YEARLY THROUGHPUT (GALLONS)		91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
MONTHLY INVENTORY LIMITS (DAILY, WEEKLY = 10%)	[2]	3%	3%	3%	3%	3%	3%	3%	3%
MONTHLY INVENTORY LIMITS (IF MORE STRINGENT REQUIREMENTS)		.5%	.5%	.5%	.5%	.5%	.5%	.5%	.5%
INVENTORY CONTROL FAILURE (% OF FACILITIES)		75%	75%	75%	75%	75%	75%	75%	75%
WATER INVENTORY LIMITS (DAILY, MONTHLY)	[3]	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%
1ST MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW)	[4]	3YR TT	3YR TT	3YR TT	5YR TT	QVW	QVW	QVW	QVW
MON. FAIL. PROB.; TT-10%, VW-30%		10%	10%	10%	10%	30%	30%	30%	30%
2ND MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW)	[4]	NA	NA	NA	NA	NA	NA	NA	NA
YEAR THAT MONITORING IS BEING RETROFITTED		NA	NA	NA	NA	NA	NA	NA	NA
LINE LEAD DETECTION THRESHOLD IF USED (0.05, 0.2, 3.0 GAL/HR)		NA	NA	NA	NA	NA	NA	NA	NA
YEAR TANK IS CATHODICALLY PROTECTED		NA	NA	NA	NA	NA	NA	NA	NA
YEAR OF MANDATORY RETIREMENT		NA	NA	NA	NA	NA	NA	NA	NA
HYDROSETTING IS: SANDSTONE (SS), SAND, CLAY		SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND
GW DEPTH DISTRIBUTION OF FACILITIES BY HYDROSETTING									
1 M		7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%
3.5 M		5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%
7.5 M		50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%
15 M		29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%
20 M		6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%

REPLACEMENT

TITLE		1B	2B	3B	4B	5B	6B	7B	8B
NUMBER OF FACILITIES		500	500	500	500	500	500	500	500
AGE DISTRIBUTION OF BARE STEEL TANKS:									
% OF TANKS THAT ARE 5 YEARS OLD OR LESS		NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 10 YEARS OLD OR LESS		NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 15 YEARS OLD OR LESS		NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 20 YEARS OLD OR LESS		NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE OVER 20 YRS OLD		NA	NA	NA	NA	NA	NA	NA	NA
NUMBER OF YEARS TANK POPULATION IS MODELED		30	30	30	30	30	30	30	30
TANK TYPE: (DW,TK PI)(LINR)(BARE)(IP)(FG)	[1]	LINR	LINR	LINR	LINR	LINR	LINR	LINR	LINR
CAPACITY (GALLONS)		10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
YEARLY THROUGHPUT (GALLONS)		91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
MONTHLY INVENTORY LIMITS (DAILY, WEEKLY = 10%)	[2]	3%	3%	3%	3%	3%	3%	3%	3%
MONTHLY INVENTORY LIMITS (IF MORE STRINGENT REQUIREMENTS)		NA	NA	NA	NA	NA	NA	NA	NA
INVENTORY CONTROL FAILURE (% OF FACILITIES)		NA	NA	NA	NA	NA	NA	NA	NA
WATER INVENTORY LIMITS (DAILY, MONTHLY)	[3]	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%
1ST MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW)	[4]	NA	NA	NA	NA	NA	NA	NA	NA
MON. FAIL. PROB.; TT-10%, VW-30%		NA	NA	NA	NA	NA	NA	NA	NA
2ND MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW)	[4]	NA	NA	NA	NA	NA	NA	NA	NA
YEAR THAT MONITORING IS BEING RETROFITTED		NA	NA	NA	NA	NA	NA	NA	NA
LINE LEAD DETECTION THRESHOLD IF USED (0.05, 0.2, 3.0 GAL/HR)		NA	NA	NA	NA	NA	NA	NA	NA
YEAR TANK IS CATHODICALLY PROTECTED		NA	NA	NA	NA	NA	NA	NA	NA
YEAR OF MANDATORY RETIREMENT		NA	NA	NA	NA	NA	NA	NA	NA
HYDROSETTING IS: SANDSTONE (SS), SAND, CLAY		SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND
GW DEPTH DISTRIBUTION OF FACILITIES BY HYDROSETTING									
1 M		7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%
3.5 M		5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%
7.5 M		50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%
15 M		29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%
20 M		6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%

Footnotes:

[1] DW = Double wall tank
LINR = Tank with liner
BARE = Bare steel tank
IP = Interim Prohibition (cathodically protected tank)
FG = Fiberglass tank

[2] Daily -- a loss of product can be detected in a day if 10% of the tank capacity is lost
Weekly -- a loss of product can be detected in a week if 10% of the tank capacity is lost
Monthly -- a loss of product can be detected in a month if 3% of monthly throughput is lost

[3] Daily -- water entering an UST can be detected in a day if the amount of water in the tank is 10% of the tank capacity
Monthly -- water entering an UST can be detected in a month if the volume of water entering the tank is 3% of the monthly throughput

[4] VW-CONT = Vapor well with a continuous sensor
VW-PER = Periodic vapor well
POLL = Pollulert
PS/BA = Paste stick bailer
TT = Tightness test
GW = Ground water monitoring well

Table C-5

OPTION:	OPTION IV (CLASS) EXISTING				REPLACEMENT			
TITLE	1A	2A	3A	4A	1B	2B	3B	4B
NUMBER OF FACILITIES	500	500	500	500	500	500	500	500
AGE DISTRIBUTION OF BARE STEEL TANKS:								
% OF TANKS THAT ARE 5 YEARS OLD OR LESS	4	4	4	50	NA	NA	NA	NA
% OF TANKS THAT ARE 10 YEARS OLD OR LESS	8	8	8	30	NA	NA	NA	NA
% OF TANKS THAT ARE 15 YEARS OLD OR LESS	28	28	28	20	NA	NA	NA	NA
% OF TANKS THAT ARE 20 YEARS OLD OR LESS	24	24	24	0	NA	NA	NA	NA
% OF TANKS THAT ARE OVER 20 YRS OLD	36	36	36	0	NA	NA	NA	NA
NUMBER OF YEARS TANK POPULATION IS MODELED	30	30	30	30	30	30	30	30
TANK TYPE: (DW,TK PI)(LINR)(BARE)(IP)(FG) [1]	BARE	BARE	BARE	FG	LINR	LINR	LINR	LINR
CAPACITY (GALLONS)	4,000	4,000	4,000	10,000	10,000	10,000	10,000	10,000
YEARLY THROUGHPUT (GALLONS)	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
MONTHLY INVENTORY LIMITS (DAILY, WEEKLY = 10%) [2]	3%	3%	3%	3%	3%	3%	3%	3%
MONTHLY INVENTORY LIMITS (IF MORE STRINGENT REQUIREMENTS)	3%	3%	3%	3%	NA	NA	NA	NA
INVENTORY CONTROL FAILURE (% OF FACILITIES)	NA	NA	NA	NA	NA	NA	NA	NA
WATER INVENTORY LIMITS (DAILY, MONTHLY) [3]	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%
1ST MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW) [4]	CVW	CVW	CVW	CVW	NA	NA	NA	NA
MON. FAIL. PROB.; TT-10%, VW-30%	30%	30%	30%	30%	NA	NA	NA	NA
2ND MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW) [4]	NA	NA	NA	NA	NA	NA	NA	NA
YEAR THAT MONITORING IS BEING RETROFITTED	NA	NA	NA	NA	NA	NA	NA	NA
LINE LEAD DETECTION THRESHOLD IF USED (0.05, 0.2, 3.0 GAL/HR)	NA	NA	NA	NA	NA	NA	NA	NA
YEAR TANK IS CATHODICALLY PROTECTED	NA	NA	NA	NA	NA	NA	NA	NA
YEAR OF MANDATORY RETIREMENT	4	4	4	4	NA	NA	NA	NA
HYDROSETTING IS: SANDSTONE (SS), SAND, CLAY	SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND
GW DEPTH DISTRIBUTION OF FACILITIES BY HYDROSETTING								
1 M	7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%
3.5 M	5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%
7.5 M	50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%
15 M	29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%
20 M	6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%

Footnotes:

[1] DW = Double wall tank
LINR = Tank with liner
BARE = Bare steel tank
IP = Interim Prohibition (cathodically protected tank)
FG = Fiberglass tank

[2] Daily — a loss of product can be detected in a day if 10% of the tank capacity is lost
Weekly -- a loss of product can be detected in a week if 10% of the tank capacity is lost
Monthly — a loss of product can be detected in a month if 3% of monthly throughput is lost

[3] Daily -- water entering an UST can be detected in a day if the amount of water in the tank is 10% of the tank capacity
Monthly — water entering an UST can be detected in a month if the volume of water entering the tank is 3% of the monthly throughput

[4] VW-CONT = Vapor well with a continuous sensor
VW-PER = Periodic vapor well
POLL = Pollulert
PS/BA = Paste stick bailer
TT = Tightness test
GW = Ground water monitoring well

Table C-6

OPTION:	OPTION V (STRINGENT) EXISTING								REPLACEMENT							
TITLE	1A	2A	3A	4A	5A	6A	7A	8A	1B	2B	3B	4B	5B	6B	7B	8B
NUMBER OF FACILITIES	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
AGE DISTRIBUTION OF BARE STEEL TANKS:																
% OF TANKS THAT ARE 5 YEARS OLD OR LESS	4	4	4	50	4	4	4	50	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 10 YEARS OLD OR LESS	8	8	8	30	8	8	8	30	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 15 YEARS OLD OR LESS	28	28	28	20	28	28	28	20	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE 20 YEARS OLD OR LESS	24	24	24	0	24	24	24	0	NA	NA	NA	NA	NA	NA	NA	NA
% OF TANKS THAT ARE OVER 20 YRS OLD	36	36	36	0	36	36	36	0	NA	NA	NA	NA	NA	NA	NA	NA
NUMBER OF YEARS TANK POPULATION IS MODELED	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
TANK TYPE: (DW,TK PI)(LINR)(BARE)(IP)(FG) [1]	BARE	BARE	BARE	FG	BARE	BARE	BARE	FG	LINR	LINR	LINR	LINR	LINR	LINR	LINR	LINR
CAPACITY (GALLONS)	4,000	4,000	4,000	10,000	4,000	4,000	4,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
YEARLY THROUGHPUT (GALLONS)	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
MONTHLY INVENTORY LIMITS (DAILY, WEEKLY = 10%) [2]	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
MONTHLY INVENTORY LIMITS (IF MORE STRINGENT REQUIREMENTS)	.5%	.5%	.5%	.5%	.5%	.5%	.5%	.5%	3%	3%	3%	3%	3%	3%	3%	3%
INVENTORY CONTROL FAILURE (% OF FACILITIES)	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
WATER INVENTORY LIMITS (DAILY, MONTHLY) [3]	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%	10%, 3%
1ST MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW) [4]	MVW+3YR	TMVW+3YR	TMVW+3YR	TMVW+3YR	TCVW	CVW	CVW	CVW	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
MON. FAIL. PROB.; TT-10%, VW-30%	30%/10%	30%/10%	30%/10%	30%/10%	30%	30%	30%	30%	NA	NA	NA	NA	NA	NA	NA	NA
2ND MONITORING USED: (VW-CONT)(VW-PER)(POLL)(PS/BA)(TT)(GW) [4]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
YEAR THAT MONITORING IS BEING RETROFITTED	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LINE LEAD DETECTION THRESHOLD IF USED (0.05, 0.2, 3.0 GAL/HR)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
YEAR TANK IS CATHODICALLY PROTECTED	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
YEAR OF MANDATORY RETIREMENT	8	8	8	8	8	8	8	8	NA	NA	NA	NA	NA	NA	NA	NA
HYDROSETTING IS: SANDSTONE (SS), SAND, CLAY	SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND	SS	SAND	CLAY	SAND
GW DEPTH DISTRIBUTION OF FACILITIES BY HYDROSETTING																
1 M	7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%	7.9%	5.0%	0.0%	5.0%
3.5 M	5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%	5.5%	43.4%	14.3%	43.4%
7.5 M	50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%	50.1%	26.4%	46.7%	26.4%
15 M	29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%	29.6%	21.2%	26.5%	21.2%
20 M	6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%	6.8%	3.9%	12.5%	3.9%

Footnotes:

[1] DW = Double wall tank
LINR = Tank with liner
BARE = Bare steel tank
IP = Interim Prohibition (cathodically protected tank)
FG = Fiberglass tank

[2] Daily -- a loss of product can be detected in a day if 10% of the tank capacity is lost
Weekly -- a loss of product can be detected in a week if 10% of the tank capacity is lost
Monthly -- a loss of product can be detected in a month if 3% of monthly throughput is lost

[3] Daily -- water entering an UST can be detected in a day if the amount of water in the tank is 10% of the tank capacity
Monthly -- water entering an UST can be detected in a month if the volume of water entering the tank is 3% of the monthly throughput

[4] VW-CONT = Vapor well with a continuous sensor
VW-PER = Periodic vapor well
POLL = Pollulert
PS/BA = Paste stick bailer
TT = Tightness test
GW = Ground water monitoring well

APPENDIX D

ECONOMIC IMPACT ASSESSMENT METHODOLOGY

Appendix D

Economic Impact Assessment Methodology for Firms in the Retail Motor Fuel Marketing Sector

D.1 Introduction

The analysis of the economic impacts of UST technical standards on firms in the retail motor fuel marketing sector (Section 6.B) was performed using an affordability model 1/ developed by Meridian Research. The model measures the economic impact of these regulations for representative firms, using the following information: total assets, annual net income, annual revenues, and number of retail motor fuel outlets and USTs owned and operated. Economic impacts are measured in terms of:

- The effect of new UST regulatory costs on firms' rate of return on assets (i.e., net income to total assets ratio), and the effect of these costs on firms' rate of return on assets on a per-facility basis;

- The number of firms that are put into a condition of financial distress by attempting to meet new UST regulatory costs and the number of retail motor fuel outlets owned by these firms that are consequently in danger of exiting the industry;

- The number of retail motor fuel outlets that are voluntarily closed by the firms that own them because the anticipated impact of new UST regulatory costs would result in a return on assets that such firms consider to be too low;

- The number of firms that fail in attempting to meet new UST regulatory costs and the number of retail motor fuel outlets owned by these firms that consequently exit the industry.

D.2 Segmentation of Retail Motor Fuel Marketing Firms in the Affordability Model

The affordability model uses 69 firms to represent the approximately 90,000 firms that own, and the 43,000 firms that operate and lease, the 193,000 retail motor fuel outlets in the retail motor fuel marketing industry. 2/ The firms in this sector were divided into ten segments based on financial, operational, and marketing characteristics. These segments are:

1/ Meridian Research, Inc. and Versar Inc., Documentation of the Affordability Model, Draft Report, March 1987.

2/ Meridian Research, Inc. and Versar Inc., Financial Responsibility for Underground Storage Tank Releases: Financial Profile of the Retail Motor Fuel Marketing Industry Sector, Draft Report, March 1987.

refiners, large jobbers, publicly held convenience stores, large privately held convenience stores, independent chains, small jobbers, small privately held convenience stores, open dealers, lessee dealers operating more than one outlet, and lessee dealers operating one outlet. The model also reports results separately for "large" firms (defined as firms owning retail motor fuel outlets with more than $4.6 million in annual sales); "small" firms (defined as firms owning retail motor fuel outlets with less than $4.6 million in annual sales); and lessee dealers, defined as firms that operate retail motor fuel outlets. Exhibit D-1 presents the number of representative firms used by the model in each industry segment, the actual number of firms in each industry segment, and the number of retail motor fuel outlets owned or operated by the firms in each industry segment.

D.3 Regulatory Costs Used by the Affordability Model

The affordability model classifies regulatory costs as either annual costs or the costs of special events. Annual costs are those costs that are always incurred each year by the firm (e.g., leak detection costs); the probability that the firm incurs these costs is 1.0. The total annual costs paid by the firm are based on the number of USTs and outlets that the firm owns. The costs of special events are those costs that a firm would not incur on an annual basis, and they include both the costs associated with random events (e.g., the costs of performing corrective action for UST releases) and one-time costs such as the costs of tank upgrading, replacement, or tank closure. These costs are based on the number of USTs owned by the firm; the probability that any given UST incurs these costs ranges from 0 to 1.0. Because it is assumed that all USTs have the same probability of incurring these costs and that all costs for special events are statistically independent, it is possible to assume that any UST owned by any firm has the same probability of incurring these special event costs.

The costs of a special event may include:

- The cost of new capital equipment and the installation of this equipment;
- Other costs, including corrective action costs, tank upgrade/-retirement costs, and closure costs.

The model allows the user to specify up to three special events: a high-cost event, a medium-cost event and a low-cost event.

The probabilities associated with special events are assigned by the user. To perform the economic impact analysis for firms in the retail motor fuel marketing sector, the costs and probabilities assigned were the costs and probabilities developed by SCI, using the UST Model.

To determine economic impacts on affected firms, the basic economic unit of the model, it is necessary to determine the costs that a firm will incur at

Exhibit D.1
INDUSTRY SEGMENTS, NUMBER OF REPRESENTATIVE FIRMS IN THE MODEL, AND THE NUMBER OF FIRMS IN EACH INDUSTRY SEGMENT IN THE RETAIL MOTOR FUEL MARKETING SECTOR

Industry Segment	Number of Representative Firms in Model	Number of Firms in Industry Segment	Number of Outlets Owned or Operated by Firms in Industry Segment
	Firms Owning Retail Motor Fuel Marketing Outlets		
Large Firms 1/:			
• Refiners	22	27	46,779
• Large Jobbers	4	5,470	39,455
• Public C-Stores	9	9	6,113
• Large Private C-Stores	3	105	7,011
• Independent Chains	9	125	5,136
Subtotal, Large Firms	47	5,736	104,494
Small Firms 2/:			
• Small Jobbers	1	3,296	6,591
• Small Private C-Stores	1	402	1,608
• Open Dealers	8	80,304	80,304
Subtotal, Small Firms	10	84,002	88,503
Subtotal, All Owners	57	89,738	192,997
	Firms Operating Retail Motor Fuel Marketing Outlets		
Lessee Dealers:			
• Operating More Than One Outlet	9	8,625	24,150
• Operating One Outlet	3	34,506	34,506
Subtotal, Lessee Dealers	12	43,131	58,656
TOTAL	69	NA	NA

Source: Meridian Research, Inc. and Versar Inc., Financial Responsibility for Underground Storage Tank Releases: Financial Profile of the Retail Motor Fuel Marketing Industry Sector, Draft Report, March 1987.

1/ Large firms own retail motor fuel outlets and have annual sales of more than $4.6 million.

2/ Small firms own retail motor fuel outlets and have annual sales of less than $4.6 million.

NA = not applicable.

all of its facilities and their associated USTs. For annual costs, the costs for a firm are the sum of the annual costs at all of the USTs or facilities that the firm is responsible for. For special events, four cost scenarios were developed for each firm. These four cost scenarios represent four out of a large set of possible cost scenarios that the firm may face. For example, with three types of corrective action cost scenarios, a firm owning ten USTs faces 10,000 possible combinations of corrective action costs. This wide set of possibilities has been reduced to four cost scenarios, labeled high-cost, medium-cost, low-cost, and no-cost scenarios. The assumptions used in developing the costs and probabilities of incurring one of these cost scenarios are described in detail in Exhibit D-2, and are outlined below:

- High-Cost Scenario: This scenario uses the probability and expected value of costs, given that at least one high-cost event occurs at any UST owned by a firm. For a firm with only one UST, this scenario uses the costs and probability of a high-cost event. For a firm with thousands of USTs, where it is a near certainty that at least one high-cost event will occur at some tank, this scenario has a probability of 1 and costs equal to the expected value of corrective action costs at all tanks in a given year. For firms of intermediate size, the probability and costs of this scenario vary with the number of tanks.

- Medium-Cost Scenario: This scenario uses the probability and expected value of costs, given that a firm incurs at least one medium-cost event at one UST and no high-cost event at any UST. The costs include the expected value of low-cost events at USTs that do not incur medium-cost events.

- Low-Cost Scenario: This scenario uses the probability and expected value of costs, given that at least one low-cost event occurs and no high- or medium-cost event occurs at any tank owned by the firm.

- No-Cost Scenario: This scenario uses the probability that the firm incurs no special events at any UST owned by the firm. This scenario has no costs (i.e., the special event costs equal zero).

The economic impact on the firm is based on the total regulatory costs paid by the firm (i.e., annual and special event costs). For each year, the model computes the impact on the firm of the regulatory costs four times, once for each of the four cost scenarios. The annual costs are always included in the calculations, because the firm always incurs these costs. The economic impacts under each of these four cost scenarios are then weighted together according to their probability of occurrence to calculate the impact on the firm for that year.

D.4 Methods of Mitigating the Costs of Special Events

The economic impacts of UST regulatory costs may be mitigated if firms are able to obtain loans to cover some of the regulatory costs or if they have

Exhibit D.2

DERIVATION OF COST SCENARIOS FOR UST SPECIAL COST EVENTS

Cost Scenario	Probability Assumption	Cost of High-Cost Events to the Firm	Cost of Medium-Cost Events to the Firm	Cost of Low-Cost Events to the Firm
High Cost	At least one high-cost event occurs at an UST owned by the firm	Expected value of high-cost events at all tanks owned by the firm, given that at least one high-cost event occurs for at least one tank owned by the firm	Expected value of medium-cost events at all tanks owned by the firm that do not incur a high-cost event	Expected value of low-cost events at all tanks owned by the firm that do not incur a high- or medium-cost event
Medium Cost	At least one medium-cost event occurs at an UST owned by the firm, and no high-cost event occurs at any UST owned by the firm	No Costs	Expected value of medium-cost events at all tanks owned by the firm, given that at least one medium-cost event occurs for at least one tank owned by the firm	Expected value of low-cost events at all tanks owned by the firm that do not incur a medium-cost event
Low Cost	At least one low-cost event occurs at an UST owned by the firm and no medium- or high-cost event occurs at any UST owned by the firm	No Costs	No Costs	Expected value of low-cost events, given that at least one low-cost event occurs for at least one tank owned by the firm
No Cost	No special event occurs at any tank owned by the firm	No Costs	No Costs	No Costs

Source: Meridian Research, Inc. 1987.

insurance to cover the corrective action cleanup costs. The model treats these possibilities in the following manner.

D.4.1 Loans

A firm may obtain a loan to cover the costs of special events such as tank capital and installation costs, corrective action costs, or tank upgrade/ retirement costs. The model computes the economic impacts of the regulatory costs under each cost scenario twice: once assuming that the firm receives a loan, and once assuming that the firm does not receive a loan. The results of these two computations are then weighted according to the probability that the firm will receive a loan. The probability that a firm will receive a loan is assigned on the basis a set of financial criteria. Exhibit D-3 presents the financial criteria used to determine the probability that a firm will receive a loan. Small firms may have difficulty obtaining loans even if they meet these loan criteria, because banks often assess the value of personal as well as business assets in deciding whether to grant a loan to small firms.

D.4.2 Insurance

The model allows a user to specify the percentage of firms in any industry segment that have pollution liability insurance. Insurance is assumed to cover all of the costs of corrective action cleanup and third-party liability awards above the deductible amount and up to the required aggregate amount of coverage. (The size of the deductibles and aggregate amounts of coverage are user options.)

D.5 Structure of the Affordability Model

The affordability model estimates the economic impacts of new UST regulations by calculating the effect of paying regulatory costs on representative firms' return on assets (net income to total assets ratios). The revised return on assets figure is then paired with the probability of failure that is associated with a return on assets of this level. These failure probabilities were derived from financial data from a sample of bankrupt and non-bankrupt firms. Exhibit D-4 shows ranges of net income to total assets ratios and their associated failure rates for firms with high and low levels of total assets.

The model computes a firm's revised net income to total assets ratio (i.e., the new net income to total assets ratio that a firm will have after it has incurred the estimated regulatory costs) three times:

- Once to calculate the failure rate when it is assumed that the firm will not receive a loan;
- Once to calculate the failure rate when it is assumed that the firm will receive a loan;

Exhibit D.3
FINANCIAL CRITERIA USED BY THE MODEL TO DETERMINE
THE PROBABILITY THAT A FIRM WILL RECEIVE A LOAN

Financial Criteria	Probability
Loan to Total Assets Ratio is Greater Than 0.5; or	
Firm's Net Income to Total Assets Ratio After Receiving a Loan Is Less Than 0.00	0.0
Loan to Total Assets Ratio Is Less Than 0.5 and Greater Than 0.1; or	
Firm's Net Income to Total Assets Ratio After Receiving a Loan Is Greater Than 0.00 and Less Than 0.06	0.5
Loan to Total Assets Ratio Is Less Than 0.1; and	
Firm's Net Income to Total Assets Ratio After Receiving a Loan Is Greater Than 0.06	1.0

Source: Meridian Research, Inc. and Versar Inc., Documentation of the Affordability Model, Draft Report, March 1987.

Exhibit D.4
PROBABILITY THAT A FIRM HAVING A NET INCOME
TO TOTAL ASSETS RATIO IN A GIVEN RANGE WILL FAIL

	Probability That a Firm Will Fail	
Firm's Net Income to Total Assets Ratio	For Firms with Total Assets of $20 Million or Less	For Firms with Total Assets of Greater Than $20 Million
Greater Than 0.040	0.0001	0.00003
0.039 to 0.000	0.0027	0.0008
-0.001 to -0.040	0.0107	0.0034
-0.041 to -0.300	0.0704	0.0265
-0.301 or less	1.0	1.0

Source: Meridian Research, Inc. and Versar Inc., Documentation of the Affordability Model, Draft Report, March 1987.

- Once to calculate the exit rate for outlets that are voluntarily closed by the firms that own them.

The equations used to compute failure rates for the loan and no-loan calculations are the same, except that the costs of a loan and of making loan payments are included in the loan calculations. The equations used to calculate the voluntary exit rate differ slightly from those used to calculate the failure rate, because the voluntary exit rate is based on a long-run rate of return on assets.

The logical structure of the affordability model is outlined in Exhibit D-5. The steps the model follows are:

- Calculate the firm's baseline before-tax income. At the beginning of each year, the model estimates the firm's baseline before-tax income, given its after-tax net income.

- The model then branches off along two tracks, one to calculate the failure rate (loan and no-loan calculations) and one to calculate the voluntary outlet exit rate.

- Calculate the firm's taxable income. Taxable income is computed by subtracting the firm's tax-deductible expenses from its baseline before-tax income. Tax-deductible expenses include:

  - All compliance costs (e.g., leak detection and tank upgrade/retirement costs and the cost of a financial responsibility instrument, etc.);

  - All corrective action and tank installation costs and third-party liability awards;

  - The depreciation on capital expenditures;

  - The interest costs of the loan.

- Calculate the firm's after-tax net income. This step comprises three sub-steps:

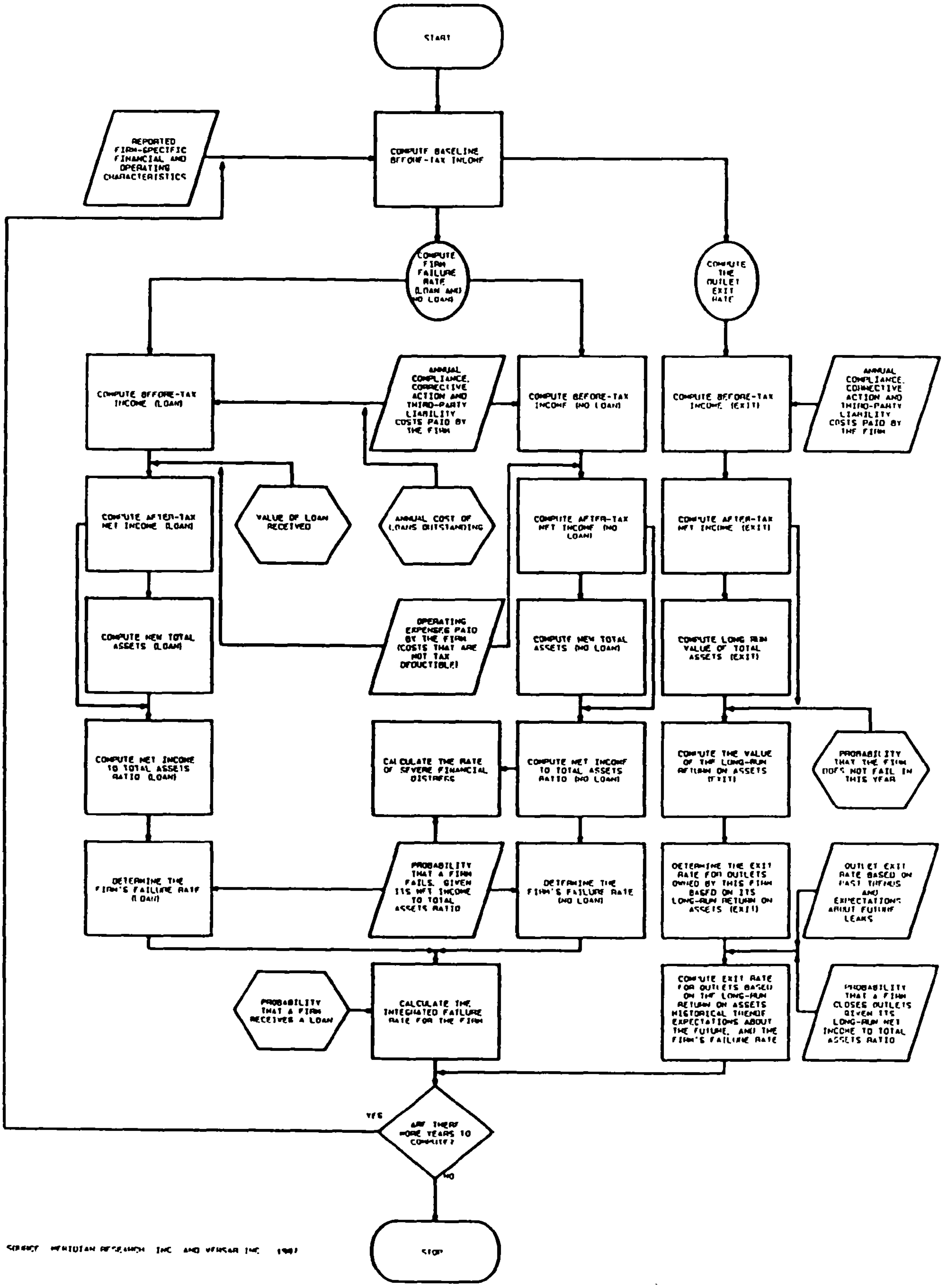
  - Calculate the firm's tax liability based on its taxable income;

  - Subtract the firm's tax liability from its before-tax income;

  - If the firm is assumed to receive a loan, the value of the loan is added to the after-tax income for the year in which the loan is received, and the loan payments are deducted from the firm's income for the life of the loan.

Exhibit D.5

THE AFFORDABILITY MODEL: LOGICAL STRUCTURE AND PROCESSES



SOURCE: MERIDIAN RESEARCH, INC. AND VERSAR INC., 1987

- Adjust the firm's total assets. If the firm's after-tax net income is negative, then the firm sells off its assets to cover its operating loss.

- Compute the firm's net income to total assets ratio (when computing the failure rate), or the long-run return on assets (when computing the voluntary exit rate). The long-run return on assets is the net income to total assets ratio after a firm incurs special costs.

- Determine whether the firm is in severe financial distress. A firm is considered to be in severe financial distress if its net income to total assets ratio, without a loan, is between -0.04 and -0.3.

- Determine a firm's failure rate or an outlet exit rate.

  - The failure of a firm is a discrete probability that is dependent on the firm's net income to total assets ratio and the size of the firm.

  - The outlet exit rate is a discrete probability function that is based on the same empirical evidence used to create the failure rate probabilities. The number of outlets that are projected to exit is based on a firm's rate of return on assets per outlet. This is then adjusted to take into account the following factors:

- The long-run decline in the number of retail motor fuel outlets in operation;

- The number of outlets that would exit the industry as a result of tank replacement costs, even in the absence of further UST regulation.

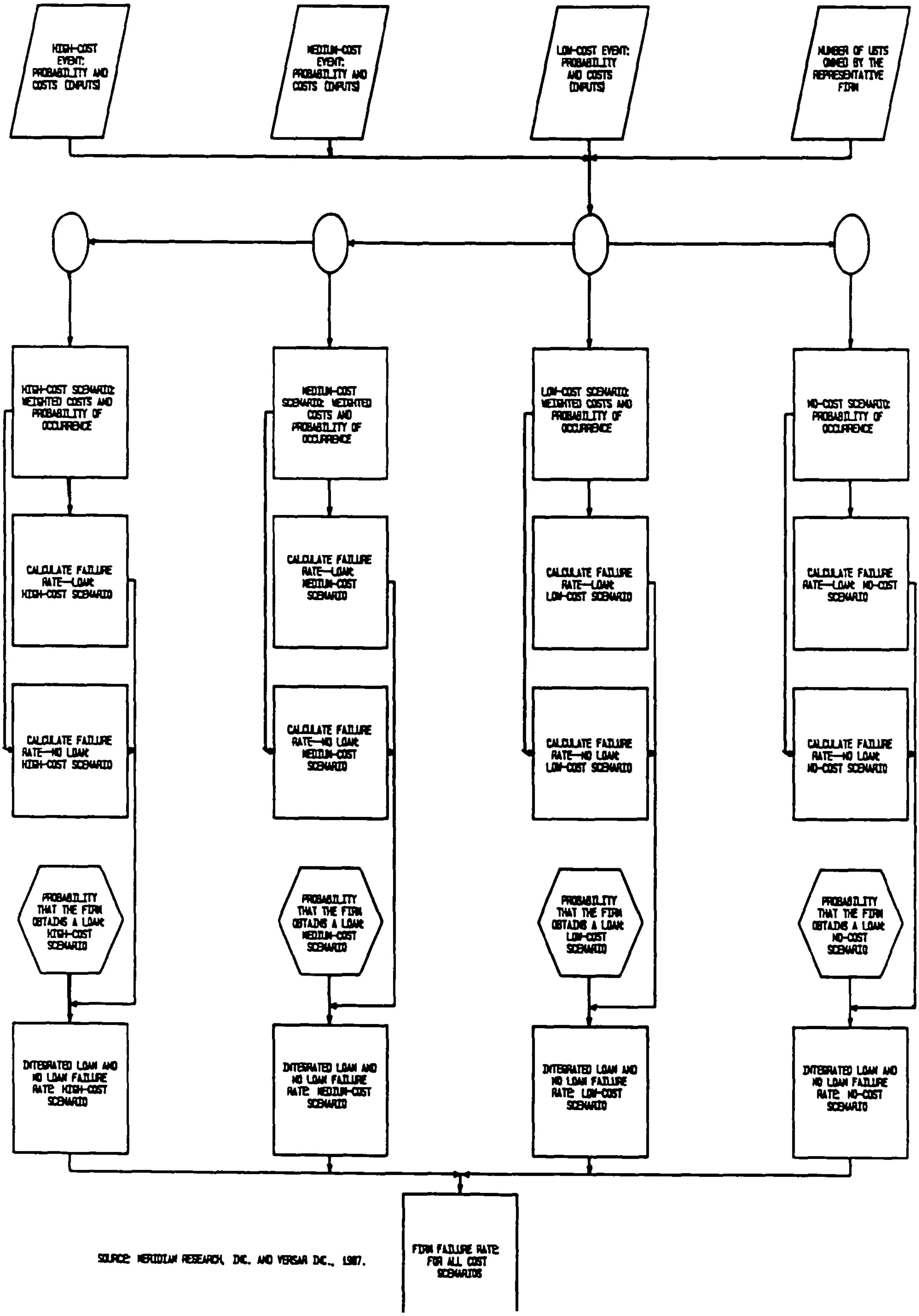
- Integrate the failure rates from the loan and no-loan calculations by weighting these two results according to the probability that the firm will receive a loan.

The model calculates economic impacts for 15 years; if more years need to be considered, the model performs the series of calculations outlined above for each subsequent year.

To accommodate the multiple cost scenarios and the availability of loans, the model goes through these calculations several times when estimating a failure rate for firms. Exhibit D-6 shows how the model reduces failure rates for each cost scenario (with and without a loan) to a single estimated failure rate for all cost scenarios.

Exhibit D.6

STRUCTURE OF THE AFFORDABILITY MODEL:
CALCULATION OF THE FIRM FAILURE RATE UNDER THE FOUR SPECIAL EVENT COST SCENARIOS, CONSIDERING THE FIRM'S ABILITY TO OBTAIN A LOAN



SOURCE: MERIDIAN RESEARCH, INC. AND VERSAR INC., 1987.

APPENDIX E

REGULATORY FLEXIBILITY ANALYSIS

Appendix E

Regulatory Flexibility Analysis

E.1. Introduction

E.1.A. The Purpose of a Regulatory Flexibility Analysis

The Regulatory Flexibility Act (P.L. 96-354) requires that regulatory agencies carefully consider the potential effects of regulation on small entities. The agency is required to prepare a Regulatory Flexibility Analysis if the proposed regulation will

> have any significant economic effect on a substantial number of individuals, small businesses, small organizations or small governmental jurisdictions. 1/

A Regulatory Flexibility Analysis is

> an analysis of the proposed rule describing whether the rule will have a significant economic impact on individuals, small businesses, small organizations, and small governmental jurisdictions, including a description of reasonable alternatives to the proposed rule which accomplish the stated objectives of the proposed rule in a manner consistent with the goals and objectives of applicable statutes and which minimize the burdensome effect of the proposed rule on such individuals, businesses, organizations and governmental jurisdictions, including alternatives consistent with the goals and objectives of applicable statutes such as--
>
> (A) The establishment of differing compliance or reporting requirements that take into account the amount of resources available to individuals, businesses, organizations and governmental jurisdictions;
>
> (B) An exemption from coverage of the proposed rule, or any part thereof, for such individuals, businesses, organizations, and government jurisdictions;
>
> (C) The clarification, consolidation, or simplification of compliance and reporting requirements under the proposed rule for such individuals, businesses, organizations, and governmental jurisdictions; or
>
> (D) The use of performance rather than design standards or any other reasonable means to reduce, in a manner consistent with the goals and objectives of applicable statutes, the burdensome effect of the rule on such individuals, businesses, organizations, and governmental jurisdictions. 2/

1/ Regulatory Flexibility Act, Public Law 96-354, Sec. 603.

2/ Ibid., Sec. 604.

E.1.B. The Purpose of This Report

This report is designed to address the basic issues of a Regulatory Flexibility Analysis, which are set forth in the Regulatory Flexibility Act and elaborated on in EPA Guidelines. 1/ These issues include the following:

- The rationale, objectives, and legal basis for the proposed rule;
- Identification of regulatory alternatives that might minimize the impact on small entities;
- The demographics of the small entities to which the rule applies;
- Compliance costs of the rule and applicable alternatives;
- Impacts of the rule on small entities--both absolutely and relative to the impacts on large entities; and
- Issues related to other rules, including overlapping regulations and exemptions or allowances granted to the affected small entities under other regulations.

E.1.C. Sources of Information and Data

This Regulatory Flexibility Analysis (RFA) is based on the Regulatory Impact Analysis (RIA) for Technical Standards for Underground Storage Tanks. 2/ The information, data, and models used were developed in the RIA and are documented there; the data and results from the RIA that are used in this report have been summarized and structured in a manner that focuses on RFA issues. Greater detail and more thorough development of these results are found in the RIA itself.

E.2. Basis for the Proposed Regulatory Action

E.2.A. Rationale for the Proposed Rule

There are an estimated 1.4 million underground tanks in use in the United States for the storage of petroleum products and chemicals. 3/ Most of these underground tanks are made of bare steel and are without protection to prevent corrosion. Moreover, most bare steel tanks are quite old, with an estimated median age in excess of 15 years. 4/ Although any tank can leak,

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1/ EPA, Guidelines for Implementing the Regulatory Flexibility Act, Feb. 9, 1982.

2/ SCI, Inc., Regulatory Impact Analysis for Technical Standards for Underground Storage Tanks, March 1987.

3/ Data Resources, Inc., Compliance Cost Calculations for EPA Regulation of Underground Storage Tanks, Preliminary Draft Report, 1985.

4/ RIA, Sec. 1.A.

older bare steel tanks are especially vulnerable. Thus a large number of these bare steel tanks is found to be leaking each year, and a larger number is thought to have leaks that have not yet been detected.

There is mounting evidence that leaks from underground storage tanks represent a significant hazard to human health and the environment. Although some costs (such as the loss of the product stored in the tanks) are borne by the owner of a leaking tank, most of the harm is inflicted on society at large. Such hazards include health risks to workers in the vicinity of a leaking tank, risks of fire and explosion, health risks from contamination of drinking water supplies, and potential agricultural losses caused by the contamination of soil or irrigation water. Corrective action--which can include removing contaminated soil, removing a floating plume, or removing a dispersed plume--is expensive. Thus, from society's point of view, it is typically more cost-effective to prevent a leak than to clean one up. The proposed regulation incorporates both approaches--corrective action for existing leaks and prevention of future tank failures.

E.2.B. Objectives and Legal Basis for the Proposed Rule

The proposed rule is intended to minimize the damage to environmental resources, especially to ground-water supplies, of leaking underground storage tanks. Under the Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act (RCRA), enacted on November 8, 1984, EPA was charged with establishing a regulatory program for underground tanks storing petroleum products and hazardous substances other than Subtitle C hazardous wastes. Under Section 9003 of Subtitle I of RCRA, the Administrator of EPA is required to promulgate regulations for release detection, prevention, and correction. The regulations promulgated pursuant to Section 9003 must include, but need not be limited to, requirements for:

- Maintaining a leak detection system, an inventory control system together with tank testing, or comparable systems or methods of identifying releases;
- Maintaining records of monitoring, leak detection, inventory control, tank testing, or comparable systems;
- Reporting of releases and corrective action taken in response to releases; and
- Closure of tanks.

For approval of a State program under Section 9004 of Subtitle I, the State program must include regulations or standards for all of these types of requirements. These regulations or standards must be "no less stringent" than the requirements promulgated under Section 9003 and the State must provide for adequate enforcement of compliance with these requirements and standards.

The proposed rule contains requirements for: construction of new tanks, systems for leak detection, retirement or upgrading of existing tanks, reporting of releases, corrective action, tank closure, and recordkeeping.

The costs of requirements for reporting of releases and for maintaining records have not been included in the main body of the RIA or in this RFA.

E.3. Identification of Regulatory Alternatives

E.3.A. Components of a Regulatory Strategy

A regulation consists of a number of major components, each of which may be associated with several regulatory requirements. In addition, when developing a regulation, various regulatory choices must be made--whether to emphasize new tanks versus existing tanks, for example, or whether to stress prevention of leaks versus remedial action. The regulatory components of the UST technical standards that have major cost implications are identified in this section. (For reasons discussed more fully in Section 4.A, this review--like the RIA and the RFA as a whole--focuses on the regulation of petroleum USTs.) A more complete discussion of the effectiveness and costs of these components is found in Section 4 of the RIA.

E.3.A.1. Construction of New Tanks

The most important issues in the construction of new tanks are protection against corrosion and provision for containment of releases from the system. One dimension of choice is materials. In increasing order of capital cost, the major materials options are:

- Bare steel;
- Coated and cathodically protected steel; and
- Non-corroding fiberglass.

When repair and replacement costs are considered, cathodically protected steel tanks are clearly the most cost-effective choice for new tanks. 1/

A second dimension of choice for new tanks is the use of impermeable liners or the addition of a second wall for the tanks and/or pipes. Such a secondary containment system--especially when used with interstitial monitoring--greatly improves the ability to contain and detect leaks. This option, however, is substantially more expensive than use of a single-walled tank.

E.3.A.2. Systems for Leak Detection

Numerous systems have been developed to allow detection of leaks or releases from underground tank systems. A partial listing, discussed further in the RIA, 2/ includes:

- Tank and pipe tightness tests;
- Line leak detectors;

1/ RIA, Sec. 4.3.

2/ RIA, Sec. 4.

- Vapor wells;
- Floating liquid sensors or liquid observation wells;
- Manually operated inventory monitoring programs;
- Automatic inventory control; and
- Interstitial space monitoring.

These systems vary in sensitivity to slow leaks, extent of leak detected, accuracy, cost, skill requirements for operation, and other aspects. Tightness tests can only be done occasionally, and vapor well monitoring may be periodic or continuous, while other types of monitoring are continually in place. Where monitoring is periodic, it is more effective--and more expensive--the more frequently it is done. Leak detection systems are generally more expensive to install for existing tanks than for new tanks. Interstitial space monitoring, of course, is appropriate only for secondary containment systems, and thus is not appropriate for existing tanks.

E.3.A.3. Retirement or Upgrading of Existing Tanks

Since the major environmental threat is posed by existing tanks, which are predominantly old and made of bare steel, a potentially important component of UST regulation is the retirement of existing tanks. Tank retirement would allow old tanks to be replaced by new tank systems that have a substantially lower potential to leak. However, requiring the retirement of tanks would be costly.

Upgrading existing tanks is an alternative to tank retirement. Several methods of upgrading can be used, including:

- Retrofitting of cathodic protection;
- Interior coating; and
- Lining or partial lining of tanks and pipes.

The costs of upgrading are less than 20 percent of the costs of purchasing and installing a new corrosion-resistant tank, and the degree of leak reduction achievable by means of upgrading appears to approach that of a new tank.

E.3.A.4. Corrective Action

In general, there are four types of corrective action. These are:

- Removal of any fumes or free product from the surface;
- Removal of contaminated soil;
- Removal of a floating plume;
- Removal of a dispersed plume.

Removal of free product is necessary to mitigate fire and explosion hazards and must be done whenever discovered. The appropriateness of any of the other types of corrective action depends on the specific circumstances involved. Removal of a floating plume or a dispersed plume, of course, is not relevant if the leak has not penetrated to the water table. Removal of contaminated soil may not be necessary (or may be only a minor task) if a leak is discovered early enough so that only a negligible amount of motor fuel has leaked. In general, the type of corrective action that is appropriate depends on the circumstances of the individual leaking tank. EPA has determined, however, that a floating plume should be removed whenever one is found.

E.3.A.5. Closure and Replacement of a Tank After Failure

When a tank has failed, it is necessary to prevent further leakage. If the business requires a tank to continue in operation, the tank must be replaced. (Even if operations cease, the tank must be closed.) In some cases it is possible to repair the tank. The proposed rule, however, requires that any tank to be repaired must be structurally sound, have no other repairs, and be repaired and relined in a manner that will prevent future releases.

E.3.A.6. Alternative Cases

As a reference case, the RIA assumes that no UST regulations other than the interim prohibition requirements are in place; that is, the RIA assumes that 89 percent of existing tanks are bare steel and the remaining 11 percent are fiberglass and are without supplementary leak detection systems. New tanks must be coated or cathodically protected, and tanks found to be leaking are replaced with coated or cathodically protected tanks. The RIA examined five alternative regulatory options, which are summarized below and in Exhibit E.1.

<u>Option I</u>. In addition to the interim prohibition requirements, this option includes the following requirements:

- All new tanks are coated and cathodically protected, with line leak detectors.
- Periodic leak detection tests are performed; these are:
  - Quarterly vapor well monitoring, or
  - Tank tightness tests every three years (for existing tanks) and every five years (for new tanks).
- Existing tanks are replaced when leaking.
- Corrective action includes the removal of floating plumes in all cases and site-by-site assessment, which is assumed in the RIA to result in the removal of the dispersed plume in 40 percent of all cases of ground-water contamination.

<u>Option II</u>. In addition to the interim prohibition requirements, this option includes the following requirements:

Exhibit E.1

COMPARISON OF THE TECHNICAL STANDARDS FOR USTs UNDER THE REGULATORY OPTIONS

Regulatory Option	Standard for New USTs 1/	Leak Detection/Monitoring Systems: Standard for Existing USTs	Leak Detection/Monitoring Systems: Standard for New or Upgraded USTs	Standard for Corrective Action Cleanup 2/	Phase-in Period
Option I	Coated and cathodically protected	Quarterly vapor wells; or tank tightness tests every 3 years	Line leak detectors; and either quarterly vapor well, or tank tightness tests every 5 years	Site-by-site assessment; removal of dispersed plume in 40 percent of the cases	Replace tanks when leaking
Option II	Same as Option I	Monthly vapor wells, or tank tightness tests every 3 years	Same as Option I	Same as Option I	Existing tanks are upgraded/ replaced within 10 years
Option III	Coated and cathodically protected with secondary containment system	Same as Option I	Interstitial monitoring using a continuous sump monitoring system	Same as Option I	Same as Option I
Option IV:					
Well-head protection areas 3/	Same as Option III	Continuous vapor well monitoring	Same as Option III	Site-by-site assessment; removal of dispersed plume in 100 percent of the cases	Existing tanks are replaced within 5 years
Non-well-head protection areas	Same as Option I	Same as Option I	Same as Option I	Site-by-site assessment; removal of dispersed plume not required	Same as Option I
Option V	Same as Option III	Continuous vapor well monitoring, or monthly vapor well monitoring and tightness tests every 3 years	Same as Option III	Same as Option I	Same as Option II

Source: RIA, Section 5.B

1/ It is assumed that all existing USTs are constructed of bare steel.

2/ It is assumed that the floating plume is removed in 100 percent of all cases when there is ground-water contamination. The percent of cases in which it is assumed that the dispersed plume is removed when there is ground-water contamination depends on the regulatory option.

3/ It is assumed that 40 percent of the tanks are in State-designated well-head protection areas.

- All new tanks are coated and cathodically protected, with line leak detectors.

- Periodic leak detection tests are performed; these are:

  - Monthly vapor well monitoring, or

  - Tank tightness tests every three years (for bare steel tanks) or every five years (for upgraded or new tanks).

- Existing tanks are upgraded to new tank standards within 10 years.

- Corrective action includes removal of floating plumes in all cases and site-by-site assessment, which is assumed in the RIA to result in the removal of the dispersed plume in 40 percent of all cases of ground-water contamination.

Option III. In addition to the interim prohibition requirements, this option includes the following requirements:

- All new tanks are coated and cathodically protected and have secondary containment systems, with continuous sump monitors.

- New tanks have interstitial continuous sump monitors. Existing tanks have periodic leak detection tests, which are assumed to be:

  - Quarterly vapor well monitoring, or

  - Tank tightness tests every three years (for bare steel tanks).

- Existing tanks are replaced when leaking.

- Corrective action includes the removal of floating plumes in all cases and site-by-site assessment, which is assumed in the RIA to result in the removal of the dispersed plume in 40 percent of all cases of ground-water contamination.

Option IV. In addition to the interim prohibition requirements, this option includes the following requirements:

Tanks in State-designated well-head protection areas (assumed to be 40 percent of tanks)

- All new tanks are coated and cathodically protected and have secondary containment systems, with continuous sump monitors.

- New tanks at well-head protection areas have interstitial continuous sump monitors. Existing tanks have periodic leak detection tests, which are assumed to consist of continuous vapor well monitoring.

- Existing tanks are retired and replaced within five years.

- Corrective action includes the removal of floating plumes in all cases and site-by-site assessment, which is assumed in the RIA to result in the removal of the dispersed plume in 100 percent of all cases of ground-water contamination.

Tanks not in State-designated well-head protection areas:

- All new tanks are coated and cathodically protected, with line leak detectors.

- Periodic leak detection test are performed; they are:

  - Quarterly vapor well monitoring, or

  - Tank tightness test every three years (for existing tanks) and every five years (for new tanks).

- Existing tanks are replaced when leaking.

- Corrective action includes the removal of the floating plume in all cases and site-by-site assessment, which is assumed by the RIA to result in the removal of the dispersed plume in none of the cases of ground-water contamination.

Option V. In addition to the interim prohibition requirements, this option includes the following requirements:

- All new tanks are coated and cathodically protected and have secondary containment systems, with continuous sump monitors.

- Intensive leak detection (for existing tanks), assumed in the RIA to be either:

  - Continuous vapor well monitoring, or

  - Monthly vapor well monitoring and three-year tightness tests.

- Existing bare steel tanks are retired and replaced with new tanks within 10 years.

- Corrective action includes the removal of floating plumes in all cases and site-by-site assessment, which is assumed in the RIA to result in the removal of the dispersed plume in 40 percent of all cases of ground-water contamination.

E.3.C. Potential Elements of Flexibility in the Proposed Rule

The alternatives outlined in Section E.3.A and the regulatory options incorporating them are summarized in Exhibit E.2. This exhibit presents the components of the proposed rule (which is Option II), the principal alternatives, and their respective options.

Exhibit E.2
REGULATORY ALTERNATIVES TO THE PROPOSED RULE

Regulatory Component	Proposed Rule (Option II)	Alternatives Considered	Considered in Option
Construction of New Tanks	Coated and cathodically protected with line leak detectors	Secondary containment systems, coated and cathodically protected tanks, with line leak detectors	III, V
		Secondary containment systems (as above) if in well-head protection area	IV
Leak Detection:			
Existing Tanks	Frequent -- Monthly vapor wells or tank tightness test every 3 years	Intensive -- Continuous vapor well monitoring, or monthly vapor well monitoring and tightness tests every 3 years	V
		Continuous vapor well monitoring if in well-head protection area	IV
New Tanks	Line leak detectors, and either quarterly vapor well monitoring or tank tightness tests every 5 years	Interstitial monitoring using a continuous sump monitoring system	III, IV (if in well-head protection area), V
Retirement and Replacement or Upgrade of Existing Bare Steel Tanks	Replace if leaking	Replace if leaking	All
	Upgrade to new tank standards (coated and cathodically protected) within 10 years	No upgrade or retirement because of age alone	I, III
		Replace and require secondary containment system within 5 years if in well-head protection area	IV
		Replace and require secondary containment system within 10 years	V
Corrective Action	Remove floating plume; site-by-site assessment of other requirements	Remove floating plume; site-by-site assessment of other requirements	All
		Remove dispersed plume in all reported cases	IV(a)

Source: RIA, Section 5.B.

Replacement or Upgrade. The proposed rule allows upgrading of existing tanks to a coated and cathodically protected status within 10 years of promulgation. Alternatives considered in the RIA included deleting any tank age requirements, mandatory retirement within a few years for tanks in well-head protection areas, and a universal tank retirement requirement. The tank upgrade requirements of the proposed rule are substantially less costly than any type of replacement requirement would have been. For example, retirement options considered involved replacing the tank with a new tank having a secondary containment system, which is more expensive than replacement with a simple coated and cathodically protected tank. Although the regulatory alternative of adopting no upgrade or retirement requirement has the lowest initial cost, analysis suggests that this choice would result in a substantially higher number of leaks and corrective action costs in the long run than the upgrade requirements in the proposed rule.

All of the options considered, and the proposed rule, require replacement, if necessary, of a leaking tank. When it is possible to repair a leaking tank, the proposal permits this less costly approach. However, the feasibility and effectiveness of repairs must be considered on a case-by-case basis.

New Tanks. The proposed rule allows new tanks to be coated and cathodically protected to protect against corrosion, which is less costly than requiring that tanks be constructed of fiberglass. This protection requirement is initially more expensive than permitting bare steel tanks, but the RIA indicates that such protection is more cost effective and has a lower long-run impact on small businesses. The proposed rule is more cost effective and has a lower long-run impact both in terms of the costs of tank repair and replacement and the costs of corrective action clean-up. The principal alternative to the proposed protection requirement would be the use of secondary containment systems; Options III and V, and, in limited circumstances, Option IV included a containment component. The proposed rule thus incorporates the least expensive option for the new tank construction component of the regulation.

Leak Detection. The proposed rule requires frequent detection, but it allows a wide variety of detection methods. The principal alternative analyzed in the RIA would require more intensive--and thus costly--continuous detection. Where secondary containment systems are required, interstitial monitoring using a continuous sump monitor is also required. Analysis has shown that better leak detection may be cost effective in the long run because it will reduce the number of corrective actions; however, the proposal permits owners and operators to use the least expensive approach to leak detection of any of the options considered.

Corrective Action. The proposed corrective action requirements cannot be precisely defined because of the site-by-site nature of the assessment needed to determine specific requirements. Like the proposed rule, however, all options included a requirement that any floating plume be removed. The RIA assumes that removal of a dispersed plume will be necessary in 40 percent of releases involving ground-water contamination. The selection of a site-by-site risk assessment for cleanup is more cost-effective than a national cleanup standard with a variance provision.

Overview. For almost all of the important components of the regulation, the proposed rule adopts the least costly of the options considered in the regulatory analysis. In instances where the initial costs of a proposed component are higher than the costs of an alternative, the alternative would be less cost effective in the long term if corrective action costs were also taken into consideration.

E.4. Demographic Analysis of Small Firms

E.4.A. Definition of Small Firm

For this Regulatory Flexibility Analysis, small businesses in the retail motor fuel marketing sector are defined as firms with less than $4.6 million in annual sales. 1/ This is the definition used by the Small Business Administration (SBA) to identify small businesses in this sector, and this annual sales figure has also been shown in EPA's preliminary analysis to reflect an appropriate size cutoff for small firms in this sector. This definition includes all firms in the retail motor fuel marketing sector with two or fewer outlets. Firms with $4.6 million in sales will typically have approximately $500,000 in assets and $250,000 in net worth. A substantial number of these small firms have fewer than 10 employees and less than $100,000 in net worth. The SBA sales-based definition of small business includes those firms most vulnerable to significant economic impacts and those firms least likely to have insurance to cover their corrective action expenditures. This definition also includes all firms with a net worth that is less than the costs of replacing three tanks or the cost of performing a corrective action that involves ground-water cleanup.

There are two major classes of firms in the small-business segment of this sector: those that own and operate their own outlets and those that operate outlets that they lease. Firms in this latter class are termed "lessee" or "independent" dealers. In the group of firms in this sector owning their own outlets are many "open" dealers, defined as firms owning and operating a single retail motor fuel outlet.

This definition of small business is based on retail motor fuel outlets. USTs also are found in two other types of uses: the storage of motor fuels for non-retail purposes and the storage of hazardous substances.

A preliminary analysis of the category of businesses owning non-retail petroleum USTs (i.e., those used to store petroleum products that are not retailed as motor fuel), revealed that such USTs are used for a variety of purposes by a large and diverse group of businesses. The most common uses of non-retail petroleum-containing USTs are to store motor fuel at facilities where fleets of vehicles or several off-the-road vehicles are located. For example, the owner of a fleet of busses or a farmer with many gasoline-powered off-the-road vehicles would be likely to have an UST at his or her facility. Owners and operators of non-retail petroleum USTs are found in all sectors of American business, including farming, timber operations, mining, manufacturing, transportation, and wholesale and retail trade; and these owners and operators own and operate firms of all sizes. Similarly, owners and operators

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1/ Federal Register, Vol. 49, No.28, p. 5032, February 9, 1984.

of USTs containing hazardous substances are also widely distributed throughout the economy.

Because firms owning non-retail petroleum and hazardous substance USTs fall into hundreds of Standard Industrial Classifications (SICs) and range in size and type from one-person nonprofit organizations to small governmental jurisdictions to major corporations, and because no data are currently available to identify these firms and entities, EPA is placing the primary emphasis of this Regulatory Flexibility Analysis on the retail motor fuel marketing sector. The use of the retail motor fuel sector as the focal point for this Regulatory Flexibility Analysis is consistent with the RIA, which also concentrates on the economic impacts of the proposed rule on firms in the retail motor fuel sector. There are several reasons for this focus:

- It is appropriate to focus on firms in the retail motor fuel sector because they have the greatest potential for economic dislocation, since:

  - There are no substitutes for the use of USTs in this sector;

  - UST costs represent a significant fraction of capital and operating costs for outlets owned by these firms; and

  - There are generally at least three USTs per retail outlet in this sector.

- The retail motor fuel sector is overwhelmingly dominated by small businesses, so that impacts on small businesses and the potential for mitigating these impacts through regulatory alternatives are probably greater in this sector than in any other sector in which USTs are found.

- Data on which to base the analysis are available for this sector in sufficient quantity and of high enough quality to ensure reasonable accuracy of analysis and that the analysis will capture most of the severe small-business impacts likely to result from promulgation of the proposed rule. In other sectors, it is often not possible to identify which firms (and thus which or how many small firms) have USTs, or how many USTs they have.

For these reasons, EPA believes that the issues that must be addressed in a Regulatory Flexibility Analysis can be best addressed by focusing the analysis on small retail motor fuel marketing outlets.

EPA has used a variety of data sources to develop estimates of the number of small businesses engaged in retail motor fuel marketing and to describe the economic and financial characteristics of this sector and these firms. The American Petroleum Institute, the National Association of Convenience Stores, the Petroleum Marketers Association of America, the Society of Independent Gasoline Marketers of America, and the Service Station Dealers of America have assisted EPA by providing data and by suggesting possible data sources. EPA also used data on the small businesses in this sector compiled by the Small Business Administration and the Department of Energy and data made available in many private-sector publications (particularly The Lundberg Letter and National Petroleum News).

E.4.B. Size Distribution, Characteristics, and Competitors of Affected Small Firms

Firms in the retail motor fuel marketing sector can be disaggregated in two dimensions: principal business of the firm, and ownership/operator status. 1/ The types of owners of retail motor fuel outlets, by principal business, include:

- Refiners, which include the "major" and "semi-major" oil companies. Major refiners -- the largest firms in the sector -- are vertically integrated oil companies owning refineries that produce petroleum products distributed through thousands of their wholesale and retail "branded" outlets;
- Jobbers, which are primarily wholesalers of petroleum products who may also own retail motor fuel outlets or convenience store outlets;
- Convenience stores, which are chains of retail stores (that for our purposes exclude jobbers) with outlets that sell motor fuels;
- Independent chain marketers, which are owners of chains of retail motor fuel marketing outlets that often sell "unbranded" or private brand petroleum products (and that for our purposes exclude jobbers and convenience stores); and
- Open dealers, which are single-outlet dealers who both own and operate their gasoline marketing operations.

Operators of retail motor fuel outlets are divided into two classes:

- Owners, which are firms of any type that both own and operate their retail outlets; and
- Lessee dealers (also called "independent" dealers), which operate retail outlets under lease arrangements, generally with refiners, jobbers, or independent chains.

Data for 1984 indicate that the retail motor fuel marketing industry was composed of an estimated 193,000 retail motor fuel outlets. The structure of ownership and operation is summarized in Exhibit E.3, which shows that of all outlets:

- 45,840 (23.7 percent) are owned and operated by large firms;
- 88,503 (45.9 percent) are owned and operated by small firms; and

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1/ Meridian Research, Inc. and Versar, Inc., Financial Responsibility for Underground Storage Tank Releases: Financial Profile of the Retail Motor Fuel Marketing Industry Sector, Draft Report, March 1987.

Exhibit E.3
LARGE- AND SMALL-BUSINESS OWNERSHIP AND OPERATION OF RETAIL MOTOR FUEL OUTLETS

Operator Size and Segment	Number of Firms	Number of Retail Outlets Owned and Operated	Number of Retail Outlets Leased and Operated
Large Businesses			
Refiners	27	9,964	-
Large Jobbers	5,470	18,742	-
Large Convenience Stores	114	13,124	-
Independent Chains	125	4,010	-
Total Large Businesses	5,736	45,840	-
Small Businesses			
Owner Operators			
Small Jobbers	3,296	6,591	-
Small Convenience Stores	402	1,608	-
Open Dealers	80,304	80,304	-
Total Small Owners	84,002	88,503	-
Lessee Operators			
Leased From			
Refiners	N.A.	-	36,817
Jobbers	N.A.	-	20,713
Independent Chains	N.A.	-	1,127
Total Lessee Operators	43,131	-	58,657
TOTAL	132,842	134,343	58,657

Source: Meridian Research, Inc. and Versar Inc., Financial Responsibility for Underground Storage Tank Releases: Financial Profile of the Retail Motor Fuel Marketing Industry Sector, Draft Report, January 1987.

N.A. = Not Applicable.

- 58,657 (30.4 percent) are owned by large firms but operated by small firms under lease arrangements.

Of the estimated 89,738 firms owning retail motor fuel outlets:

- 5,736 (6.4 percent) are large firms; and

- 84,002 (93.6 percent) are small firms.

Firms owning retail motor fuel outlets range in size from some of the largest corporations in the world to small businesses with no reported payroll, and the number of outlets owned by one firm ranges from one to several thousand. The retail motor fuel sector, however, is made up predominantly of small firms. Over three-quarters of all retail motor fuel outlets are operated by small firms, and nearly 15 out of every 16 firms owning retail motor fuel outlets are small firms.

Open dealers were estimated to operate just over 80,300 retail motor fuel outlets (41.6 percent of all outlets). Open dealers vary widely in terms of firm size and age of outlet. Some have new outlets and over $500,000 in assets, while others have 30-year-old tanks and $42,000 in assets. EPA estimates that the typical (i.e., median) open dealer has $90,000 in net worth, $210,000 in assets, and $14,000 in annual after-tax profits. Such a typical open dealer firm is thus a business earning a reasonable profit (a 6.7 percent rate of return on assets) and having a reasonable expectation of continuing in business.

Small business owners in the retail motor fuel sector include owners of small chains of retail outlets. It is common for owners of small chains to own 2 or 3 retail outlets and also to act as wholesale suppliers for several open dealers. (This business pattern is particularly common in rural areas.) It is also common for a firm in this sector to own a chain of several convenience stores, for which gasoline sales are not generally the primary line of business (and some of whose outlets may not sell gasoline at all). EPA estimates that there were approximately 3,700 such small business chains owning and operating approximately 8,200 retail motor fuel outlets (4.2 percent of all outlets).

Approximately 58,650 motor fuel outlets (30.4 percent) are estimated to be owned by large firms and operated under lease arrangements by independent dealers. Large, vertically integrated petroleum firms constitute an estimated 62.8 percent of these owners; jobbers constitute an estimated 35.3 percent; and other independent chains make up 1.9 percent. The chains owned by nonrefinery firms may consist of as many as 100 retail motor fuel outlets. Outlets operated by lessee dealers range in characteristics from some of the most modern and efficient outlets in the country to some of the most financially marginal operations in the retail motor fuel sector. EPA estimates that the typical (i.e., median) single-outlet lessee dealer has $62,000 in net worth, $82,000 in assets, and $6,000 in annual after-tax profits. Such a typical lessee dealer firm is thus a very small firm, but one which is nevertheless earning a reasonable profit (a 7.3 percent rate of return on assets) and has a reasonable expectation of continuing in business.

Although the typical open dealer and lessee dealer are sound businesses, there are marginal firms in both categories. A marginal firm is defined as one that is making very low profits or that has an aging outlet and cannot afford to invest any substantial amount of money into this outlet. In time, outlets age and become more marginal, and EPA estimates that existing outlets have tended to exit the industry at a rate of about 4.1 percent per year. This outlet exit rate is based on the number of outlets that exited the industry in 1984 (the base year of this analysis) and on the expected number of outlets that would exit in the future, even in the absence of further UST regulation, as a result of baseline tank replacement. 1/ Because many of the outlets that close are replaced by new businesses that are small, this 4.1 percent exit rate does not necessarily mean that the small business share of the retail motor fuel marketing sector is significantly declining.

E.5. Analysis of Compliance Costs

This chapter summarizes the costs of compliance associated with the proposed rule and the regulatory alternatives considered. Costs are first summarized by cost element and then described in the form of several scenarios.

E.5.A. Cost Components

E.5.A.1. Costs of New Tanks

Proposed rule. Under the proposed rule, all new tanks (whether installed at a new retail motor fuel outlet or installed at an existing outlet as a replacement for a bare steel tank) must be coated and cathodically protected single-walled tank systems with improved line leak detectors. The estimated cost of such a system is $20,000 per tank--$6,000 in capital cost for the tank itself and $14,000 for installation. 2/

Alternatives Considered. The principal alternative--incorporated in Options III, V, and, in limited circumstances, IV--is a secondary containment system consisting of a protected single-walled tank with a liner. The estimated cost of such a system is $23,000--$6,000 in capital cost for the tank itself and $17,000 for installation. 3/

E.5.A.2. Costs of Upgrading or Replacing Non-Leaking Tanks

Proposed rule. The proposed rule allows the upgrading of existing bare steel tanks to new tank standards (coating and cathodic protection). The estimated cost of upgrading is $3,050. 4/ The upgrading must be carried out within 10 years, but the RIA assumes that two tanks at the same outlet will not be upgraded in the same year.

1/ Meridian Research, Inc. and Versar, Inc., Documentation of the Affordability Model, Draft Report, March 1987.

2/ Based on engineering estimates.

3/ Based on engineering estimates.

4/ RIA, Sec. 4.C.

Alternatives Considered. Of the several alternatives considered by EPA, the least expensive in terms of initial outlays is the alternative of requiring tank replacement when leaking. This alternative was included in Options I and III; however, this alternative led in the long term to estimated corrective action costs that were substantially higher than those of other options--enough higher to increase the overall costs of the regulation. 1/ The other principal alternative would have required that existing tanks be retired and replaced with new tanks. (New tanks would require a secondary containment system.) The costs of replacing one tank under such a requirement would be $35,500--$12,500 2/ for closure of the existing tank and $23,000 for the purchase and installation of a new tank. The costs of retiring and replacing a three-tank system with a secondary containment system would be $86,500. Option IV would have required the replacement of old tanks within well-head protection areas within 5 years, while Option V contemplated the replacement of all old tanks within 10 years.

E.5.A.3. Costs of Monitoring and Leak Detection

Proposed rule. The proposed rule allows owners and operators to use any of several methods of monitoring and leak detection; 3/ the RIA assumes that one of two types of monitoring and leak detection will be used:

- Tank tightness testing (done every three years for old tanks and every five years for upgraded tanks) at a cost of an estimated $500 per tank; or

- Vapor well monitoring, which has an estimated capital cost of $1,500 per facility for the vapor wells; the monthly monitoring required thereafter has an estimated cost of $75 per test, or an annual cost of $900 per facility.

For pipes, the RIA assumes that line leak detectors, at an estimated capital cost of $1,050 per facility, will be used. In addition to routine monitoring costs, the cost of leak verification (required if a leak is suspected) is estimated to be $4,000.

Alternatives considered. The principal monitoring alternative involves continuous monitoring, including (in the case of a secondary containment system) interstitial monitoring. For existing tanks, this would require continuous monitoring, i.e., a continuous vapor well at an estimated capital cost of $6,220 per facility (and operating costs that are estimated to be negligible). Continuous monitoring of a new (or replacement) tank with a liner could be done with a continuous sump monitor, which has an estimated cost of $750 per tank.

1/ RIA, Sec. 5.C.

2/ Based on engineering cost estimates.

3/ RIA, Sec. 4.B.

The cost savings in the proposed rule are only realized when the cost of the leak detection system is considered in tandem with the cost of the tank system. For example, although the cost of a continuous sump is less than that of a line leak detector, it is not possible to install a continuous sump on a tank that is not lined.

E.5.A.4. Costs of Replacement of Leaking Tanks

Proposed rule. Replacement of a leaking tank is estimated to have the same costs as purchasing and installing a new tank. The costs of closure that would be associated with removing the old tank are assumed in the RIA to be included in the costs of corrective action. The estimated cost of replacing a tank with a coated and cathodically protected system is $20,000. It is estimated that tanks must be replaced in 60 percent of occurrences of each kind of release. In the remaining 40 percent of cases, it is estimated that the tank can be repaired at a cost of $6,500. 1/

Alternatives considered. As in the proposed requirements, replacement of a leaking tank is estimated to cost the same as a new tank, and the costs of tank closure are assumed to be incorporated into the costs of corrective action. The principal alternative considered, however, involved replacement of a leaking tank with a tank and a secondary containment tank system, the estimated cost of which is $23,000.

E.5.A.5. Costs of Corrective Action

The costs of corrective action were estimated in the RIA on a probabilistic basis, which involves consideration of several levels of severity of non-plume release and several levels of severity of plume release. For example, the costs of corrective action for a non-plume release 2/ are estimated to have an expected value of:

$$\$19,100 = (0.2 \times \$2,700) + (0.8 \times \$23,200)$$

The costs of corrective action for a small plume release 3/ (i.e., one with an area of less than 25 square meters) are estimated to have an expected value of $33,200 if only the floating plume is cleaned up and $59,200 if the dispersed plume must also be cleaned up. The costs of corrective action for a large plume release 4/ are estimated to have an expected value of:

$$\$123,700 = (0.6 \times \$56,200) + (0.1 \times \$131,200) + (0.1 \times \$206,200) + (0.2 \times \$281,200)$$

1/ Based on engineering estimates.

2/ Based on data provided by Roy F. Weston, Inc., in a memo to the Emergency Response Division of EPA, Nov. 17, 1986.

3/ Based on data provided by SCI, Inc., using UST Model estimates.

4/ Based on data provided by Roy F. Weston, Inc., in a memo to the Emergency Response Division of EPA, Nov. 17, 1986.

The overall costs of corrective action for the first five years under the proposed rule are based on the following baseline estimates of release rates: 1/

- 3.3 percent of existing tanks per year will experience non-plume releases. Non-plume releases account for 28 percent of all releases.

- 2.2 percent of existing tanks per year will experience small plume releases requiring clean-up of the floating plume only. Such small plume releases account for 19 percent of all releases.

- 3.3 percent of existing tanks per year will experience small plume releases requiring clean-up of both floating and dispersed plumes. Such small plume releases account for 28 percent of all releases.

- 3.0 percent of existing tanks per year will experience large plume releases. Large plume releases account for 25 percent of all releases.

Although the relative proportions of different types of releases varied among the regulatory options considered by EPA, the corrective action costs associated with a given type of release were essentially the same under all of the options.

E.5.A.6. Summary

The compliance costs of different actions or events are summarized in Exhibit E.4 for the proposed rule and for the major alternatives considered (which are essentially incorporated in Option V). Exhibit E.4 identifies several areas of substantial actual or potential cost differences between the proposed rule and its principal regulatory alternatives.

- The proposed requirement to upgrade existing tanks is approximately $30,000 less expensive per tank than the costs of any alternative that requires mandatory retirement of a non-leaking UST.

- Monitoring and leak detection under the proposed rule are less costly than the interstitial monitoring that would have been required by some options. These cost savings are only realized when the cost of the tank system and its accompanying monitoring system are added together.

- Replacement of leaking tanks under the proposed rule is $3,000 (13 percent) less expensive than the alternatives considered under other options.

- Corrective action is sufficiently expensive--and sufficiently more expensive for plume releases than for non-plume releases--to justify requiring leak prevention and early leak detection to reduce the overall impact of UST regulation.

1/ SCI, Inc., using UST Model estimates.

Exhibit E.4
COSTS OF INDIVIDUAL COMPLIANCE ACTIONS

Action/Event	Proposed Rule	Alternative
Monitoring (Existing Tanks)	$1,050 initial and either $1,500 initial plus $900 annual or $500 per tank every 3 years (5 after upgrading)	$6,220 initial cost
Monitoring (New Tanks)	$2,550 initial plus $900 annual	$750 initial cost[1/]
Tank Upgrade or Closure and Replacement	$3,050 per tank	$35,500 per tank
Leak Verification	$4,000	$4,000
Replacement of Leaking Tank	$20,000	$23,000
Expected Value of Corrective Action		
Non-Plume Release	$19,100	$19,100
Small Plume Release -- Floating Plume Only	$33,200	$33,200
-- Both Floating and Dispersed Plume	$59,200	$59,200
Large Plume Release	$123,700	$123,700

Source: Meridian Research, Inc. and Versar Inc., based on cost estimates using the UST Model and engineering estimates.

1/ This alternative can only be used if tanks have a secondary containment system. Such tanks have a unit cost $3,000 higher than the cost of some new tanks that may be installed under the proposed rule.

E.5.B. Selected Cost Scenarios

E.5.B.1. Monitoring with No Release

Proposed rule. In the absence of a leak, the proposed rule involves two types of expenses for existing tanks:

- Monitoring costs of $500 per tank ($1,500 for a 3-tank facility) every 3 years, or $1,500 in initial costs and $500 per facility per year thereafter. In addition, installation of line leak detectors entails an initial cost of $1,050.

- Upgrading tanks at $3,050 per tank. For a 3-tank facility, this cost is assumed by the RIA to be incurred three times within 10 years.

Alternatives considered. Under the alternatives considered, monitoring costs would have been equal to those of the proposed rule; however, tank replacement costs under the alternatives were substantially greater than under the proposal. However, under the mandatory tank replacement requirements specified in some options, every existing tank would have had to be replaced with a tank and secondary containment system, at a total cost per tank of $36,250, which includes:

- $12,500 in tank closure costs;

- $6,000 for the new tank itself;

- $17,000 for installation; and

- $750 for installation of sump monitoring equipment.

Thereafter, under the replacement requirements of some of the options considered, cost savings would accrue as a result of the monitoring; depending on the monitoring system in use, this savings could have been substantial.

E.5.B.2. Minimal Release

The smallest estimated release is assumed by the RIA to impose the following costs in addition to the costs of routine monitoring and tank upgrading or retirement:

- $4,000 for leak verification;

- $2,700 for corrective action; and

- $6,500 for tank repair.

This estimated cost of $13,200 is assumed to be imposed at the time the leak is discovered; the same costs would have been incurred under the regulatory alternatives.

E.5.B.3. Average Non-Plume Release

Proposed rule. In the event of an average non-plume release, a retail motor fuel outlet is assumed to incur the following costs:

- $4,000 for leak verification;
- $19,100 for corrective action; and
- $20,000 for tank replacement (or $6,500 for tank repair).

This estimated $43,100 in costs (or $29,600 if the tank is repaired only) is assumed to be incurred at the time the leak is discovered. If the leaking tank is bare steel, a firm would save the $3,050 associated with upgrading the tank.

Alternatives considered. Under any option that required that new tanks have secondary containment systems, the costs of an average non-plume release would have been:

- $4,000 for leak verification;
- $19,100 for corrective action;
- $23,000 for tank replacement; and
- $750 for installation of sump monitoring equipment.

This estimated $46,850 in costs would have been incurred at the time the leak was discovered. If the leaking tank was bare steel, the firm would have saved the $36,250 in costs associated with retirement of the old tank.

E.5.B.4. Average Small Plume Release

Proposed rule. In the event of an average small plume release (i.e., one covering an area of less than 25 square meters), a retail motor fuel outlet is assumed to incur the following costs:

- $4,000 for leak verification;
- Corrective action costs of:
  - $33,200 for a floating plume only, or
  - $59,200 for a floating and dispersed plume;
- $20,000 for tank replacement (or $6,500 for tank repair).

This entire estimated cost of $57,200--or $83,200--(or $43,700 and $69,700, respectively, if the tank is repaired) is assumed to be incurred at the time the leak is discovered. If the leaking tank is bare steel, of course, the firm would save the $3,050 in upgrading costs.

Alternatives considered. Under any option that required that new tanks have secondary containment systems, the costs of an average small-plume release will be:

- $4,000 for leak verification;
- Corrective action costs of:
  - $33,200 for a floating plume only, or
  - $59,200 for a floating and dispersed plume;
- $23,000 for tank replacement; and
- $750 for installation of sump monitoring equipment.

This estimated cost of $60,950--or $86,950--would have been incurred at the time the leak was discovered. If the leaking tank was bare steel, the firm would have saved the $36,250 in costs associated with retirement of an old tank.

E.5.B.5. Average Large Plume Release

Proposed rule. In the event of an average large plume release (i.e., one covering an area greater than 25 square meters), a retail motor fuel outlet is assumed by the RIA to incur the following costs:

- $4,000 for leak verification;
- $123,700 for corrective action; and
- $20,000 for tank replacement (or $6,500 for tank repair).

This estimated $147,700 in costs (or $134,200, if the tank is repaired) is assumed to be incurred at the time the leak is discovered. If the leaking tank is bare steel, the firm would save the $3,050 in costs associated with upgrading the tank.

Alternatives considered. Under an option requiring that new tanks have secondary containment systems, the costs of an average large plume release would have been:

- $4,000 for leak verification;
- $123,700 for corrective action;
- $23,000 for tank replacement; and
- $750 for installation of sump monitoring equipment.

This estimated $151,450 in costs would have been incurred at the time the leak was discovered. If the leaking tank was bare steel, the firm would have saved the $36,250 in costs associated with the retirement of the old tank.

E.6. Analysis of Competitive Effects

E.6.A. Characteristics Affecting the Degree of Impact

E.6.A.1. Monitoring, Tank Replacement, and Tank Failure

Compliance costs can be grouped into those associated with three types of events:

- Routine monitoring and tank upgrading, which will occur in any event;
- Retirement and replacement of a tank; and
- Tank failure, including tank replacement and corrective action associated with a release.

These three types of circumstances have very different cost impacts on the firms that own USTs.

Routine no-failure monitoring and upgrading. The costs of monitoring and leak detection under the proposed rule depend on the approach adopted by the owner or operator of the UST in question. The proposed rule allows--as an interim measure for the first decade after promulgation--existing tanks to be monitored by tightness tests performed every three years (after upgrading, this interval increases to five years). This is estimated to cost $1,500 per test for a three-tank outlet. At a 6.9 percent discount rate (the estimated real cost of borrowing used in the Impact Analysis in the RIA) 1/ --and assuming that tests are done in the third, sixth, and ninth years--the present value cost of these tests is $3,055. For monthly vapor well monitoring, which the proposed rule allows for new as well as existing tanks, the initial cost is estimated to be $1,500, and the subsequent estimated annual costs are $900. At a 6.9 percent discount rate, the present value of costs over a 10-year horizon is $7,850, and over a 20-year horizon it is $11,110. Under the regulatory alternative requiring continuous monitoring, the initial cost (and present value cost) for a continuous vapor well is $6,220. Sump monitoring equipment is estimated to cost only $2,260 (initial cost) for a three-tank outlet, but this cost would be associated with the construction of a new outlet or the replacement of an existing tank; it would not be likely to occur separately. Finally, line leak detectors are estimated to cost $1,050 per outlet, an initial cost that would be incurred regardless of the method of tank monitoring used.

The proposed rule's requirement to upgrade existing tanks has associated costs estimated to be $3,050 per tank. It is also possible to spread this cost out over time by upgrading tanks in different years. Thus, 10-year monitoring and upgrading of 3 tanks under the proposed rule have a combined present value cost of approximately $11,000 to $15,000 (depending both on the method of tank monitoring used and on when the tanks are upgraded). This cost is only a fraction of the cost of one new tank.

1/ Meridian Research, Inc. and Versar, Inc., Documentation of the Affordability Model, Draft Report, March 1987.

Tank replacement. A mandatory tank replacement program is almost an order of magnitude more expensive than the proposed requirement for ongoing monitoring and tank upgrading. Even if the new tank standard consisted only of a requirement for coating and cathodic protection, the costs of closure and replacement would be $32,500 per tank, or $78,500 for a 3-tank facility. If the new tank standard required a double containment system, closure and replacement costs would be $35,500 per tank--or a total of about $86,500 for a 3-tank facility. Although the impact of these costs in any year--as well as their present value--could be somewhat reduced by phasing, these costs are substantial for an individual outlet.

Tank failure. Tank failure can impose even higher costs on a firm, although just how much higher depends on the basis used for comparison. The expected value of corrective action is $19,100 for a non-plume release and $123,700 for a plume release. Leak verification costs are estimated to be $4,000. In addition the tank would have to be replaced, although separate closure costs would not be incurred in this event. These costs would be $20,000 for a simple cathodically protected tank or $23,000 for a secondary containment system. As opposed to the $11,000 to $15,000 in costs that would be incurred if no release occurs, a non-plume release would have a net impact of $43,100 under a requirement for single-walled cathodically protected tanks and $46,100 under a secondary-containment tank requirement, and a large plume release would have a net impact of $147,000 under a requirement for single-walled cathodically protected tanks and $150,700 under a secondary-containment requirement. Compared to a regulation that included a requirement for the mandatory retirement of old tanks--and thus that saved the cost of tank closure--the net impact of an average non-plume release would be $10,600 more per tank than the proposed tank retirement costs (although $48,400 less than the cost of replacing all three tanks). In addition, the net impact of an average large plume release would be $115,200 more per tank than the costs of a requirement for the mandatory retirement of one single-walled tank (and $38,200 more than mandatory retirement of all three tanks). Thus, although the costs of an average non-plume release would add relatively little to the costs of tank retirement, such a requirement would have impacts three to four times those that would be incurred if there was no release. An average large plume release would have additional cost impacts that would substantially exceed the impact of the proposed tank retirement requirement, and these impacts would be roughly 10 times as great as the impacts of the proposed monitoring and upgrading requirements.

E.6.A.2. Age of Facility and UST

The age of a facility with USTs may be related to both the condition and type of USTs located there. In general, the older a bare steel tank is, the more likely it is to leak within a given number of years. Thus firms with older facilities may be--and firms owning older USTs will be--more likely to suffer the high-cost impacts associated with releases the older their tanks are. Conversely, most fiberglass tanks, cathodically protected tanks, and double containment systems are found in new facilities, and in facilities owned by firms with tank upgrading programs. Protected tanks have approximately one-sixth the probability of leaking over a 30-year period that bare steel tanks do. Thus new facilities and new USTs have a probability of incurring corrective action costs that is 80-85 percent lower than that of old facilities with bare steel tanks. 1/ In the absence of further regulation, new facilities are also more likely to have monitoring systems that will detect a release relatively early. Firms with new facilities and USTs are therefore likely to have relatively low-cost releases. This situation is accentuated when a facility that is being constructed is compared with an old facility that has bare steel tanks. When a tank at an old facility is replaced, tank closure costs (estimated to be $12,500 per tank) are incurred; when a new facility is constructed, these costs are not incurred. Closure costs are sufficiently high that it would be cheaper, for example, to install a coated, cathodically protected tank with a secondary containment system at a facility under construction than it would be to replace an old tank with a new bare steel tank at an existing facility. Further, facilities that are being constructed today tend to have leak detection systems installed at the time of construction. The costs of these measures thus add little to the total cost of constructing a new facility. However, in such a case the new facility would have made a net capital investment in additional tanks, while the old facility would have no net investment and thus a newly constructed facility can meet tank construction standards (and enjoy related savings in terms of the expected value of corrective action costs) essentially without impact because it would have installed the tanks anyway. A firm that is building a new facility to enter the retail motor fuel market will have correspondingly lower compliance costs than an old facility with old tanks. Thus, although one of the effects of this regulation may be to force existing outlets owned by small businesses to exit, it may also provide an opportunity for new outlets to enter the industry.

E.6.A.3. Firm Size

A firm's compliance costs and cost impacts are principally related to the number of tanks owned or operated by the firm. Except for the costs of vapor well monitoring and line leak detectors (the costs of which are relatively constant per outlet), all costs are either associated with a number of tanks or the number and severity of releases, which are expected to be related to the number of tanks (or to a given type of tank). Inherent economies of scale in terms of compliance activity per tank or per outlet are minimal. The RIA estimates, for example, that the cost of installing one new secondary containment system is $23,000, whereas the cost of installing three such tanks simultaneously is $68,000.

However, economies of scale can be realized if all three USTs are replaced at one time rather than individually; closure costs when one tank is replaced are $12,500, but are only $18,500 if three tanks are replaced simultaneously. This economy of scale may give large firms an advantage, because they are better able to finance the costs of replacing all three tanks simultaneously. Small firms, which will have to spread costs of tank replacement out by replacing one tank at a time, will thus pay $19,000 more than if they replaced all tanks at once.

1/ RIA, Sec. 4.B.

The number of tanks at retail motor fuel outlets does not vary much with the size of the facility. At a minimum, a very small outlet in a rural area may have only two tanks--storing leaded regular and unleaded regular gasoline, for example. A very large outlet may have four USTs, to store leaded regular, unleaded regular, unleaded premium, and diesel (or, in some cases, kerosene). Nevertheless, one outlet that has 20 times (or more) the level of sales of a second outlet is likely to have at most twice as many USTs. There are thus substantial economies of scale in regulatory costs per gallon of motor fuel sold per outlet. However, the volume of sales per outlet is not related to the size of the firm owning or operating the outlet; both small and large firms own high-volume outlets.

Compliance costs are relatively constant per retail motor fuel outlet and do not vary greatly with respect to the size of the outlet (i.e., number of tanks or sales volume). Thus, there are few economies of scale to be realized as the number of outlets owned per firm increases; in fact, the compliance costs incurred per firm will generally be proportional to the number of outlets owned.

Firm size may be coincidentally related to the magnitude of compliance costs in one of two senses. First, large firms may be adding new outlets, whereas small firms (other than those entering the market for the first time) may have older outlets. For such new outlets (as noted above), the impacts of the regulation will be relatively small. Second, some large firms (especially refining firms) already have in place a program of upgrading retail outlets and replacing old tanks. The costs of such an existing program cannot be attributed to the proposed regulation.

Although firm size itself has little relation to regulatory costs per outlet, larger firms tend to be more able to survive the impacts of regulatory costs than small firms. As discussed in detail in Section E.6.C.2, firms owning multiple outlets can pool regulatory costs among outlets. This results in lower overall regulatory costs per outlet for large firms than for one-outlet firms that experience a serious release. Further, large firms will normally have better access to credit, making it easier for large firms to pay for tank upgrading or the costs of corrective action.

E.6.B Effects on Profitability

E.6.B.1. Classes of Small Businesses

As noted in Section E.4., there are at least three distinct types of small businesses in the retail motor fuel sector: open dealers, who make up 56.3 percent of small firms in this sector; small chains, which constitute 2.6 percent of small firms; and lessee dealers, who make up 41.1 percent of small firms. Of these groups, open dealers are relatively straightforward to analyze, since they tend to own and operate only one outlet and motor fuel retailing is their principal business.

The analysis of profitability was conducted assuming that small firms will not be able to obtain insurance or to receive support from State UST funds designed to assist small firms to meet the costs of corrective action. Such State assistance might include loans, loan guarantees, insurance, or other programs designed to smooth the regulatory burden over time or over a larger affected population. The assumption that neither the insurance industry nor State funds will be available to assist small firms in meeting their corrective action costs reflects the situation confronted by most small firms today. EPA hopes to encourage both the insurance industry and the States to provide UST coverage for small firms in the future. If such coverage becomes available at a reasonable cost, the adverse impacts on small businesses predicted by this Regulatory Flexibility Analysis could be significantly overestimated.

Small jobbers and small convenience stores are involved in other lines of business. Moreover, most of these firms operate more than one outlet that retails motor fuel. Because of this combination of characteristics, it is not possible to obtain financial data on individual outlets; however, the major economic impacts on typical firms in these segments can be analyzed by examining all outlets simultaneously.

Lessee dealers present unique problems for analysis. The dealers themselves are small businesses, and at least three-quarters of them operate only one outlet. However, the firms from whom they lease their outlets-- refiners (62.8 percent), jobbers (35.3 percent), and independent chains (1.9 percent)--are virtually all large businesses. This relationship is difficult to analyze because it is not generally clear whether the owner or the lessee will bear the burden of regulatory costs. Currently, the most common lease arrangement makes the lessee dealer responsible for "sounding the alarm" (i.e., for operating whatever leak detection and inventory control systems have been agreed on by the owner and lessee) but not for maintaining or replacing tanks or paying for corrective action. However, some lessors are attempting to alter these arrangements to increase the responsibilities of lessees by, for example, holding the lessee responsible for releases or requiring the lessee to buy the tanks. 1/ Even if the owner initially pays the costs, it is entirely possible--and certainly in the owner's interest--to pass costs through to the lessee in the form of rent increases. A further practical consideration is that financial data on the individual outlets of any owner are not available, while financial data for single-outlet lessee dealers are available. It is therefore not generally feasible to look directly at the impacts of regulatory costs on the owner on an outlet-specific basis--even if he bears all of these costs. The Agency will therefore examine the impact of regulatory costs on leased outlets in terms of profitability of independent lessee dealers. There are two possible methods of rationalizing this approach. The first is to assume that lessee outlets are roughly as profitable to the owners as they are to the operators--i.e., to let impacts on the operator be a proxy for impacts on the owner. The second is to assume that the owner will find a way to pass through the most important costs to the lessee regardless of the legal responsibilities set forth in the lease. The Agency believes that this approach will provide a reasonable approximation of major impacts, such as those associated with the closing of an outlet.

1/ Notes of meeting with the Service Station Dealers of America, 1986.

E.6.B.2. Analysis of Impacts on the Median Dealers

Economic impacts were analyzed in detail for two typical retail motor fuel dealers, the median open dealer and the median single-outlet lessee dealer. Each of these representative firms has median levels of net income, total assets, and net worth for its class of firm. For the median open dealer, net assets are $210,000, net annual income is $14,000, and net worth is $90,000. For the median lessee dealer, net assets are $82,000, net annual income is $6,000, and net worth is $62,000. The financial impacts incurred in a single year as a result of the costs of different compliance activities related to different events are summarized for these two median firms in Exhibit E.5. To measure these impacts on individual firms, compliance costs are adjusted for the portion of these costs that will be borne by the government in the form of investment tax credits on new tanks and in the form of reduced corporate profits tax payments.

Routine monitoring. Testing three tanks has an after-tax cost of $1,275. This reduces the rate of return of both types of median firms to approximately 6 percent, which is still a good rate of return. The impact of testing is further reduced by the fact that these costs are incurred no more often than once every four years.

Vapor well monitoring has an initial cost that is similar to the cost of tank testing--$1,275 after taxes--and a cost that is only 60 percent of this in subsequent years, and thus the impact on the profits of these small businesses will be similar to that of tank testing. Line leak detectors have a smaller cost--$1,050, or $892 after taxes--and a correspondingly smaller impact on profits.

Tank upgrading. Upgrading one tank has an after-tax cost of $2,593. This reduces the rate of return of the median open dealer to about 5.5 percent, and it decreases the median lessee dealer's rate of return to just over 4 percent. Thus even in the year in which a tank is upgraded, it is possible for these firms to finance this activity out of profits and still retain at least a fair rate of return. Under the proposed rule, a dealer with three tanks need not upgrade a tank more frequently than once every three years to meet the 10-year regulatory deadline. This will further spread the impact of the tank upgrading requirement.

Tank retirement. The after-tax costs of closing a tank are $10,625. For closure and replacement with a single-walled coated and cathodically protected tank, the after-tax costs are $27,115. The impact of tank closure costs alone would reduce the rate of return of the median open dealer to 1.6 percent, and it would reduce the rate of return of the median lessee dealer to a very poor level of -3.2 percent. Closure and replacement would place both types of median firms in severe financial distress--rates of return of -6.2 percent for the median open dealer and of -25.7 percent for the median lessee dealer--for the year in which replacement occurred.

Considered in a broader perspective, this means that the after-tax cost of retiring three tanks equals six years of net income for the median open dealer. Since zero profits for an extended period of years substantially eliminates the value of savings in corporate profits tax, it is arguably more

Exhibit E.5
IMPACTS ON PROFITABILITY OF SELECTED COMPLIANCE ACTIVITIES AND EVENTS

Activity/Event	Cost of Action Before Tax	Cost of Action Adjusted 1/	Median Open Dealer	Median Lessee Dealer
Pre-Regulation				
Net Income			$ 14,000	$ 6,000
Net Income/Assets			6.67%	7.32%
Financial Condition			Good	Good
Test Three Tanks	$ 1,500	$ 1,275		
Net Income			$ 12,725	$ 4,725
Net Income/Assets			6.06%	5.76%
Financial Condition			Good	Good
Upgrade One Tank	$ 3,050	$ 2,593		
Net Income			$ 11,407	$ 3,407
Net Income/Assets			5.43%	4.15%
Financial Condition			Good	Fair
Tank Retirement				
Tank Closure	$ 12,500	$10,625		
Net Income			$ 3,375	-$ 2,625
Net Income/Assets			1.61%	-3.20%
Financial Condition			Fair	Poor
Tank Closure and Replacement 2/	$ 32,500	$27,115 3/		
Net Income			-$ 13,115	-$ 21,115
Net Income/Assets			-6.25%	-25.75%
Financial Condition			Severe Distress	Severe Distress
Non-Plume Release				
Leak Verification and Corrective Action	$ 23,100	$ 19,635		
Net Income			-$ 5,635	-$ 13,635
Net Income/Assets			-2.68%	-16.63%
Financial Condition			Poor	Severe Distress
Leak Verification, Corrective Action and Tank Repair	$ 29,600	$ 25,160		
Net Income			-$ 11,160	-$ 19,160
Net Income/Assets			-5.31%	-23.37%
Financial Condition			Severe Distress	Severe Distress

Exhibit E.5 (Continued)

Activity/Event	Cost of Action Before Tax	Cost of Action Adjusted 1/	Median Open Dealer	Median Lessee Dealer
Leak Verification, Corrective Action and Tank Replacement	$ 43,100	$ 36,125 3/		
Net Income			-$ 22,125	-$ 30,125
Net Income/Assets			-10.54%	-36.74%
Financial Condition			Severe Distress	Failure
Small Plume Release with Clean-up of Floating Plume				
Leak Verfication and Corrective Action	$ 37,200	$ 31,620 3/		
Net Income			-$ 17,620	-$ 25,620
Net Income/Assets			-8.39%	-31.24%
Financial Condition			Severe Distress	Failure
Leak Verification, Corrective Action and Tank Repair	$ 43,700	$ 37,145		
Net Income			-$ 23,145	-$ 31,145
Net Income/Assets			-11.02%	-37.98%
Financial Condition			Severe Distress	Failure
Leak Verification, Corrective Action and Tank Replacement	$ 57,200	$ 48,110 3/		
Net Income			-$ 34,110	-$ 40,110
Net Income/Assets			-16.24%	-48.91%
Financial Condition			Severe Distress	Failure
Small Plume Release with Clean-up of Floating and Dispersed Plume				
Leak Verfication and Corrective Action	$ 63,200	$ 53,720 3/		
Net Income			-$ 39,720	-$ 47,720
Net Income/Assets			-18.91%	-58.20%
Financial Condition			Severe Distress	Failure

Exhibit E.5 (Continued)

Activity/Event	Cost of Action Before Tax	Cost of Action Adjusted 1/	Median Open Dealer	Median Lessee Dealer
Leak Verification, Corrective Action and Tank Repair	$ 69,700	$ 59,245		
Net Income			-$ 45,245	-$ 53,245
Net Income/Assets			-21.55%	-64.93%
Financial Condition			Severe Distress	Failure
Leak Verification, Corrective Action and Tank Replacement	$ 83,200	$ 70,210 3/		
Net Income			-$ 56,210	-$ 64,210
Net Income/Assets			-26.77%	-78.30%
Financial Condition			Severe Distress	Failure
Large Plume Release				
Leak Verification and Corrective Action	$127,700	$108,545		
Net Income			-$ 94,545	-$102,545
Net Income/Assets			-45.02%	-125.05%
Financial Condition			Failure	Failure
Leak Verification, Corrective Action and Tank Repair	$134,200	$114,070		
Net Income			-$100,070	-$108,070
Net Income/Assets			-47.65%	-131.79%
Financial Condition			Failure	Failure
Leak Verification, Corrective Action and Tank Replacement	$147,700	$125,035 3/		
Net Income			-$111,035	-$119,035
Net Income/Assets			-52.87%	-145.16%
Financial Condition			Failure	Failure

Source: Meridian Reserach, Inc. and Versar Inc., using the affordability model.

1/ Adjustment is based on Cost x (1-TR), where marginal corporate tax rate, TR, is estimated to be 15 percent. Where losses are made, it is assumed that the deduction will be carried over, since costs do not recur annually.

2/ New standard is a single-walled cathodically protected tank.

3/ Cost of new tank ($6,000) is reduced by 10 percent income tax credit prior to adjustments for tax described in note. 1/

appropriate to look at the pre-tax costs, which are the equivalent of seven years of the profits of the median open dealer. For the median lessee dealer, the impact is far more severe; the pre- and after-tax cost of retiring three tanks is equal to more than 13 years of net income. The total after-tax costs of retiring three tanks would exceed the net worth of the median lessee dealer by about one third, or $20,000, and the total pre-tax costs of retiring three tanks would slightly exceed the net worth of the median open dealer.

For firms that typically have a planning horizon of less than 5 years, an expense large enough to absorb six years or more of profits could easily persuade the owner to leave the industry, and costs in excess of 10 years of profits would almost certainly do so. Second, because of limited access to credit, even the median open dealer may be unable to raise the funds to pay for tank closure and replacement; a replacement tank system cannot be used as collateral to provide security for a loan the way a tank system for a newly constructed facility could. On the other hand, although the business as a whole can expect to produce regular income, the investment in tank replacement (like expenditures on corrective action) is not itself an income-producing investment. This consideration is especially important in view of the fact that these costs would equal or exceed the net worth of either type of median dealer.

A non-plume release. As Exhibit E.5 shows, the expected value of the after-tax cost of leak verification and corrective action for a non-plume release is $19,635. This alone would absorb more than the net income of the median open dealer and would be three times the net income of the median lessee dealer. Corrective action would leave the median open dealer in poor financial condition (-2.7 percent rate of return), and it would leave the median lessee dealer in severe financial distress (-16.6 percent rate of return).

The expected value of the total costs of corrective action for a non-plume release and tank replacement are $36,125 after taxes and $43,100 before taxes (the before-tax cost becomes more relevant when losses are this large relative to annual net income). This is about one-third more than the costs of retiring one tank. This impact would place the median open dealer in severe financial distress, and it is estimated to be sufficient to cause the median lessee dealer to fail. However, if a tank can be repaired, the total after-tax cost declines to $25,160. This somewhat smaller cost, however, is still sufficient to put both types of median dealer in severe financial distress.

In a broader context, the average before-tax cost impact of a non-plume release is equal to two or three years' net income and one-third to one-half the net worth of the median open dealer. For the median lessee dealer, the cost is equal to five to seven years' net income and 50 to 70 percent of net worth. This perspective tends to confirm the conclusion that the median open dealer could well remain in business--if financing could be obtained--but the median lessee dealer would likely close if he had to pay for a non-plume release.

A small plume release. As Exhibit E.5 shows, the expected value of the after-tax cost of leak verification and corrective action for an average small plume release (i.e., one less than 25 square meters in area) is $31,620 if only a floating plume must be cleaned up and $53,720 if a dispersed plume must also be cleaned up. Corrective action costs for a floating plume alone are twice the annual net income of the median lessee dealer. Paying these costs would leave the median open dealer in severe financial distress (-8.4 percent rate of return). The additional costs of cleaning up a dispersed plume are nearly four times the annual net income of the median open dealer and nine times the annual net income of the median lessee dealer. These costs would leave the median open dealer in severe financial distress (-18.9 percent rate of return) and cause the median lessee dealer to fail (-58.2 percent rate of return).

When tank replacement costs are included, the impact becomes more severe. Average after-tax costs are $48,110 if only a floating plume is cleaned up and $70,210 in cases in which a dispersed plume is also cleaned up. For clean-up of a floating plume, the costs exceed three times the annual net income of the median open dealer and seven times the annual net income of the median lessee dealer. Bearing these costs would put the median open dealer in severe financial distress (-16.2 percent rate of return) and would cause the median lessee dealer to fail (-48.9 percent rate of return). If a dispersed plume is also cleaned up, the costs would exceed five times the annual net income of the median open dealer and are nearly 12 times the annual net income--and more than the net worth--of the median lessee dealer. Bearing these costs would put the median open dealer in very severe financial distress (-26.8 percent rate of return) and would cause the median lessee dealer to fail (-78.3 percent rate of return).

If a tank can be repaired rather than replaced, the average total after-tax costs are reduced to $37,145 if only a floating plume is cleaned up and $59,245 if a dispersed plume is also cleaned up. Despite this reduced cost, the median open dealer would still be in severe financial distress--and the median lessee dealer would still fail--in both cases.

A large plume release. As Exhibit E.5 shows, an average large plume release (i.e., one greater than 25 square meters in area) has an expected value in after-tax leak verification and corrective action costs of $108,545 (although the pre-tax costs of $127,700 may again be a more appropriate measure because of the size of the loss). These after-tax costs alone are nearly eight year's net income for the median open dealer, 18 years' net income for the median lessee dealer, and are substantially greater than the net worth of either type of median dealer. This is clearly enough to cause either type of median dealer to fail. The after-tax costs of tank replacement, which would be necessary to continue in business, are $125,035--or $114,070 if the tank can be repaired--which merely raises the already high probability that both median dealers will fail.

E.6.B.3. Summary of Effects on Profitability for the Median Dealer

The proposed rule requires the monitoring and upgrading of all tanks, regardless of circumstances. The costs of these provisions could easily be financed by either median firm out of average profits in the year in which they were incurred and still leave the firm with a fair to good rate of return. Moreover, these costs would not occur in more than six of the first 10 years that the regulations were in force. Thus the impact of these provisions on the profitability of a median firm is relatively minor.

In contrast, a requirement to retire existing tanks and replace them with new tanks meeting a cathodic protection standard would have a severe impact. One-year costs would place either type of median firm in severe financial distress. The cost of retiring three tanks would approximately equal the median open dealer's net worth and six or seven years' of his net income. This would probably be enough to induce the median open dealer to leave the industry. These costs would substantially exceed both the median lessee dealer's net worth and a decade of his net income. Costs of this magnitude would almost certainly induce the owner to close the outlet or the dealer to leave the industry. If the new tank standards required a secondary containment system, costs (including monitoring equipment) would be nearly 20 percent higher than those for retirement and replacement. It would then be a virtual certainty that both types of median dealer would close rather than incur such costs.

The costs of an average non-plume release could be severe enough to force the median open dealer to fail and would be likely to force the median lessee dealer out of business, regardless of whether the owner or the dealer initially bore the costs. This result depends somewhat on the severity of the release and the availability of financing. A small plume release that required clean-up of a dispersed plume would--on average--force the median open dealer very close to failure and would clearly be costly enough to force the median lessee dealer to fail. An average large plume release would force either type of median dealer to fail in virtually every circumstance.

Analyzing the median firm has its limitations, since it provides little information about impacts on firms at either end of the distribution of financial characteristics, such as marginal firms; median values give no insights as to how many marginal firms there are or what their financial condition is. This is important for an analysis of monitoring and tank upgrading costs; for example, for a firm with a net income of $1,000 or less, these costs alone will exceed a decade of profits and probably induce the firm to leave the industry. For other events, however, analyzing impacts on the median firm is far more useful. Given the results derived above, it can be predicted with reasonable confidence that a majority of small firms would leave the retail motor fuel sector rather than face the costs associated with the mandatory retirement of existing tanks and that a majority of firms that experience a release will fail as a result of costs associated with the release.

E.6.B.4. Analysis of the Impact on Small Firms

The impact of UST regulation on small firms as a whole was performed using an affordability model. The affordability model uses the release rates estimated by the UST Model, the costs of corrective action, and the compliance costs discussed above to measure the economic impacts of regulation on all firms in the retail motor fuel sector. The economic impact analysis is presented in Section 6.B of the RIA. A summary of the structure of the affordability model appears in Appendix D of the RIA.

The analysis of economic impacts on small firms uses the affordability model to assess the percentage of outlets owned by small firms that will exit the retail motor fuel sector and to identify the factors responsible for these exits. The main results of this analysis are presented in this section. These results are summarized in terms of the cumulative percentage of small-firm-owned outlets surviving at the close of years 5, 10, and 15 after implementation of the proposed UST regulations.

Some retail outlets in the motor fuel sector will exit the industry even without the imposition of regulatory costs on their owners; exits occurring in the absence of regulatory costs are termed "natural" exits. Natural exits were extrapolated from past industry exit trends and are based on expectations about future releases in the absence of further UST regulation. 1/ The natural exit was estimated by dividing the number of exits predicted by past industry exit trends, which were assumed to continue for the next 15 years, by the number of retail outlets owned by small firms (i.e., firms with less than $4.6 million in assets) now in the industry.

To determine the percentage of total exits attributable to the proposed rule (and to the other regulatory options analyzed), the percentage of natural exits was subtracted from the percentage of exits predicted to occur under the rule. The difference between these percentages was then attributed to the impact of regulatory costs. Exits caused by regulatory costs are divided into two categories:

- Exits attributed to tank replacement. This category of exit includes all exits (above the percentage of natural exits) attributable to the impact of the costs of leak detection, mandatory tank upgrading, replacement of tanks that cannot be repaired after a release, or mandatory tank closure and replacement.

- Exits attributed to corrective action. This category of exit includes those where the firm owning the outlet could meet all UST regulatory costs other than those of corrective action but would fail if forced to incur corrective action costs.

When a firm fails as a result of a large release it cannot afford to clean up, the exit of its affected outlets could be attributed either to the costs of tank replacement or the costs of corrective action, because either cost by itself may be sufficient to cause the firm to fail. In this analysis, such exits are attributed to the costs of tank replacement.

Through the end of year 5, 19 percent of outlets owned by small firms would exit without any further UST regulation. At the close of year 5, the proposed rule has a higher predicted percentage of small-firm-owned outlets surviving in business--29 percent--than any other option. The total impact of the regulation on exit is defined as the difference between survival based on the continuation of natural exit and survival assuming all regulatory costs are incurred. This reflects a total impact of 52 percent of small-firm-owned outlets exiting the industry as a result of the proposed rule (see Exhibit E.6). Option V, which has the highest expenditures for mandatory tank replacement during years 1-5, has the lowest percentage of small-firm-owned

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1/ Meridian Research, Inc. and Versar Inc., Documentation of the Affordability Model, Draft Report, March, 1987.

Exhibit E.6
ECONOMIC IMPACTS OF PROPOSED REGULATION (OPTION II) ON SMALL FIRMS IN THE RETAIL MOTOR FUEL MARKETING INDUSTRY, ASSUMING NO REVENUE INCREASE OR REVENUE INCREASES OF 1, 3, OR 5 PERCENT

Scenario	Percentage of Existing Outlets		
	Year 5	Year 10	Year 15
Base Case - No Further UST Regulation			
Survival Based on the Continuation of Natural Exit	81	72	64
Regulation Under Proposed (Option II) Requirements			
No Revenue Increase			
Exit Due to Regulatory Costs[1]	52	51	49
Percentage Surviving	29	21	15
1 percent Revenue Increase			
Exit Due to Regulatory Costs[1]	40	40	39
Percentage Surviving	41	32	25
3 percent Revenue Increase			
Exit Due to Regulatory Costs[1]	19	18	17
Percentage Surviving	62	54	47
5 percent Revenue Increase			
Exit Due to Regulatory Costs[1]	7	4	1
Percentage Surviving	74	68	63

Source: Meridian Research, Inc. and Versar Inc., using affordability model results.

1 Calculated as the difference between survival based on continuation of natural exit and percentage surviving given all regulatory costs and the indicated revenue increase.

outlets surviving (18 percent). Although the overall percentages of outlets surviving are similar for all options analyzed, the composition differs:

- Under the proposed rule and Options I and III, which do not have mandatory tank replacement, only 2 percent of outlets are predicted to exit because of tank replacement costs, but 52 percent are predicted to exit because of corrective action costs.

- Under Option IV, which has mandatory tank replacement in a limited number of cases, 15 percent of outlets are predicted to exit because of tank replacement costs, and 39 percent are predicted to exit because of corrective action costs.

- Under Option V, which has universal mandatory tank replacement and the most stringent leak detection measures, 41 percent of outlets are predicted to exit because of tank replacement costs, but only 22 percent are predicted to exit because of corrective action costs.

As would be expected, the percentage of outlets surviving is lower in subsequent years. Most of this increased exit is due to natural exit, which is 28 percent over 10 years and 36 percent over 15 years. Total predicted 10-year survival under the proposed rule is 21 percent (with other options ranging from 11 to 18 percent). The total predicted 15-year survival under the proposed rule is 15 percent (with other options ranging from 7 to 12 percent). This represents the total-exit impact of the proposed rule of 51 percent over 10 years and 49 percent over 15 years (see Exhibit E.6). In all time horizons, small-firm-owned outlet survival for the proposed rule is better than that of any other option analyzed. The relative pattern of tank replacement and corrective action impacts described above continues in the 10- and 15-year horizons, but the impacts of tank replacement costs become relatively more important for Option IV and V as time goes by. For the proposed rule, tank replacement impacts become zero in 10 years and -2 percent in 15 years. This reflects a reduction in the natural exit caused by tank replacement or upgrading--the only option analyzed for which this occurs.

These results show that--in terms of the percentage of surviving outlets owned by small firms--the proposed rule is superior to the other options considered. In terms of the economic impacts of tank replacement or upgrade alone, the proposed rule is also superior to the other options considered.

The most important source of substantial impacts of the proposed UST regulation is the cost of corrective action. EPA estimates that 89 percent of all small businesses owning retail motor fuel outlets would fail if they were forced to meet the full costs of corrective action for a release sufficiently serious to reach ground water. Fourteen percent of all small businesses owning retail motor fuel outlets would fail if they were forced to pay the average costs of corrective action for a release that does not reach ground water; in this second case, most of the firms that would fail would be considered marginal. If releases requiring a corrective action with average costs occur at the level estimated by the RIA, and if no revenue increases are possible for small businesses, 10 percent of small firms will fail in each of the first five years as a result of these corrective action costs. EPA also estimates that corrective action costs may be high enough and frequent enough to cause many independent marketers to close outlets that are operated by lessee dealers. It is possible, however, that these closed outlets might be replaced by newer facilities, which might in turn be operated by lessee dealers.

E.6.C. Potential Price and Revenue Effects

E.6.C.1. Potential Recovery of Regulatory Costs from Increased Revenues

If firms were able to recover their regulatory costs by increasing their revenues, they could offset impact on their profits. The revenues of retail motor fuel marketing firms might increase, for two reasons:

- The retail price of motor fuels could rise and provide a higher margin that could be used to pay these costs.

- As outlets exit the industry, the volume of motor fuel sales at the remaining outlets could increase. This increase in volume would provide the firm with higher profits because the relatively fixed costs of operation would be spread over a higher volume of sales. This would enable owners to pay their regulatory costs from this higher profit margin. In the retail motor fuel sector, a 12-15 percent increase in the volume of motor fuels sold would have about the same effect on net revenue as a 1 percent increase in price (with no cost increase).

To the extent that revenue increases, regulatory costs need not have an impact on profits. Thus the regulatory burden will be borne by consumers (if prices rise) or by the firms that exit the industry (if the volume of sales of the remaining outlets rises). Since any analysis of regulatory flexibility is particularly concerned with possibilities that might prevent substantial numbers of firms from failing, the analysis will focus on price increases rather than volume increases for outlets that survive a substantial number of failures.

Exit and survival for various levels of revenue increase are shown in Exhibit E.6 1/ for retail motor fuel outlets owned by small firms. Cumulative survival at the end of 5, 10, and 15 years is shown for both natural exit (defined in Section E.6.B.4.) and the proposed rule. The cumulative exit of currently existing small-firm-owned outlets estimated to be caused by the proposed rule (i.e., above and beyond natural exit) is:

- 52 percent after 5 years and 49 percent after 15 years, if there is no associated increase in the retail price of gasoline;

- 40 percent after 5 years and 39 percent after 15 years, if there is a price increase of 1 percent;

- 19 percent after 5 years and 17 percent after 15 years, if there is a price increase of 3 percent;

- 7 percent after 5 years and 1 percent after 15 years, if there is a price increase of 5 percent.

1/ RIA, Sec. 6.B.

These results show that, on average, the impacts of the proposed rule can be virtually eliminated by a 5 percent increase in the retail price of motor fuel. With a 3 percent price increase, however, the proposed rule would still cause 17 percent of all currently existing small-firm-owned outlets to exit the industry. Nevertheless, a 5 percent price increase--about $0.04 per gallon in late 1986 prices--is relatively small compared with gasoline price fluctuations over the last 5 to 10 years.

E.6.C.2. Ability of Small Firms to Pass Costs Through to Customers

The analysis presented above indicates that a relatively modest price increase would allow small retail motor fuel marketing firms to recover enough of their compliance costs so that the number of outlets exiting--net of natural exit--resulting from the proposed rule would be negligible in the long run. In the case of UST regulation in the retail motor fuel sector, however, the ability of impacted firms to pass their costs through to customers in the form of price increases will be severely limited. A number of competitive factors lead to this conclusion:

- There are few substitutes for gasoline, but there are many substitutes for gasoline purchased from an individual outlet. Thus, although market demand for retail gasoline as a whole is relatively inelastic, demand at individual outlets can be highly sensitive to price.

- UST regulatory costs are largely independent of the quantity of gasoline pumped at a given outlet. Regulatory costs per gallon are therefore likely to be much less for a high-volume outlet than for a low-volume outlet. This will limit the potential for lower volume outlets to pass compliance costs through to customers.

- Some outlets are much further along in programs to prevent and detect releases. Such outlets will incur relatively few compliance costs for either tank upgrading or corrective action. Competition from them will thus tend to limit the ability of other outlets to pass compliance costs through in the form of higher prices.

- Entry into the retail motor fuel sector is easy. A new convenience store with both gasoline and grocery sales, for example, can be constructed and stocked for $250,000 to $500,000. 1/ Newly built facilities will experience little or no cost impacts related to new tank standards. They also will have relatively low corrective action costs, because their tanks will not be bare steel. Thus competition from actual or potential entrants into the retail motor fuel market will limit the ability of existing firms with old tanks to pass compliance costs through to customers.

1/ National Association of Convenience Stores, <u>1985 State of the Convenience Store Industry</u>, 1985.

> The size of regulatory compliance costs per outlet depends critically on whether or not a release occurs, and on the size and nature of the release and the costs of responding to it. In the absence of UST insurance, these costs will not be spread evenly over outlets. Thus competition from outlets that do not experience a release will tend to prevent outlets that do have a release from passing the related corrective action and tank replacement costs through to consumers.

The extremely uneven--and largely random--distribution of compliance costs is a key factor in analyzing impacts. A 3-tank motor fuel outlet that experiences no release will have 10-year monitoring and tank upgrading costs that average roughly $1,500 per year. An outlet that has a large plume release will probably incur costs in excess of $100,000 and--if it is an open dealership--will fail as a result. Moreover, the impact of this disparity in regulatory costs on large and small firms is quite different. By way of illustration, if 20 out of 100 open dealers have large plume releases, this 20 percent will fail even if the average compliance cost alone would not have been enough to cause any of the 100 dealers to fail. The result is different, however, for larger firms--say 5 larger firms, each with 20 outlets, 4 of which experience large plume releases. In each case the firm's other 16 outlets may earn enough profit to compensate the firm for the costs of compliance associated with all 20 of its outlets; whether or not the four outlets with releases remain open, the firm itself will not fail if the average compliance costs for all 20 outlets is less than the net income of the firm. The key difference between the larger firm and the open dealer lies in the pooling of risk that a firm with multiple outlets can achieve, even if insurance is not available. (In addition, a larger firm is likely to have better access to credit to cover an unusually costly release than will an open dealer.) Thus, while the large firm may face higher average regulatory costs than small firms that have no releases, the ability to pool risk will result in a large cost advantage over small firms that do experience releases.

The numerical illustration presented above is borne out in the analysis of larger firms. Results for large retail motor fuel firms other than refineries are shown in Exhibit E.7. These results indicate that, with no revenue increase, the average large firm will be in financial distress over a 5-year horizon, but will break even (zero net income) over a 10-year horizon. If price increases are possible, however, the situation for a large firm improves substantially. As little as a one-percent price increase is sufficient to make the rate of return (net of compliance costs) greater than the baseline rate of return over a 10-year horizon, although the rate of return for the large firms over five years is still negative as a result of regulatory costs. A 3-percent price increase, however, is sufficient nearly to produce a rate of return over 50 percent higher than the baseline rate of return even in the first five years and to more than double the baseline rate of return over a longer period. A 5-percent price increase would produce rates of return three to four times the baseline level. Clearly, with a price increase of 2 percent or more, larger firms would be more than able to recover average compliance costs--including those of very costly releases--from increased revenues by pooling risk among outlets.

This pooling option is not available to small firms. Indeed, the analysis in Section 6.B indicates that even with a 3-percent price increase, the proposed rule would still produce the exit (net of natural exit) of 19 percent of

Exhibit E.7
ECONOMIC IMPACT OF REGULATION UNDER THE PROPOSED RULE ON THE RATE OF RETURN FOR LARGE FIRMS 1/, ASSUMING REVENUE INCREASES OF 1, 3, OR 5 PERCENT

Scenario	After-tax Rate of Return on Total Assets Years 1-5 (%)	Years 6-10 (%)	Years 11-15 (%)
Base Case--No Regulation	4.2	4.2	4.2
Proposed Rule with No Revenue Increase	-8.6	0.0	2.0
Proposed Rule with Revenue Increase			
1 Percent Revenue Increase	-1.9	4.6	6.1
3 Percent Revenue Increase	7.1	11.9	13.2
5 Percent Revenue Increase	14.2	18.8	20.1

Source: Meridian Research, Inc. and Versar Inc., using affordability model results.

1/ Firms with more than $4.6 million in sales, except refiners.

current small firms. Yet a 3-percent price increase would make the rate of return for larger firms both high enough to cover average compliance costs and attractive enough to stimulate substantial entry.

These various facets of the competitive market make it unlikely that a substantial level of compliance costs can be passed through to customers. Moreover, to the extent that costs can be passed through, it is likely to be routine compliance costs (monitoring and possibly tank upgrades) that are borne by most outlets rather than corrective action costs that are borne only by outlets experiencing releases. A revenue increase would itself do nothing to alter the distribution among small firms of regulatory costs, which under the proposed rule is largely a function of the fact and severity of releases. A price increase large enough to defray the costs related to a release would certainly attract fierce competition from new entrants and existing firms that did not have to bear corrective action and tank replacement costs or could pool these costs among many outlets. Thus it is most unlikely that the major cost impacts, which are likely to force a small firm to close but which are borne only by some outlets, can be passed through to consumers.

E.6.D. Economic Effects

E.6.D.1. Effect of Failures and Other Exits from the Industry

The analysis presented above indicates that UST regulation will have a very substantial impact on the ability of small firms to survive--that many firms will voluntarily leave the industry rather than incur compliance costs, and many more will fail as a result of the costs associated with a release. EPA's estimates of the impacts of different release events on the exit (including failures) of single-outlet small firms can be summarized as follows:

- Monitoring and Tank Upgrading. If there is no release, the event with the greatest impact in one year under the proposed rule is a tank upgrade. An estimated 0.5 percent of small firms would exit as a result of this cost impact.

- Mandatory Tank Replacement. Under options that require mandatory replacement, an estimated 35.2 percent of small firms would exit as a result of the cost impact of replacing one tank in a single year, and an estimated 76.3 percent of small firms would exit as a result of the cost impact of replacing three tanks in one year. (If secondary containment systems were required, these exits would be 35.5 percent and 87.5 percent, respectively.) The actual impact lies somewhere in between, since three tanks must be replaced but all three do not have to be replaced in one year. Analysis of the median open dealer, however, suggests that exit would be over 50 percent. These estimated exits also indicate another dimension of the regulatory requirements: the rapid phasing in of an expensive requirement has a substantially higher impact than a more gradually phased requirement.

- Non-Plume Release. It is estimated that, as a result of the average cost impact of a non-plume release, 3.16 percent of single-outlet dealers would fail if the tank could be repaired, and 15.6 percent would fail if the higher costs of tank replacement were required.

- Small Plume Release. It is estimated that 27.7 percent of single-outlet dealers would fail as a result of the average cost impact of a small plume release that involved only cleaning up of a floating plume, and 64.2 percent of single-outlet dealers would fail as a result of the average cost impact of a small plume release that involved cleaning up the floating and dispersed plume.

- Large Plume Release. It is estimated that 88.3 percent of single-outlet dealers would fail as a result of the average cost impact of a large plume release.

- All Releases. It is estimated that a firm that has a release at one of its USTs has a 48 percent chance of failing. It is possible that the firm will have more than one release in a single year and very likely that it will have more than one release in the first five years after implementation.

The overall conclusions about the cumulative percentage of exit among all open dealers, performed with the affordability model and presented in the RIA, are presented in Exhibit E.6.

The results of the analysis of exits under the proposed rule can be summarized as follows: 1/

- Cumulative natural exit is estimated to be:

  -- 19 percent through year 5;

  -- 28 percent through year 10; and

  -- 36 percent through year 15.

- Cumulative exit attributable to the impact of regulatory costs is estimated to be:

  -- 52 percent through year 5;

  -- 51 percent through year 10; and

  -- 49 percent through year 15.

- Total cumulative survival of existing firms is estimated to be:

  -- 29 percent through year 5;

  -- 21 percent through year 10; and

  -- 15 percent through year 15.

1/ RIA, Sec. 6.B.

Exits attributed to the impact of the costs of the proposed rule were slightly lower than the exits attributed to the costs of the four regulatory options examined in the RIA. A regulation that causes 40 percent of existing small firms to leave the industry clearly has a significant impact on a substantial number of small businesses.

E.6.D.2. Effect on Production

The high percentage of exit estimated to result from impacts of the proposed rule suggests that production (i.e., retail services) will be sharply reduced. For several reasons, however, this is not necessarily the case.

- When an outlet closes, sales will tend to be diverted to other outlets in the neighborhood.
- New entry into the retail motor fuel sector is relatively easy, and, relative to existing firms, new entrants have a low level of compliance costs associated with tank construction and a low risk of releases.
- If production threatens to fall sharply, the retail price of gasoline will probably rise somewhat, which will both slow exit and stimulate new entry.

Just how much production falls depends largely on how much gasoline prices rise. Price increases will tend to be transitory, however, since they will stimulate sales by new entrants and by high-volume outlets that have not experienced releases. Decreases in production can be expected to be quite small compared with the percentage of gross exits.

E.6.D.3. Effect on Employment

The level of employment in the retail motor fuel sector depends on a variety of factors. These include the number of retail outlets, the volume of sales per outlet, the average hours maintained by outlets, and other institutional factors such as the percentage of gasoline sold through self-service pumps. If a substantial percentage of existing firms exit, employment in this sector will be reduced. Yet entry of new firms and increases in the volume of sales of other surviving firms will tend to offset this effect. There may be a tendency for employment to fall relative to motor fuel sales if existing firms have full-service outlets and the outlets that replace them are convenience stores or "gas-and-go" outlets. However, the effects on employment are difficult to estimate with precision.

E.6.D.4. Effect on Market Structure

The proposed regulation will tend to have more impact on marginal firms and on low-volume firms than on financially healthy firms. It seems probable that some reduction in the total number of retail outlets will also occur. Firms owning large numbers of outlets--principally refiners and the largest convenience stores--may experience somewhat smaller impacts to the extent that they already have programs to retire and upgrade USTs. The overall percentage of small firms that exit can be expected to be substantially higher than the percentage of large firms that exit because small firms cannot pool regulatory costs among outlets. Nevertheless, it is not clear that a significant increase in market concentration will result from the proposed rule. Several factors are important:

- The regulation will provide significant opportunities for new entry, and large firms have no obvious advantages over small firms when it comes to entry.

- Of the total number of retail outlets owned by large firms, 56 percent are operated by independent lessee dealers rather than by the large firms themselves. Thus a move by large firms to expand the number of outlets they own would be likely to result in an increase in the number of lessee dealer firms.

- High-volume outlets, which are likely to gain the most business, are owned by relatively small businesses as well as large businesses.

- One of the fastest growing classes of retail motor fuel outlets--convenience stores--may not be small by the SBA definition but are small enough to reduce rather than increase overall measures of industry concentration.

The proposed rule can be expected to cause a substantial reduction in the number of small firms currently in the sector; however, this does not mean that large firms will gain substantial market share. There may be little net reduction in the number of small retail motor fuel firms. Even if the firms that gain the most are not "small" in the sense used in this analysis, they are unlikely to be large enough to increase market concentration.

E.6.E. Potential for Alternatives to Reduce the Impacts on Small Entities

The basic purpose of the Regulatory Flexibility Act and of any regulatory flexibility analysis is to examine alternatives to the proposed rule that may have a smaller impact on small businesses than the rule itself, and to adopt such alternatives whenever possible. There are two basic types of alternatives: 1) exemption of small businesses; and 2) alternate provisions in the regulation that would apply to small businesses.

E.6.E.1. Small Business Exemption

Small businesses own or operate 76 percent of retail motor fuel outlets in the United States. Retail motor fuel outlets of different sizes differ only slightly in the number of USTs they own. To the extent that the probability of a release is related to the size of the firm owning the facility at all, USTs owned by small firms may be somewhat more likely to leak than USTs owned by large firms, because small-firm-owned USTs are slightly more likely to be bare steel. There is no inherent relationship between the size of the firm that owns an UST and the threat posed to human health and the environment by a release from an UST. In short, at least three-quarters of the potential damage to human health and the environment that is expected to occur as a result of releases from USTs is likely to be associated with USTs owned or operated by small businesses. Any exemption for small businesses--especially an exemption from the corrective action requirements, which cause the greatest impacts on small businesses--would therefore fail to achieve the statutory goals set forth in Subtitle I.

E.6.E.2. Alternative Regulatory Provisions for Small Businesses

The potential for promulgating alternative provisions for small businesses that would be less burdensome than the provisions of the proposed rule is virtually eliminated by one basic fact: The provisions in the proposed rule are already substantially less burdensome than available alternatives. In particular:

- Continuous monitoring would have a capital cost four times as great as that of the frequent monitoring required by the proposed rule. Moreover, the tank tightness tests allowed as an interim measure for existing USTs have no capital costs, and their present value cost (over a 10-year horizon) is less than half that of any other method. This minimizes the potentially adverse impact on small businesses of immediate compliance with new tank detection requirements.

- Mandatory replacement of bare steel tanks would be approximately ten times more expensive than the tank upgrading required by the proposed rule. A mandatory replacement requirement would cause something like half the single-outlet firms to exit the industry, whereas the requirement as proposed will have minimal impacts.

- Secondary containment systems are nearly 20 percent more expensive than the proposed rule's new tank requirement of a coated and cathodically protected system. By avoiding these higher initial costs, the proposed rule minimizes the adverse impact on small businesses.

- The proposed rule allows leaking tanks to be repaired, within limits designed to ensure that tank repair is technically sound. This saves an estimated $13,500 (about two-thirds of the installed cost of a new tank) over the costs of replacing a tank. Tank repair would be particularly attractive to small businesses that would wish to continue their operations by repairing their existing tanks. It would produce a percentage of exit for single-outlet firms that is estimated to be one-quarter lower than tank replacement exits in the event of a nonplume release.

Virtually the only element of any of the options analyzed that would have a lower direct financial impact on small businesses than the requirements of the proposed rule would be a waiver of the requirement to upgrade or replace bare steel tanks in circumstances other than detection of a release. This provision itself, however, would have a very significant impact on a substantial number of small firms, since it would provide no protection against releases--and there is a better than 50 percent chance that a small business will fail when a release occurs.

Leak detection is part of the proposed rule, and it is considered by EPA to be a requirement that is essential to the program. Indeed, leak detection is the key to other elements of flexibility in the proposed rule, especially the gradual phasing in of provisions and the allowing of tank upgrades rather than replacement. Moreover, the costs of the leak detection requirement are not estimated to have significant economic impacts on small businesses.

The gradual phasing in of provisions is an element of regulation often used to minimize the impacts on small businesses. The proposed rule, however, already utilizes this approach. Because rapid upgrading would have the highest up-front costs, the greatest impact on small businesses, and might simply not be practical, the proposed rule allows tank upgrades to be spread out over 10 years.

Corrective action is not precisely prescribed in the proposal, except for the mandatory requirement to clean up any floating plume. The site-specific assessment approach embodied in the proposed rule, which was designed to seek out cost-effective solutions, is itself an element of flexibility that will minimize impacts on small businesses.

In promulgating the proposed rule, EPA has attempted to provide as much flexibility for small firms as possible. Inclusion of alternative provisions that would further reduce the burden on small firms thus does not appear to be a realistic possibility.

E.6.E.3. The Regulatory Flexibility Act and UST Regulations

In mandating the consideration and use of less burdensome alternatives for small entities, the Regulatory Flexibility Act is concerned with two types of situations: either there are substantial economies of scale in some aspect of compliance, so that small entities will have high unit costs, and/or small businesses constitute a relatively minor part of the problem, so that less thorough compliance by this part of an industry will produce relatively little harm. For USTs, at least in the retail motor fuel sector, neither of these situations holds. Compliance costs vary a great deal, but this variability is unrelated to economies of scale with respect to number of outlets or to firm size. Collectively, small businesses contribute significantly to a large and serious problem, so that ignoring them would leave the problem unsolved. The potential basis for relieving the burden on small businesses that the Regulatory Flexibility Act envisioned thus does not exist in the case of the regulation of USTs.

A P P E N D I X   F

METHODOLOGY FOR ESTIMATING RISK

APPENDIX F

METHODOLOGY FOR ESTIMATING RISK

1. INTRODUCTION

1.1 Purpose of the Risk Estimation Methodology

The methodology for calculating risk that is used in this report and referred to in Chapter 7 is an ordered, logical set of steps that transforms data on the UST problem into estimates of risks to human health. It is intended to support the regulatory impact analysis (RIA) by providing detailed estimates of the damages that leaking USTs are likely to impose in the baseline (that is, with no further regulation). In addition, when the methodology is applied to the anticipated situation under the proposed regulations and the alternatives, we can obtain a measure of the damage reductions provided by the regulations compared to the baseline. This measure is an important component of the process of estimating the regulatory benefits.

1.2 Purpose of This Appendix

This appendix is intended to provide a conceptual overview of the risk estimation methodology, and descriptions of the individual steps required by the methodology and how they fit together to produce estimates of risks to humans.

An additional purpose of this appendix concerns the assumptions made in the course of the analysis. While the methodology builds as directly as possible on empirical data and data outputs from simulations performed using the UST Model, we found that assumptions had to be made at several key points. The appendix discusses the bases for the key assumptions and how they affect the results. One major purpose of this appendix is to present the methodology in sufficient detail to allow interested parties to provide useful suggestions for changes and improvements in the estimation procedures.

This appendix, as well as the sections of the main body of the report that deal with risk analysis, was prepared by ICF Incorporated, and describes work done by ICF and Pope-Reid Associates (PRA) in conjunction with Sobotka & Co., Inc. (SCI).

1.3 Organization of the Appendix

The appendix is divided into five sections. This first section introduces the methodology, with a schematic look at situations that impose risk. The first section also presents an overview of the three-stage approach used for estimating risk: 1) estimating the risks in each of a large number of scenarios; 2) estimating the frequency of each scenario; and 3) integrating these steps to provide a distribution of individual risks ans an estimate of aggregate population risk.

The second, third, and fourth sections cover in detail each of the three stages of the risk estimation approach in turn. The second section describes the individual steps taken to estimate risks in given scenarios, and presents the data inputs and outputs of the process. The third section describes the steps taken to estimate the nationwide frequency, or probability, of each of the scenarios whose risks have been estimated. As in the second section, the data inputs and outputs are presented. The fourth section integrates the estimates of risks by scenario and scenario probabilities described in the second and third sections.

Finally, the fifth section discusses the most important assumptions used in the analysis. We describe each of the assumptions in the context of the risk estimation steps in which they are involved. We then discuss the basis for each assumption is discussed, and the effect that changes in the assumptions would have on the results.

1.4 A Schematic Look at a Situation that Imposes Risk

A generalized scenario for the kind of risk-imposing UST incident considered by the methodology can be described briefly as follows. An underground gasoline storage tank or its associated piping fails, and releases gasoline over some period of time before the failure can be detected and stopped. Before the release is discovered, the released product moves downward through the backfill surrounding the tank, and then into the unsaturated zone. If enough time elapses, the released product contacts the top of the water table aquifer and, since gasoline is lighter than water, it spreads out over the ground water into a floating plume. By various processes, chemical components move out of the floating plume and into the ground water.

The contaminants travel along through the aquifer, moving downgradient and spreading out. A private well, sunk into the surficial (unconfined) aquifer some distance away, withdraws contaminated water after the dispersed plume reaches it. Through drinking the contaminated water, exposure occurs over time, until the release is discovered or exposure ends because the water becomes too contaminated to use.

The risk imposed in this case will depend on the concentrations the contaminant reaches at the receptor well, the length of time over which exposure occurs, the toxicologic potency of the gasoline components, and, for population risk, the number of exposed individuals. The highest risk to any individual is generally experienced by those using the closest downgradient well, where concentrations will be highest over the longest period of time.

Scenarios like this one occur at many locations, each with a different combination of tank type, release rates and duration, aquifer depths and material, ground-water velocity, and distribution of wells. To estimate the total risk and the distribution of the maximum risk, then, we need a methodology that is able to estimate total and maximum risks for each of a large number of scenarios, and then combine these estimates using information on the frequency with which each scenario is likely to occur.

2. RISK ESTIMATION BY SCENARIO

2.1 Components of the Scenarios

We assessed risk from exposure to gasoline for 9,720 different exposure scenarios in each regulatory option. These scenarios comprise combinations of three tank designs, four vadose zone types, nine floating plume sizes, three ground-water velocities, and 30 exposure well locations.

2.1.1 Tank Designs

We assumed that existing tanks in the base case were made of either bare steel or fiberglass, in proportions of 89 percent bare steel to eleven percent fiberglass. All replacement tanks were assumed to be protected tanks. The tank design affects the frequency with which leaks develop, and the leak rate once a failure has occurred.

2.1.2 Vadose Zone Types

The four vadose zone types were sandstone/limestone/shale, sand, metamorphic/igneous, and silt/clay. The vadose zone type influences the dimensions of the floating gasoline plume for a given leak.

2.1.3 Floating Plume Size

Given a population of 1.4 million tanks, the UST model predicted the number and average duration of plumes of different sizes. No plumes were predicted with a size of greater than 10,000 square meters for any vadose zone type. The plumes that were predicted fell into nine size ranges (0-1, 1-10, 10-25, 25-100, 100-500, 500-1,000, 1,000-2,000, 2,000-5,000, and 5,000-10,000 square meters). The floating plume size affects the transfer of benzene from the floating plume to the aqueous (ground-water) phase and the degree to which the contaminant is concentrated along the centerline of the dispersed plume.

2.1.4 Ground-Water Velocities

Ground-water velocity affects the transit time for benzene to reach the wells, and its concentration in the water reaching the wells. We considered three different ground-water velocities: 0.1 m/day, 1 m/day, and 5 m/day. Pope-Reid Associates (PRA) developed a modified version of the Wilson-Miller analytic solute transport model. This model simulates concentrations resulting from a point source release of contaminant. In order to simulate an area source of finite size, multiple benzene injection points were used. We assumed the same retardation factor (7.6) in all media. This is a mid-range value (the estimated range for most aquifer media is approximately 4-12) and mainly affects the timing of the arrival of benzene at an exposure well; the variation in predicted concentrations is not great if different retardation factors are used.

2.1.5 Position of Exposure Wells

Benzene concentrations were estimated at 30 exposure wells located in a grid covering a range of transport distances that may be achieved up to the time the leak is discovered. The grid has wells at distances of 10, 25, 50, 100, 250, 500, 1,000, 2,000, and 2,500 m downgradient located on the downgradient centerline and at 50 m and 100 m transverse to the centerline. Well locations relate to the intensity and duration of exposure to benzene in the drinking water.

We combined all of these information elements, and predicted risk to individuals for each of these scenarios within each regulatory option. We also combined our estimate of individual risk with an estimate of population risk.

2.2 Calculation of Risks

This section describes the methodology used for calculating human health risks in the UST Model and presents examples of these calculations. PRA generated a separate benzene concentration profile (showing predicted concentrations over time at a fixed depth) for each combination of vadose zone type, floating plume size, ground-water velocity, and exposure well position. The risk estimation methodology produces an estimate of human health risks for each concentration profile that is dependent on the size of the population affected at the exposure well and the duration of the exposure.

The first step in calculating risk is to limit the number of years of exposure according to the duration of the plume. Under the assumption that the plume is removed when the leak is detected, benzene concentrations at exposure wells occur only prior to detection.

The next step is to adjust the initial concentrations predicted by PRA's transport model by a loading rate factor, to take into account the benzene mass loading rate to ground water. This adjustment factor enters the calculation of risk as shown in equation (1):

$$CA_i = ML * Co_i \qquad (1)$$

where:

CA_i = adjusted benzene concentration (ug/l)

ML = mass loading adjustment (dimensionless)

Co_i = initial predicted concentration (ug/l).

Yearly benzene concentrations in drinking water are converted into chemical doses to exposed individuals. The risk estimation methodology predicts chronic effects and is based on lifetime chemical dose. Therefore, yearly chemical concentrations must be transformed to average lifetime dose levels in mg/kg-day. The yearly concentration is converted to an annual dose by assuming that average human body weight is 70 kg, and absorption efficiency is 100%, thereby yielding equation (2) for the yearly dose computation:

$$D_i = (2\ l\ /70\ kg/day) * CAi\ (ug/l) = 0.029 \qquad (2)$$

where:

D_i = yearly dose in mg/kg-day

0.029 = conversion factor of concentrations in ug/l into dose in mg/kg/day.

The yearly dose profile is then transformed into a profile of 70 year average doses, assuming an individual life span of 70 years using equation (3):

$$DA = \sum_{t=i-70}^{i} D_i / 70 \qquad (3)$$

where:

DA = average lifetime dose (mg/kg/day)

i = current year.

Finally, carcinogenic risk is predicted in each year for an individual having received a full lifetime exposure using equation (4):

$$R = 1 - \exp(-H * DA) \qquad (4)$$

where:

R = lifetime individual risk

H = potency or unit risk of benzene $(mg/kg\text{-}day)^{-1}$

DA = lifetime average dose (mg/kg-day)

Population risk is calculated by multiplying individual risk by the number of people exposed.

2.3. Examples of Risk Scenarios

In order to make the risk estimation procedure more concrete, we have constructed two specific scenarios to use as examples. One is a typical or median situation, in that its individual characteristics would not lead us to label it either a particularly high or particularly low risk case. Partly to emphasize the wide range in characteristics related to risk, and partly to make clear that the typical case is not the only type of risk scenario considered, we have structured the second example to be a high-risk case.

2.3.1 A Typical Risk Scenario

In this scenario, there is a gasoline storage tank situated in a sand aquifer, where ground water is moving 1.0 meter per day. The nearest downgradient private well is 100 m away. The nearest public well is much further away, on the other side of a small river, and thus would not be affected by any releases from the UST.

The tank begins to leak, slowly at first, so that the loss of product is not immediately noticed (given the inventory control procedures used by the UST operators). The leak rate grows over time until the leak is detected at the end of two years. By the time of detection, the release has formed a roughly circular floating plume 100 m2 in area.

2.3.2 Predicted Concentrations and Risks in the Typical Risk Scenario

For this scenario, PRA's transport model calculates initial concentrations for the two years as shown in Exhibit F.1. Given the aquifer type, the loading rate adjustment was 3,500 meaning that the injection of benzene into the ground water from the floating plume is 3,500 times as fast as would be predicted on the basis of diffusion across the area of the floating plume/ground water interface alone. The application of this adjustment factor yields the adjusted concentrations shown in the second column of Exhibit F.1.

The yearly dose for each individual using the well computed using equation (2) are shown in the third column of Exhibit F.1.

The average lifetime dose is calculated using equation (3), and is shown in the fourth column of Exhibit F.1. Finally, the risk computed in each of the years is shown in the last column.

Population risk at this well in this individual scenario is equal to the number of individuals using the well times the individual risk shown in Exhibit F.1. Population risk for the release would include additional risks for any other wells affected by the release. Because it was assumed that the exposure well is the closest to the UST, the risks to the individuals using it would be designated as the risks to the most exposed individuals (MEI) for this tank.

EXHIBIT F.1

COMPUTATION OF RISKS FROM A TYPICAL SCENARIO

(assumes sand aquifer, 100 m^2 plume, two year duration, nearest well at 100 m, and ground-water velocity at 1.0 m/day)

Year	Initial Concentration (mg/l)	Adjusted Concentration* (mg/l)	Yearly Dose (mg/l)	Lifetime Dose (mg/l)	Lifetime Individual Risk
1	4.28 E-9	1.48 E-5	4.28 E-7	6.11 E-9	1.8 E-10
2	2.03 E-5	7.07 E-2	2.03 E-3	2.92 E-5	8.5 E-7

* Adjustment factor = 3,500.

Source: UST Model outputs and calculations by ICF.

2.3.4 A High Risk Situation

Some factors tending to increase risk include larger plumes; longer lasting plumes; slower ground water (which raises maximum concentrations and thus maximum risks for nearby wells); closer exposure wells; more individuals exposed per well; and more exposure wells. One composite high-risk scenario could consist of several of these factors combined. We present below the risk calculations for a scenario in which a tank is located in a sandstone aquifer, and leaks for ten years before the release is discovered, creating a 3,500 m^2 floating plume. In addition, the ground-water velocity is slower, at 0.1 meters per day rather than 1.0. The nearest exposure well is only 50 meters away.

2.3.5 Predicted Concentrations and Risks in a High Risk Scenario

Exhibit F.2 presents the calculations used to estimate risks from the release to individuals at the nearest well. MEI risks are more than 1,000 times higher than in the more typical case, and population risks for this well are also much higher. Population risk from the release would be calculated with data on individual risks at all of the affected wells.

2.4 Constituents of Concern in the Release

2.4.1 Composition of Gasoline

Gasoline is a complex mixture of chemicals largely composed of hydrocarbons. Modeling all of the compounds present in gasoline and evaluating their potentially harmful effects would be an enormous effort. A more manageable approach for predicting health effects from gasoline is to select chemicals to serve as surrogates for the complex mixture. In order to pick the most effective chemicals to use in modeling gasoline, a variety of factors were considered. These included composition of gasoline and the relative concentration of constituents both in the complex mixture and in its aqueous solution; toxicity and health hazards caused by gasoline as a whole as well as by individual constituents; and factors affecting exposure potential, such as mobility and persistence.

Theoretically 1,200 to 1,500 different hydrocarbons could be present in gasoline. However, only 100-200 compounds are likely to exist in concentrations that can be identified at the levels of detection of current analytical techniques (Shehata, 1983). Ninety-eight percent of these compounds are hydrocarbons. Composition of gasoline varies according to the source of crude oil, variations in the individual petroleum streams used to blend gasoline, selection of the stream used in blending, and the season of the year for which the gasoline is blended. Despite this variability, similar components can be found in most gasolines; although the concentrations of these components are quite variable (Shehata, 1983).

EXHIBIT F.2

COMPUTATION OF RISKS FROM A HIGH-RISK SCENARIO

(assumes sandstone aquifer, 3500 m2 plume, ten year duration, nearest well at 50 m, and ground-water velocity at 0.1 m/day)

Year	Initial Concentration (mg/l)	Adjusted Concentration* (mg/l)	Yearly Dose (mg/l)	Lifetime Dose (mg/l)	Lifetime Individual Risk
1	2.95 E-9	5.86 E-6	1.7 E-7	2.4 E-9	1.0 E-10
2	1.89 E-5	3.35 E-2	9.7 E-4	1.4 E-5	4.0 E-7
3	2.76 E-4	5.48 E-1	1.5 E-2	2.3 E-4	6.7 E-6
4	1.07 E-3	2.13	6.2 E-2	1.1 E-3	3.2 E-5
5	2.39 E-3	4.75	1.4 E-4	3.1 E-3	8.9 E-5
6	5.87 E-3	11.66	3.4 E-1	7.9 E-3	2.3 E-4
7	7.73 E-3	15.36	4.4 E-1	1.4 E-2	4.1 E-4
8	9.61 E-3	19.09	5.5 E-1	2.2 E-2	6.4 E-4
9	1.14 E-2	22.65	6.6 E-4	3.1 E-2	8.9 E-4
10	1.3 E-2	25.83	7.5 E-1	4.2 E-2	1.2 E-3

* Adjustment factor = 1,987.

Source: UST Model outputs and calculations by ICF.

Additives are added to gasoline to improve its performance as a motor fuel. These compounds may be added for antiknock properties, or as antioxidants, surfactants, and deposit modifiers. They are usually added in very small quantities. Some of the additivies to leaded gasoline, including tetraethyl lead, and ethylene dibromide (EDB) are quite toxic. However, the phase-out of leaded gasoline will serve to lower the concentration and amount of lead and EDB stored in tanks, reducing their significance as ground-water pollutants.

2.4.2 Health Hazards from Gasoline and Its Constitutents

Few studies on whole gasoline are available; the Carinogen Assessment Group (CAG) has derived a risk value for whole gasoline but it was derived from an animal bioassay rather than human studies. An effective chemical surrogate for gasoline should be present in significant quantities and also be responsible for a significant portion of the toxicity expected from gasoline. Therefore, in order to identify effective surrogate chemicals for gasoline it is important to determine components in gasoline that are responsible for the majority of its toxicity. Gasoline can be divided into four major classes of hydrocarbon components: alkanes, olefins, alicyclic compounds, and aromatic compounds; chemical additives also should be considered. A good general discussion of the toxicity of these gasoline constituents can be found in Drinking Water and Health, written by the National Academy of Sciences (1982). This report states that the alkane fraction of gasoline has relatively low toxicity, the olefin fraction exhibits little toxicity other than weak anesthetic properties, and the alicyclic hydrocarbons act as general anaesthetics and have depressant effects on the central nervous system with a relatively low degree of acute toxicity. The alicyclic compounds are not cumulative and have little, if any significant toxicity upon prolonged exposure.

The report also indicates that aromatic hydrocarbons generally have been regarded as the most toxic fraction of petroleum and petroleum solvents, and that this fraction is also the most soluble in water. The aromatic fraction contains benzene, alkyl derivatives of benzene, and small quantities of various polynuclear aromatic hydrocarbons. Benzene, because of its volatility, unique myelotoxcity, and carcinogenic potential, is the most toxic component. The toxicity of toluene, the xylenes, and other alkylated benzene derivatives is considerably lower. Although chemical additives have a fairly high degree of toxicity, their concentrations in gasolines are quite low. Moreover, they have a relatively low solubility in water.

Consequently, the report concludes that an assessment of the toxicity of drinking water contaminated by crude oil or refined petroleum products should focus on the aromatic fraction. Further it determines that, because benzene is the most acutely toxic member of the aromatic fraction and also has the highest solubility in water, the toxicity of drinking water polluted by crude or refined petroleum will be determined largely on the basis of benzene content.

Based on the discussions in the National Academy of Sciences report and the concentrations of individual chemicals in gasoline we identified the toxic properties and potencies of benzene, toluene, ethyl benzene, and ethylene dibromide. Using standard EPA intake assumptions and the acceptable chronic intake levels, we calculated acceptable ground-water concentrations for each of these chemicals assuming that all the exposure to a given pollutant comes from ground water.

A comparison of these concentrations showed that EDB produces serious effects at much lower concentrations than the other chemicals under consideration, and that concentrations of benzene producing significant harmful effects are considerably lower than those of the alkylated aromatics. Because EDB is an additive to leaded gasoline only, both EDB and benzene should be modeled as the chemicals of concern for leaded gasoline. For unleaded gasoline, the chemical of concern based on health effects should be benzene alone. The Carcinogen Assessment Group has determined a unit risk value of 0.029 $(mg/kg/day)^{-1}$ for benzene and this value is derived from human epidemiologic data.

In addition to toxicity, the exposure potential for possible surrogate chemicals for gasoline was considered. Consideration was given to factors affecting the environmental fate and transport of components of gasoline as well as their toxicity and concentration. A paper by Johnson and Dendrous (1984) reports that "the primary mode of gasoline migration occurs after the gasoline product has dissolved in ground water ... Thus, the hydrocarbons that dissolve into the ground water constitute the greatest threat to public water supplies." Both EDB and benzene are fairly soluble.

Benzene has a water solubility of 1.75×10^{3} mg/l (U.S. EPA, 1984A) and EDB has a water solubility of 4.3×10^{3} mg/l (Verschueren, 1983). Toluene has a water solubility of 5.3×10^{2} mg/l (U.S. EPA, 1984B), which is similiar to those of ethyl benzene and xylene. Hexane, a representative of the aliphatic compounds, has a solubility of 9.5 mg/l (National Academy of Sciences, 1982). Benzene, because of its high water solubility compared to other hydrocarbon components of gasoline, may be concentrated by a factor of ten in the water soluble fraction of gasoline (the portion that dissolves in ground water and migrates with it) (Guard et. al., 1983).

Once dissolved in ground water, components of gasoline may move with the ground water, absorb to soil, or be degraded by biological and physical mechanisms. Evidence in the literature suggests that straight-chain paraffins are the most susceptible to microbial degradation (Davis et. al., 1972). Cycloparaffins have been found to be poorly oxidized by microorganisms (Van der Linden and Thijsse, 1965). Biodegradation of aromatics has been reported but not quantified (Brookman et. al., 1985), and evidence suggests that it may be slow in anaerobic environments. Basically, the conclusion for benzene biodegradation is that it is possible, even probable in some environments, but not sufficiently generalizable or quantifiable to justify rapid biodegradation in general modeling efforts. EDB is very slowly degraded, having a reported half-life for chemical degradation of 2.5 years (Vogel and Reinhard, 1983).

Absorption to soil particles varies depending on pH, organic content of the soil, soil moisture content, consistency of soil, and temperature (Brookman et. al., 1984). Some generalizations have been made suggesting that the absorbability of hydrocarbons decreases in the order of olefins ≥ aromatics ≥ cycloalkanes ≥ alkanes (Houzim, 1978). Higher molecular weight hydrocarbons absorb preferentially in all hydrocarbon systems and soils (Moore, 1976), suggesting that benzene will be the least absorbed aromatic hydrocarbon. Other studies report that benzene is not greatly absorbed in soil or some kinds of clay (Rodgers et. al., 1980). Consequently, benzene will migrate with the ground water and will not be greatly attenuated.

2.4.3. Conclusion

In light of the information on toxicity, concentration, and exposure potential, benzene appears to be a reasonable chemical to serve as a surrogate for gasoline exposure and health effects. Benzene appears in concentrations ranging from 0.5 to 5 percent of the total gasoline volume. It is one of the most toxic chemicals in gasoline. Certainly it is the most toxic chemical appearing in significant concentrations, especially in unleaded fuel, which does not contain EDB. Unleaded fuel already accounts for 60 percent of gasoline demand and will continue to increase its share of the gasoline market. EPA has proposed complete elimination of leaded gasoline as early as January 1988, reducing further the problem of lead and EDB contamination. Benzene is one of the more soluble components of gasoline and is only moderately adsorbed onto the soil, resulting in a high exposure potential. Consequently, benzene is the best choice to represent risks from gasoline exposure, although EDB may also be modeled for leaded gasoline.

We chose to use the Carcinogen Assessment Group's unit risk value (0.029 $(mg/kg/day)^{-1}$) for benzene rather than a risk value derived from a recent animal bioassay for whole gasoline because the former value was derived from human epidemiologic data. This represents an upper bound (95 percent-level) confidence limit on the carcinogenic potency of benzene. Preliminary calculations suggest that the use of value for whole gasoline would raise estimated risks by less than a factor of two. Also, we believe benzene is better choice than gasoline to determine risk because the components of gasoline would separate as they moved within the ground water so exposure to whole gasoline is unlikely to occur.

2.5 Rate of Transfer of Benzene from the Floating Phase to Ground Water

We determined that there are three potential rate-limiting steps for the concentration of benzene in the aqueous plume. These are the total mass of benzene available (i.e., the benzene mass leak rate), the transfer rate across the pore surface area within the floating plume, and the infiltration leaching rate. Each of these values was calculated as shown in the equations below for different plume sizes and vadose zones, and the slowest rate for each combination of plume size and vadose zone was used as the rate of transfer from the floating plume to the aqueous phase.

LEAK RATE = A x T x P x F x Dens / Dur

A = floating plume area,
T = floating plume thickness
P = porosity,
F = fraction of pore space occupied by gasoline,
Dens = density of benzene in gasoline,
Dur = duration of leak

TRANSFER RATE ACROSS PORE AREA = A x T x SVR x Flux

SVR = surface to volume ratio,
Flux = flux across surface

INFILTRATION LEACHING RATE = A x I x S

I = net infiltration,
S = solubility of benzene in a gasoline: water system, assumed to be 55 mg/L.
I = W x (1 - RO) x (1 - E), where
W = available water (precipitation + pad washdown),
RO = runoff coefficient (assumed to be 0.90), and
E = evaporation coefficient (assumed to be 0.25).

Values for T, P, F, SVR, and Flux are provided in Exhibit F.3.

2.6. Transport Modeling to Estimate Benzene Concentrations

Three different ground-water velocities were considered (0.1m/day, 1m/day, and 5m/day) in order to cover the range of velocities for the different vadose zone types. The model used was a modified version of the Wilson-Miller analytic solute transport model, which simulates concentrations that result fnom a point-source contaminant release. We used multiple benzene injection points in order to simulate a source of finite area. The retardation factors for most aquifer media fall in the range of four to twelve and we chose a mid-range value (7.6) to represent the retardation factor in all media. The variation in predicted concentration using difficult retardation factors is not great.

We used the model to estimate benzene concentrations at 30 wells screened two meters below the surface of the aquifer. The wells are located on a grid downgradient of the tank covering a range of distances that may be reached before the leak is discovered. The grid has wells on the centerline, and at 50m and 100m transverse to the centerline, at distances of 10, 25, 50, 100, 250, 500, 1000, 2000, and 2500m downgradient. No account was taken of effects of pumping drawdown on benzene transport nor of the fact that a well that pentrates the floating plume could withdraw part of this plume.

EXHIBIT F.3

VARDOSE ZONE PROPERTIES FOR CALCULATING BENZENE TRANSFER FROM THE FLOATING PLUME TO THE AQUEOUS PHASE

Vadose Zone Type	Symbol	Sandstone/Limestone/Shale	Sand	Silt/Clay	Metamorphic/Igneous
Floating Plume Thickness, m.	T	0.11	0.11	6.6	0.11
Porosity	P	0.35	0.35	0.425	0.35
Fraction of Pore Space Occupied by Gasoline	F	0.6	0.6	0.6	0.6
Surface/Volume Ratio, m^{-1}	SVR	980,000	31,000	4,300,000	310,000
Flux, $mg/(M^2\text{-sec})$	Flux	5.5×10^{-7}	5.5×10^{-7}	5.5×10^{-7}	5.5×10^{-7}

2.7 Type of Aquifer

The modeling was done under the assumption that the ground water being contaminated is found in unconfined, surficial aquifers. It was also assumed that exposure to humans is through ground water from wells that tap into these unconfined aquifers. In an unconfined aquifer, the water table (the dividing line between the saturated and unsaturated zones) forms the upper surface. Water from wells in unconfined aquifers comes from dewatering of the saturated zone. Transmissivities of unconfined aquifers may fluctuate and are a product of aquifer hydraulic conductivity and the thickness of the saturated zone. These aquifers are in direct communication with the ground surface by percolation through the unsaturated zone. Thus, unconfined aquifers have a higher potential for contamination than confined or semi-confined aquifers because of their direct communication with the surface.

2.8 Duration of Exposure

2.8.1 Detection of Leak

In all cases we assumed that exposure would stop within one year of detection of a gasoline leak from an underground storage tank. We did not consider cases where tank owners or operators do not take corrective action after detecting a leak.

2.8.2 Taste/Odor Threshold for Gasoline

We predicted risks based on two sets of assumptions; in both scenarios leak detection stops exposure (see above). In the first scenario, exposure ceases earlier if the modeled levels of gasoline in the plume correspond to a total gasoline concentration that exceeds the taste or odor threshold; in the second scenario concentrations above the taste/odor threshold do not terminate exposure.

Taste and odor can serve as an indicator of ground water contamination from gasoline that has leaked from underground storage tanks because some of its constituents can be detected by the taste and odor they impart to the ground water. It is unlikely that people will drink contaminated water if it has a noticable taste or odor, so taste and odor thresholds are key factors in determining whether water contamination by gasoline poses a significant risk to human health. If chemicals are present in concentrations above their odor threshold, the presence of contamination will be noticed, and we assume consumption of contaminated water will be halted, and further risk will be averted. If an odorous compound is not present, or is present in insufficient concentration, the contamination will not be detected and exposure will continue.

Taste and odor thresholds are subjective and great discrepancies exist in the literature between thresholds for individual chemicals. In addition, the components with the lowest toxicological thresholds may not be the ones with the lowest taste and odor thresholds. Thus, certain components can serve as warning flags but may not be hazardous themselves. Based on the threshold values of certain components, a value for the taste/odor threshold for gasoline can be determined and it can be assumed that this threshold will limit ingestion exposures to benzene and other toxic components of gasoline.

Because no threshold values for gasoline could be found in the literature, the taste/odor threshold for gasoline was based on those of its components. Taste or odor thresholds from aqueous solutions are available for only three major components of the water soluble fraction (WSF): benzene, toluene, and ethylbenzene. Benzene appears to have the highest threshold value which is over an order of magnitude higher than that of ethylbenzene, as determined by Alexander (1982). Benzene is, however, the most soluble of the three compounds, and thus is likely to appear in considerably larger concentrations in ground water. Considering concentration in gasoline, solubility, and theresholds, it is unlikely that using toluene or ethylbenzene rather than benzene would result in significantly different threshold values. In fact, analyses of the WSF of gasoline (Guard et. al., 1983) have shown similiar concentration and percent ranges for benzene and toluene; the ratio of benzene to toluene is 1 to 1.3.

Although it is likely that chemical odors or taste are additive, we were unable to locate any significant experiments concerning additivity of thresholds so, to be conservative, no assumption about additivity was made. Benzene odor thresholds for aqueous solutions range from 33.3 mg/l to 0.072 mg/l in the sources we identified. The 0.072 mg/l threshold should be considered a minimum value because the experimental conditions and sensitivity of the panelists are likely to bias the results to give lower thresholds. The taste threshold for benzene in water was reported as 0.5 mg/l. Published toluene odor threshold values are less variable than those reported for benzene, with an average of 2.2 mg/l (or ppm) and should provide a better indicator of an odor threshold for the general population. If the ratio of benzene to toluene is assumed to be 1 to 1.3, this odor threshold would cause detection of ground-water contamination at a benzene concentration of approximately 1.7 mg/l. Thus, we used 1.7 mg/l (benzene) as the effective odor threshold for modeling.

2.8.3 Dermal and Inhalation Exposure

None of our scenarios considers dermal or inhalation exposure from continued use of water for washing or showering after ingestion ceases. Work performed since these model runs were completed indicates that dermal exposures may exceed ingestion exposures, and inhalation exposures are similar to ingestion exposures. Moreover, these exposures could continue, via washing and showering, even after a leak is detected and bottled water is substituted for well water for cooking and drinking purposes. Therefore, we may have underestimated risks by neglecting these exposure routes.

3. ESTIMATING SCENARIO FREQUENCIES

This section describes the methods used for calculating the frequencies of each scenario. Topics covered are the way tank ages and aquifer depth distributions are built into the UST Model; the UST Model outputs in terms of plume size and duration distributions; estimated distributions of aquifer materials and ground-water velocities; estimates of exposed populations; and distributions of distances from tanks to the nearest wells. In addition, the estimated frequencies of the sample scenarios introduced in Section 2 are presented.

3.1 Distributions of Floating Plume Size, Incorporating Tank Age and Ground-Water Depth

The data on the releases used in the risk estimation process include, as covered in Section 2, the area of the floating gasoline plume, the length of time it exists before it is detected, and its hydrogeological setting. This section explains how the UST Model outputs are combined with information on the distribution of hydrogeological characteristics to yield detailed joint frequency distributions of plume characteristics.

The UST Model analysis is intended to simulate the releases from the entire national population of USTs over the next thirty years. Because the relevant characteristics of this population are so diverse, a large number of separate simulations must be performed, varying the characteristics from one simulation to another. For technical reasons, the simulations are grouped in runs tracking the performance of 500 tanks each; some characteristics are varied within each run while other characteristics are varied only between runs.

Within each run, each simulated tank is assigned an age as of the promulgation of the regulations: five, ten, fifteen, twenty, or twenty-five years. The proportion of each 500 tanks assigned to each age group is determined on the basis of data on actual age distributions by type of tank; these distributions are shown in Exhibit F.4. Each of the 500 tanks within a run is also assigned a depth to ground water: 1.0, 3.5, 7.5, 15, or 25 meters, in proportion to PRA estimates of the frequency with which these depths occur for given aquifer types. PRA made these estimates based on a mapping effort described below. These frequencies are shown in Exhibit F.5. Exhibit F.6 shows one example of a joint distribution of tank ages and ground-water depths used in a run with a specific tank type and aquifer composition.

Between runs, the most important variables that are changed are the aquifer material, the type of tank, and the leak detection methods employed. Two types of existing tanks and as many as six different aquifer materials were used for the UST Model runs for each set of detection assumptions. All of the runs were the same size; thus, to ensure that the outputs reflected the characteristics of the population as a whole, the outputs were weighted by estimates of their frequency before being combined into weighted averages.

EXHIBIT F.4

DISTRIBUTION OF EXISTING TANK TYPES AND AGES

TANK AGE:	5	10	15	20	25	TOTAL BY TYPE
BARE STEEL	4%	8%	28%	24%	36%	100%
FIBERGLASS	50%	30%	20%	0	0	100%

Source: SCI estimates.

EXHIBIT F.5

DISTRIBUTION OF DEPTHS TO GROUND WATER BY AQUIFER TYPE

	DEPTH FROM GROUND SURFACE TO TOP OF WATER TABLE (METERS)				
	1	3.5	7.5	15	25
AQUIFER TYPE					
SANDSTONE/LIMESTONE/SHALE	2%	6%	55%	30%	7%
SAND/GRAVEL	5%	33%	29%	31%	2%
IGNEOUS/METAMORPHIC	6%	0%	0%	17%	77%
SILT/CLAY	0%	13%	49%	31%	8%

Source: PRA estimates.

EXHIBIT F.6

EXAMPLE OF JOINT AGE/GROUND WATER DEPTH DISTRIBUTION: BARE STEEL EXISTING TANK; SAND/GRAVEL AQUIFER TYPE

PERCENTAGE OF TANKS

TANK AGE AT PROMULGATION	DEPTH TO GROUND WATER (METERS)					
	1	3.5	7.5	15	25	TOTAL
5	0.2	1.3	1.2	1.2	0.1	4%
10	0.4	2.6	2.3	2.5	0.2	8%
15	1.4	9.2	8.1	8.7	0.6	28%
20	1.2	7.9	7.0	7.4	0.5	24%
25	1.8	11.9	10.4	11.2	0.7	36%
TOTAL	5%	33%	29%	31%	2%	100%

NUMBER OF TANKS IN A 500-TANK RUN

TANK AGE AT PROMULGATION	DEPTH TO GROUND WATER (METERS)					
	1	3.5	7.5	15	25	TOTAL
5	1	7	6	6	0	20
10	2	13	12	12	1	40
15	7	46	41	43	3	140
20	6	40	35	37	2	120
25	9	59	52	56	4	180
TOTAL	25	165	145	154	10	500

Source: Calculated from Exhibits F.4 and F.5.

The combinations of tank material and aquifer material used in the runs are shown in Exhibit F.7. The exhibit also shows the assumed frequencies of each combination, which were used to weight the outputs. EPA data on types of existing tanks were used to establish the weights for bare steel vs. fiberglass existing tanks: 89 percent bare steel vs. 11 percent fiberglass. A careful analysis by Pope Reid Associates, Inc.(PRA), of the joint distribution of service stations and hydrogeologic settings, based on work done by the Office of Pesticide Programs using the DRASTIC ground-water vulnerability index,[1] was used to establish the basic frequencies of aquifer material. These frequencies were then used as the basis for the frequencies used in the analysis, which combined some of the less frequently found aquifer categories with more common types found to yield similar outputs. For fiberglass tanks, which are much less common than bare steel tanks and less likely to leak, all aquifer types were represented by sand, to allow the analysis to concentrate on the bare steel tanks. Exhibit F.8 shows the originally estimated frequencies, and the way they were transformed into the frequencies used to weight the outputs.

3.2 Assumptions About Ground-water Velocities

The range of ground-water velocities near USTs, which affects the dilution of contaminant plumes as well as the speed with which the contaminant can reach a receptor, was represented by three discrete categories: 0.1 meters per day; 1.0 meter per day; and 5 meters per day. The relative frequencies of these velocities, which can be expected to vary by aquifer composition, were developed by PRA. The frequencies used in the analysis are shown in Exhibit F.9.

3.3 UST Model Outputs As Used

From each of the UST Model runs, the outputs used in the risk analysis are the floating plume areas and durations from all of the tanks. The floating plume areas are broken down into categories that range from less than one square meter up to 10,000 square meters. The average duration between the start of a release and the time it is detected is reported separately for each of the 9 size categories. An example of these outputs is provided in Exhibit F.10. The exhibit reveals that each run is divided into releases that take place before the original tank is replaced, and those releases that take occur after replacement. The total number of plumes in each size category, and the weighted average duration for each (weighting together the plumes from the existing tanks and the replacement tanks) is found by combining the two, as shown.

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[1] Aller, L. T. Bennett, J.H. Lehr, R.J. Potty, 1985. DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Sections. USEPA, Office of Research and Development, Ada, OK.

EXHIBIT F.7

DISTRIBUTION OF TANKS BY AQUIFER TYPE (INCLUDING ALL AQUIFER TYPES EXAMINED)

SANDSTONE/LIMESTONE/SHALE	21%
SAND	31%
GRAVEL	1%
IGNEOUS/METAMORPHIC	8%
SILT/CLAY	39%

Source: PRA estimates.

EXHIBIT F.8

DISTRIBUTION OF TANKS BY AQUIFER TYPE SHOWING COMBINATIONS USED IN ANALYSIS

BARE STEEL EXISTING TANKS:

	ORIGINAL	AS MODIFIED
SANDSTONE/LIMESTONE/SHALE	21%	21%
SAND	31%	40%
GRAVEL	1%	(COMBINED WITH SAND)
IGNEOUS/METAMORPHIC	8%	(COMBINED WITH SAND)
SILT/CLAY	38%	38%

FIBERGLASS EXISTING TANKS:

	ORIGINAL	AS MODIFIED
SANDSTONE/LIMESTONE/SHALE	21%	
SAND	31%	100%
GRAVEL	1%	
IGNEOUS/METAMORPHIC	8%	
SILT/CLAY	38%	

EXHIBIT F.9

JOINT DISTRIBUTION OF GROUND-WATER VELOCITIES AND AQUIFER TYPES

AQUIFER COMPOSITION	GROUND-WATER VELOCITY (METERS PER DAY) 0.1	1.0	5.0	TOTAL BY TYPE
SANDSTONE/LIMESTONE/SHALE	13.1	1.9	6.2	21%
SAND/GRAVEL/IG/META	0.9	19.5	19.2	40%
SILT/CLAY	6.7	23.0	9.1	39%
TOTAL BY VELOCITY	21%	44%	35%	100%

Source: PRA estimates.

3.4 Adjustment for First Plumes

In many cases, the UST Model predicts that more than one plume will form per tank over the thirty-year period studied. This can happen because both the existing tank and its replacement fail, or because a pipe failure associated with the existing tank could be followed by the failure of the tank. The data in Exhibit F.10, for example, shows an average of 1.13 plumes associated with each existing bare steel tank, and an additional 0.16 plumes for the replacement tanks, for a total of 1.29 plumes per installed tank.

There is a problem with assuming that two identical plumes from one tank cause a total of twice as much risk as one plume. We expect that after private wells near the tank have been found to be contaminated by the first plume, the wells' users will switch to another water source. Even if the first plume is cleaned up, it is unlikely that the lost private wells will ever be used again. This means that the second or third plume at a site will impose very little additional risk.

We have adjusted for this phenomenon by estimating the number of first plumes per tank that will occur within each floating plume size interval, based on the expected total number of plumes. The calculation method employed assumed only one tank per facility (which is more accurate for non-service station UST facilities than for service stations) and that the size distribution of first, second, and later plumes are identical. Under these assumptions, it is possible to estimate the number of facilities that have at least one plume, given the expected total number of plumes, as $1-e^{(-p)}$, where e is 2.721 (the base of natural logarithms) and p is the expected number of plumes per tank. For example, if the expected number of plumes per tank is 1.29, then the expected fraction of tanks with at least one plume is $1-e^{(-1.29)}$, or 0.72. This value gives us the expected number of first plumes per site, which can be compared to the expected total number of plumes per site. The ratio of these two values, 0.72/1.29, which is the the proportion of plumes that are first plumes, was multiplied by the expected number of plumes of each size category to yield an estimate of the number of first plumes in each size category. This assumes that the size distribution of plumes is the same for first plumes as for later plumes. The estimate of first plumes for the data in Exhibit F.10 is shown in Exhibit F.11.

3.5 Exposed Populations

We used two distinct approaches to estimating exposure. One was developed with the aim of predicting total population risks, whereas a separate, more conservative approach was used in predicting the distribution of risks to the most exposed individuals at each site.

Average densites of persons using private wells near USTs was calculated based upon data for a random sample of 1991 zip codes obtained by SCI, using data from the Federal Reporting Data System and the National Planning Data Corporation. For each zip code, we calculated the total population served by

EXHIBIT F.10

SAMPLE UST MODEL OUTPUT: DISTRIBUTION OF RELEASE SIZES AND DURATIONS

FLOATING PLUME SIZE (SQUARE METERS)	PLUMES PER EXISTING TANK	PLUMES PER REPLACEMENT TANK	TOTAL PLUMES PER TANK
0-1	0.02	0.01	0.03
1-10	0.06	0.05	0.11
10-25	0.05	0.04	0.09
25-100	0.18	0.03	0.21
100-500	0.38	0.01	0.39
500-1000	0.24	0.00	0.24
1000-2000	0.16	0.01	0.17
2000-5000	0.02	0.01	0.03
5000-10000	0.01	0.01	0.02
TOTAL	1.13	0.16	1.29

FLOATING PLUME SIZE (SQUARE METERS)	AVERAGE DURATION OF EXISTING TANK PLUMES (YEARS)	AVERAGE DURATION OF REPLACEMENT TANK PLUMES (YEARS)	WEIGHTED AVERAGE DURATION, ALL PLUMES (YEARS)
0-1	1.3	1.0	1.2
1-10	1.8	7.1	4.2
10-25	2.4	11.7	6.6
25-100	2.0	15.9	4.1
100-500	2.9	3.4	2.9
500-1000	4.2	--	4.2
1000-2000	6.8	13.7	7.1
2000-5000	9.0	14.5	10.1
5000-10000	4.5	--	4.5

* Run of 500 Bare Steel Existing Tanks, Combination of Ages and Ground-Water Depths, Sandstone/limestone/shale Aquifer, Base Case Assumptions

Source: UST Model Outputs.

EXHIBIT F.11

NUMBER OF PLUMES PER TANK ADJUSTED TO INCLUDE ONLY FIRST PLUMES

PLUME SIZE	TOTAL PLUMES PER TANK	ESTIMATED FIRST PLUMES PER TANK
0-1	0.03	0.02
1-10	0.11	0.07
10-25	0.09	0.05
25-100	0.21	0.12
100-500	0.39	0.22
500-1000	0.24	0.13
1000-2000	0.17	0.09
2000-5000	0.03	0.01
5000-10000	0.02	0.01
TOTAL	1.29	0.72

private wells and divided by the area in acres to get the population per acre served by private wells. We used service stations as a surrogate for tanks. The density of persons using private wells for each zip code was multiplied by the number of service stations in that zip code and the products were summed. Dividing this sum by the total number of service stations in the sample gave the average private-well-using population per acre. A similar method was used to calculate the population at risk per acre from public wells.

The areas around each exposure well in the ground-water modeling grid were calculated, and the average population at risk from both public and private wells was determined for each exposure well by multiplying this area by the total population at risk per acre. The population at risk for each exposure well is listed in Exhibit F.12. We then applied this population distribution to the individual risk, to give the cumulative population cancer risks for each plume size, ground-water velocity, and vadose zone type.

A potential weakness of the approach used to estimate average well-using population near USTs is that it is based on the population density over an entire zip code. This average density could be lower than the density immediately surrounding USTs, thereby leading to over-estimates of the distance from USTs to the nearest well. For the analysis of MEI risks, therefore, we used a case-by-case approach that looked explicitly for wells in the immediate vicinity of a sample of 45 actual service stations. These service stations all are located in zip codes where at least 90 percent of the population user water from private wells. The distance from the service station to the closest downgradient well was estimated using maps showing nearby structures, assuming that the tank was directly below the service station and that all nearby structures had private wells on site. These distribution factors were also used to weight the risk estimates. The cumulative frequency distribution for distance from tank to closest well is shown in Exhibit F.13.

3.6 Estimated Frequencies of Example Scenarios

By combining estimates of the joint distributions of plume sizes and frequencies; aquifer types; groundwater velocities, and well distributions, we estimate the total number of USTs that will fall into each scenario. These estimated frequencies are used to weight the estimated risks to generate nationwide distributions and totals. For example, we estimate that out of 1.4 million tanks, 14,844 will (in the base case) fall into the aquifer composition, plume size, and ground water velocity scenario represented by the "typical" case described in Section 2. Of these, 4,443 will have the closest well about 100 m away.

Similarly, for the high risk scenario, there will be 6,737 USTs with the same aquifer, plume, and velocity characteristics. Of those, 419 will also have the closest well 50 m away.

EXHIBIT F.12

POPULATION DISTRIBUTION AT EXPOSURE WELLS: NUMBER OF PEOPLE POTENTIALLY EXPOSED AT EACH WELL

Distance Downgradient, (meters)	Distance from Centerline (meters) 0	50 *	100*+
10	0.23	0.23	0.57
25	0.26	0.26	0.65
50	0.49	0.49	1.2
100	1.3	1.3	3.3
250	2.6	2.6	6.5
500	4.9	4.9	12.0
1,000	6.5	6.5	17.0
1,500	6.5	6.5	17.0
2,000	6.5	6.5	17.0
2,500	16.0	16.0	41.0

* The numbers displayed in the cells are for each (tranverse) side of the plume. The total population exposed for these wells is twice the number shown here.

+ The plume is assumed to potentially affect wells as far as 200 m from the centerline.

DISTANCE TO NEAREST WELL

Cumulative Frequency Distribution

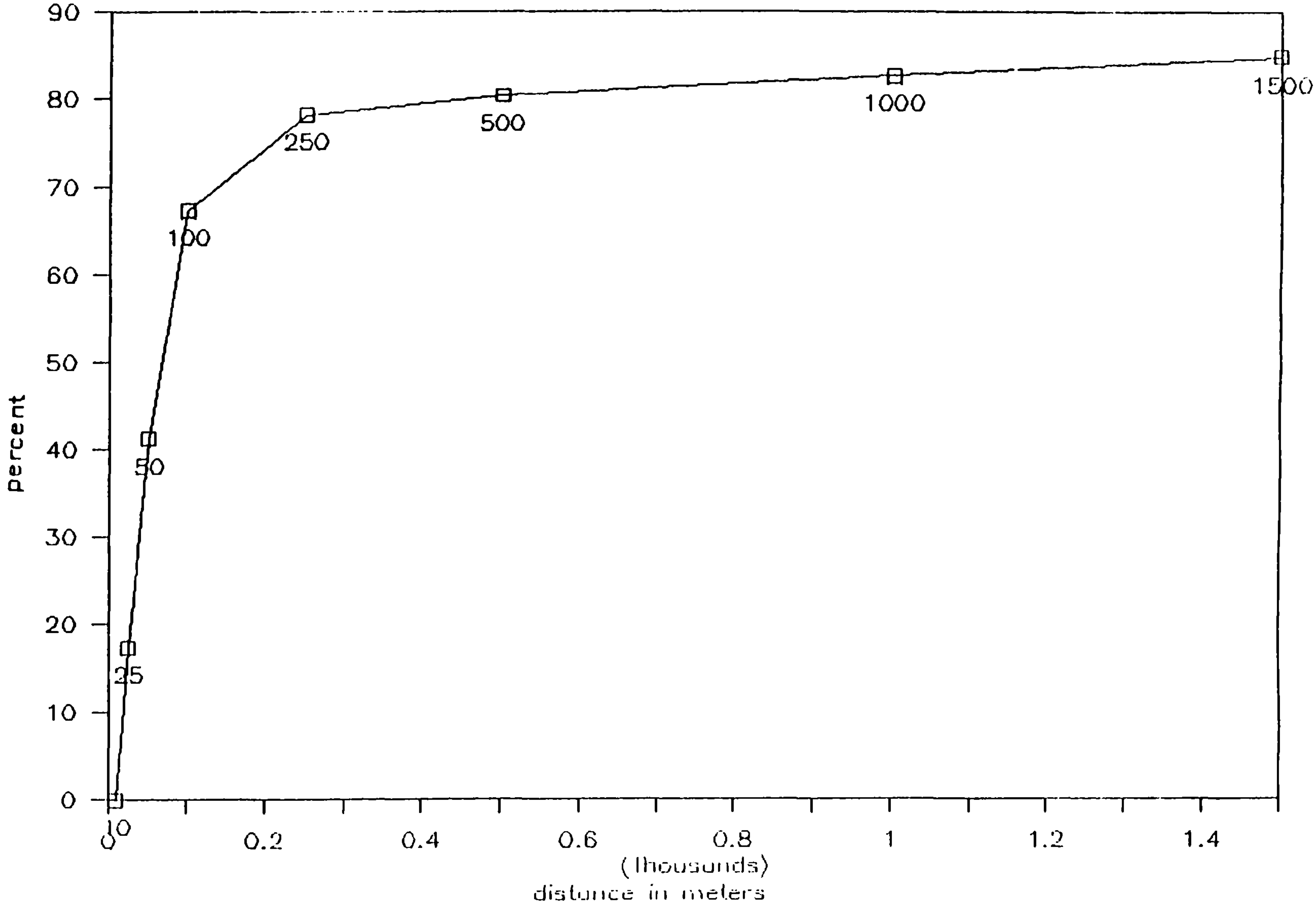

EXHIBIT F.13

4. COMBINING ESTIMATES OF RISK BY SCENARIO AND SCENARIO PROBABILITIES

The preceding sections described the details of the methodology used to calculate the risks imposed by a given release and exposure scenario, and the frequencies with which each specific scenario will occur. This section very briefly decribes the combination of these two basic steps to produce estimated maximum exposed individual (MEI) and population risks across all scenarios, again referring to the two example scenarios introduced earlier.

4.1 Estimating the Distribution of MEI Risk

Section 2 described the calculation of the risk to the most exposed individual in each of a large number of scenarios. Section 3 described the methodology used to estimate how commonly each of these scenarios occurs in the total population of 1.4 million USTs. These data were combined to yield a distribution of MEI risk. For example, by taking all scenarios with MEI risk between 10^{-3} and 10^{-2}, and adding their frequencies, we obtain the total predicted number of USTs out of the UST population that will impose risks between 10^{-3} and 10^{-2}. Repeating this procedure for each risk category yields the information needed to produce a complete distribution of MEI risks. The high risk scenario, for instance, imposes an MEI risk of 1.2×10^{-3}, and has a frequency of 419 USTs out of the entire population. The frequency of 419 would be added to the sum of the frequencies of all of the other scenarios imposing risks greater than 10^{-3} but less than 10^{-2}. The frequency of the typical risk scenario, 4,443, would be added to the frequency of the other senarios with risks of between 10^{-7} and 10^{-6}, which is the approximate degree of MEI risk associated with the typical risk scenario described in Sections 2 and 3.

4.2 Estimating Population Risk

To estimate population risk, the risk to each individual at an exposure well in each scenario is multiplied by the estimated number of individuals at that well to yield the total risk for each instance in which the scenario occurs. Multiplying by the scenario's frequency yields the total risk for all instances of that scenario. Summing these totals across all scenarios gives the total population risk imposed by all USTs. Carrying the high-risk scenario through this procedure yields risks of 1.2×10^{-3} per individual; given the assumption of 0.23 exposed individuals and the frequency of 419 per 1.4 million tanks, the high risk scenario by itself imposes a total of 2.5×10^{-1} cases. Similarly, the lower individual risk scenario contibutes 4.9×10^{-3} cases to the total, based on 4,443 tanks, 1.3 persons per well on average, and a risk of 8.5×10^{-7} per individual.

4.3 Comparisons Among Regulatory Alternatives

A separate MEI risk distribution and total risk estimate was prepared for the baseline and for each regulatory alternative, using data on plume sizes and durations generated by the UST Model under detection and prevention assumptions appropriate to each alternative. The separate MEI risk distributions and total risk estimates then allow risk-based comparisons to be made across alternatives.

5. ASSUMPTIONS MADE IN THE RISK ANALYSIS AND THEIR EFFECT ON RESULTS

As is clear from the preceding sections, the risk estimation methodology relies, at some crucial points, on assumptions for which supporting data are hard to find. This section summarizes the most important assumptions, the reasons they were made, and the most likely direction of any bias that the use of the assumptions imparts to the results.

5.1 Using Benzene Instead of Whole Gasoline or EDB

Risk estimates were based on the Carcinogen Assessment Group's unit risk value for benzene, rather than on estimates of the risks that either whole gasoline or EDB pose. The use of estimates for the risk of whole gasoline would, according to preliminary calculations, raise the estimated risk by less than a factor of two; the use of the estimate for EDB could increase the estimated risks by an order of magnitude. Thus, it would appear that the use of benzene as the basis for the risk estimates could mean that risks are underestimated.

Benzene was, nonetheless, considered the appropriate chemical of concern because the hazard it poses has been assessed using human epidemiologic data, and because it is and will continue to be widely present in gasoline. By contrast, the value for whole gasoline was based on an animal bioassay, and EDB will be phased out of gasoline rapidly. In the context of the regulatory impact analysis, risks from EDB are significant primarily for releases that began in the past but have not yet been discovered.

5.2 Confined vs. Unconfined Aquifers

The risk analysis assumes that all wells near USTs draw from unconfined, surficial aquifers. These aquifers, which are not protected from contamination in the unsaturated zone by any relatively impermeable confining layers, are much more vulnerable to releases from UST than deeper, confined aquifers. Predicted concentrations of benzene are therefore much higher than they would be if the analysis had included confined aquifers.

In some areas of the country large proportions of wells probably tap the less-vulnerable confined aquifers. Available data, however, did not allow a nationwide estimate of the relative proportions of confined and unconfined aquifers. For this reason, the more conservative assumption of 100 percent unconfined aquifer wells was made.

5.3 Depth of Well Screens

The risk analysis assumed that all wells are screened two meters below the surfaoe of the water table. That is, they draw water only at that particular level in the aquifer. Concentrations of benzene are relatively constant at varying depths at a distance of about 500 m or more from a source of contamination, but very close to a floating source of contamination the concentrations can rise dramatically near the top of the ground water table.

Most wells are probably screened at depths below two meters to minimize the chance that the well will be dry when the water table fluctuates, and to ensure a cleaner source of water. Thus, the assumption of a two-meter screen depth is a conservative one, more likely to result in overestimates of risks, rather than underestimates. Furthermore, any wells very near a source and screened very close to the water table's surface are likely to draw in some of the floating plume. This could be expected to lead to early detection of the plume, thereby reducing risk rather than increasing it.

5.4 Exclusion of Dermal and Inhalation Exposures

The risk estimates assumed all risk results from ingestion of benzene, with no significant contribution from other exposure routes. This assumption was made based on preliminary analysis showing that other routes, including dermal and inhalation exposures, could be expected to contribute only a small amount of risk incremental to that from ingestion.

Further analysis has shown that human health risks from leaking USTs may be significantly underestimated if dermal and inhalation exposures are ignored. The dermal dose of exposure to benzene may actually be somewhat greater than the ingestion dose, thereby making exposure through activities such as showering and bathing the major pathway for human health risk associated with leaking USTs. The underestimation of risk may be further exacerbated because, while ingestion exposures are likely to stop after the taste and odor threshold is reached, dermal and inhalation exposures might continue.

5.6 End of Exposure at the Time of Release Detection

The risk analysis assumed that all exposure stopped as soon as the release was detected. This assumption was based on the idea that detection would be associated with reporting of the release and notification of the affected individuals.

There may be cases, however, in which a release is detected and stopped by an UST operator but not reported to the authorities. In addition, there may be cases in which some of the wells affected are unknown to the authorities, who are therefore unable to notify the wells' users. In either case, some cases of ingestion exposure could continue long after the detection of the release. Dermal and inhalation exposure could, as noted above, continue even after notification and the end of ingestion exposure, depending on the nature of the response to the contamination of the well water.

This possibility of continued exposure means that the estimated risks are understated to some degree. This problem is exacerbated by the fact that the relationship between risk and length of exposure is supralinear, since the length of time raises both the duration and concentration of the exposure.

5.6 Benzene Transfer and its Dependence on Service Station Pad Washdown

The risk estimates are linearly related to the predicted rate of transfer of benzene from the floating plume to the ground water. As discussed in previous sections, this rate can be limited by a number of parameters, all of which are subject to some uncertainty. The frequency with which service station operators wash down the concrete pad covering the USTs is one area of uncertainty in predicting of the rate at which water infiltrating through the unsaturated zone influences the benzene loading rate. In the risk analysis, it was assumed that the pad is washed down (in the absence of rain) 350 days per year. If this is an overestimate of the frequency of pad washdowns, the reported results could be overestimates of risk. Further data collection indicates, however, that the assumed frequency of washdown is a reasonable estimate of the actual frequency at most well-operated service stations.

5.7 Estimates of the Distributions of Wells

As decribed in an earlier section, well locations were estimated differently for the purposes of estimating population and maximum individual risks. Estimates of total population risk were based on assumptions of independent distributions of wells and USTs across each zip code, since average densities of wells by zip codes were used as the basis of the estimates of the exposed populations at each well grid point. This analysis did not account for the possibility that, within a given area, wells and USTs may cluster in one heavily-populated subregion, where well densities near the USTs will be significantly higher than the value estimated for the area as a whole.

Preliminary analyses indicate that actual densities of wells near USTs could be two to three times higher than the estimates used in the analysis, due to the clustering of wells and USTs. The predicted population risk is proportional to the estimated density of wells; thus, the population risk as reported may be understated.

Estimates of the distribution of risks to the most exposed individual, on the other hand, were derived based on a small sample of actual service stations and distances to nearby structures. In order to allow the assumption that each nearby structure represented a well, the analysis was limited to regions known to use private wells almost exclusively. Because further analysis has tentatively shown that regions of high private well use are rare, and services stations are seldom found in these regions, it is clear that the estimated frequencies of MEI risks are significantly overstated by the analysis.

5.8 Risks from First Plume Only

The analysis assumed that after the first plume from an UST discovered, nearby private wells affected or potentially affected by contamination from the UST will be taken out of service. Any subsequent leaks will therefore impose no risk. This assumption could result in slight underestimates of risk to the degree that later plumes reach beyond the area contaminated by the first plume, into areas with wells that are still in use.

5.9 Use of Average Plume Durations, Combining Plumes from Existing and Replacement Tanks

As discussed in section 3, the risk analysis was based on numbers of plumes from both existing and replacement tanks, and the average plume duration for each plume size catagory. The use of average plume duration introduces a subtle form of distortion into the analysis, because of the fact that risks rise more than linearly in proportion to duration. The prevention of one or two plumes of short duration, which will reduce actual risk, will raise the average duration of plumes. This apparent increase in duration actually causes the estimated risk to increase, in spite of reduction in the number of plumes.

On the whole, this form of bias has little effect on the results. When regulatory alternatives with different degrees of effectiveness at preventing plumes are compared, however, this bias can mask the true relative risk reduction of the alternatives. This problem appears most clearly if the regulatory alternatives differ only in terms of their provisions for replacement tanks: the alternative that prevents the most releases in replacement tanks can appear to reduce baseline risk less than an alternative that allows releases to occur but detects them after a short time. By including a few more short-duration releases, the latter alternative's average release duration is pulled down, reducing the estimated risk associated with it. Because the plumes from the replacement tanks are probably not the first plumes at a site (because replacements are typically made after the existing tank has failed), and because the methodology is intended to focus on the risks of the first plumes only, it seems inappropriate that releases from the replacement tanks should affect the relative risk rankings of the alternatives. This distortion could be avoided in large part by performing the risk analysis separately on the plumes from existing tanks and the plumes from the replacement tanks.

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