Appendix G: Extrapolation Methods

APPENDIX CONTENTS

INTRODUCTION

EPA estimates both cost and benefits of environmental regulations based on a random stratified sample of MP&M facilities.[1] EPA then estimates national level costs and benefits by extrapolating analytic results from sample facilities to the national level using statistically determined sample facility weights.

Sample facility weights used in the benefit cost analysis of environmental regulations are based on detailed questionnaire stratification. Stratification means dividing the population of facilities into a number of non-overlapping sub-populations (strata). These strata consist of facilities that are homogeneous with respect to facility size (i.e., number of employees or revenue) or engineering characteristics such as wastewater flow because this information was not available at the time the sample frame was developed. The sample weights for facilities in the sample are based on the total population in each category and probabilities of selection in each stratum.

EPA traditionally uses a ***standard linear weighting technique*** (hereafter, traditional extrapolation) to estimate national compliance costs, changes in pollutant removals, and national-level benefits of environmental regulations. However, using sample weights that are based only on facility-specific (e.g., engineering) characteristics and various non-facility factors can lead to a conditional bias in the estimation of national-level benefits. In particular, this approach omits consideration of important non-facility factors that influence the occurrence and size of benefits.

Non-facility factors that are likely to affect the occurrence and size of benefits from reduced sample facility discharges and that are not reflected in the standard stratification and sample-weighting approach include the receiving water body type and size and the size of the population residing in the vicinity of a sample facility. Furthermore, co-occurrences of facilities discharging to the same reach may also affect the occurrence of benefits. Many of the environmental assessment and benefits analyses include comparisons of the estimated baseline and post-compliance pollutant concentrations (e.g., sludge concentrations or in-waterway concentrations) with the relevant threshold values. Because the effect of aggregate discharges from several facilities is likely to be different from the sum of effects from these facilities considered independently, it is also important to account for the likelihood of joint discharges of MP&M facilities to the same reach.

The Agency used two approaches to address omission of these important non-facility factors (i.e., water body type and size, affected population, and co-occurrence of MP&M discharges) in designing the MP&M facilities sample. First, EPA adjusted sampling weights through ***post-stratification*** using two variables receiving water body type and size and the size of the population residing in the vicinity of the sample facility. Section G.1 presents the method of doing this adjustment. Second, EPA used a ***differential sample weighting technique*** in developing national estimates of environmental effects and benefits. This method accounts for the presence of more than one facility with different sample weights discharging directly or indirectly (through a POTW) to reaches affected by multiple MP&M dischargers. Section G.2 of this appendix describes the differential sample weighting technique.

EPA used both the traditional extrapolation-based weights and the sample weights adjusted through post-stratification (hereafter, post-stratification extrapolation) to analyze the final MP&M rule's benefits. The benefit estimates based on the post-stratification extrapolation weights are used to validate general conclusions that EPA draws from its main analysis based on the traditional extrapolation method. In addition to developing national benefit estimates based on both traditional and

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[1] A census of all MP&M facilities was not performed due to the large size of the MP&M industry.

post-stratification extrapolation weights, EPA developed a third estimate of national benefits based on the Ohio case study results.[2] Section G.3 of this appendix discusses this method in detail. The Agency recognizes that the extrapolation method used for the Ohio case study results is not rigorous. Therefore, this method is used to supplement the main results.

G.1 USING RAKING TO ADJUST MP&M FACILITY SAMPLE WEIGHTS

Omitting information that affects the occurrence and size of benefits from the original sample frame's design may lead to conditional bias in MP&M rule benefit estimates. To address this problem, EPA used a post-stratification weight-adjustment method called ***raking*** to account for two additional variables that were not accounted for in the original sample design and that may affect benefit occurrence:

- physical characteristics of the receiving water body (including type and size); and
- size of the population residing in the vicinity of the sample facility.

G.1.1 Data Sources

EPA first classified the universe of MP&M facilities into different poststrata. The Agency relied on three data sources to identify discharge reach characteristics and the population size in the vicinity of the discharge reach:

1. EPA's Permit Compliance System database (PCS) indicated water bodies to which MP&M facilities discharge;

2. EPA's Reach File 1 (RF1) provided additional information on the receiving water bodies, including water body type, flow characteristics, and counties abutting these water bodies; and

3. Census data provided information on county populations.

The PCS database provides information on facilities covered by NPDES permits. The database covers only those facilities that discharge directly to surface or ground water. No information is available on the location of MP&M facilities that discharge to surface water indirectly or via POTWs. EPA therefore limited post-stratification to direct discharging facilities. The Agency used the resulting adjusted sample weights to estimate national-level benefits for only the final regulatory option, which covers only direct discharging facilities. Chapters 13 through 19 of this report present benefit estimates in various benefit categories considered in this analysis.

The extent of improvement in estimation accuracy depends on the reliability of the information used for post-stratification. Accordingly, it was necessary to understand and account for PCS database limitations in implementing a post-stratification approach. The PCS database is designed to provide information on a facility's SIC codes, facility flow, and receiving reach characteristics. These characteristics include water body name and type, stream ID, and stream flow. Although these data can be used to classify facilities in the identified poststrata, these fields are not always populated in the database. To fill missing data, EPA combined data from PCS with supplementary analyses and information from RF1, using the following framework:

- PCS provided a stream ID and information on the water body type and flow characteristics. EPA obtained stream characteristics from PCS and used the stream ID to obtain information on counties abutting the reach from RF1;

- PCS provided a stream ID, but not the water body type and flow characteristics. EPA used the stream ID to obtain information on water body type, flow characteristics, and counties abutting the reach from RF1;

- PCS provided water body name and type, but not stream ID and flow characteristics. EPA first used facility lat/long data to assign the PCS facility to the nearest reach that matches the water body name provided in PCS. The Agency then used the identified stream ID from RF1 to obtain information on water body type, flow characteristics, and counties abutting the reach from RF1;

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[2] See Chapter 21 for a detailed discussion the Ohio case study.

- PCS provided no receiving stream information on the, but facility lat/long data were available. EPA first used these data to assign the PCS facility to the nearest reach. The Agency then used the identified stream ID to obtain information on water body type, flow characteristics, and counties abutting the reach;

- PCS provided neither information on the receiving stream nor facility lat/long data. EPA assumed the distribution of the receiving water body characteristics, including the size of the population residing in the counties abutting the receiving reaches, to be similar to the distribution of these characteristics across facilities with known characteristics.

PCS identifies 4,290 direct discharging facilities with MP&M SIC codes that had active NPDES permits 1997. Of these, EPA classified 3,242 facilities into the poststrata considered in this analysis. Because the total number of PCS facilities with MP&M SIC codes differs from the sum of sampling weights of direct dischargers considered in the final regulation, the Agency assumed that the sum of the sampling weights provides the correct estimate of the MP&M facility universe. Thus, the count of facilities in the benefits analysis matches the number of MP&M facilities. This analysis yielded an adjustment factor of 2,832/ 3,242= 0.87 Table G.1 lists facility counts from PCS data, adjusted to equal the sample frame total.

Table G.1: Facility Counts from PCS Data
(Adjusted to Equal the Sample Frame Total)

First Variable: Water Body Type and Size		Second Variable: Population Size	
Variable Category	**PCS Facilities Count**	**Variable Category**	**PCS Facilities Count**
Bay-Lakes Combined	288	Pop≤100,000	934
Small Streams	543	100,000<Pop≤500,000	1155
Medium Streams	1514	500,000<Pop≤1,000,000	403
Large Streams	487	1,000,000<Pop≤2,000,000	276
		2,000,000<Pop≤4,000,000	47
		Pop<4,000,000	17
Total	2,832		2,832

Source: PCS data.

G.1.2 Raking Adjustment

Raking is a post-stratification method that can be used when multiple variables form the poststrata. If the original sampling weights need to be adjusted using post-stratification with two variables, then the analysis must create a set of poststrata resulting from the cross-classification of the two post-stratification variables. EPA's analysis used the following steps:

1. Combine the variables "water body type" (four categories), with "population size residing in the vicinity of the sampled facility" (six categories) to yield 24 poststrata.

2. Classify each sampled facility into one of the 24 poststrata.

3. Determine how many facilities fall into each poststratum.

4. Multiply the sampling weight of a facility in a poststratum by the ratio of the number of facilities in the population in the poststratum to the sum of the sampling weights of all facilities in that stratum. If the number of facilities in the population are known only by each category of the two variables, then the weights can be adjusted through raking.

This section briefly describes the raking procedure.

Water body type was one of the two post-stratification variables used for raking. EPA originally used six categories of this variable: Bay/Ocean, Great Lakes, Lakes, Lakes, Small Streams, Medium Streams, and Large Streams. However, the number of MP&M sample facilities in Bay/Ocean, Great Lake, and Lake categories was too small for some categories to implement raking. Therefore, EPA combined categories in which the number of facilities in the sample was either zero or too small to create four categories:

- Bay-Lakes Combined (includes, Bays, Oceans, Great Lakes and Lakes);
- Small Streams;
- Medium Streams; and
- Large Streams.

Table G.2 shows the number of sampled facilities in each category of water body type, the sum of the sampling weights of the sampled facilities, and the known number of facilities in the population in that category. Comparing the sum of the MP&M facilities sampling weights and the PCS-based count of facilities for each category of water body type shows that Bay-Lake Combined and Small Streams are under-represented in the MP&M sample frame while Medium and Large Streams are over-represented.

Table G.2: Facility Distribution by Water Body Type

Number of Facilities in the MP&M Sample Frame	MP&M Sample Frame		PCS Facilities	
	Number of Facilities in the Sample	Sum of the Sampling Weights	Number of Facilities in the Population	Ratio of Number PCS to Sample-Weighted Facilities
Bay-Combined	7	38.7	288	7.44
Small Streams	7	231.3	543	2.35
Medium Streams	43	1,439.4	1514	1.05
Large Streams	25	1,122.6	487	0.43
Total	82	2,832.0	2,832.0	1.00

Source: PCS data.

Table G.3 shows the six population categories created in the EPA analysis. Comparing the sum of the MP&M facilities' sampling weights and the PCS-based count of facilities corresponding to each category of water body type shows that facilities from the population size category of less than 100,000, greater than 4,000,000, and greater than 2,000,000 but less than 4,000,000 are over-represented in the sample. Conversely, facilities in the population categories from 100,000 to 500,000 and from 500,000 to 1,000,000 are under-represented.

Table G.3: Distribution of Facilities by Population Size

Population	MP&M Sample Frame		PCS Facilities	
	Number of Facilities in the Sample	Sum of the Sampling Weights	Number of Facilities in the Population	Ratio of Sample-Weighted to PCS Facilities
Pop≤100,000	18	1,303.0	934	1.40
100,000<Pop≤500,000	35	1,171.8	1,155	1.01
500,000<Pop≤1,000,000	12	136.3	403	0.34
1,000,000<Pop≤2,000,000	12	121.6	276	0.44
2,000,000<Pop≤4,000,000	3	61.8	47	1.31
>4,000,000	2	37.6	17	2.21
Total	82	2,832.0	2,832.0	1.00

Source: PCS data.

Raking is an iterative process in which adjusted sample weights are synthetically generated to match known characteristics of the population along single stratification dimensions and, as a result, should reflect the population characteristics within multi-dimensional stratification cells. The iterative process works as follows. First, EPA multiplied the sampling weight of each facility in each category of water body type by the ratio of the total number of facilities in the population to the sum of the sampling weights in that category. For example, using the numbers in Table G.2, EPA multiplied the sampling weights of all sampled facilities in the Bay-Combined category by the ratio 288/38.7 = 7.44. The sum of the adjusted weights, 38.72x 7.44=288.08, is the known population total. Similarly, EPA multiplied all the sampling weights of facilities in the Large Streams category by the ratio 487/1122.6 = 0.43, to yield 1,122.6x0.43= 482.7 as the sum of the adjusted weights. EPA performed the same calculations for the other categories of water body type.

These calculations match the sum of the sampling weights to the known control totals for the single stratification dimension of water body type. At this first step, however, it is very unlikely that the resulting sums will agree with the known number of facilities within categories of the second stratification dimension, population size category. Table G.4 shows the sum of the adjusted sampling weights and the PCS population totals by population sizes after Iteration 1.

Table G.4: Sum of the Sampling Weight by Population Category after Iteration 1

Population	Sum of the Adjusted Sampling Weights	Number of Facilities in the Population (PCS Based)
≤100,000	1,542.49	934
100,000<Pop≤500,000	728.62	1,155
500,000<Pop≤1,000,000	133.42	403
1,000,000<Pop≤2,000,000	294.18	276
2,000,000<Pop≤4,000,000	58.31	47
>4,000,000	74.99	17
Total	2,832.01	2,832

Source: U.S. EPA analysis.

To correct for this inconsistency, EPA multiplied each weight by the ratio of the known total to the sum of the adjusted weights for each facility in each population size category. For example, the Agency multiplied each facility in the first population category by the ratio 934/1542.49. Now, the resulting sum of the adjusted weights agrees with the category totals for the population category, but differs from the category totals for water body type.

EPA therefore repeated this process of sequentially adjusting sample weights *one dimension at a time* until the sum of the adjusted sampling weights simultaneously agreed with the total population counts of facilities for *both* water body type and population size categories. After seven iterations, the sum of the sampling weights agreed with PCS-based counts for both variables except for a difference of less than one.

Tables G.5 and G.6 show the sum of the sampling weights before and after this iterative process in each cell. Obtaining the estimated numbers in each cell of Table G.6 by aggregating the final raked sampling weights may yield better estimates of the cell populations than summing the original sampling weights in Table G.5.

Table G.5: Estimated Number of MP&M Facilities in each Poststratum before Raking

Population Size	Water Body Type				
	Bay-Combination	Small Streams	Medium Streams	Large Streams	Total
Pop≤100,000	0	151	1,114	38	1,303
100,000<Pop500,000	11	9	208	944	1,172
500,000<Pop≤1,000,000	1	25	31	79	136
1,000,000<Pop≤2,000,000	27	19	25	51	122
2,000,000<Pop≤4,000,000	0	0	51	11	62
>4,000,000	0	27	10	0	37
Total	39	232	1,439	1,122	2,832

Source: PCS data.

Table G.6: Estimated Number of MP&M Facilities in Each Poststratum after Raking

Population	Water Body Type				Total
	Bay-Combination	Small Streams	Medium Streams	Large Streams	
Pop≤100,0000	0	204	726	4	934
100,000<Pop≤500,000	112	50	575	418	1155
500,000<Pop≤1,000,000	16	210	126	51	403
1,000,000<Pop≤2,000,000	161	64	39	13	277
2,000,000<Pop≤4,000,0000	0	0	45	2	47
>4,000,0000	0	14	3	0	17
Total	289	542	1,514	488	2,833

Source: U.S. EPA analysis

Tables G.5 and G.6 show that sampling weights increase for small stream facilities in the population ≤100,000 category, while sampling weights decrease for medium and large stream facilities in the same population category, due to their over-representation in the sample.

G.2 METHODOLOGY FOR DEVELOPING SAMPLE-WEIGHTED ESTIMATES FOR SITES WITH MORE THAN ONE MP&M FACILITY

The MP&M analysis is based on a random stratified sample of MP&M facilities intended to provide detailed information about specific facility characteristics and to provide national estimates with these characteristics. They are not reach-specific sample weights designed to estimate the national occurrence of reaches associated with a specific characteristic of MP&M discharges. For example, the sum of MP&M sample facility weights discharging to one reach is an accurate estimate of the number of national *facilities* similar to the sample facilities, but is not a valid national estimate of all potential MP&M discharges to that reach or the number of *reaches* similar to that reach. Accordingly, to use the sample weights to estimate the number of similar facilities on similar reaches nationwide requires some adjustments to the standard sample-weight based extrapolation process.

It may not be valid to assume that the co-location of sample facilities is similar to the co-location characteristics of all MP&M facilities. This point is illustrated by the case in which two sample facilities with different weights discharge to the same reach. Assume that one of these two sample facilities has a sample weight of five and the other has a sample weight of 200. The sample weights indicate that there are four additional facilities in the U.S. that are economically and technically similar to the facility with the weight of five. It is also correct to estimate that the other four facilities will discharge the same volume of the same pollutants as the other four facilities. Now let us assume that there are 199 other facilities nationwide similar to the facility with the weight of 200. The more numerous facilities represented by the facility with a weight of 200 could only rarely be co-located with one of the four facilities represented by the sample facility with a weight of five.

EPA developed a method that accounts for joint occurrence on reaches of facilities with different statistical weights to estimate the number of reaches affected by MP&M facilities nationwide. EPA created a series of new discharge variables (a discharge event) for each reach affected by MP&M sample facilities, and assigned weights for the discharge events that provide a national estimate of pollutant discharges across all reaches. The sample discharge events (flows and pollutant loadings) are calculated based on the sum of the flows and pollutant loadings for subsets of the MP&M sample facilities that discharge to that reach. The weights for the discharge events are developed from the facility weights for those subsets of facilities. The calculation includes direct MP&M facility discharges and indirect discharges from POTWs (for options that include them) after considering pollutant removals from POTW treatment.

The number of discharge events on a sample reach equals the number of unique sample weights for the facilities on the reach. EPA calculated a sample weight for each discharge event based on the sample weights of the facilities contributing loadings and flows to the event. Table G.7 illustrates discharge event calculations and corresponding sample weights. Steps for calculating the relevant parameters for discharge events on reaches affected by multiple discharges are as follows:

- Rank pollutant loadings (or discharge flows) in ascending order of facility sample weight for each pollutant of concern discharged by one or more of those facilities.

- Generate the first discharge event loadings (or flows) as the total loadings (or flows) from all sample facilities on the reach. Assign the smallest sample weight to the first discharge event (Wt_1 in Table G.7) among the facilities discharging to the reach. A smaller sample weight relative to the others means that this facility represents no other population facilities that could occur jointly with the other facilities. The weight of the first facility is therefore considered as “used up,” and that facility’s loadings (or flows) are not included in subsequent discharge events defined for the reach.

- Generate subsequent discharge events by removing the loadings (or flows) of facilities with the smallest sample weight from a running sum of loadings (or flows) of all facilities in the ranking. The weight assigned to each subsequent event is the remaining *unused* weight of the facility with the smallest weight among the facilities remaining in the particular discharge event. Calculate this weight as the difference between the weight of the next facility in the ranking and the weight of the previous facility (Wt_2-Wt_1).

EPA avoids double counting indirect dischargers by including the discharge flow of any given POTW into a reach only once in any given discharge event, even when multiple sample facilities discharge indirectly into one POTW.

This methodology generates a set of discharge events (loadings or flows) for each pollutant discharged to the reach. The following steps illustrate application of the differential weighting technique to estimating the national number of reaches on which ***ambient water quality criteria (AWQC)*** are exceeded:

- assign a weight to each discharge event based on the weights of the facilities discharging to the reach;

- combine the effluent flow with the stream flow of the reach;

- divide the pollutant loading into the stream flow to determine the pollutant concentration caused by the event;

- compare pollutant concentration to AWQC values to determine whether the concentration exceeds those values;

- identify an estimated AWQC “exceedance” if the concentration is greater than a criterion; and

- give the AWQC exceedance event the weight of the discharge event, to establish national estimates of the number of reaches on which an AWQC is exceeded.

Table G.7: Construction of Discharge Events for Any Pollutant Discharged to Any Reach

Event Number	Loadings and Flows Assigned to Event	Weight Assigned to Event
One	$\sum_{i=1}^{N} Load_i \text{ or } Flow_i$	Wt_1
Two	$\sum_{i=2}^{N-1} Load_i \text{ or } Flow_i$	Wt_2 - Wt_1
⇓	⇓	⇓
N - 2	$Load_{N-2}$ + $Load_{N-1}$ + $Load_N$ $Flow_{N-2}$ + $Flow_{N-1}$ + $Flow_N$	Wt_{N-2} - Wt_{N-3}
N - 1	$Load_{N-1}$ + $Load_N$ $Flow_{N-1}$ + $Flow_N$	Wt_{N-1} - Wt_{N-2}
N	$Load_N$ +$Flow_N$	Wt_N - Wt_{N-1}

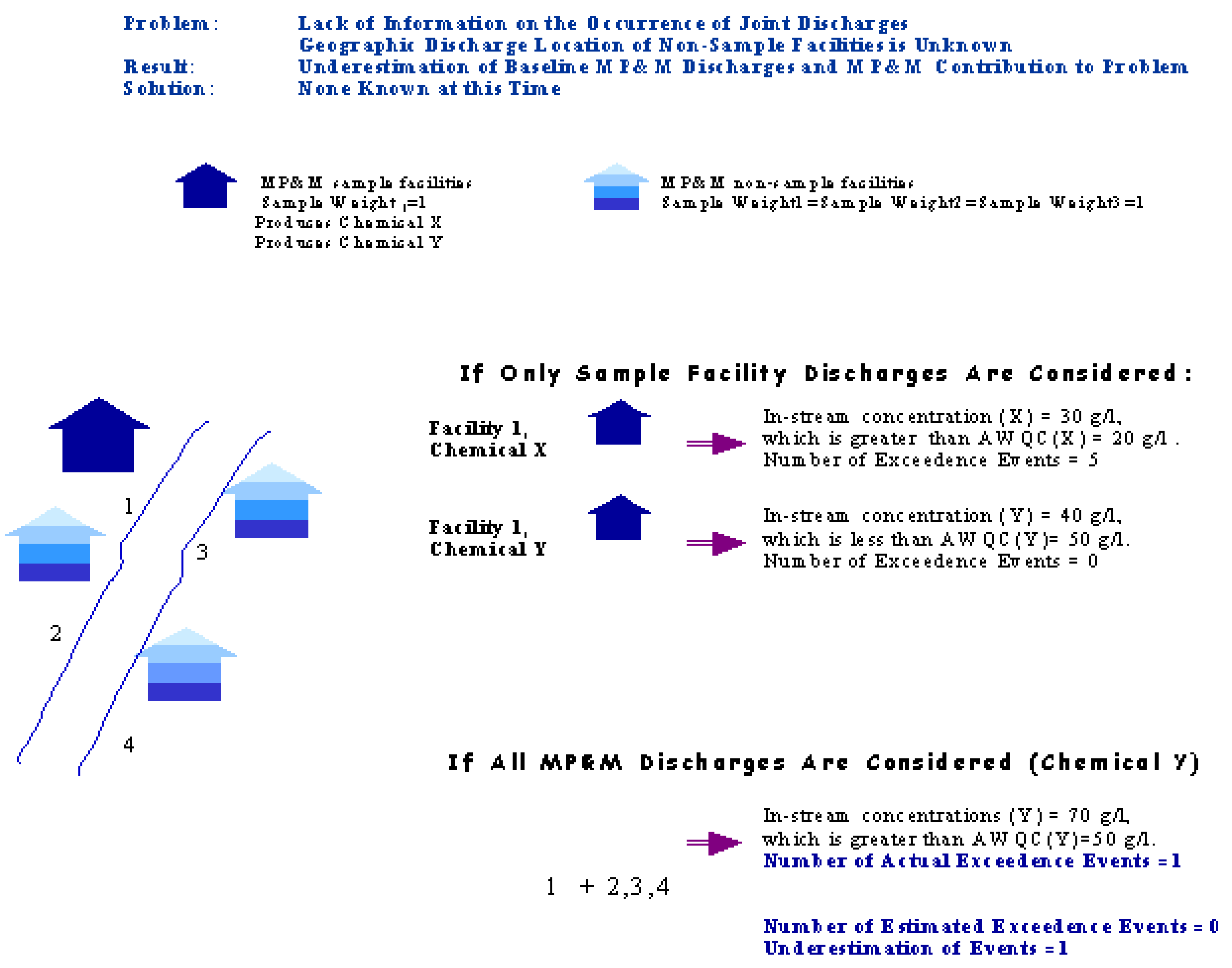
Notes: N sample facilities discharge to the reach and are ranked in ascending order of sample weight and indexed by i (1 = facility with smallest weight, N = facility with largest weight); $Load_i$ = Loading from facility i; $Flow_i$ = Flow from facility i or the POTW associated with facility i; Wt_i = Sample weight of facility i; and a POTW's flow is included only once per event, even if multiple facilities in that event discharged through that POTW, to avoid over-counting the POTW's flow.

Source: U.S. EPA analysis.

This weighting method is a relatively simplistic approach to a complex analytic issue, and does not provide a precise estimate of the national distribution of in-stream MP&M pollutant concentrations that reflects the true co-location characteristics of MP&M facilities. A statistically-valid estimate of that distribution is not possible given the design of the Section 308 surveys. However, the differential weighting technique does correct for the significant overstatement of benefits that would result from using a simple weighting approach to estimate national reach characteristics. The Agency believes that this method is a reasonable approach to addressing this issue, given time and resource constraints. Approaches that are both more sophisticated and more expensive might not yield significantly different aggregate findings.

Figure G.1 provides a graphical example of a hypothetical reach to which three known sample facilities discharge. Table G.8 provides a numeric example of this calculation for a hypothetical reach to which three known sample facilities discharge.

Figure G.1a: Estimating MP&M Pollutant Loadings to Receiving Streams When Using a Random Sample of MP&M Facilities



Problem: Lack of Information on the Occurrence of Joint Discharges
Geographic Discharge Location of Non-Sample Facilities is Unknown
Result: Underestimation of Baseline MP&M Discharges and MP&M Contribution to Problem
Solution: None Known at this Time

If Only Sample Facility Discharges Are Considered:

Facility 1, Chemical X: In-stream concentration (X) = 30 g/l, which is greater than AWQC (X) = 20 g/l. Number of Exceedence Events = 5

Facility 1, Chemical Y: In-stream concentration (Y) = 40 g/l, which is less than AWQC (Y)= 50 g/l. Number of Exceedence Events = 0

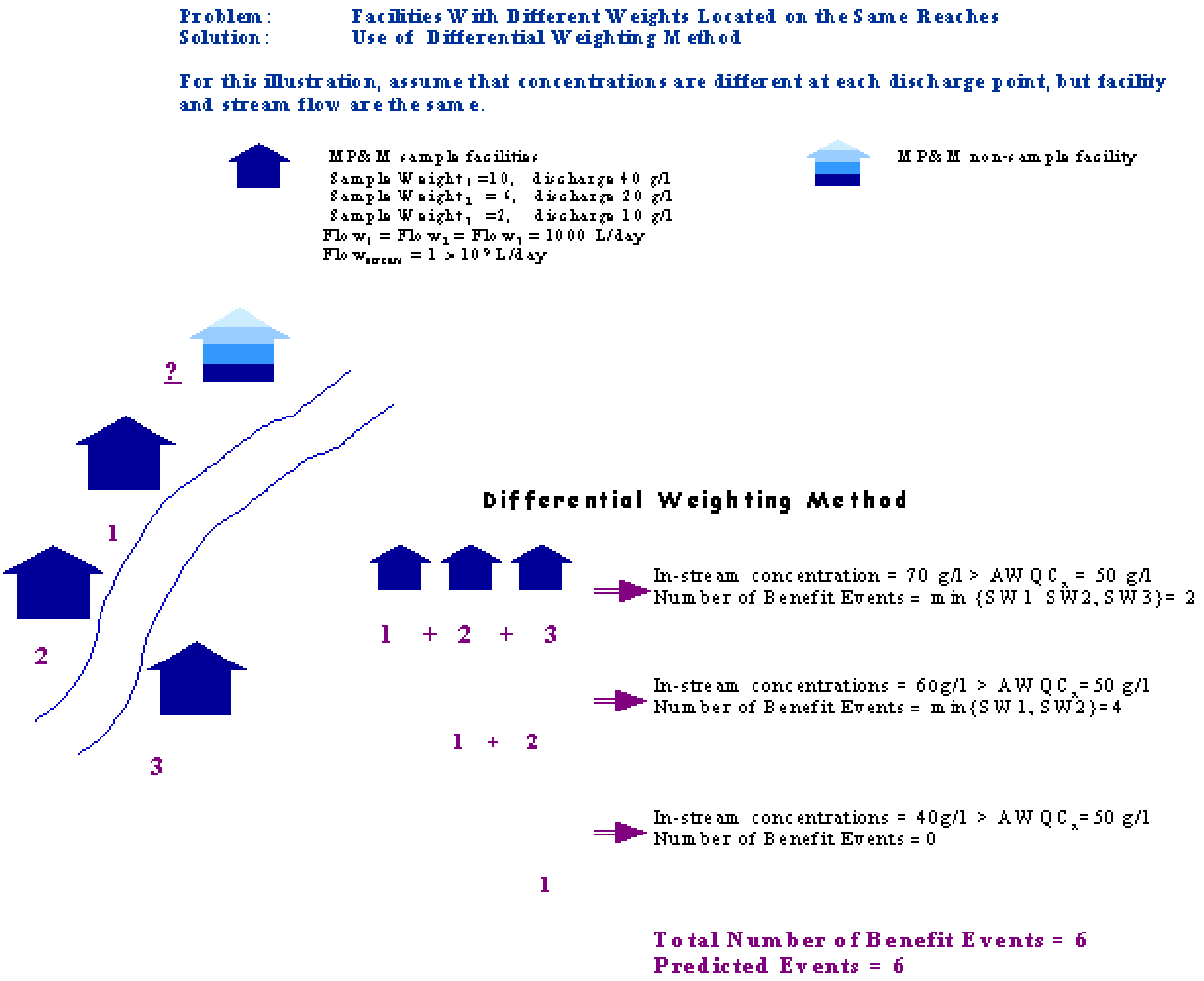
If All MP&M Discharges Are Considered (Chemical Y)

1 + 2,3,4: In-stream concentrations (Y) = 70 g/l, which is greater than AWQC (Y)=50 g/l.
Number of Actual Exceedence Events = 1

Number of Estimated Exceedence Events = 0
Underestimation of Events = 1

Source: U.S. EPA analysis.

Figure G.1b: Estimating MP&M Pollutant Loadings to Receiving Streams When Using a Random Sample of MP&M Facilities



Problem: Facilities With Different Weights Located on the Same Reaches
Solution: Use of Differential Weighting Method

For this illustration, assume that concentrations are different at each discharge point, but facility and stream flow are the same.

Sample $\text{Weight}_1 = 10$, discharge 40 g/l
Sample $\text{Weight}_2 = 6$, discharge 20 g/l
Sample $\text{Weight}_3 = 2$, discharge 10 g/l
$\text{Flow}_1 = \text{Flow}_2 = \text{Flow}_3 = 1000$ L/day
$\text{Flow}_{\text{stream}} = 1 \times 10^9$ L/day

In-stream concentration = 70 g/l > $AWQC_x$ = 50 g/l
Number of Benefit Events = min {SW1 SW2, SW3}= 2

In-stream concentrations = 60g/l > $AWQC_x$=50 g/l
Number of Benefit Events = min{SW1, SW2}=4

In-stream concentrations = 40g/l > $AWQC_x$=50 g/l
Number of Benefit Events = 0

Total Number of Benefit Events = 6
Predicted Events = 6

Note: The situation may be further complicated by actually having a non-sampled MP&M facility on the same reach. The differential weighting method does not address this issue.

Source: U.S. EPA analysis.

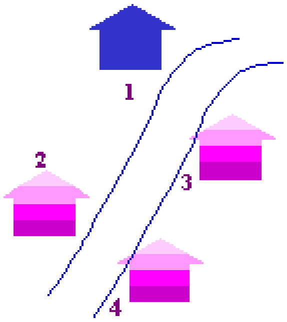
Figure G.1c: Estimating MP&M Pollutant Loadings to Receiving Streams When Excluding Background Concentrations

Problem 3: **Omitting Discharges from Non-MP&M Facilities**
Results: **Uncertainty, May Underestimate or Overestimate Benefits**

MP&M sample facilities
Sample Weight$_i$ = 15

Non-MP&M facilities

Case I: Underestimation of Benefits When all Discharges are Considered



If Only Sample Facility Discharges Are Considered:

Baseline
In-stream concentration (X) = 30 g/l < AWQC(X) = 40 g/l
Number of Baseline Exceedence Events = 0.

Post Compliance
In-stream concentration (X) = 15 g/l< AWQC(X)= 40 g/l
Number of Postcompliance Exceedence Events = 0
Number of Benefit Events = 0

If Non-MP&M Discharges Are Considered

Baseline 1 + 2,3,4
In-stream concentrations (X) = 50g/l > AWQC(X)=40 g/l
Number of Exceedence Events = 15

Post Compliance 1 + 2,3,4
In-stream concentrations (X) = 35 g/l < AWQC(X)=40 g/l
Number of Exceedence Events = 0
Number of Benefit Events = 15

Case 2: Overestimation of Benefits When all Discharges are Considered

If Only Sample Facility Discharges Are Considered

Baseline
In-stream concentration (X) = 30 g/l > AWQC(X) = 20 g/l
Number of Baseline Exceedence Events = 15.

Post Compliance
In-stream concentration (X) = 15 g/l< AWQC(X)= 20 g/l
Number of Postcompliance Exceedence Events = 0
Number of Benefit Events =15

If Non-MP&M Discharges Are Considered

Baseline 1 + 2,3,4
In-stream concentrations (X) = 95g/l > AWQC(X)=20 g/l
Number of Exceedence Events = 15

Post Compliance 1 + 2,3,4
In-stream concentrations (X) = 80 g/l > AWQC(X)=20 g/l
Number of Exceedence Events = 15
Number of Benefit Events = 0

Source: U.S. EPA analysis.

Table G.8: Example of Differential Sample Weighting Technique

Facility	Weight	Pollutant A lbs/yr	Flow gal/year
Raw data:			
1	10	5	2,000,000
2	3	2	4,000,000
3	1	12	10,000,000
Total	14	19	16,000,000
Reach flow (gal/year):			100,000,000
Calculating flow and pollutant loadings for the reach:			
1. Rank facilities in ascending order of weights			
3	1	12	10,000,000
2	3	2	4,000,000
1	10	5	2,000,000
2. Calculate flow and pollutant loadings for discharge event 1 with weight = 1			
Facility	**Pollutant A lbs/yr**	**Flow gal/year**	**Remaining Weight**
3	12	10,000,000	0
2	2	4,000,000	2
1	5	2,000,000	9
Event 1	19	16,000,000	
3. Eliminate the facility with the lowest weight and calculate flow and pollutant loadings for discharge event 2 with weight = 2 (3-1)			
2	2	4,000,000	0
1	5	2,000,000	7
Event 2	7	6,000,000	
4. Eliminate the facility with the next lowest weight and calculate and pollutant loadings for discharge event 3 with weight = 7 (10-3)			
1	5	2,000,000	0
Event 3	5	2,000,000	

5. Estimate national in-stream concentrations based on the flows, loadings, and weights for each discharge event and the reach flow

Discharge Event	Pollutant A Loading lbs/yr	Facility Flow gal/year	Stream Flow gal/year	Total Flow gal/year	In-stream Concentration ppb	Weight
1	19	16,000,000	100,000,000	116,000,000	0.0955	1
2	7	6,000,000	100,000,000	106,000,000	0.0385	2
		2,000,000	100,000,000	102,000,000	0.0286	7
Total Affected Reaches:						10

Source: U.S. EPA analysis.

G.3 METHODOLOGY FOR EXTRAPOLATION OF OHIO CASE STUDY RESULTS TO THE NATIONAL LEVEL

EPA extrapolated the Ohio case study results to the national level based on three key factors that affect the occurrence and magnitude of benefits:

- the estimated change in MP&M pollutant loadings, which reflects the potential for improvements in surface water quality;

- the level of recreational activities on the reaches affected by MP&M discharges. Recreational level reflects the degree to which potentially affected water resources are likely to be in demand by local residents; and

- the average household income level, which affects the willingness-to-pay (WTP) for water quality improvements.

G.3.1 Change in Pollutant Loads

The first step in applying this alternative extrapolation method was to develop a measure of benefits per pound of pollutant removed for each category of benefits. EPA developed this measure by simply dividing the state-level benefit estimates by the total number of pounds of pollutant removed by the regulation in the state of Ohio ($ per pound of pollutant removed). EPA developed three different measures to better represent the relationship between pollutants and benefit categories:

- ***Cancer health benefits:*** EPA divided cancer benefits from the Ohio case study by total carcinogen pounds removed in Ohio to estimate cancer health benefit per pound of carcinogen load removed;

- ***Lead health benefits:*** EPA divided lead health benefits from the Ohio case study by total lead pounds removed in Ohio to estimate lead health benefit per pound of lead load removed; and

- ***Recreational benefits:*** EPA divided recreational benefits from the Ohio case study by total pounds of pollutants removed (i.e., all pollutants except for total dissolved solids and biological oxygen demand) in Ohio to estimate recreational benefit per pound of pollutant load removed.

All of these values are readily available from the Ohio case study. EPA extrapolated the state-level benefits for each of these benefit categories to the national level. First, the Agency multiplied the three estimated benefit per pound of pollutant values for Ohio by the total number of pounds of pollutant removed in each of the three pollutant categories at the national level. Then, EPA summed across the three benefit categories to obtain an initial estimate for total benefits at the national level.

G.3.2 Level of Recreational Activities on Reaches Affected by MP&M Discharges

The second step was to adjust for differences between Ohio and the nation in the level of recreational activity on reaches affected by MP&M discharges. The level of recreational activity reflects the degree to which water resources likely to be affected by MP&M discharges are in demand by local residents. EPA accounted for differences between Ohio and the nation in recreational intensity because the total user value of water quality improvements is a function of the number of users associated with a particular reach. For this adjustment factor, EPA used the ratio of the number of recreational user days per reach mile at the national level to the number of recreational user days per reach mile in Ohio. Due to data limitations preventing identification of all reaches affected by MP&M discharges, this analysis used total recreational user days and reach miles nationally and in Ohio, rather than only for those reaches affected by MP&M discharges. EPA used the National Demand Study (NDS) to estimate the number of user days for each recreation activity. Appendix N of this report provides the relevant data by state and recreation activity. To estimate the number of recreational user days, EPA summed the activity-specific values over the four activities considered in this analysis (i.e., recreational fishing, boating, swimming, and wildlife viewing). EPA's Reach File 1 provided information on the total number of reach miles in Ohio and in the 48 contiguous states. The Agency then calculated the number of user days per reach mile in the state of Ohio and in the nation by simply dividing the total number of user days by the total number of reach miles in the corresponding region. EPA then calculated the adjustment factor as follows:

$$\begin{aligned} \textit{Recreational Activity AF} &= \frac{\textit{Average Number of Recreational User Days per Reach Mile in the U.S.}}{\textit{Average Number of Recreational User Days per Reach Mile in Ohio}} \\ &= \frac{2{,}306}{4{,}148} = 0.5559 \end{aligned} \qquad (G.1)$$

G.3.3 Differences in Household Income

In the third step, EPA adjusted the extrapolated benefits based on the expectation that the WTP for water quality improvements will vary with household income level for different parts of the country. The adjustment factor used is the ratio of the average household income of the nation to the average household income of Ohio. This adjustment factor assumes that households around the country are willing to pay the same proportion of their incomes for water quality improvements, although the absolute value of this dollar amount will vary due to regional differences in average household income. The average household income of the nation is estimated as a weighted average, with the median household income for each state weighted by the proportion of MP&M facilities located in that state. The U.S. Census Bureau's Current Population Surveys (March 1999, 2000, and 2001) provide the basis for data on the median household income by state for the year 2000.[3] The 1992 Economic Census provides information on total MP&M facilities by state.[4]

$$\begin{aligned} Income\ AF &= \frac{(Weighted)\ Median\ Household\ Income\ in\ the\ U.S.}{Median\ Household\ Income\ in\ Ohio} \\ &= \frac{\$42{,}909}{\$43{,}894} = 0.9776 \end{aligned} \tag{G.2}$$

G.4 RESULTS

Table G.9 presents national benefits based on the extrapolation of Ohio case study results. Based on this approach, the monetary value of benefits from reduced MP&M discharges is $2.5 million (2001$) for the final option. This estimate is 60% higher compared to the benefit estimate based on the traditional extrapolation methodology (i.e., $1.5 million (2001$)). As noted in the prior discussion, this difference is likely to be due to the more rigorous approach used for the Ohio case study.

The national-level analysis of human health benefits finds negligible health benefits from the final rule. In contrast, the Ohio-based extrapolation of human health benefits yields $10,860 and $295,202 (2001$) in human health benefits at the national level from reduced incidences of cancer cases and adverse health impacts from lead exposure, respectively. As shown in Table G.9, the estimated human health benefits to Ohio residents exceed the national-level benefits based on this extrapolation method. This finding is due to the fact that the estimated pollutant removals for lead and carcinogens in Ohio exceed those at the national level. As discussed in Appendix H, EPA administered 1,600 screener questionnaires to augment information on Ohio's MP&M facilities. The Agency used information from the sampled MP&M facilities to estimate discharge characteristics of non-sampled MP&M characteristics (see Appendix H for detail on estimating sample facility discharges in Ohio). As a result, the MP&M facilities included in the case study analysis represent a significant portion of the MP&M facility universe in Ohio. In contrast, the sample facilities used at the national-level analysis represent only 2 percent of the MP&M facility universe. Thus, analytic findings from the national-level analysis may have a larger than desired degree of uncertainty due to a very small sample size.

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[3] Source: http://www.census.gov/hhes/income/income00/statemhi.html

[4] Appendix J presents information on distribution of MP&M facilities by state.

Table G.9: Extrapolation of Ohio Case Study Results to the National Level (2001$)

Category	Ohio	Nation
Pounds removal of carcinogens	52.45	17.86
Total cancer benefits	$31,895.42	$10,860.86
Total cancer benefits per pound removal of carcinogens	$608.11	
Pounds removal of Lead	217.06	118.54
Total lead benefits	$540,549.14	$295,202.69
Total lead benefits per pound removal of lead	$2,490.32	
Pounds removal of total pollutants	483,258.02	5,412,810.88
Total recreational benefits	$250,932.62	$2,810,612.05
Total recreational benefits per pound removal of total pollutants	$0.52	
Nonuse benefits (½ of total recreational benefits)	$125,466.31	$1,405,306.03
Total benefits prior to application of adjustment factors	$948,843.49	$4,521,981.63
Reach miles	11,927	713,702
Annual recreation days (millions)	49	1,646
Annual recreation days per reach mile	4,148	2,306
Recreational activity adjustment factor		0.5559
Total benefits prior to application of income adjustment factor		$2,513,907.82
Average household income	$43,894	$42,909
Income Adjustment factor		0.9776
Total benefits		$2,457,494.66

Source: U.S. EPA analysis.

GLOSSARY

ambient water quality criteria (AWQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

differential sample weighting technique: weighting method for all threshold value-based analyses, such as the lead-related benefits analysis.

reach: a specific length of river, lake, or marine shoreline

standard linear weighting technique: weighting method used where the effects being considered (e.g., compliance costs) are linearly additive over facilities.

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Appendix H: Fate and Transport Model for DW and Ohio Analyses

APPENDIX CONTENTS

INTRODUCTION

For the drinking water (DW) and Ohio analyses, EPA used a simplified fate and transport model to quantify the fate and transport of MP&M pollutant releases to surface waters. This model estimates pollutant concentrations at the initial point of discharge and below the initial discharge ***reach***.

The national MP&M analysis considered pollutant concentrations only at the point of discharge (see Appendix I.2.2). The drinking water and Ohio analyses account for the in-stream concentrations of pollutants at the initial point of discharge and in reaches downstream from the initial discharge reach.

This appendix describes the equations characterizing the model, its underlying assumptions, and the data sources used in model estimation. EPA combined the equations defining the model with geographic information (reach flow, velocity, length, etc.) to estimate pollutant concentrations at the initial point of discharge and below the initial discharge reach.

The estimation of pollutant concentrations below the initial discharge reach includes several factors that reduce the in-stream pollutant concentrations with the passage of time. These factors include: ***volatilization***, ***sedimentation***, and chemical decay from ***hydrolysis*** and ***microbial degradation***. EPA adjusted concentrations for changes in stream flow volume in downstream reaches. The discussion below outlines the main assumptions of this analysis. Although more advanced models are available that account for time-variable flow, sediment transport, channel geometry changes within a reach, and detailed simulation of all in-stream processes, these models will not necessarily produce more accurate results without sufficient data to support the input parameters. Estimates of the additional input parameters required by these models are subject to a high degree of uncertainty when applied on a national scale, and gathering such data is beyond the scope of this study.

EPA has previously applied the approach used in this analysis. For example, the first-order contaminant degradation relationship described below in Equation H.1 is currently being used by the Office of Pollution Prevention and Toxics for exposure analysis in the Risk Screening Environmental Indicator ***(RSEI)*** model (U.S. EPA, 1999).

H.1 MODEL EQUATIONS

The total pollutant concentration in the water columns for each reach included in the analysis is calculated by the following equation expressed in generic terms of mass (M), length (L), and time (T):

$$C_r = \frac{W_r}{Q} x e\left[-\left(\frac{V_r}{H}\right)\left(\frac{x}{V}\right)\right] \tag{H.1}$$

where:

C_T = total toxicant concentration in the water column (M/L^3),
W_T = mass input rate of toxicant (M/T),
Q = river flow (L^3/T),
V_T = overall net loss rate of chemical (L/T),
H = flow depth (L),
x = distance downstream from the point of release (L), and
U = flow velocity (L/T).

In reaches where more than one facility discharges or where pollutant loadings occur from upstream reaches, the mass input rate (W_T) represents a combined input rate from all relevant industrial facilities affecting the reach. The relevant industrial facilities in the drinking water risk analysis are all MP&M sample facilities (see Chapter 13). The relevant industrial facilities in the Ohio case study analysis include:[1]

- all sample MP&M facilities,
- non-sample MP&M facilities, and
- non-MP&M facilities.

The overall net loss rate of chemical (V_T) is given by:

$$V_T = V_{Td} + V_{Ts} = (k_l + K_d H) \times f_d + v_n f_p \tag{H.2}$$

where:

V_T = overall net loss rate of chemical (L/T),
V_{Td} = dissolved chemical loss rate (L/T),
V_{Ts} = loss of chemical due to sediment interaction (L/T),
k_l = volatilization transfer coefficient (L/T),
K_d = dissolved chemical decay rate (hydrolysis and microbial degradation) (1/T),
H = flow depth (L),
f_d = dissolved fraction of toxicant (unitless),
v_n = net loss of solids (L/T), and
f_p = particulate fraction of toxicant (unitless).

The dissolved and particulate fractions of the pollutant, f_d, and f_p , respectively, are estimated by:

$$f_d = \frac{1}{1 + K_p S} \tag{H.3}$$

and

$$f_p = \frac{K_p S}{1 + K_p S} \tag{H.4}$$

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[1] See Chapter 22 for detail.

where:

K_p = partition coefficient [L^3/M], and
S = suspended solids [M/L^3].

The dissolved concentration of ***metals*** and most other pollutants in the water column is generally considered a more accurate expression than the total concentrations of the toxic or bioavailable fraction. For this reason, EPA modified Equation (H.1) to express the pollutant concentrations in terms of dissolved concentration. The dissolved fraction of a pollutant is estimated as:

$$C_d = f_d \times C_T \qquad \text{(H.5)}$$

Substituting Equation (H.1) for C_T yields the dissolved pollutant concentration for downstream distance x from the discharge reach:

$$C_d = \frac{\dfrac{W_T}{Q} \times e \left[- \left(\dfrac{K_d^{\,H} + k_l}{(1 + K_p{}^{S})^H} + \dfrac{v_N K_p{}^{S}}{(1 + K_p{}^{S})^H} \right) \times \left(\dfrac{x}{U} \right) \right]}{1 + K_p{}^{S}} \qquad \text{(H.6)}$$

H.2 MODEL ASSUMPTIONS

The following three principal assumptions underlie Equation H.5:

H.2.1 Steady Flow Conditions Exist within the Stream or River Reach

This assumption is necessary due to this study's broad geographical coverage. This assumption significantly reduces the computational effort and input parameter requirements and still produces a good first-order fate and transport model of pollutants in surface waters.

The pollutant concentration is completely mixed, both laterally (across the stream) and vertically (with depth) within each reach. The approach involves a two-dimensional model in which the concentration is uniform over the entire cross-section of the stream reach but varies with the distance of the reach. EPA assumed that the contaminant completely mixes at the point of release. This assumption will likely underestimate the concentration of a contaminant release in areas where mixing is incomplete (e.g., shore-hugging plume) and overestimate concentrations in areas beyond the point showing incomplete mixing (e.g., in areas beyond a shore-hugging plume).

H.2.2 Longitudinal Dispersion of the Pollutant is Negligible

The model does not account for mixing outside the plane of discharge along the river reach, although it predicts variation in pollutant concentrations over distance due to both pollutant fate and decay and the differing hydrology of downstream reaches. In natural streams, longitudinal velocity gradients due to channel irregularities can cause mixing, thereby decreasing the peak concentrations as the contaminant moves downstream from the point of release. Under steady-state situations, however, the longitudinal dispersion of the pollutant is assumed to be negligible.

The solution of the dispersion equation approximates a first-order decay function such as the one shown in Equations H.1 and H.5 under steady flow conditions and complete lateral and vertical mixing.

H.2.3 Flow Geometry, Suspension of Solids, and Reaction Rates Are Constant within a River Reach

EPA assumes the data that describe a river reach and that are calculated for a reach to be constant for the full extent of the reach.

H.3 HYDROLOGIC LINKAGES

EPA modeled pollutant concentrations for a distance of 500 km downstream from the discharge point in the drinking water risk analysis. In the Ohio case study analysis, EPA used the lesser of 500 km or the distance to the Ohio border from the initial discharge point to identify reaches potentially affected by pollutant discharges from the discharge point. The Agency obtained information on the hydrologic linkages between reaches from the RSEI Model (U.S. EPA, 1999). The data file in RSEI provided flow (mean flow, 7Q10) and velocity (mean, low) data for each reach.

EPA used the process equations listed above to estimate both the initial pollutant concentrations at the beginning of each reach and the changes in concentrations as pollutants traveled to the end of the reach. The concentration at the end of each reach served as the value for the beginning of the next reach.

H.4 ASSOCIATING RISK WITH EXPOSED POPULATIONS

The number of individuals served by each drinking water intake is an output of the fate and transport model described in this appendix. If a drinking water intake exists on the initial reach or any downstream reach, then the model calculates the in-stream pollutant concentration at that intake. Data on the population served by the intake is saved with the concentration for further analysis (see Chapter 13 for a discussion of the cancer risk assessment).

H.5 DATA SOURCES

Data sources used for the fate and transport model are discussed briefly in the section below, by categories of information.

H.5.1 Pollutant Loading Data Used in the Drinking Water Risk Analysis

EPA estimated annual pollutant loadings (kg/yr) for the direct and indirect sample MP&M facilities analyzed under the various regulatory options.[2] The Agency first adjusted pollutant loadings for indirect dischargers to reflect POTW treatment, and then divided annual pollutant loadings by the number of days in one year (365) to establish daily pollutant loadings.

H.5.2 Pollutant Loading Data Used in the Ohio Case Study Analysis

EPA estimated pollutant discharges from both MP&M and significant non-MP&M sources at the reaches included in the Ohio case study analysis. Consumer perception and valuation of enhanced water-based recreational opportunities depend on the absolute level of pollutant contamination at recreation sites, and on the change in contamination from the baseline to the post-compliance cases. For this reason, capturing the effect of concurrent discharges from all MP&M and other pollutant sources is particularly important for the recreational benefits analysis.

EPA used the Office of Water's ***BASINS*** software package to identify all possible point source dischargers contributing to ambient pollutant concentrations at a given reach. BASINS is a GIS-based system that serves as a database management system for water quality monitoring, point-source pollutant discharge, and various geo-technical data. Several sources provide information on point source discharges to BASINS, including the ***Permit Compliance System (PCS)*** and ***Toxic Release Inventory (TRI)*** databases. Version 2.0 includes data reported through 1996. Preprogrammed queries in BASINS

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[2] EPA is not establishing pretreatment standards for indirect dischargers under the final rule.

generate information on various point source discharge variables at either the state or watershed level. BASINS data on point source dischargers include:

- location information on major industrial dischargers, including PCS facilities and facilities reporting under TRI;
- SIC codes;
- flow volume; and
- discharge characteristics for up to 50 pollutants or parameters for PCS facilities.

The following sections describe steps used to characterize both MP&M and non-MP&M discharges in Ohio.

a. Characterize MP&M facility discharges

EPA used different approaches to assign discharge characteristics to MP&M facilities in Ohio, based on the level of information available for each facility. The Agency divided all MP&M facilities into three groups, based on the level of information provided by different sources:

❖ *Facilities covered by the detailed Phase 1 and 2 questionnaire (hereafter, sampled MP&M facilities)*

The detailed surveys contain data on:

- discharge status;
- discharge volume;
- industrial processes used;
- pollution prevention activities;
- employment, revenue, and costs.

EPA engineers estimated loadings of 126 MP&M pollutants using information on facilities' processes and pollution prevention activities.[3] All MP&M facilities in this group therefore have extensive data on their location, size, and discharge characteristics.

❖ *Facilities covered by the detailed Iron and Steel questionnaire (hereafter sampled I&S facilities)*

The detailed I&S survey contained data similar to the detailed MP&M survey. EPA engineers used data on I&S facilities' processes and pollution prevention activities to estimate pollutant loadings from these facilities.

❖ *Facilities covered by the Phase 2 screener questionnaire or that were covered by the Phase 1 mini-DCP (hereafter, MP&M screener facilities).*

The screener surveys contain significantly fewer data on MP&M facilities. The data collected from the screener survey recipients include:

- facility location, which can be used to assign the facilities to receiving waterways or receiving POTWs;
- SIC codes;
- discharge status (i.e., whether the facility discharges process wastewater and the approximate amount);
- employment and revenue data;
- whether the facility is engaged in manufacturing, maintenance or repairing activities; and

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[3] There are 132 pollutants of concern. EPA engineers estimated pollutant loadings for only the pollutants for which EPA is considering calculating pollutant removals at each option. For example, pollutant loadings are not provided for sodium, calcium, and TDS.

- data on MP&M unit operations (including type of MP&M unit operations performed at the site, and whether process wastewater is discharged as a result of each operation).

The project engineers used these data to estimate pollutant loadings for these facilities. Loading estimates for the screener facilities, which are based on less comprehensive information, involve greater uncertainty.

❖ ***Facilities that respond to neither the screener nor detailed questionnaires (hereafter referred to as non-sampled MP&M facilities)***

To address the problem of omitted discharge information on non-sampled MP&M facilities, EPA used information from the 1600 screener MP&M facilities and a random draw approach to assign the relevant characteristics for non-sampled MP&M facilities. Each screener facility represents *n* non-sampled facilities, where *n* is determined by the screener facility sample weight. All non-sampled facilities are smaller indirect dischargers because all direct MP&M facility dischargers and large indirect discharging facilities in Ohio are covered by the long, short, or screener questionnaire.

The exact location of non-sampled facilities is unknown. All non-sampled facilities discharge to one of the Ohio POTWs because they are indirect dischargers. The Agency assigned *n* facilities represented by each screener facility to the receiving POTWs by drawing a random sample of *n* POTWs from the universe of POTWs in Ohio.[4] The Agency assigned screener facility characteristics (i.e., pollutant loadings) to all *n* facilities represented by the screener facility.

EPA used a random draw procedure for all observations from the screener survey that have a sample weight greater than one.

b. Characterize non-MP&M point source discharges

EPA used preprogrammed queries in BASINS to obtain information on all non-MP&M point source discharges in Ohio. BASINS data on non-MP&M point source dischargers include:

- location,
- SIC codes,
- flow volume, and
- discharge characteristics for up to 50 pollutants or parameters for PCS facilities.

The Agency assigned discharge characteristics to all non-MP&M industrial direct discharges based on the information provided in BASINS. POTW effluent may contain pollutants from both MP&M and non-MP&M discharges. The Agency combined information from BASINS with loading estimates provided by the project engineers to estimate total pollutant loadings from a given POTW. This analysis used the following assumptions to estimate total POTW pollutant loadings under the baseline discharge levels:

- If a POTW was not estimated to receive discharges from the MP&M facilities, then the analysis used POTW loadings reported in BASINS.
- If a pollutant or a parameter was not reported in BASINS, then the analysis used aggregate loadings from all MP&M facilities discharging to a given POTW to calculate total POTW loadings of a given pollutant.
- If a POTW was estimated to receives discharges from MP&M facilities and a given pollutant was reported in BASINS, then the analysis used the greater of the aggregate loadings from all MP&M facilities or POTW loadings reported.

EPA estimated post-compliance pollutant loadings from each POTW by subtracting the estimated reduction in the MP&M facility loadings for a given pollutant from its total baseline loadings for a given POTW.

c. Characterize non-point source discharges

The water quality analysis in Ohio used empirical data on ***Total Kjeldahl Nitrogen (TKN)*** concentrations to characterize the baseline water quality conditions. Empirical data on in-stream concentrations captured TKN contribution from both point

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[4] The Agency was unable to validate random assignments because POTWs do not know all of their MP&M dischargers.

and non-point sources under baseline conditions. EPA estimated changes in TKN concentrations resulting from the final rule by using the estimated pollutant loading reductions from MP&M sources and the water quality model described above. The Agency assumed that the non-point source contribution of toxic pollutants found in MP&M effluent to ambient concentrations of these pollutants in Ohio's streams and lakes is negligible.

GLOSSARY

BASINS: a software package that serves as a database management system for water quality monitoring, point source pollutant discharge, and various geo-technical data, and also provides an analytic platform for modeling in-stream pollutant concentrations over an entire watershed based on multiple sources of pollutants within the watershed. (http://www.epa.gov.OST/BASINS)

hydrolysis: the decomposition of organic compounds by interaction with water. (http://www.epa.gov/OCEPAterms)

metals: inorganic compounds, generally nonvolatile, and which cannot be broken down by biodegradation processes. They are a particular concern because of their prevalence in MP&M effluents. Metals can accumulate in biological tissues, sequester into sewage sludge in POTWs, and contaminate soils and sediments when released to the environment. Some metals are quite toxic even when present at relatively low levels.

microbial degradation: a process whereby organic molecules are broken down by microbial metabolism.

Permit Compliance System (PCS): a computerized database of information on water discharge permits, designed to support the National Pollutant Discharge Elimination System (NPDES). (http://www.epa.gov/ceisweb1/ceishome/ceisdocs/pcs/pcs-exec.htm)

MP&M reach: a reach to which an MP&M facility discharges.

sedimentation: letting solids settle out of wastewater by gravity. (http://www.epa.gov/OCEPAterms)

Total Kjeldahl Nitrogen (TKN): the total of organic and ammonia nitrogen. TKN is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

Toxic Release Inventory (TRI): database of toxic releases in the United States compiled from SARA Title III Section 313 reports. (http://www.epa.gov/OCEPAterms)

volatilization: a process whereby chemicals dissolved in water escape into the air. (http://www.epa.gov/OCEPAterms)

ACRONYMS

PCS: Permit Compliance System
RSEI: Risk Screening Environmental Indicator model
TKN: Total Kjeldahl Nitrogen
TRI: Toxic Release Inventory

REFERENCES

U.S. Environmental Protection Agency (U.S. EPA). 1999. Risk-Screening Environmental Indicators Model: Version 1.0, July 6, Washington, DC: Office of Pollution Prevention and Toxics. http://www.epa.gov/opptintr/env_ind/index.html.

Appendix I: Environmental Assessment

INTRODUCTION

This Environmental Assessment estimates the environmental impact of MP&M discharges on water bodies and POTWs under both current conditions and those corresponding to four regulatory options: the Final Option, Proposed/NODA Option, Directs + 413 to 433 Upgrade Option, and Directs + All to 433 Upgrade Option.[1] EPA estimates four types of environmental impacts:

- the occurrence of pollutant concentrations in excess of EPA ***ambient water quality criteria (AWQC)*** for protection of human health in waterways (e.g., streams, lakes, bays, and estuaries) receiving discharges from MP&M facilities;
- the occurrence of pollutant concentrations in excess of AWQC for protection of aquatic species in waterways receiving discharges from MP&M facilities;
- the occurrence of POTW inhibition problems resulting from MP&M facilities' discharges; and
- barriers to POTWs' use of preferred sewage sludge management or disposal methods (i.e., beneficial land application or surface disposal), due to metals discharges from MP&M facilities.

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EPA also estimated changes in human health risk from reduced exposure to MP&M pollutants via consumption of contaminated fish and drinking water. Chapters 13 and 14 of this EEBA present both the methodology used to estimate human health impacts from exposure to MP&M pollutants and the results of this analysis.

EPA assessed potential environmental impacts of MP&M discharges on the receiving water bodies and POTWs by using pollutant fate and toxicity data in conjunction with various modeling techniques. EPA quantified the releases of 132 pollutants of concern under the final and alternative regulatory options.[2] EPA then evaluated potential site-specific aquatic life and human health impacts resulting from the baseline and post-regulation pollutant releases. EPA compared projected water concentrations for each pollutant to either (a) EPA water quality criteria, or (b) toxic effect levels (i.e., lowest reported

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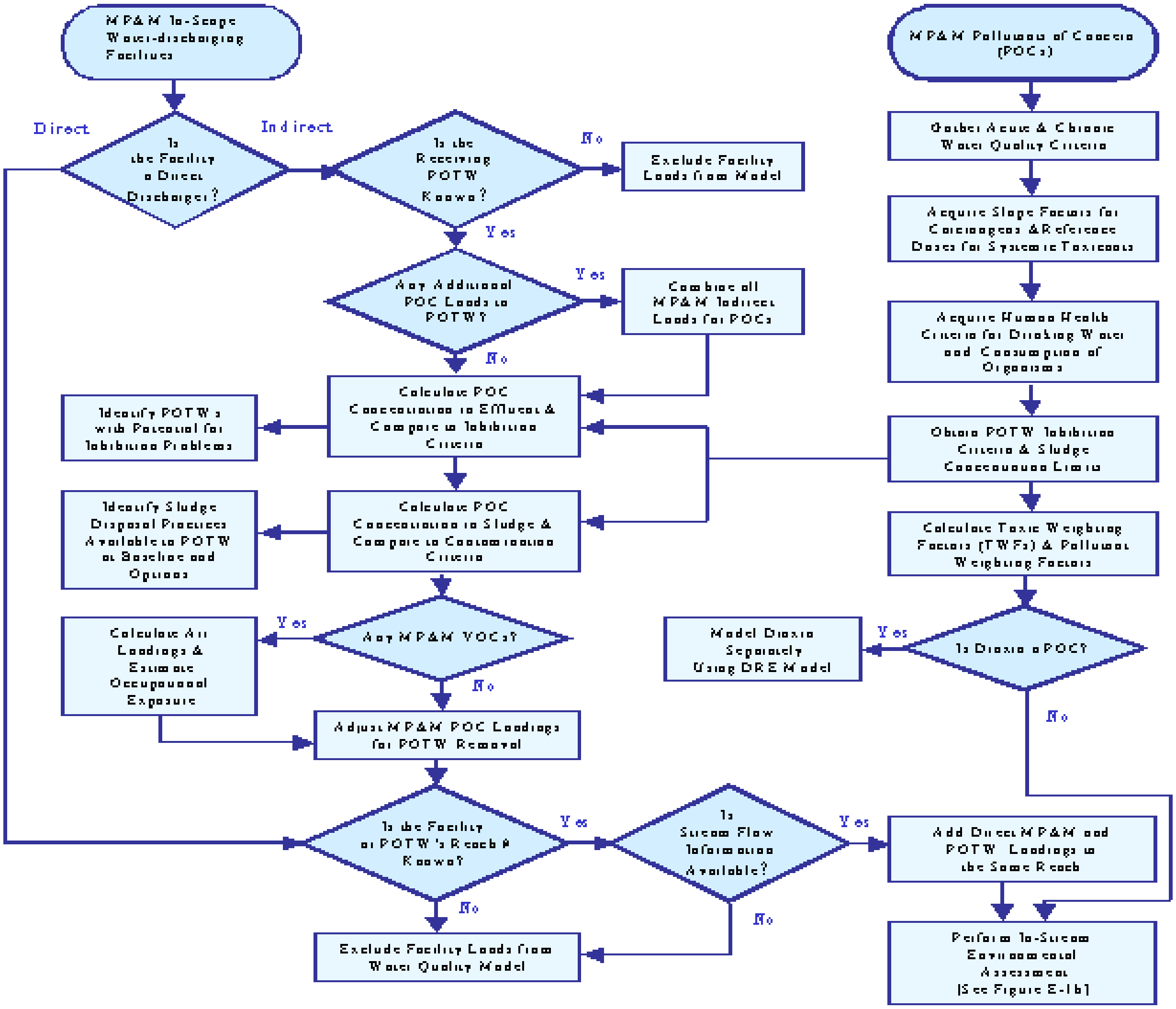
[1] The results of the Proposed/NODA Option are not directly comparable to the final option alternatives. The total number of facilities reported for the Proposed/NODA Option analysis differs from the facility count reported for the final rule and the two upgrade options. After deciding in July 2002 not to consider the NODA option as the basis for the final rule, EPA performed no more analysis on the NODA option, including not updating facility counts and related analyses for the change in subcategory and discharge status classifications.

[2] EPA originally identified 150 MP&M POCs. Of these 150 POCs, the Agency estimated loadings for 132 pollutants for the phase 2 proposal and NODA. The benefits analysis presented in earlier chapters is based on 132 pollutants for which loadings are available. The final regulation covers only the Oily Wastes subcategory and benefit reductions were estimated for 122 pollutants.

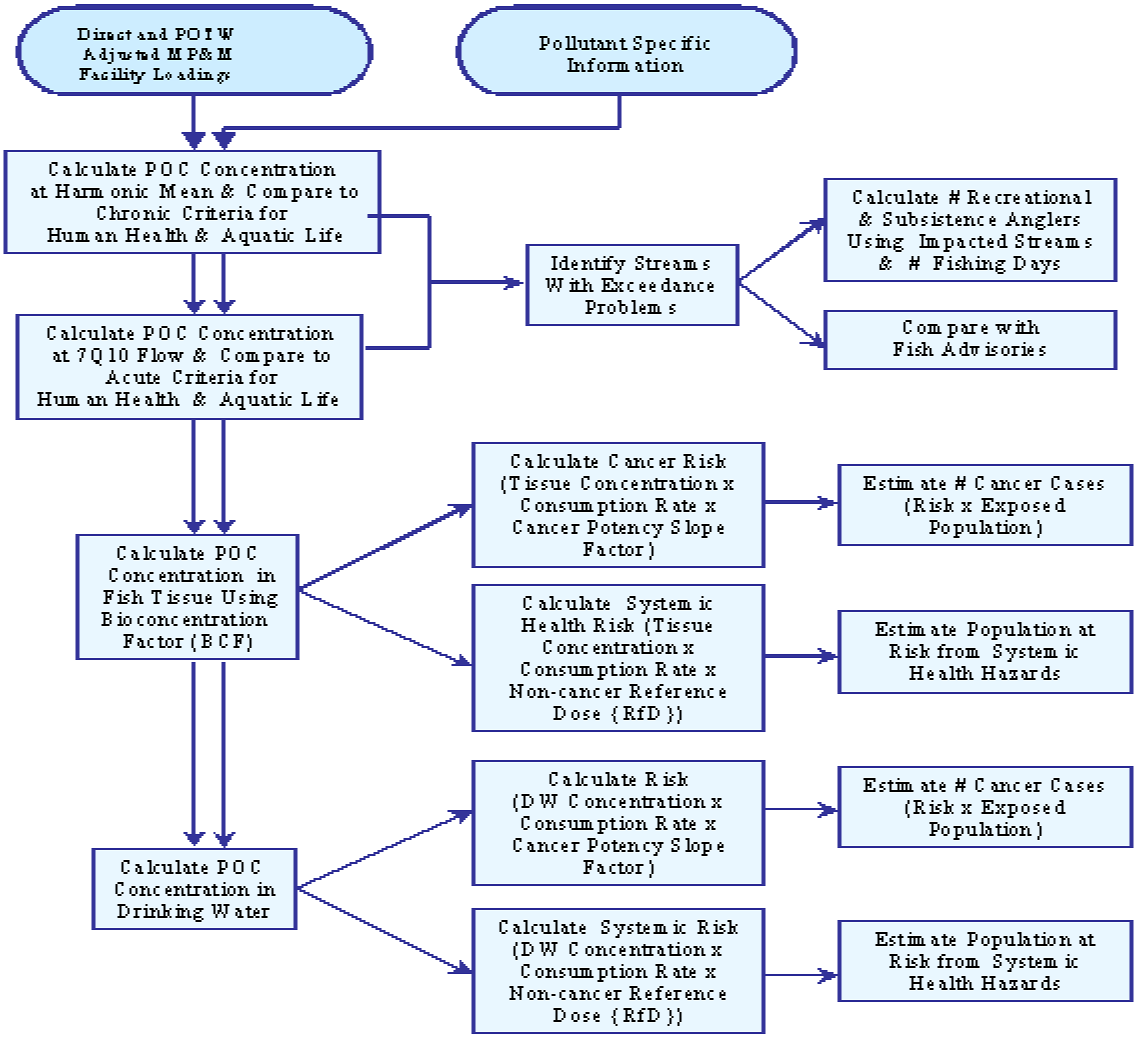
or estimated toxic concentration that causes a problem) in the absence of water quality criteria for a pollutant. Figure I.1 depicts steps used in the environmental assessment. The following sections detail these analytic steps.

Figure I.1a: MP&M Environmental Impact Assessment



Source: U.S. EPA analysis.

Figure I.1b: MP&M Environmental Impact Assessment (Continued)



Source: U.S. EPA analysis.

The remainder of this appendix is organized as follows. Section I.1 provides information on the pollutants found in MP&M discharges. Section I.2 describes the methodology used to estimate environmental impacts, including extrapolation of sample sets to the national level and estimates of water quality impacts. Section I.3 describes data sources for both MP&M facilities and POTWs. Section I.4 presents the environmental assessment results.

I.1 MP&M POLLUTANT CHARACTERIZATION

The extent of human and ecological exposure and risk from environmental releases of toxic chemicals depends on chemical-specific properties, the mechanism and media of release, and site-specific environmental conditions. Chemical-specific properties include toxic effects on living organisms, and the fate of chemicals in the environment. EPA estimated the fate of MP&M pollutants based on their propensity to volatilize, adsorb onto sediments, bioconcentrate, and biodegrade. EPA characterized the fate and toxicity of MP&M pollutants in three steps:

- identifying ***pollutants of concern (POCs)*** in MP&M discharges,
- compiling physical-chemical and toxicity data for those pollutants, and
- grouping pollutants based on their characteristics.

The pollutant-specific fate and toxicity data were used in various portions of the quantitative benefits assessment. In addition, EPA summarized the distribution of MP&M pollutants based on their fate and toxicity properties using the groupings developed in the third step. This summary is presented in Chapter 12.

I.1.1 Identifying MP&M Pollutants

EPA sampled MP&M facilities nationwide to assess the concentrations of pollutants in MP&M effluents. The Agency collected samples of raw wastewater from MP&M facilities and applied standard water analysis protocols to identify and quantify the pollutant levels in each sample. EPA used these analytical data, along with selection criteria, to identify 132 contaminants of potential concern. MP&M POCs include 43 ***priority pollutants (PP)***, 3 conventional pollutants, and 86 nonconventional pollutants.

EPA then evaluated the potential environmental fate of these pollutants and their toxicity to humans and aquatic receptors. EPA was able to assess the potential fate and toxicity of 118 of these pollutants, including 43 priority pollutants (33 priority organics, nine priority metals and one inorganic) and 75 nonconventional pollutants (50 nonconventional organics, 18 nonconventional metals, and seven nonconventional inorganics). Table I.1 presents the potential fate and toxicity, based on known characteristics of each chemical, of 132 pollutants of concern. Potential fate and toxicity data are not available for four conventional, 2 nonconventional, and eight bulk nonconventional pollutants (also listed in Table I.1) associated with adverse water quality impacts, as described in Section 12.1.3 of this report.

Table I.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC [f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
O	Acenaphthene	83329	Moderate	Low	Moderate	Low	Moderate	Moderate	Moderate	Low	✓				✓
O	Acetone	67641	Low	Low	Low	Low	Moderate	Low	Insignificant	Moderate	✓				
O	Acetophenone	98862	Low	Low	Unknown	Unknown	Low	Low	Low	Moderate	✓			✓	
O	Acrolein	107028	High	High	High	High	Moderate	Nonadsorptive	Moderate	Low	✓			✓	✓
O	Aniline	62533	Moderate	High	Low	Low	Low	Low	Low	Moderate		✓		✓	
O	Anthracene	120127	High	High	High	Moderate	Moderate	High	Moderate	Resistant	✓				✓
O	Benzoic acid	65850	Low	Low	Unknown	Unknown	Low	Low	Low	Moderate	✓				
O	Benzyl alcohol	100516	Low	Low	Low	Low	Low	Nonadsorptive	Insignificant	Moderate	✓				
O	Biphenyl	92524	Moderate	Low	Low	Low	Moderate	Moderate	Moderate	Moderate	✓			✓	
O	Bis(2-ethylhexyl) phthalate	117817	Unknown	Unknown	Unknown	Unknown	Nonvolatile	High	Moderate	Moderate	✓	✓	M	✓	✓
O	Bromo-2-chlorobenzene, 1-	694804	Low	Low	Unknown	Unknown	Moderate	Moderate	Moderate	Low					
O	Bromo-3-chlorobenzene, 1-	108372	Low	Low	Unknown	Unknown	Moderate	Moderate	Moderate	Low					
O	Butyl benzyl phthalate	85687	Moderate	Low	Moderate	Low	Low	High	Moderate	Moderate	✓				✓
O	Carbon disulfide	75150	Low	High	Unknown	High	High	Low	Low	Unknown	✓			✓	
O	Chlorobenzene	108907	Low	Low	Low	Low	High	Low	Low	Low	✓		M	✓	✓
O	Chloroethane	75003	Low	Low	Unknown	Unknown	High	Low	Low	Low	✓	✓		✓	✓
O	Cresol, o-	95487	Low	Low	Low	Low	Low	Low	Low	Moderate	✓			✓	
O	Cresol, p-	106445	Low	Low	Unknown	Unknown	Low	Low	Low	High	✓			✓	
O	Cyanide	57125	High	High	High	High	Unknown	Low	Insignificant	Moderate	✓		M		✓
O	Cymene, p-	99876	Low	Low	Low	Low	High	Moderate	High	Low					
O	Decane, n-	124185	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Dibenzothiophene	132650	Moderate	Low	Unknown	Unknown	Moderate	High	High	Unknown					
O	Dichloroethene, 1,1-	75354	Low	Low	Low	Low	High	Low	Low	Resistant	✓	✓	M	✓	✓
O	Dichloromethane	75092	Low	Low	Low	Low	High	Low	Insignificant	Low	✓	✓	M	✓	✓
O	Dimethyl phthalate	131113	Low	Low	Low	Low	Nonvolatile	Low	Low	Moderate				✓	✓
O	Dimethylformamide, N,N-	68122	Low	Low	Unknown	Unknown	Nonvolatile	Nonadsorptive	Insignificant	Moderate	✓			✓	
O	Dimethylphenanthrene, 3,6-	1576676	Moderate	Moderate	Unknown	Unknown	Low	High	High	Moderate					
O	Dimethylphenol, 2,4-	105679	Low	Low	Unknown	Unknown	Low	Low	Moderate	Moderate	✓				✓
O	Di-n-butyl phthalate	84742	Moderate	Low	Moderate	High	Low	Moderate	Moderate	Moderate	✓			✓	✓
O	Dinitrophenol, 2,4-	51285	Low	Low	Low	Low	Low	Moderate	Insignificant	Resistant	✓			✓	✓
O	Dinitrotoluene, 2,6-	606202	Low	Moderate	Unknown	Unknown	Low	Low	Low	Resistant	✓				✓
O	Di-n-octyl phthalate	117840	Moderate	Moderate	Unknown	Unknown	Low	Moderate	High	Low	✓				✓
O	Dioxane, 1,4-	123911	Low	Low	Unknown	Unknown	Low	Low	Insignificant	Resistant		✓		✓	
O	Diphenylamine	122394	Low	Low	Unknown	Unknown	Low	Moderate	Moderate	Moderate	✓				
O	Diphenyl ether	101848	Moderate	Low	Low	Unknown	Moderate	Moderate	Moderate	Moderate					
O	Docosane, n-	629970	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Dodecane, n-	112403	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Eicosane, n-	112958	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Ethylbenzene	100414	Low	Low	Moderate	Moderate	High	Low	Low	Moderate	✓		M	✓	✓
O	Fluoranthene	206440	High	High	High	Moderate	Moderate	High	High	Resistant	✓				✓
O	Fluorene	86737	Moderate	High	Moderate	Moderate	Moderate	Moderate	Low	Low	✓				✓
O	Hexacosane, n-	630013	Low	Low	Low	Low	Unknown	Unknown	Unknown	Moderate					
O	Hexadecane, n-	544763	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Hexanoic acid	142621	Low	Low	Unknown	Unknown	Moderate	Low	Low	Moderate					
O	Hexanone, 2-	591786	Low	Low	Unknown	Unknown	Moderate	Low	Low	Moderate	✓				
O	Isobutyl alcohol	78831	Low	Low	Low	Low	Moderate	Low	Insignificant	Moderate	✓				

Table I.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC [f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
O	Isophorone	78591	Low	Low	Low	Low	Low	Low	Insignificant	Low	✓	✓		✓	✓
O	Isopropylnaphthalene, 2-	2027170	Moderate	Moderate	Unknown	Unknown	Moderate	High	High	Unknown					
O	Methyl ethyl ketone	78933	Low	Low	Low	Low	Moderate	Nonadsorptive	Insignificant	Moderate	✓			✓	
O	Methyl isobutyl ketone	108101	Low	Low	Low	Low	Moderate	Low	Insignificant	Moderate	✓			✓	
O	Methyl methacrylate	80626	Low	Low	Unknown	Unknown	Moderate	Low	Low	Low	✓			✓	
O	Methylfluorene, 1-	1730376	Moderate	Low	Unknown	Unknown	Moderate	High	High	Unknown					
O	Methylnaphthalene, 2-	91576	Low	Low	Moderate	Moderate	Moderate	Moderate	High	Moderate	✓				
O	Methylphenanthrene, 1-	832699	Moderate	Moderate	Unknown	Unknown	Low	High	High	Unknown					
O	Naphthalene	91203	Low	Low	Low	Low	Moderate	Low	Low	Moderate	✓			✓	✓
O	Nitrophenol, 2-	88755	Low	Low	Low	Low	Low	Low	Low	Low					✓
O	Nitrophenol, 4-	100027	Low	Low	Low	Low	Nonvolatile	Low	Moderate	Moderate	✓			✓	✓
O	Nitrosodimethylamine, N-	62759	Low	Low	Low	Low	Nonvolatile	Low	Insignificant	Resistant		✓		✓	✓
O	Nitrosodiphenylamine, N-	86306	Low	Low	Low	Low	Low	Moderate	Moderate	Low		✓			✓
O	Nitrosopiperidine, N-	100754	Low	Low	Unknown	Unknown	Nonvolatile	Nonadsorptive	Insignificant	Resistant					
O	Octacosane, n-	630024	Low	Low	Low	Low	Unknown	Unknown	Unknown	Moderate					
O	Octadecane, n-	593453	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Parachlorometacresol	59507	Low	Low	Unknown	Unknown	Low	Low	Moderate	Low	✓				✓
O	Phenanthrene	85018	Moderate	Moderate	Moderate	Moderate	Moderate	High	Moderate	Resistant					✓
O	Phenol	108952	Low	Low	Low	Low	Low	Low	Insignificant	High	✓			✓	✓
O	Pyrene	129000	Moderate	Moderate	Unknown	Unknown	Moderate	High	High	Resistant	✓				✓
O	Pyridine	110861	Low	Low	Unknown	Unknown	Low	Nonadsorptive	Insignificant	Moderate	✓				
O	Styrene	100425	Low	Low	Low	Low	High	Low	Low	Low	✓		M	✓	
O	Terpineol, alpha-	98555	Low	Low	Unknown	Unknown	Moderate	Low	Low	Moderate					
O	Tetrachloroethene	127184	Low	Low	Low	Low	High	Low	Low	Resistant	✓	✓	M	✓	✓
O	Tetracosane, n-	646311	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Tetradecane, n-	629594	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Toluene	108883	Low	Low	Low	Low	High	Low	Low	Moderate	✓		M	✓	✓
O	Triacontane, n-	638686	Low	Low	Low	Low	Unknown	Unknown	Unknown	Moderate					
O	Trichloroethene	79016	Low	Low	Low	Low	High	Low	Low	Resistant	✓	✓	M	✓	✓
O	Trichlorofluoromethane	75694	Low	Low	Unknown	Unknown	High	Low	Low	Resistant	✓				
O	Trichloromethane	67663	Low	Low	Low	Low	High	Low	Insignificant	Resistant	✓	✓	THM	✓	✓
O	Tripropyleneglycolmethylether	20324338	Low	Low	Unknown	Unknown	Nonvolatile	Low	Insignificant	Moderate					
O	Xylene, m-	108383	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Xylene, m- & p-*	179601231	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Xylene, o-	95476	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Xylene, o- & p-*	136777612	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Ziram \ Cymate	137304	High	High	Low	Low	Nonvolatile	Nonadsorptive	Insignificant	Resistant	✓				
M	Aluminum	7429905	Moderate	Moderate	Unknown	Unknown	Nonvolatile	High	Moderate	Resistant	✓		SM		
M	Antimony	7440360	Low	Low	Low	Low	Nonvolatile	High	Insignificant	Resistant	✓		M		✓
M	Barium	7440393	Low	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓		M		
M	Beryllium	7440417	Moderate	High	Unknown	Unknown	Nonvolatile	High	Low	Resistant	✓		M		✓
M	Cadmium	7440439	High	High	High	High	Nonvolatile	High	Moderate	Resistant	✓		M		✓
M	Calcium	7440702	Unknown	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					
M	Chromium	7440473	Moderate	Moderate	Low	Moderate	Nonvolatile	High	Low	Resistant	✓		M		
M	Chromium hexavalent	18540299	High	Moderate	Low	Moderate	Nonvolatile	High	Low	Resistant	✓		M		
M	Cobalt	7440484	Low	Moderate	Unknown	Moderate	Nonvolatile	High	Unknown	Resistant	✓				

Table I.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC [f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
M	Copper	7440508	High	High	High	High	Nonvolatile	High	Moderate	Resistant	✓		TT		✓
M	Gold	7440575	Unknown	Unknown	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					
M	Iron	7439896	Unknown	Low	Low	Low	Nonvolatile	High	Unknown	Resistant	✓		SM		
M	Lead	7439921	High	High	Moderate	High	Nonvolatile	High	Low	Resistant			TT		✓
M	Magnesium	7439954	Low	Low	Unknown	Unknown	Nonvolatile	High	High	Resistant					
M	Manganese	7439965	Unknown	Low	Unknown	Moderate	Nonvolatile	High	Unknown	Resistant	✓		SM		
M	Mercury	7439976	High	High	High	High	High	High	High	Resistant			M		✓
M	Molybdenum	7439987	Unknown	Moderate	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Nickel	7440020	Moderate	Moderate	High	High	Nonvolatile	Low	Low	Resistant	✓		M		✓
M	Selenium	7782492	High	High	Moderate	Moderate	Nonvolatile	High	Insignificant	Resistant	✓		M		
M	Silver	7440224	High	High	High	High	Nonvolatile	High	Insignificant	Resistant	✓		SM		✓
M	Sodium	7440235	Low	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					
M	Thallium	7440280	Low	Moderate	Low	Low	Nonvolatile	High	Moderate	Resistant	✓		M		✓
M	Tin	7440315	Unknown	Moderate	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Titanium	7440326	Unknown	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Vanadium	7440622	Low	High	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Yttrium	7440655	Unknown	Unknown	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					
M	Zinc	7440666	Moderate	Low	High	Moderate	Nonvolatile	High	Low	Resistant	✓		SM		
OI	Ammonia as N	7664417	Low	Low	Low	Low	Moderate	Nonadsorptive	Unknown	Moderate					
OI	Arsenic	7440382	Moderate	Low	High	Moderate	Unknown	Unknown	Low	Unknown	✓	✓	M		✓
OI	Boron	7440428	Unknown	Moderate	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	✓				
OI	Chloride	16887006	Low	Low	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown			SM		
OI	Fluoride	16984488	Low	Low	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	✓		M		
OI	Phosphate	14265442	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown					
OI	Sulfate	14808798	Unknown	Low	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown			SM		
OI	Sulfide	18496258	Unknown	High	Unknown	High	Unknown	Unknown	Unknown	Unknown					
OI	Phosphorus (as PO4)		Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown					
CP	BOD 5-day (carbonaceous)	C-003													
CP	Oil and Grease														
CP	Oil and Grease (as Hem)	C-036													
CP	Total Suspended Solids (TSS)	C-009													
BNCP	Amenable Cyanide	C-025													
BNCP	Chemical Oxygen Demand (COD)	C-004													
BNCP	Total Dissolved Solids (TDS)	C-010													
BNCP	Total Kjeldahl Nitrogen	C-021													
BNCP	Total Organic Carbon (TOC)	C-012													

Table I.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC [f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
BNCP	Total Petroleum Hydrocarbons (as Sgt-hem)	C-037													
BNCP	Total Recoverable Phenolics	C-020													
BNCP	Weak-acid Dissociable Cyanide	C-042													

Table Notes:
Unless indicated otherwise, all metals are assumed to be nonvolatile, to have high adsorption, and to be resistant to biodegradation.

[a] Type
O = Organic
M = Metal
OI = Other Inorganic
CP = Conventional Pollutant
BNCP = Bulk Nonconventional Pollutant
[b] BCF = Bioconcentration Factor
[c] Biodeg = Biodegradation Potential
[d] RfD = Reference Dose
[e] SF = Slope Factor
[f] DWC = Drinking Water Criteria
[g] Drinking Water Criteria Codes
M = Maximum Contaminant Level (MCL) established for health-based effect
SM = Secondary Maximum Contaminant Level (SMCL) established for taste or aesthetic effect
THM = MCL established for trihalomethanes
TT = Treatment technology action level established
[h] HAP = Hazardous Air Pollutant
[i] PP = Priority Pollutant

Source: U.S. EPA analysis.

I.1.2 Physical-Chemical Characteristics and Toxicity Data of MP&M Pollutants

Pollutants present in MP&M effluents can have significant effects on human health and aquatic receptors. EPA used various data sources to evaluate both pollutant-specific fate and toxicity and potential human health effects, including:

- ***reference doses (RfDs***),
- ***cancer potency slope factors (SFs)***,
- ***human health-based water quality criteria (WQC***),
- ***maximum contaminant levels (MCLs)*** for drinking water protection and other drinking water related criteria, and
- ***hazardous air pollutant (HAP)*** and priority pollutant (PP) lists.

To evaluate potential fate and effects in aquatic environments, the Agency relied on:

- measures of acute and chronic toxicity to aquatic species,
- bioconcentration factors for aquatic species,
- ***Henry's Law (H)*** constants (to estimate volatility),
- adsorption coefficients (to estimate association with bottom sediments), and
- biodegradation half-lives (to estimate the removal of chemicals via microbial metabolism).

The data sources used in the assessment include:

- EPA ambient WQC documents and updates;
- EPA's ASsessment Tools for the Evaluation of Risk ***(ASTER)***;
- the AQUatic Information REtrieval System ***(AQUIRE)*** and the ***Environmental Research Laboratory-Duluth fathead minnow database***;
- EPA's ***Integrated Risk Information System (IRIS)***;
- EPA's ***Health Effects Assessment Summary Tables (HEAST)***;
- EPA's 1991 and 1993 ***Superfund Chemical Data Matrix (SCDM)***;
- Syracuse Research Corporation's ***CHEMFATE*** and ***BIODEG*** databases; and
- EPA and other government reports, scientific literature, and other primary and secondary data sources.

EPA also obtained information on chemicals for which the sources listed above did not provide physical-chemical properties and/or toxicity data, to ensure that the assessment be as comprehensive as possible. To the extent possible, EPA estimated values for the chemicals using the ***quantitative structure-activity relationship (QSAR)*** model incorporated in ASTER. The Agency also used published linear regression correlation equations to determine some physical-chemical properties.

a. Human health effects

EPA used various data sources to determine pollutant-specific toxicity to human health. EPA obtained RfDs and SFs from IRIS, HEAST, and EPA's Region II Risk-Based Concentration ***(RBC)*** table. EPA developed drinking water criteria and human health-based AWQC values for two exposure routes: (1) ingesting the pollutant via contaminated aquatic organisms only (carcinogens and non-carcinogens), and (2) ingesting the pollutant via both water and contaminated aquatic organisms (non-carcinogens only). Table I.2 summarizes pollutant toxicity data pertaining to human health. In addition to fate and toxicity data, Table I.1 also includes HAP and PP lists. Short descriptions and definitions for each of the measures of human health effects are provided below.

Table I.2: Human Health Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Human Health AWQC Values				
		Ingesting Water and Organisms	Ingesting Organisms Only	Slope Factor	Reference Dose	Drinking Water Criteria
		(µg/l)	(µg/l)	(mg/kg/day)	(mg/kg/day)	(µg/l)
51285	Dinitrophenol, 2,4-	70	14000		0.002	
57125	Cyanide	700	220000		0.02	200
59507	Parachlorometacresol	56000	270000		2	
62533	Aniline	5.8	95	0.0057		
62759	Nitrosodimethylamine, N-	0.00069	8.1	51		
65850	Benzoic acid	130000	2900000		4	
67641	Acetone	3500	2800000		0.1	
67663	Trichloromethane	5.7	470	0.0061	0.01	100
68122	Dimethylformamide, N,N-	3500	220000000		0.1	
75003	Chloroethane	12	520	0.0029	0.4	
75092	Dichloromethane	4.7	1600	0.0075	0.06	5
75150	Carbon disulfide	3400	94000		0.1	
75354	Dichloroethene, 1,1-	0.057	3.2	0.6	0.009	7
75694	Trichlorofluoromethane	9100	66000		0.3	
78591	Isophorone	36	2600	0.00095	0.2	
78831	Isobutyl alcohol	10000	1500000		0.3	
78933	Methyl ethyl ketone	21000	6500000		0.6	
79016	Trichloroethene	3.1	92	0.011	0.006	5
80626	Methyl methacrylate	48000	2300000		1.4	
83329	Acenaphthene	1200	2700		0.06	
84742	Di-n-butyl phthalate	2700	12000		0.1	
85018	Phenanthrene					
85687	Butyl benzyl phthalate	3000	5200		0.2	
86306	Nitrosodiphenylamine, N-	5	16	0.0049		
86737	Fluorene	720	1500		0.04	
88755	Nitrophenol, 2-					
91203	Naphthalene	680	21000		0.02	
91576	Methylnaphthalene, 2-	75	84		0.02	
92524	Biphenyl	720	1200		0.05	
95476	Xylene, o-	42000	100000		2	10000
95487	Cresol, o-	1700	30000		0.05	
98555	Terpineol, alpha-					
98862	Acetophenone	3400	98000		0.1	
99876	Cymene, p-					
100027	Nitrophenol, 4-	220	1100		0.008	
100414	Ethylbenzene	3100	29000		0.1	700
100425	Styrene	6700	160000		0.2	100
100516	Benzyl alcohol	10000	810000		0.3	
100754	Nitrosopiperidine, N-					
101848	Diphenyl Ether					
105679	Dimethylphenol, 2,4-	540	2300		0.02	
106445	Cresol, p-	170	3100		0.005	
107028	Acrolein	410	1000		0.02	

Table I.2: Human Health Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Human Health AWQC Values		Slope Factor	Reference Dose	Drinking Water Criteria
		Ingesting Water and Organisms	Ingesting Organisms Only			
		(µg/l)	(µg/l)	(mg/kg/day)	(mg/kg/day)	(µg/l)
108101	Methyl isobutyl ketone	2800	360000		0.08	
108372	Bromo-3-chlorobenzene, 1-					
108383	Xylene, m-	42000	100000		2	10000
108883	Toluene	6800	200000		0.2	1000
108907	Chlorobenzene	680	21000		0.02	100
108952	Phenol	21000	4600000		0.6	
110861	Pyridine	35	5400		0.001	
112403	Dodecane, n- (a)					
112958	Eicosane, n- (a)					
117817	Bis(2-ethylhexyl) phthalate	1.8	5.9	0.014	0.02	6
117840	Di-n-octyl phthalate	37	39		0.02	
120127	Anthracene	4100	6800		0.3	
122394	Diphenylamine	470	1000		0.025	
123911	Dioxane, 1,4-	3.2	2400	0.011		
124185	Decane, n-					
127184	Tetrachloroethene	320	3500	0.052	0.01	5
129000	Pyrene	230	290		0.03	
131113	Dimethyl phthalate	310000	2900000			
132650	Dibenzothiophene					
137304	Ziram \ Cymate	700	220000000		0.02	
142621	Hexanoic acid					
206440	Fluoranthene	300	370		0.04	
544763	Hexadecane, n- (a)					
591786	Hexanone, 2-	1400	65000		0.04	
593453	Octadecane, n- (a)					
606202	Dinitrotoluene, 2,6-	34	900		0.001	
629594	Tetradecane, n- (a)					
629970	Docosane, n-					
630013	Hexacosane, n- (b)					
630024	Octacosane, n- (b)					
638686	Triacontane, n- (b)					
646311	Tetracosane, n- (b)					
694804	Bromo-2-chlorobenzene, 1-					
832699	Methylphenanthrene, 1-					
1576676	Dimethylphenanthrene, 3,6-					
1730376	Methylfluorene, 1-					
2027170	Isopropylnaphthalene, 2-					
7429905	Aluminum	20000	47000		1	50
7439896	Iron	300			0.3	300
7439921	Lead					15
7439954	Magnesium					
7439965	Manganese	50	100		0.14	50
7439976	Mercury	0.05	0.051			2
7439987	Molybdenum				0.005	
7440020	Nickel	610	4600		0.02	
7440224	Silver	170	110000		0.005	100
7440235	Sodium					
7440280	Thallium	1.8	6.5		0.00007	2

Table I.2: Human Health Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Human Health AWQC Values				
		Ingesting Water and Organisms	Ingesting Organisms Only	Slope Factor	Reference Dose	Drinking Water Criteria
		(µg/l)	(µg/l)	(mg/kg/day)	(mg/kg/day)	(µg/l)
7440315	Tin				0.6	
7440326	Titanium				4	
7440360	Antimony	14	4300		0.0004	6
7440382	Arsenic	0.02	0.16	1.5	0.0003	50
7440393	Barium	1000			0.07	2000
7440417	Beryllium	66	1100		0.002	4
7440428	Boron				0.09	
7440439	Cadmium	14	84		0.0005	5
7440473	Chromium	50000	1000000		1.5	100
7440484	Cobalt				0.06	
7440508	Copper	650	1200		0.04	1300
7440575	Gold					
7440622	Vanadium				0.007	
7440655	Yttrium					
7440666	Zinc	9100	69000		0.3	5000
7440702	Calcium					
7664417	Ammonia as N					
7782492	Selenium	170	11000		0.005	50
14265442	Phosphate					
14808798	Sulfate					250000
16887006	Chloride					250000
16984488	Fluoride				0.06	4000
18496258	Sulfide	100	10000			
18540299	Chromium hexavalent	100	2000		0.003	100
20324338	Tripropyleneglycolmethyl ether					
136777612	Xylene, o- & p- (c)	42000	100000		2	10000
179601231	Xylene, m- & p- (c)	42000	100000		2	10000
C003	BOD 5-day (carbonaceous)					
C004	Chemical Oxygen Demand (COD)					
C009	Total Suspended Solids (TSS)					
C010	Total Dissolved Solids (TDS)					
C012	Total Organic Carbon (TOC)					
C020	Total Recoverable Phenolics					
C021	Total Kjeldahl Nitrogen					
C025	Amenable Cyanide					
C036	Oil And Grease (as Hem)					
C037	Total Petroleum Hydrocarbons (as Sgt-hem)					
C042	Weak-acid Dissociable Cyanide					
	Phosphorus (as PO4)					
	Oil and Grease					

Sources: U.S. EPA (1980), U.S. EPA (1984), U.S. EPA (1997), U.S. EPA (1998), U.S. EPA (1998/99), Worthing (1987).

❖ *Systemic toxicants*

Systemic toxicants are chemicals that EPA believes can cause significant non-carcinogenic health effects when present in the human body above chemical-specific toxicity thresholds. These effects may result from acute or chronic chemical exposures, and include:

- systemic health effects (i.e., loss of one or more neurological, respiratory, reproductive, immunological, or circulatory functions);
- organ-specific toxicity (e.g., liver and kidney effects);
- developmental toxicity (e.g., reduced weight in newborns or loss of IQ); and
- lethality.

EPA typically relies on animal toxicity data to develop RfDs for systemic toxicants that can enter the human body via ingestion. These values represent chemical concentrations expressed in mg of pollutant/kg body weight/day. Certain exposed populations are considered to be protected if these chemical concentrations are not exceeded. These populations include sensitive groups, such as young children or pregnant women. EPA included all available RfD data for the MP&M pollutants of concern (POCs) in the analysis.

❖ *Carcinogens*

Carcinogens are chemicals that EPA believes can cause or have the potential to cause cellular damage, which can lead to tumors or cancers in humans, either directly or indirectly. Unlike systemic toxicants, most carcinogens are not believed to have a toxicity threshold. Any amount of a carcinogen therefore has the potential to result in a cancer event, even though such a probability can be very small at low concentrations. The Agency has developed SFs, using animal or epidemiological data, that express the probability that a chemical will induce tumor or cancer development. EPA included all available SF data for the MP&M POCs in the analysis.

❖ *Drinking water criteria*

EPA developed human health-based drinking water criteria to assess the health hazards associated with the presence of certain toxic chemicals in drinking water. The criteria are usually presented as MCLs. MCLs for non-carcinogens represent chemical-specific concentrations (expressed in **µg/l**) that are not expected to result in adverse health effects in exposed populations if not exceeded in drinking water. MCLs for carcinogens represent chemical-specific concentrations (expressed in µg/l) that are expected to result in less than one additional cancer case per million lifetime exposures if not exceeded in drinking water. The Agency also investigated additional drinking water criteria, including:

- **Secondary Maximum Contaminant Levels (SMCLs)** established for taste or aesthetic effects,
- MCLs established specifically for trihalomethanes, and
- **action levels** developed on the basis of treatment technology.

EPA included all the available primary and secondary drinking water criteria for the MP&M POCs in the analysis.

❖ *Pollutant uptake via water and/or organisms*

EPA has developed WQC for numerous priority toxic pollutants to protect the health of humans who consume water and organisms or only organisms obtained from aquatic habitats contaminated by those PPs. The criteria, expressed in µg/l, represent concentrations in surface waters that will cause adverse health effects in humans when exceeded. EPA obtained all available human health WQC for the MP&M POCs and included them in the analysis.

❖ *Priority pollutants (PPs)*

Priority pollutants are 126 individual chemicals, defined by the Agency as toxic, that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater, or soil samples. These chemicals are of particular concern to the Agency because of their high toxicity or persistence in the environment. EPA identified all MP&M PPs and included them in the analysis.

❖ *Hazardous air pollutants (HAPs)*

HAPs are compounds that EPA believes may represent an unacceptable risk to human health if present in the air. HAPs, expressed in $\mu g/m^3$, can be of particular concern to POTW workers if released into the air at high enough concentrations during the wastewater treatment cycle. EPA identified all HAPs among the MP&M POCs analyzed.

b. Aquatic receptor effects

The potential impact of chemicals on aquatic receptors can be assessed qualitatively based on five effect and fate parameters:

- aquatic toxicity (acute and chronic),
- bioconcentration,
- volatilization,
- adsorption, and
- biodegradation.

Site-specific risks require a measure of exposure and cannot be quantified using this approach. Chemicals can be classified and ranked in terms of their impacts on aquatic receptors, however, by using the five parameters discussed below. Table I.3 summarizes the measured or estimated values of these parameters for the MP&M POCs. Each effect and fate parameter is described below.

Biological oxygen demand (BOD), ***oil and grease (O&G)***, ***pH***, and ***total suspended solids (TSS)***: These fate/effect parameters are relevant only for specific chemicals. These parameters are not available for the conventional pollutants or bulk nonconventional pollutants, such as ***total petroleum hydrocarbons (TPH)***, ***alkalinity***, ***total organic carbon (TOC)***, or ***total Kjeldahl nitrogen (TKN)***. Most of these pollutants are responsible for significant environmental impacts, however. Section 12.2.4 outlines these impacts in greater detail.

❖ *Aquatic toxicity data*

The Agency addressed two general classes of aquatic toxicity:

- ***Acute toxicity (AT)*** assesses the impacts of a pollutant after a relatively short exposure duration, typically 48 and 96 hours for invertebrates and fish, respectively. The endpoint of concern is mortality, reported as the ***LC50***. This value represents the concentration lethal to 50 percent of the test organisms for the duration of the exposure.
- ***Chronic toxicity (CT)*** assesses the impact of a pollutant after a longer exposure duration, typically from one week to several months. The endpoints of concern are one or more sub-lethal responses, such as changes in reproduction or growth in the affected organisms. The results are reported in various ways, including ***EC1*** or ***EC5*** (i.e., the concentration at which one percent or five percent of the test organisms show a significant sub-lethal response), ***NOEC (No Observed Effect Concentration), LOEC (Lowest Observed Effect Concentration)***, or ***MATC (Maximum Allowable Toxicant Concentration)***.

❖ *Bioconcentration factor (BCF) data*

The ***bioconcentration factor*** (***BCF***, measured in ***l/kg***) is a good indicator of the potential for a chemical dissolved in the water column to be taken up by aquatic biota across external surface membranes, usually fish gills. The BCF is defined as follows:

$$BCF = \frac{\text{equilibrium chemical concentration in target organism (mg/kg, wet weight)}}{\text{mean chemical concentration in surrounding water } (\mu g/L)} \quad (I.1)$$

EPA analyzes POCs with elevated BCF values because these pollutants can bioconcentrate in aquatic organisms and transfer up the food chain if they are not metabolized and excreted. This transfer can result in significant exposures to predators (including humans) consuming contaminated fish or shellfish.

Although the bioaccumulation factor (BAF) is a better measure of the potential for a chemical dissolved in the water column to be taken up by aquatic biota, field measured BAFs are not yet available. EPA recognizes that using bioconcentration factors will underestimate the risk to aquatic organisms.

❖ *Volatilization data*

Volatilization is a process whereby chemicals dissolved in water escape into the air. Chemicals with higher volatilization potential are typically of less concern to aquatic receptors because they tend to be removed quickly from the water column. These volatile pollutants are a concern to human health when inhaled. For aquatic receptors, however, POCs with higher volatilization potential present lower hazards.

EPA used the air/water partitioning coefficient H to estimate a chemical's volatilization potential. H represents the ratio of a chemical's aqueous phase concentration to its equilibrium partial pressure in the gas phase (at 25°C); units are typically expressed as **$atm.m^3/mole$**. Metals do not have measurable partial pressures (with some notable exceptions, including several organic mercury compounds), and are therefore considered to be nonvolatile unless otherwise indicated.

❖ *Adsorption data*

Adsorption is a process whereby chemicals associate preferentially with the **organic carbon (OC)** found in soils and sediments. Highly adsorptive compounds tend to accumulate in sludge or sediments. Such chemicals are also more likely to be taken up by **benthic** invertebrates and to affect local food chains. Both accumulation in sediment and the effect on local food chains make these chemicals more likely to impact higher predators, including humans.

EPA used the **adsorption coefficient (K_{oc})** to assess the potential of organic MP&M POCs to associate with organic carbon. K_{oc} represents the ratio of the target chemical adsorbed per unit weight of organic carbon in the soil or sediment to the concentration of that same chemical in solution at equilibrium. Metals in the aquatic environment typically end up in the sediment phase but do not bind to the organic carbon (except for nickel). The Agency assumed that all metals show a high affinity for sludge and sediments independent of their negligible K_{oc} values.

❖ *Biodegradation data*

Biodegradation is a process whereby organic molecules are broken down by microbial metabolism. Biodegradation represents an important removal process: compounds that are readily biodegraded generally represent lower intrinsic hazards because they can be eliminated rapidly. These compounds are therefore less likely to create long-term toxicity problems or to accumulate in sludge or sediments and organisms. Chemicals that biodegrade slowly or not at all can accumulate and linger for longer periods of time in sludge or sediments, and represent a higher hazard to aquatic receptors.

EPA used **biodegradation half-life** to estimate the potential for an organic chemical to biodegrade in the aquatic environment. Biodegradation half-life represents the number of days a compound takes to be degraded to half of its starting concentration under prescribed laboratory conditions. Metals do not biodegrade.

Table I.3 summarizes pollutant toxicity data pertaining to aquatic life.

Table I.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Freshwater Aquatic Life		Saltwater Aquatic Life		Bio concentration Factor	Henry's Law Constant	Adsorption Coefficient (K$_{oc}$)	Bio degradation Half-Life
		Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
51285	Dinitrophenol, 2,4-	1160	790	1500	940	1.51	0.000000443	2386	263
57125	Cyanide	22	5.2	1	1	1		45	16
59507	Parachlorometacresol	4050	1300			79	0.0000025	604	100
62533	Aniline	250	4	29400	2940	19.9	0.0000019	54	26
62759	Nitrosodimethylamine, N-	280000	4000	4300000	430000	0.026	0.000000263	12	180
65850	Benzoic acid	180000	17178			15	0.00000154	182	16
67641	Acetone	6210000	1866000	5640000	10000	0.39	0.00004	18	7
67663	Trichloromethane	13300	6300	19610	1961	3.75	0.00367	40	180
68122	Dimethylformamide, N,N-	7100000	710000			0.005	0.000000018	6.1	16
75003	Chloroethane	65614	21069			7.2	0.00882	37.6	28
75092	Dichloromethane	330000	82500	256000	2560	0.91	0.00219	28	28
75150	Carbon disulfide	2100	2		2	11.5	0.0303	89	
75354	Dichloroethene, 1,1-	11600	5114	224000	22400	5.6	0.0261	343	180
75694	Trichlorofluoromethane	17387	6412			49	0.097	93	360
78591	Isophorone	120000	11000	12900	1290	4.38	0.00000576	25	28
78831	Isobutyl alcohol	949000	4000	600000	60000	2.2	0.0000118	61.7	7.2
78933	Methyl ethyl ketone	3220000	233550	1287000	128700	1	0.00006	5.2	7
79016	Trichloroethene	40700	14850	14000	2000	10.6	0.0103	104	360
80626	Methyl methacrylate	191000	19100			6.6	0.00034	22	28
83329	Acenaphthene	580	208	970	710	242	0.00009	3890	102
84742	Di-n-butyl phthalate	850	500	450	3.4	89	0.00000181	6310	23
85018	Phenanthrene	180	19	110	11	486	0.00002	18800	200
85687	Butyl benzyl phthalate	820	260	510	400	414	0.00000126	17000	7
86306	Nitrosodiphenylamine, N-	5800	1000	3300000	33000	136	0.000005	1200	34
86737	Fluorene	212	8	1000	100	30	0.00006	2830	60
88755	Nitrophenol, 2-	160000	3451	32000	16000	13.5	0.00000947	114	28
91203	Naphthalene	1600	370	1200	120	10.5	0.00048	871	20
91576	Methylnaphthalene, 2-	1133	417	600	60	2566	0.00052	8500	20
92524	Biphenyl	360	230	4600	460	436	0.0003	1400	7
95476	Xylene, o-	3820	1332	6000	600	208	0.00519	129	28
95487	Cresol, o-	14000	2251	10200	1020	18	0.0000012	103	7
98555	Terpineol, alpha-	12742	4879			48	0.0000544	589	15

Table I.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Freshwater Aquatic Life		Saltwater Aquatic Life		Bio concentration Factor	Henry's Law Constant	Adsorption Coefficient (K_{oc})	Bio degradation Half-Life
		Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
98862	Acetophenone	162000	31094			11	0.00001	45	16
99876	Cymene, p-	6500	237	4400	440	770	0.011	4000	100
100027	Nitrophenol, 4-	7680	1300	7170	1900	79	0.000000000415	236	7
100414	Ethylbenzene	9090	4600	430	43	37.5	0.00788	250	10
100425	Styrene	4020	402	9100	910	13.5	0.00283	920	28
100516	Benzyl alcohol	10000	1000	15000	1500	4	0.000000743	6.1	16
100754	Nitrosopiperidine, N-	1019538	282592				0.000000275	9	180
101848	Diphenyl Ether	4000			240	930	0.000448	7800	15
105679	Dimethylphenol, 2,4-	2120	1970			94	0.000000951	18	7
106445	Cresol, p-	7500	2570			17.6	0.000001	49	0.667
107028	Acrolein	14	5.8	55	5.5	215	0.00012	5	28
108101	Methyl isobutyl ketone	505000	50445	812000	81200	2.4	0.00014	19	7
108372	Bromo-3-chlorobenzene, 1-	1784	682			190	0.00078	1500	100
108383	Xylene, m-	16000	3900	12000	1200	208	0.00718	190	28
108883	Toluene	5500	1000	6300	5000	10.7	0.00664	95	22
108907	Chlorobenzene	2370	2100	10500	1050	10.3	0.00377	275	150
108952	Phenol	4200	200	5800	2410	1.4	0.000000333	30.2	3.5
110861	Pyridine	93800	25000			2	0.00000888	5	7
112403	Dodecane, n- (a)	18000	1300	500000	50000	14500		95000	17
112958	Eicosane, n- (a)	18000	1300	500000	50000	100000		30000000	17
117817	Bis(2-ethylhexyl) phthalate					130	0.0000001	87420	23
117840	Di-n-octyl phthalate	690	69			5460	0.000000445	2390	28
120127	Anthracene	2.78	2.2	40	16	478	0.00007	16000	460
122394	Diphenylamine	3790	734			269	0.000000496	1910	20
123911	Dioxane, 1,4-	9850000	1457300			0.4	0.0000048	17	180
124185	Decane, n- [a]	18000	1300	500000	50000	8800		58200	17
127184	Tetrachloroethene	4990	510	10200	450	30.6	0.0184	363	360
129000	Pyrene	591	61			1110	0.000011	62700	1900
131113	Dimethyl phthalate	33000	1700	58000	5800	36	0.000000105	40	7
132650	Dibenzothiophene	420	122			1100	0.00002	11000	
137304	Ziram \ Cymate	8	1.8	5200	520	0.001		0.4	
142621	Hexanoic acid	320000	15170			16	0.0000225	38	12

Table I.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Freshwater Aquatic Life		Saltwater Aquatic Life		Bio concentration Factor	Henry's Law Constant	Adsorption Coefficient (K_{oc})	Bio degradation Half-Life
		Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
206440	Fluoranthene	45	7.1	40	16	1150	0.0000161	41700	440
544763	Hexadecane, n- (a)	18000	1300	500000	50000	32300		207000	17
591786	Hexanone, 2-	428000	38868			6.6	0.000113	12	16
593453	Octadecane, n- (a)	18000	1300	500000	50000	10100		66900	17
606202	Dinitrotoluene, 2,6-	18500	60			12	0.000000747	100	180
629594	Tetradecane, n- (a)	18000	1300	500000	50000	19500		126000	17
629970	Docosane, n- [b]	530000	68000	500000	50000	100000		110000000	17
630013	Hexacosane, n- (b)	530000	68000	500000	50000				17
630024	Octacosane, n- (b)	530000	68000	500000	50000				17
638686	Triacontane, n- (b)	530000	68000	500000	50000				17
646311	Tetracosane, n- (b)	530000	68000	500000	50000	100000		420000000	17
694804	Bromo-2-chlorobenzene, 1-	2942	1196			240	0.0006	1500	100
832699	Methylphenanthrene, 1-	555	54			4790	0.0000078	36000	
1576676	Dimethylphenanthrene, 3,6-	543	21			33000	0.0000053	330000	20
1730376	Methylfluorene, 1-	627	115			3300	0.00008	33000	
2027170	Isopropylnaphthalene, 2-	540	78			3200	0.00063	33000	
7429905	Aluminum	750	87			231			
7439896	Iron		1000	33000	3300				
7439921	Lead	65	2.5	210	8.1	49			
7439954	Magnesium	64700	6470			85215			
7439965	Manganese		388		10				
7439976	Mercury	1.4	0.77	1.8	0.94	5500	0.018	30000	
7439987	Molybdenum		27.8						
7440020	Nickel	470	52	74	8.2	47		300	
7440224	Silver	3.4	0.34	1.9	0.19	0.5			
7440235	Sodium	1640000	1020000						
7440280	Thallium	1400	40	2130	213	116			
7440315	Tin		18.6						
7440326	Titanium		191						
7440360	Antimony	3500	1600	4800	2900	1			
7440382	Arsenic	340	150	69	36	44			
7440393	Barium	410000	2813						

Table I.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Freshwater Aquatic Life		Saltwater Aquatic Life		Bio concentration Factor	Henry's Law Constant	Adsorption Coefficient (K_{oc})	Bio degradation Half-Life
		Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
7440417	Beryllium	130	5.3			19			
7440428	Boron		31.6						
7440439	Cadmium	4.3	2.2	42	9.3	64			
7440473	Chromium	570	74	1100	50	16			
7440484	Cobalt	1620	49		10				
7440508	Copper	13	9	4.8	3.1	360			
7440575	Gold								
7440622	Vanadium	11200	9						
7440655	Yttrium								
7440666	Zinc	120	120	90	81	47			
7440702	Calcium		200000						
7664417	Ammonia as N	13300	3060	3800	570		0.0000161	3.1	16
7782492	Selenium	12.83	5	290	71	4.8			
14265442	Phosphate								
14808798	Sulfate		1000000						
16887006	Chloride	860000	230000						
16984488	Fluoride	1600	160						
18496258	Sulfide		2		2				
18540299	Chromium hexavalent	16	11	1100	50	16			
20324338	Tripropyleneglycolmethylether	2484600	683870			0.2	0.0000000001	46	16
136777612	Xylene, o- & p- [c]	2600	1205	6000	600	208	0.0076	260	28
179601231	Xylene, m- & p- [c]	2600	1205	6000	600	208	0.0076	260	28
C003	BOD 5-day (carbonaceous)								
C004	Chemical Oxygen Demand (COD)								
C009	Total Suspended Solids (TSS)								
C010	Total Dissolved Solids (TDS)								
C012	Total Organic Carbon (TOC)								
C020	Total Recoverable Phenolics								
C021	Total Kjeldahl Nitrogen								
C025	Amenable Cyanide								
C036	Oil and Grease (as Hem)								

Table I.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Freshwater Aquatic Life		Saltwater Aquatic Life		Bio concentration Factor	Henry's Law Constant	Adsorption Coefficient (K_{oc})	Bio degradation Half-Life
		Acute Value (μg/l)	Chronic Value (μg/l)	Acute Value (μg/l)	Chronic Value (μg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
C037	Total Petroleum Hydrocarbons (as Sgt-hem)								
C042	Weak-acid Dissociable Cyanide								
	Phosphorus (as PO4)								
	Oil and Grease								

[a] Aquatic toxicity data for n-decane are reported based on structural similarity

[b] Aquatic toxicity data for n-docosane are reported based on structural similarity

[c] Values for the most stringent isomer (p-Xylene) are assumed

Sources: Arthur D. Little (1983), Arthur D. Little (1986), Birge et al. (1979), Clay (1986), Holdway and Spraque (1979), ICF, Inc. (1985), Leblanc (1980), Lyman et al. (1981), U.S. Atomic Energy Commission (1973), U.S. EPA (1972), U.S. EPA (1976), U.S. EPA (1980), U.S. EPA (1993), U.S. EPA (1998/99a), U.S. EPA (1998/99b), Zhang and Zhang (1982).

I.1.3 Grouping MP&M Pollutants Based on Risk to Aquatic Receptors

The impact assessment for aquatic receptors looks at the six individual fate and effects parameters for each MP&M POC, including acute and chronic aquatic toxicities, bioconcentration factors, Henry's Law constants, adsorption coefficients, and biodegradation half-lives. EPA grouped POCs with similar attributes, and assigned qualitative descriptors of potential environmental behavior and impact to each group. This grouping was used to describe the range of MP&M pollutant characteristics in Chapter 12. The grouping described below focuses specifically on aquatic environments and their biological receptors; it does not cover the human health toxicity data discussed in the previous section.

Table I.4 provides a summary of the categorization scheme for the six fate and effects parameters.

Table I.4: Summary of Categorization Scheme For Six Fate and Effects Parameters

Parameter	High Hazard	Moderate Hazard	Low Hazard	Insignificant Hazard
Acute Toxicity (AT)	AT < 100µg/l	100 ≤ AT≤ 1,000µg/l	AT > 1,000µg/l	
Chronic Toxicity (CT)	CT < 10µg/l	10 ≤ CT ≤ 100µg/l	CT > 100µg/l	
Bioconcentration Factor (BCF)	BCF > 500	50 ≤ BCF ≤ 500	5 ≤ BCF < 50	BCF < 5
Henry's Law Constant (H)	$H > 10^{-3}$	$10^{-5} \leq H \leq 10^{-3}$	$3.0\text{x}10^{-7} \leq H < 10^{-5}$	$H < 3.0\text{x}10^{-7}$
Adsorption Coefficient (K_{OC})	$K_{oc} > 10,000$	$1,000 \leq K_{oc} \leq 10,000$	$10 \leq K_{oc} < 1,000$	$K_{oc} < 10$
Biodegradation Half-Life ($t_{1/2}$)	$t_{1/2} < 7$ d	$7 \text{ d} \leq t_{1/2} < 28$ d	$28 \text{ d} \leq t_{1/2} < 180$ d	$t_{1/2} \geq 180$ d

Source: U.S. EPA analysis.

a. Acute and chronic aquatic toxicity

EPA used the available AT data to group chemicals according to their relative short-term effects on aquatic organisms, using the following categories:

AT < 100µg/l	High acute toxicity
100µg/l ≤ AT ≤ 1,000µg/l	Moderate acute toxicity
AT > 1,000 µg/l	Low acute toxicity

These categories reflect the fact that acute toxicity decreases when higher concentrations of a pollutant are required to induce short-term mortality in the test organisms. EPA's Office of Pollution Prevention and Toxics (OPPT) uses this categorization as guidance to assess data submitted in ***Premanufacture Notices (PMN)*** (EPA, 1996).

EPA used the available CT data to group chemicals according to their relative long-term effects on aquatic organisms, based on the following categories:

CT < 10µg/l	High chronic toxicity
10µg/l ≤ CT ≤ 100µg/l	Moderate chronic toxicity
CT > 100 µg/l	Low chronic toxicity

These categories assume that CT occurs at a concentration averaging one tenth of that responsible for acute toxicity. They also reflect the fact that chronic toxicity decreases when higher concentrations of a pollutant are required to induce longer-term lethal or sub-lethal responses in the test organisms.

b. Bioconcentration factor (BCF)

EPA used the available BCF data to group chemicals according to their potential to bioconcentrate in aquatic organisms, based on the following categories:

$BCF > 500$	High potential to bioconcentrate
$50 \leq BCF \leq 500$	Moderate potential to bioconcentrate
$5 \leq BCF < 50$	Low potential to bioconcentrate
$BCF < 5$	No significant potential to bioconcentrate

These categories reflect the fact that decreased BCF reduces the intrinsic hazard of a chemical to aquatic receptors, because the chemical is less likely to accumulate in biological tissues.

c. Volatilization potential

EPA used available H data to group organic chemicals according to their potential to volatilize from water into air, based on the following categories:

$H > 10^{-3}$	High potential to volatilize
$10^{-5} \leq H \leq 10^{-3}$	Moderate potential to volatilize
$3.0 \times 10^{-7} \leq H < 10^{-5}$	Low potential to volatilize
$H < 3.0 \times 10^{-7}$	No potential to volatilize

Increased volatility decreases a chemical's hazard to aquatic receptors because the chemical is more likely to quickly move from the receiving water into the atmosphere. (The opposite is true for human health; hazard to human health *increases* with increased volatility because a volatile chemical is more available for intake by inhalation.)

d. Adsorption potential

EPA used the available K_{oc} to group the organic POCs according to their potential to adsorb to sediments, based on the following categories:

$K_{oc} > 10{,}000$	High potential for adsorption
$1{,}000 \leq K_{oc} \leq 10{,}000$	Moderate potential for adsorption
$10 \leq K_{oc} < 1{,}000$	Low potential for adsorption
$K_{oc} < 10$	No significant adsorption

A lower adsorption potential indicates a lower potential for a chemical to be a hazard to aquatic receptors. The lower the adsorption potential the less likely a chemical is to accumulate in sediments or to affect benthic invertebrates and to be taken up into local food chains.

e. Biodegradation potential

EPA used biodegradation half-lives to group organic POCs according to their potential to biodegrade, based on the following categories:

$t_{1/2} < 7$ d	Rapid rate of biodegradation
$7 \text{ d} \leq t_{1/2} < 28$ d	Moderate rate of biodegradation
$28 \text{ d} \leq t_{1/2} < 180$ d	Slow rate of biodegradation
$t_{1/2} \geq 180$ d	Resistant to biodegradation

A faster rate of biodegradation by microbial metabolism decreases an organic chemical's hazard to aquatic receptors. The more rapid the rate of biodegradation, the more quickly a chemical will be removed from the aquatic environment. Most metals occur as inorganic compounds (notable exceptions include organic forms of certain metals, such as mercury, lead, or selenium), and are not removed by biodegradation. EPA assumes that all metals are resistant to biodegradation for the purposes of this assessment.

I.1.4 Assumptions and Limitations

The following are the major assumptions and limitations associated with the data compilation and categorization used in the MP&M analysis:

- Some data are estimated, and subject to uncertainty;
- Data are unavailable for some chemicals and parameters;
- The POCs considered in this study do not include all the constituents that may be present in MP&M pollutants;
- Data derived from laboratory tests may not accurately reflect conditions in the field; and
- Available aquatic toxicity and bioconcentration test data may not represent the most sensitive species.

I.2 METHODOLOGY

I.2.1 Sample Set Data Analysis and National Extrapolation

This analysis uses discharge information from 862 sample MP&M facilities (excluding two sample facilities in Puerto Rico) that discharge directly or indirectly to 607 receiving waterways (521 rivers/streams, 62 bays/estuaries, and 24 lakes). The in-stream water quality analysis excluded eight of the 62 marine reaches due to data limitations. EPA performed environmental assessment on a basis of the sample facility data. The Agency then extrapolated findings from the sample facility analyses to the national level using two alternative extrapolation methods: (1) traditional extrapolation and (2) post-stratification extrapolation. EPA also used the differential extrapolation technique in addition to both traditional and post-stratification approaches when a sample reach was estimated to receive discharges from multiple facilities. Appendix G provides detailed information on the extrapolation approaches used in this analysis. Based on the extrapolation methods used in this analysis, EPA estimates that approximately 43,901 MP&M facilities discharge to between 29,500 and 40,000 water bodies nationwide.[3]

EPA evaluated the national-level environmental impacts of reducing pollutant discharges from MP&M facilities to the nation's water bodies for the final rule. EPA considered only pollutant loadings from MP&M facilities to particular water bodies in the national analysis. With one exception, EPA did not take background loadings from other sources into account. For the analysis of sewage sludge quantity, EPA was able to use information from the Phase 2 Section 308 survey of POTWs to estimate total metal loadings from all sources to a POTW of a given size (i.e., small, medium, and large). The Agency based this estimate on survey estimates of the average number of small, medium, and large MP&M facilities discharging to a POTW in each size category and the percent contribution of total metal loadings discharged from MP&M facilities.

I.2.2 Water Quality Modeling

EPA used four different equations to model the impacts of MP&M discharges on receiving waterways. EPA used a simple stream dilution model for MP&M facilities that discharge into streams or rivers. This model does not account for fate processes other than complete immediate mixing.[4] EPA derived the facility-specific data (i.e., pollutant loading and facility flow) used in this equation from sources described in Sections 3.1 and 5.2 of this report.

The Agency used one of three receiving stream flow conditions (the lowest one-day average flow with a recurrence interval of 10 years (1Q10), the lowest consecutive seven-day average flow with a recurrence interval of 10 years (7Q10), and the harmonic mean flow), depending on the criterion or toxic effect level being considered.

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[3] These estimates include facilities that were assessed to be baseline closures by the MP&M economic analysis.

[4] EPA used an exponential decay model to estimate pollutant concentrations for the analysis of cancer risk from drinking water consumption for streams. This model is discussed in detail in Appendix G.

The 1Q10 and 7Q10 flows are used in comparisons of in-stream concentrations with acute and chronic aquatic life criteria or toxic effect levels, respectively, as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991).

The harmonic mean flow, defined as the inverse mean of reciprocal daily arithmetic mean flow values, is used in comparisons of in-stream concentrations with human health criteria or toxic effect levels based on lifetime exposure. EPA recommends the long-term harmonic mean flow as the design flow for assessing potential long-term human health impacts. Harmonic mean flow is preferable to arithmetic mean flow because in-stream pollutant concentration is a function of, and inversely proportional to, the stream flow downstream of the discharge.

The event frequency represents the number of times an exposure event occurs during a specified time period. EPA set the event frequency equal to the facility operating days to assess impacts on aquatic life. The calculated in-stream concentration is thus the average concentration on days the facility is discharging wastewater. EPA set the event frequency at 365 days to assess long-term human health impacts. The calculated in-stream concentration is thus the average concentration on all days of the year. This frequency leads to a lower calculated concentration because of the additional dilution from days when the facility is not operating, but it is consistent with the conservative assumption that the target population is present to consume drinking water every day and contaminated fish throughout an entire lifetime. The following equation calculates in-stream concentration for streams and rivers:

$$C_{is} = \frac{L}{(OD \cdot FF) + (EF \cdot SF)} \tag{I.2}$$

where:

C_{is} = in-stream pollutant concentration (μg/L);
L = facility pollutant loading (μg/yr); for indirect dischargers, $L = L_{\text{indirect facility}} * (1\text{-}TMT)$, where TMT is POTW treatment removal efficiency (unitless);
OD = facility or POTW operating days (days/yr);
FF = MP&M facility flow (L/day); for indirect dischargers, FF = POTW flow (L/day);
EF = event frequency (days/yr); and
SF = receiving stream flow (L/day).

EPA used the following simple steady-state model for facilities that discharge into lakes other than the Great lakes. This model takes into account pollutant degradation and the hydraulic residence time of the lake:

$$C_{lake} = \frac{C_i}{(1 + T_w \cdot k)} \tag{I.3}$$

where:

C_{lake} = steady-state lake concentration of pollutant (μg/L),
C_i = steady-state inflow concentration of pollutant (μg/L),
T_w = mean hydraulic residence time (yr),
k = first-order pollutant decay rate (yr-1), and

$$T_w = \frac{V}{Q} \tag{I.4}$$

where:

V = lake volume (m^3), and
Q = mean total inflow rate (m^3/yr).

EPA used alternative means to predict pollutant concentrations suitable for comparison with ambient criteria or toxic effect levels for facilities discharging to hydrologically complex waters, such as bays and estuaries. Where possible, EPA employed site-specific ***critical dilution factors (CDFs)*** to predict the concentration at the edge of a mixing zone. Where CDFs were not available, EPA used available estuarine ***dissolved concentration potentials (DCPs)***.

EPA obtained site-specific CDFs from a survey of states and regions conducted by EPA's Office of Pollution Prevention and Toxics (*Mixing Zone Dilution Factors for New Chemical Exposure Assessments*, U.S. EPA, 1992a). The dilution model for estimating estuary concentrations by using a CDF is presented below:

$$C_{es} = \frac{L}{EF \cdot FF \cdot CDF} \tag{I.5}$$

where:

C_{es} = estuary pollutant concentration (µg/L);
L = facility pollutant loading (µg/yr); for indirect dischargers, $L = L_{\text{indirect facility}} * (1\text{-TMT})$, where TMT is POTW treatment removal efficiency (unitless);
EF = event frequency (days/yr);
FF = facility flow (L/day); for indirect dischargers, FF = POTW flow (L/day); and
CDF = critical dilution factor (unitless).

EPA used acute CDFs to evaluate acute aquatic life effects and chronic CDFs to evaluate chronic aquatic life or adverse human health effects. EPA assumed that the drinking water intake and fishing location are at the edge of the chronic mixing zone. EPA set the event frequency equal to the facility operating days for comparison with aquatic life criteria or toxic effect levels, and equal to 365 days for comparison with human health criteria or toxic effect levels.

The ***National Oceanic and Atmospheric Administration (NOAA)*** has developed DCPs to predict pollutant concentrations in various salinity zones for each estuary in NOAA's ***National Estuarine Inventory (NEI)***. A DCP represents the concentration of a nonreactive dissolved substance under well-mixed, steady-state conditions given an annual load of 10,000 tons. DCPs account for the effects of flushing by considering the freshwater inflow rate, and dilution by considering the total estuarine volume. DCPs reflect the predicted estuary-wide response, and may therefore not be indicative of concentrations at the edge of much smaller mixing zones. The dilution model used for estimating pollutant concentrations using DCPs is presented below:

$$C_{es} = \frac{L \cdot DCP}{BL \cdot CF} \tag{I.6}$$

where:

C_{es} = estuary pollutant concentration (µg/L);
L = facility pollutant loading (kg/yr); for indirect dischargers,
$L = L_{\text{indirect facility}} *(1\text{-TMT})$, where TMT is POTW treatment removal efficiency (unitless);
DCP = dissolved concentration potential (µg/L);
BL = benchmark load (10,000 tons/yr); and
CF = conversion factor (907.2 kg/ton).

EPA determined potential water quality impacts by comparing projected waterway pollutant concentrations to EPA water quality criteria or toxic effect levels for the protection of aquatic life and human health. EPA determined water quality exceedances by dividing the projected waterway pollutant concentration by the EPA water quality criteria or toxic effect levels for the protection of aquatic life and human health. A value greater than one indicates an exceedance.

I.2.3 Impact of Indirect Discharging Facilities on POTW Operations

a. Analysis of biological inhibition

Inhibition of POTW operations occurs when high levels of toxics, such as metals or cyanide, kill the bacteria required for the wastewater treatment process. EPA analyzed inhibition of POTW operations by comparing calculated POTW influent concentrations with available inhibition levels. Exceedances are indicated by a value greater than one. POTW influent concentrations are estimated as:

$$C_{pi} = \frac{L}{OD \cdot PF} \tag{I.7}$$

where:
C_{pi} = POTW influent concentration (µg/L),
L = facility pollutant loading (µg/yr),
OD = facility operating days (days/yr), and
PF = POTW flow (L/day).

b. Analysis of sludge disposal practices

EPA also analyzed the effects of MP&M discharges on POTW operations by comparing the estimated concentrations of metals in sewage sludge with the published metals concentration limits for preferable sewage sludge disposal or use practices. In particular, EPA examined:

- whether MP&M baseline discharges would prevent POTWs from being able to meet the metals concentration limits required for more favorable and lower-cost sewage sludge use/disposal practices (i.e., beneficial land application and surface disposal); and
- whether limitations on the selection of management practices would be removed under the final rule.

EPA estimated the sewage sludge concentrations of eight metals for sample facilities under baseline and post-regulatory option discharge levels. EPA compared these concentrations with the relevant metals concentration limits for three sewage sludge management options: Land Application-High (Concentration Limits), Land Application-Low (Ceiling Limits), and Surface Disposal. Metal concentrations in sewage sludge are estimated as:

$$C_{sp} = \frac{L \cdot TMT \cdot PART \cdot SGF}{OD \cdot PF} \tag{I.8}$$

where:
C_{sp} = sewage sludge pollutant concentration (mg/kg),
L = facility pollutant loading (µg/yr),
TMT = POTW treatment removal efficiency (unitless),
PART = pollutant-specific sludge partition factor (unitless),
SGF = sludge generation factor (mg/kg per µg/L),
OD = POTW operating days (days/yr), and
PF = POTW flow (L/day).

EPA derived the facility-specific data to evaluate POTW operations from the sources described in Sections 3.1 and 5.2. EPA examined multiple MP&M facilities discharging to the same POTW by summing the individual loadings before calculating the POTW influent and sewage sludge concentrations.

The ***partition factor*** is a chemical-specific value representing the fraction of the load expected to partition to sewage sludge during wastewater treatment. For this analysis, EPA used a sludge generation factor of 5.96 mg/kg per µg/L. This factor indicated that the resulting concentration in sewage sludge is 5.96 mg/kg dry weight for every 1 µg/L of pollutant removed from wastewater and partitioned to sewage sludge.

I.2.4 Assumptions and Limitations

The following discussion focuses on major assumptions and limitations associated with these in-stream water quality analyses.

a. Other source contributions

EPA did not account for "other source contributions" of MP&M pollutants to estimate in-stream concentrations of these pollutants. Accounting for the discharges from other sources is important because assessing benefits from reduced exceedance of AWQC limits depends on comparing concentrations of pollutants from all sources with applicable thresholds. Analyses must also identify situations in which threshold criteria are exceeded in the baseline case but met under a regulatory option. Failing to account for other source contributions has an uncertain effect on estimated benefits. For example, if non-sample MP&M facilities are major contributors to aggregate pollutant discharges to a receiving stream, then the analysis will likely understate the extent of aquatic habitat improvements that may be accomplished by reduced MP&M pollutant discharges. Conversely, if the total MP&M contribution to the aggregate pollutant discharges to a receiving stream is not significant, then reducing MP&M discharges may reduce but not eliminate AWQC exceedances, and the benefits of the MP&M regulation can be overstated. The net effect of the following are unknown:

- excluding other sources understates the number and extent of baseline exceedances;
- excluding non-sample MP&M facilities understates the reduction in MP&M pollutant discharges due to the rule; and
- the number of cases in which estimated baseline exceedances are eliminated may be either over- or understated, depending on the contribution of pollutants from non-MP&M sources.

b. Water body modeling

EPA made four major assumptions concerning all water body modeling, and two major assumptions specific to stream modeling. These assumptions are summarized below:

- Complete mixing of POTW discharge flow occurs immediately. This mixing results in the calculation of an "average" concentration, even though the actual concentration may vary across the width and depth of the water body.
- Pollutant loads to the receiving water body are continuous and representative of long-term facility operations. This assumption may overestimate long-term risks to human health and aquatic life, but may underestimate potential short-term effects.
- In the absence of data from EPA's ***Permit Compliance System (PCS)*** on specific individual POTW flow, POTW daily flow rates were set equal to the simple arithmetic mean flow among minor POTWs reporting flows in PCS. The arithmetic mean for minor POTWs was used because all POTWs receiving discharges from the sample MP&M facilities for which flow data are not available in the PCS database are classified as minor dischargers in the PCS database.
- EPA used 1Q10 and 7Q10 receiving stream flow rates to estimate aquatic life impacts, and harmonic mean flow rates to estimate human health impacts, when modeling stream reaches. EPA estimated 1Q10 low flows by using the results of a regression analysis conducted for OPPT of 1Q10 and 7Q10 flows from representative U.S. rivers and streams (Versar, 1992). EPA estimated harmonic mean flows from the mean and 7Q10 flows as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991). These flows may not be the same as those used by specific states to assess impacts.
- Where data on stream flow parameters were not available, EPA set mean and 7Q10 flow values equal to the corresponding mean values associated with reaches located upstream and downstream of the sample reach.

c. Exposure analyses

MP&M exposure assessment in freshwater locations uses two sets of human health-based AWQC:

- AWQC for the protection of human health from the consumption of organisms and drinking water, and
- AWQC for the protection of human health from consumption of organisms only.

MP&M exposure assessments in marine locations use AWQC for the protection of human health from the consumption of organisms only, because saltwater is not used for drinking water supply.

d. Extrapolation from sample set to national level

Although the sample set should represent a national group of facilities discharging to waterways and POTWs, effluent from an individual sample facility may have a different potential environmental impact than effluent from the facilities it is assumed to represent. For example, a facility that discharges to a stream with a very low flow may be similar to the facilities it represents in all aspects except available dilution in the receiving stream. The sample frame used in the MP&M analysis was not designed to take receiving water body characteristics into account. Using sample weights to extrapolate environmental impacts may either under- or overstate estimated impacts.

I.3 DATA SOURCES

The following three sections describe the various data sources used to evaluate water quality and POTW impacts.

I.3.1 Facility-Specific Data

Section I.2.1 provides detailed information on sample size and distribution, and on receiving waterways. The names, locations, and the flow data for the POTWs to which the MP&M facilities discharge were obtained from the MP&M facility surveys and EPA's PCS database. EPA took alternative measures to obtain a complete set of receiving POTWs if these sources did not yield information for a given facility. EPA used latitude/longitude coordinates (if available) to locate those POTWs that have not been assigned a reach number in PCS. EPA identified the nearest POTW in the case of facilities for which the POTW receiving the plant discharge could not be positively identified. EPA based its identification of the closest linear distance on the latitude/longitude coordinates of the MP&M facility or the city in which it was located. EPA then identified the corresponding reach in PCS, and obtained POTW flow from the Needs Survey or PCS.

EPA identified reaches to which direct MP&M facilities discharge by identifying the receiving reach in PCS or by identifying the nearest reach. EPA based its identification of the closest linear distance on the MP&M facility’s latitude/longitude coordinates.

I.3.2 Water body-Specific Data

a. Streams and rivers

EPA used 1Q10, 7Q10, and mean flow data for the 521 streams and rivers. EPA obtained 7Q10 and mean flow data from the W.E. Gates study data or from measured stream flow data, both of which are contained in EPA's **GAGE** file. The W.E. Gates study contains calculated average and low flow statistics based on the best available flow data and on drainage areas for reaches throughout the United States. The GAGE file also includes average and low flow statistics based on measured data from **United States Geological Survey (USGS)** gaging stations. In the absence of data on stream flow parameters, EPA set 7Q10 and mean flow values equal to the corresponding median values associated with the sample reaches. EPA used the results of a regression analysis conducted for OPPT of 1Q10 and 7Q10 flows from representative U.S. rivers and streams (Versar, 1992) to estimate 1Q10 flows. EPA estimated harmonic mean flows from the mean and 7Q10 flows as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991).

b. Lakes

EPA used data on hydraulic residence time (i.e., the amount of time water remains in a lake) to analyze small lakes, and CDFs (which describe dilution in a portion of a lake) to analyze the Great lakes.[5]

The sample MP&M facilities discharged directly to one lake reach and indirectly to 23 lake reaches: 15 to small lakes, 3 to sections of Lake Erie, 5 to sections of Lake Michigan, and 1 to a section of Lake Ontario. EPA calculated the average hydraulic residence time for small lakes based on lake surface and drainage areas. EPA obtained data on lake surface and drainage area from the U.S. Army Corps of Engineers, Major Dams: Map Layer Description File (USCE, 1999). CDFs were readily available for Lake Michigan, but not for the three sample reaches on Lake Erie. EPA arithmetically averaged the seven chronic CDFs available for reaches discharging to Lake Erie (1, 1, 4, 4, 10, 10, 4) (U.S. EPA, 1992a, p. A-4) for the three reaches being modeled.

c. Estuaries and bays

Sixty-two bays and estuaries receive discharges from sample MP&M facilities. Data necessary to support water quality modeling were not available for eight of the 62 bays/estuaries. A dilution model predicted pollutant concentrations in the chronic and acute mixing zones, based on site-specific CDFs (U.S. EPA, 1992a and Versar, 1994), to estimate the pollutant concentrations in 28 of these complex water bodies.

Both acute and chronic CDFs were available for 20 of the 62 bays/estuaries. EPA estimated acute and chronic CDFs for New York bays/estuaries by arithmetically averaging available values for nearby New Jersey sites discharging to the Arthur Kill (acute: 1.5, 4.0, 5.0; chronic: 5; 20; 10) and Upper New York Bay (acute: 8.0; chronic: 22.9). Acute and chronic CDFs for Buzzards Bay in Massachusetts were estimated by arithmetically averaging values for nearby Massachusetts and Rhode Island sites discharging to the Atlantic Ocean.

EPA could not identify or approximate chronic CDFs for the remaining 13 sample reaches. Acute CDFs are available for 46 of the 62 bays/estuaries. EPA extrapolated acute CDFs for two bays/estuaries in Florida by using CDFs for another Florida bay. Likewise, EPA extrapolated acute CDFs for four bays/estuaries in California by using CDFs for another California bay.

EPA obtained DCP values for five of the 13 sample bays/estuaries for which CDFs were not available from the Development of Mixing Zone Dilution Factors report (Versar, 1994). EPA then used a dilution model that predicts pollutant concentrations in the estuarine environment using a site-specific DCP value.

I.3.3 Information Used to Evaluate POTW Operations

Since many MP&M facilities considered in the alternative options are indirect dischargers, the Agency consulted with POTWs as they would have had to implement the rule. EPA consulted with POTWs individually and through the Association of Municipal Sewerage Agencies (AMSA). In addition, EPA consulted with pretreatment coordinators and State and local regulators.

EPA used removal efficiency rates, inhibition values, and sewage sludge regulatory levels to evaluate POTW operations. EPA obtained POTW removal efficiency rates from several sources. The Agency developed rates from POTW removal data and pilot-plant studies or used removals for a similar pollutant when data were not available. Use of the selected removal rates assumes that the evaluated POTWs are well-operated and have at least secondary treatment in place (U.S. EPA, 2000).

EPA obtained inhibition values from the *Guidance Manual for Preventing Interference at POTWs* (U.S. EPA, 1987a) and from *CERCLA Site Discharges to POTWs: Guidance Manual* (U.S. EPA, 1990). EPA used the most conservative values for activated sludge (i.e., the lowest influent concentrations that would cause inhibition). The Agency used a value based on compound type (e.g., aromatics) for pollutants with no specific inhibition value.

EPA obtained sewage sludge regulatory levels from the Federal Register 40 CFR Part 257 et al., *Standards for the Use or Disposal of Sewage Sludge; Final Rules* (February 19, 1993) and from the Federal Register 59(38):9095-9099 (February 25, 1994) and 60(206):54,764-54,770 (October 25, 1995) for eight metals regulated in sewage sludge. EPA used pollutant limits established for the final use or disposal of sewage sludge when the sewage sludge is applied to agricultural and non-agricultural land or is applied to a dedicated surface disposal site.

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[5] Small lakes are defined as any non-Great lakes, including reservoirs.

Finally, EPA obtained sludge partition factors from the *Report to Congress on the Discharge of Hazardous Wastes to Publicly-Owned Treatment Works* (Domestic Sewage Study) (U.S. EPA, 1986).

Table I.5 lists POTW treatment removal efficiency rates, inhibition values, sewage sludge partition factors, and sewage sludge regulatory levels used in the evaluation of POTW operations.

Table I.5: POTW-Related Data for 132 MP&M Pollutants

CAS Number	Pollutant Name	POTW Inhibition Level Value (µg/l)	POTW Sludge Partition Factor	Sludge Criteria Value (mg/kg)	POTW Removal Efficiency Rate (Percentage)
51285	Dinitrophenol, 2,4-	1000	0.10000000149		77.51
57125	Cyanide	5000	1		70.44
59507	Parachlorometacresol	5000	0.07900000364		63
62533	Aniline	1000	0.1		93.41
62759	Nitrosodimethylamine, N-		0.1		77.51
65850	Benzoic acid	10000	0.1		80.5
67641	Acetone	120000	0.1		83.75
67663	Trichloromethane	500000	0.015		
68122	Dimethylformamide, N,N-	1000	0.1		87
75003	Chloroethane		0.0075		77.51
75092	Dichloromethane	150000	0.1395		54.28
75150	Carbon disulfide	50000	0.0075		84
75354	Dichloroethene, 1,1-	150000			77.51
75694	Trichlorofluoromethane	700			77.32
78591	Isophorone	120000	0.079		77.51
78831	Isobutyl alcohol	1000000	0.1		28
78933	Methyl ethyl ketone	120000	0.1		96.6
79016	Trichloroethene	20000	0.0578		77.51
80626	Methyl methacrylate	120000			99.96
83329	Acenaphthene	500000	0.366		98.29
84742	Di-n-butyl phthalate	10000	0.216		84.66
85018	Phenanthrene	500000	0.366		94.89
85687	Butyl benzyl phthalate	10000	0.452		81.65
86306	Nitrosodiphenylamine, N-				90.11
86737	Fluorene	500000	0.366		69.85
88755	Nitrophenol, 2-	50000			26.83
91203	Naphthalene	500000	0.275		94.69
91576	Methylnaphthalene, 2-	5000	0.079		28
92524	Biphenyl	5000	0.366		96.28
95476	Xylene, o-	5000	0.149		77.32
95487	Cresol, o-	90000	0.079		52.5
98555	Terpineol, alpha-	1000000	0.1		94.4
98862	Acetophenone	120000	0.1		95.34
99876	Cymene, p-	5000	0.0075		99.79
100027	Nitrophenol, 4-	50000	0.1		77.51
100414	Ethylbenzene	200000	0.06		93.79
100425	Styrene	500000	0.149		93.65
100516	Benzyl alcohol	1000000	0.1		78
100754	Nitrosopiperidine, N-	1000			77.32
101848	Diphenyl Ether	1000			77.32
105679	Dimethylphenol, 2,4-	40000	0.079		77.51

Table I.5: POTW-Related Data for 132 MP&M Pollutants

CAS Number	Pollutant Name	POTW Inhibition Level Value (µg/l)	POTW Sludge Partition Factor	Sludge Criteria Value (mg/kg)	POTW Removal Efficiency Rate (Percentage)
106445	Cresol, p-	90000	0.079		71.67
107028	Acrolein	50	0.10000000149		77.51
108101	Methyl isobutyl ketone	120000	0.1		87.87
108372	Bromo-3-chlorobenzene, 1-	100			77.32
108383	Xylene, m-	5000	0.149		95.07
108883	Toluene	200000	0.278		96.18
108907	Chlorobenzene	140000	0.154		96.37
108952	Phenol	90000	0.146		95.25
110861	Pyridine	1000	0.1		95.4
112403	Dodecane, n- (a)				
112958	Eicosane, n- (a)				
117817	Bis(2-ethylhexyl) phthalate	10000	0.728		59.78
117840	Di-n-octyl phthalate	10000	0.075		68.43
120127	Anthracene	500000	0.55		77.51
122394	Diphenylamine	1000	0.08		77.32
123911	Dioxane, 1,4-	120000	0.1		45.8
124185	Decane, n-				9
127184	Tetrachloroethene	20000	0.034		84.61
129000	Pyrene	500000	0.366		83.9
131113	Dimethyl phthalate		0.1		77.51
132650	Dibenzothiophene	5000	0.366		84.68
137304	Ziram \ Cymate	50			
142621	Hexanoic acid	10000			84
206440	Fluoranthene	5000	0.366		42.46
544763	Hexadecane, n- (a)				
591786	Hexanone, 2-	120000			77.32
593453	Octadecane, n- (a)				
606202	Dinitrotoluene, 2,6-	5000	0.1		77.51
629594	Tetradecane, n- (a)				
629970	Docosane, n-				88
630013	Hexacosane, n- (b)				
630024	Octacosane, n- (b)				
638686	Triacontane, n- (b)				
646311	Tetracosane, n- (b)				
694804	Bromo-2-chlorobenzene, 1-	100			77.32
832699	Methylphenanthrene, 1-	5000	0.366		84.55
1576676	Dimethylphenanthrene, 3,6-	500000	0.366		84.55
1730376	Methylfluorene, 1-	500000	0.366		84.55
2027170	Isopropylnaphthalene, 2-	500000	0.1		77.32
7429905	Aluminum		1		91.36
7439896	Iron	5000	1		81.99
7439921	Lead	100	1	300	77.45
7439954	Magnesium	1000000	1		14.14
7439965	Manganese	10000	1		35.51
7439976	Mercury	100	1	17	71.66
7439987	Molybdenum		1		18.93
7440020	Nickel	5000	1	420	51.44

Table I.5: POTW-Related Data for 132 MP&M Pollutants

CAS Number	Pollutant Name	POTW Inhibition Level Value (μg/l)	POTW Sludge Partition Factor	Sludge Criteria Value (mg/kg)	POTW Removal Efficiency Rate (Percentage)
7440224	Silver	30	1		88.28
7440235	Sodium	3500000	1		2.69
7440280	Thallium		1		71.66
7440315	Tin	9000	1		42
7440326	Titanium		1		91.82
7440360	Antimony		1		66.78
7440382	Arsenic	40	1	41	65.77
7440393	Barium		1		15.98
7440417	Beryllium		1		71.66
7440428	Boron	1000	1		30.42
7440439	Cadmium	500	1	39	90.05
7440473	Chromium	1000	1		80.33
7440484	Cobalt		1		6.11
7440508	Copper	1000	1	1500	84.2
7440575	Gold		1		32.52
7440622	Vanadium	20000	1		9.51
7440655	Yttrium		1		32.52
7440666	Zinc	5000	1	2800	79.14
7440702	Calcium	2500000	1		8.54
7664417	Ammonia as N	480000			38.94
7782492	Selenium		1	100	34.33
14265442	Phosphate				57.41
14808798	Sulfate				84.61
16887006	Chloride				57.41
16984488	Fluoride				61.35
18496258	Sulfide	25000			57.41
18540299	Chromium hexavalent	1000	1		57.41
20324338	Tripropyleneglycolmethylether	120000			52.4
136777612	Xylene, o- & p- (c)	5000	0.149		36832
179601231	Xylene, m- & p- (c)				
C003	BOD 5-day (carbonaceous)				89.12
C004	Chemical Oxygen Demand (COD)				81.3
C009	Total Suspended Solids (TSS)				
C010	Total Dissolved Solids (TDS)				
C012	Total Organic Carbon (TOC)				70.28
C020	Total Recoverable Phenolics				57.41
C021	Total Kjeldahl Nitrogen				57.41
C025	Amenable Cyanide				57.41
C036	Oil and Grease (as Hem)				86.08
C037	Total Petroleum Hydrocarbons (as Sgt-hem)				
C042	Weak-acid Dissociable Cyanide				
	Phosphorus (as PO4)				
	Oil and Grease				

Sources: U.S. EPA (1985), U.S. EPA (1987), U.S. EPA (1990).

In the absence of data on POTW flow rates, EPA set the POTW flow rate equal to the arithmetic mean flow among minor POTWs in the PCS database, using the following steps:

1. Calculate arithmetic mean flow among minor POTWs in the PCS database. The estimated arithmetic mean flow for minor POTWs in the PCS database is one million gallons per day (MGD).

2. Set POTW flow rate equal to the relevant arithmetic mean flow. For all POTWS with missing flow data, EPA set their flow rates equal to the arithmetic mean flow rate for minor POTWs in the PCS database, one MGD.

I.4 RESULTS

EPA assessed the environmental impacts of MP&M dischargers on water bodies and POTWs under the baseline conditions and those corresponding to four regulatory options: the Final Option, Proposed/NODA Option, and two 433 Upgrade Options on the basis of sample facility data. The Agency extrapolated the findings from the sample facility analyses to the national level using facility sample weights, as described in Appendix G.

MP&M facilities nationwide currently discharge an estimated 53 million pounds of pollutants per year to publicly-owned treatment works (POTWs) and approximately 6.2 million pounds of pollutants directly to surface waters. MP&M facility effluents contain 42 priority or toxic pollutants, 81 nonconventional pollutants, and three conventional pollutants (BOD, TSS, and O&G).

EPA estimates that the final rule will lead to a modest reduction in pollutant discharges to the waters of the U.S. As shown by Table I.6, the regulation will reduce discharges of pollutants with acute and chronic effects on aquatic life by 8,959 and 12,270 pounds per year, respectively. The final rule does not regulate indirect dischargers and thus will not reduce pollutant loads received by POTWs.

EPA estimates that the Proposed/NODA Option, Directs + 413 to 433 Upgrade Option, and Directs + All to 433 Upgrade Option would remove 3,299, 91, and 110 thousand pounds per year of eight sewage sludge contaminants, respectively. In addition, the Proposed/NODA Option, Directs + 413 to 433 Upgrade Option, and Directs + All to 433 Upgrade Option would result in 30,226, 133, and 551 thousand pounds per year reduction in 86 pollutants causing inhibition of POTW operations.

The Proposed/NODA Option would reduce discharges of pollutants with acute and chronic effects on aquatic life by 97 and 117 million pounds per year, respectively. The Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option would reduce discharges of 132 and 353 thousand pounds of pollutants with acute effects on aquatic life, and 136 and 576 thousand pounds of pollutants with chronic effects on aquatic life, respectively.

Table I.6: MP&M Facility Discharges (National Basis)[a]

Category	POTW Impacts			Receiving Stream Impacts: Aquatic Life Toxicity	
	Activated Sludge Inhibition	Biosolids Contaminants	HAP	Acute	Chronic
Selected Option					
# of Pollutants	N/A	N/A	N/A	106	113
Baseline (1,000 lbs/yr)	N/A	N/A	N/A	868	1,154
Post-Compliance (1,000 lbs/yr)	N/A	N/A	N/A	859	1,142
Proposed/NODA Option					
# of Pollutants	85	8	35	105	112
Baseline (1,000 lbs/yr)	39,594	3,589	408	141,522	187,742
Post-Compliance (1,000 lbs/yr)	9,369	290	189	44,827	70,428
Directs + 413 to 433 Upgrade					
# of Pollutants	86	8	35	106	113
Baseline (1,000 lbs/yr)	1,085	253	3	868	1,154
Post-Compliance (1,000 lbs/yr)	952	161	3	935	1,018
Directs + All to 433 Upgrade					
# of Pollutants	86	8	35	106	113
Baseline (1,000 lbs/yr)	1,085	253	3	868	1,154
Post-Compliance (1,000 lbs/yr)	534	143	3	514	578

[a] Excludes loadings from facilities projected to close in the baseline. See Chapter 5.

Source: U.S. EPA analysis.

I.4.1 Human Health Impacts

Under this human health benefit category EPA assessed the reduced occurrence of pollutant concentrations that are estimated to exceed human health-based AWQC. This analysis provides an alternative measure of the expected reduction in risk to human health. Table I.7 presents information on baseline and post-compliance exceedances of human health AWQC criteria for all the regulatory options.

EPA estimates that in-stream concentrations of four pollutants (i.e., arsenic, iron, manganese, and n-nitrosodimethylamine) will exceed human health criteria for consumption of water and organisms in 78 receiving reaches nationwide as the result of baseline MP&M pollutant discharges. EPA estimates that there are human health AWQC exceedances caused by n-nitrosodimethylamine (NDMA). EPA did not consider NDMA pollutant reductions in its benefits analyses because of the low number of detected values for that pollutant. EPA estimates that the final rule will not eliminate the occurrence of concentrations in excess of human health criteria for consumption of water and organisms and for consumption of organisms on any of the reaches on which baseline discharges are estimated to cause concentrations in excess of AWQC values.

The Proposed/NODA Option would eliminate instances of in-stream pollutant concentrations exceeding AWQC limits for consumption of water and organisms and consumption of organisms only in 63 and 68 reaches, respectively, nationwide. The Directs + 413 to 433 Upgrade Option would not eliminate any instances of in-stream pollutant concentrations exceeding AWQC limits for consumption of water and organisms and consumption of organisms only. The Directs + All to 433 Upgrade Option would not eliminate any occurrences of pollutant concentrations in excess of AWQC values for consumption of water and organisms, but would eliminate instances of pollutant concentrations in excess of AWQC values for consumption of organisms only in 21 reaches nationwide. As noted above the Agency did not estimate reductions in NDMA loadings under the post-compliance scenario due to data limitations.

Table I.7: Summary of Estimated AWQC Exceedances for Protection of Human Health (National Basis)

Category	Human Health Water and Organisms			Human Health Organisms Only		
	Streams (No.)	Pollutants (No.)	Total Exceedances	Streams (No.)	Pollutants (No.)	Total Exceedances
Selected Option: Traditional Extrapolation						
Baseline	78	4	121	21	1	21
Post-Compliance	78	4	121	21	1	21
Selected Option: Post-Stratification Extrapolation						
Baseline	112	4	154	21	1	21
Post-Compliance	112	4	154	21	1	21
Proposed/NODA Option						
Baseline	5,852	26	7,085	197	12	335
Post-Compliance	5,789	21	6,667	128	9	212
Directs + 413 to 433 Upgrade						
Baseline	78	4	121	21	1	21
Post-Compliance	78	4	121	21	1	21
Directs + All to 433 Upgrade						
Baseline	78	4	121	21	1	21
Post-Compliance	78	2	78	0	0	0

Source: U.S. EPA analysis.

Table I.8 summarizes pollutants estimated to exceed human health-based AWQC criteria for consumption of water and organisms under the baseline and post-compliance conditions.

Table I.8: Summary of Pollutants Estimated to Exceed Human Health-Based AWQC Criteria for Consumption of Water and Organisms (National Basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Aniline	0	0	0	0	20	17	0	0	0	0
Antimony	0	0	0	0	0	0	0	0	0	0
Arsenic	45	45	45	45	772	557	45	45	45	45
Bis(2-ethylhexyl) phthalate	0	0	0	0	85	43	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0	0	0
Chloroethane	0	0	0	0	17	14	0	0	0	0
Copper	0	0	0	0	16	0	0	0	0	0
Cresol, p-	0	0	0	0	9	9	0	0	0	0
Dibenzofuran	0	0	0	0	12	9	0	0	0	0
Dichloroethene, 1,1-	0	0	0	0	97	81	0	0	0	0
Dichloromethane	0	0	0	0	17	17	0	0	0	0
Dinitrophenol, 2,4-	0	0	0	0	9	9	0	0	0	0
Dinitrotoluene, 2,6-	0	0	0	0	9	9	0	0	0	0
Dioxane, 1,4-	0	0	0	0	17	17	0	0	0	0
Fluoranthene	0	0	0	0	9	9	0	0	0	0
Iron	21	21	21	21	28	0	21	21	21	0
Isophorone	0	0	0	0	9	9	0	0	0	0
Manganese	21	21	21	21	54	0	21	21	21	0
Mercury	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	9	9	0	0	0	0
Nickel	0	0	0	0	16	0	0	0	0	0
Nitrophenol, 4-	0	0	0	0	9	9	0	0	0	0
Nitrosodimethylamine, N-	32	32	67	67	5,789	5,789	32	32	32	32
Nitrosodiphenylamine, N-	0	0	0	0	17	17	0	0	0	0
Pyrene	0	0	0	0	9	9	0	0	0	0
Pyridine	0	0	0	0	12	9	0	0	0	0
Thallium	0	0	0	0	16	0	0	0	0	0
Trichloroethene	0	0	0	0	21	17	0	0	0	0
Trichloromethane	0	0	0	0	12	12	0	0	0	0
Total Exceedances	121	121	154	154	7,085	6,667	121	121	121	77

[a] Base = Baseline discharge level

[b] PC = Post-Compliance discharge level

Source: U.S. EPA analysis.

Table I.9 summarizes pollutants estimated to exceed human health-based AWQC criteria for consumption of organisms only under the baseline and post-compliance conditions.

Table I.9: Summary of Pollutants Estimated to Exceed Human Health-Based AWQC Criteria for Consumption of Organisms Only (National Basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Aniline	0	0	0	0	12	9	0	0	0	0
Antimony	0	0	0	0	0	0	0	0	0	0
Arsenic	0	0	0	0	154	111		0	0	0
Bis(2-ethylhexyl) phthalate	0	0	0	0	24	12	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0	0	0
Chloroethane	0	0	0	0	0	0	0	0	0	0
Copper	0	0	0	0	16	0	0	0	0	0
Cresol, p-	0	0	0	0	0	0	0	0	0	0
Dibenzofuran	0	0	0	0	12	9	0	0	0	0
Dichloroethene, 1,1-	0	0	0	0	17	17	0	0	0	0
Dichloromethane	0	0	0	0	0	0	0	0	0	0
Dinitrophenol, 2,4-	0	0	0	0	0	0	0	0	0	0
Dinitrotoluene, 2,6-	0	0	0	0	0	0	0	0	0	0
Dioxane, 1,4-	0	0	0	0	0	0	0	0	0	0
Fluoranthene	0	0	0	0	9	9	0	0	0	0
Iron	0	0	0	0	0	0	0	0	0	0
Isophorone	0	0	0	0	0	0	0	0	0	0
Manganese	21	21	21	21	32	0	21	21	21	0
Mercury	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0
Nickel	0	0	0	0	16	0	0	0	0	0
Nitrophenol, 4-	0	0	0	0	0	0	0	0	0	0
Nitrosodimethylamine, N-	0	0	0	0	27	27	0	0	0	0
Nitrosodiphenylamine, N-	0	0	0	0	9	9	0	0	0	0
Pyrene	0	0	0	0	9	9	0	0	0	0
Pyridine	0	0	0	0	0	0	0	0	0	0
Thallium	0	0	0	0	0	0	0	0	0	0
Trichloroethene	0	0	0	0	0	0	0	0	0	0
Trichloromethane	0	0	0	0	0	0	0	0	0	0
Total Exceedances	21	21	21	21	335	212	21	21	21	0

[a] Base = Baseline discharge level

[b] PC = Post-Compliance discharge level

Source: U.S. EPA analysis.

I.4.2 Aquatic Life Effects

EPA evaluated the effects of MP&M facility discharges on aquatic habitats and ecosystem functioning under the baseline conditions and the post-compliance scenarios corresponding to the four regulatory alternatives considered for the MP&M regulation. This analysis compared the estimated baseline and post-compliance in-stream concentrations of MP&M pollutants with AWQC for aquatic species. As noted in the preceding sections, aquatic life AWQCs addressed in this analysis set the upper limit on pollutant concentrations assumed to be protective of aquatic life.

Table I.10 presents the number of MP&M discharge reaches on which pollutant concentrations are estimated to exceed chronic and acute exposure criteria for protection of aquatic life. EPA estimated that, as the result of baseline MP&M pollutant discharges, in-stream concentrations exceed acute exposure criteria for aquatic species in 18 and 15 receiving reaches nationwide based on the traditional extrapolation and post-stratification extrapolation, respectively. In addition, baseline in-stream concentrations in 353 and 350 receiving reaches exceed chronic AWQC for protection of aquatic life based on the traditional extrapolation and post-stratification extrapolation, respectively.

Table I.10: Summary of Estimated AWQC Exceedances for Protection of Aquatic Life (National Basis)

Category	Acute Aquatic Life			Chronic Aquatic Life		
	Streams (No.)	Pollutants (No.)	Total Exceedances	Streams (No.)	Pollutants (No.)	Total Exceedances
Selected Option: Traditional Extrapolation						
Baseline	18	4	35	353	9	423
Post-Compliance	9	1	9	344	5	362
Selected Option: Post-Stratification Extrapolation						
Baseline	15	4	26	350	9	402
Post-Compliance	9	1	9	344	5	362
Proposed/NODA Option						
Baseline	330	17	631	928	47	2,582
Post-Compliance	86	12	254	539	39	1,369
Directs + 413 to 433 Upgrade						
Baseline	18	4	35	353	9	423
Post-Compliance	0	0	0	53	3	53
Directs + All to 433 Upgrade						
Baseline	18	4	35	353	9	423
Post-Compliance	0	0	0	32	2	32

Source: U.S. EPA analysis.

Based on the traditional extrapolation**,** EPA estimates that the final option will eliminate concentrations in excess of acute and chronic criteria in nine reaches. Likewise, EPA estimates that the final option will eliminate concentrations in excess of acute and chronic criteria in six reaches based on the post-stratification extrapolation.

The Proposed/NODA Option, Directs + 413 to 433 Upgrade Option, and Directs + All to 433 Upgrade Option would eliminate exceedances of chronic AWQC values on 389, 300, and 321 reaches, respectively. These options would also eliminate in-stream pollutant concentrations in excess of acute AWQC value on 244, 18, and 18 reaches under the Proposed/NODA Option, Directs + 413 to 433 Upgrade Option, and Directs + All to 433 Upgrade Option, respectively.

Table I.11 presents the number MP&M reaches on which pollutant concentrations are estimated to exceed chronic AWQC for protection of aquatic life by pollutant.

Table I.11: Summary of Pollutants Estimated to Exceed Chronic AWQC for Protection of Aquatic Life (National Basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Acenaphthene	0	0	0	0	9	9	0	0	0	0
Acrolein	0	0	0	0	44	33	0	0	0	0
Aluminum	0	0	0	0	32	12	0	0	0	0
Ammonia as N	0	0	0	0	51	0	0	0	0	0
Aniline	0	0	0	0	45	42	0	0	0	0
Anthracene	0	0	0	0	64	29	0	0	0	0
Biphenyl	0	0	0	0	9	9	0	0	0	0
Butyl benzyl phthalate	0	0	0	0	9	0	0	0	0	0
Cadmium	9	0	6	0	70	21	9	0	9	0
Carbon disulfide	0	0	0	0	38	34	0	0	0	0
Chromium	0	0	0	0	46	12	0	0	0	0
Cobalt	0	0	0	0	12	12	0	0	0	0
Copper	9	9	9	9	344	69	9	0	9	0
Cyanide	0	0	0	0	3	0	0	0	0	0
Di-n-butyl phthalate	0	0	0	0	9	9	0	0	0	0
Di-n-octyl phthalate	0	0	0	0	12	12	0	0	0	0
Dibenzofuran	0	0	0	0	21	12	0	0	0	0
Dibenzothiophene	0	0	0	0	15	12	0	0	0	0
Dimethylphenanthrene, 3,6-	0	0	0	0	24	21	0	0	0	0
Dinitrophenol, 2,4-	0	0	0	0	9	9	0	0	0	0
Dinitrotoluene, 2,6-	0	0	0	0	21	21	0	0	0	0
Diphenyl Ether	0	0	0	0	21	21	0	0	0	0
Fluoranthene	0	0	0	0	30	24	0	0	0	0
Fluorene	0	0	0	0	27	21	0	0	0	0
Fluoride	0	0	0	0	54	13	0	0	0	0
Iron	0	0	0	0	12	0	0	0	0	0
Isopropylnaphthalene, 2-	0	0	0	0	15	12	0	0	0	0
Lead	0	0	0	0	244	83	0	0	0	0
Magnesium	0	0	0	0	12	12	0	0	0	0
Manganese	0	0	0	0	32	0	0	0	0	0
Methylfluorene, 1-	0	0	0	0	15	12	0	0	0	0
Methylnaphthalene, 2-	0	0	0	0	12	12	0	0	0	0
Methylphenanthrene, 1-	0	0	0	0	15	12	0	0	0	0
Molybdenum	0	0	0	0	103	39	0	0	0	0
Naphthalene	0	0	0	0	9	9	0	0	0	0
Nickel	0	0	0	0	163	16	0	0	0	0
Phenanthrene	0	0	0	0	24	21	0	0	0	0
Phenol	0	0	0	0	9	0	0	0	0	0
Pyrene	0	0	0	0	21	21	0	0	0	0
Selenium	0	0	0	0	78	50	0	0	0	0
Silver	9	0	6	0	166	131	9	0	9	0
Styrene	0	0	0	0	9	0	0	0	0	0
Sulfide	0	0	0	0	293	283	0	0	0	0

Table I.11: Summary of Pollutants Estimated to Exceed Chronic AWQC for Protection of Aquatic Life (National Basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Tin	0	0	0	0	83	21	0	0	0	0
Titanium	0	0	0	0	6	0	0	0	0	0
Vanadium	0	0	0	0	157	142	0	0	0	0
Zinc	9	0	6	0	85	33	9	0	9	0
Total Exceedances	35	9	26	9	2,582	1,369	35	0	35	0

[a] Base = Baseline discharge level
[b] PC = Post-Compliance discharge level
Source: U.S. EPA analysis.

Table I.12 presents the number MP&M reaches on which pollutant concentrations are estimated to exceed acute AWQC for protection of aquatic life by pollutant.

Table I.12: Summary of Pollutants Estimated to Exceed Aquatic Life Based Acute AWQC (National Basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Acenaphthene	0	0	0	0	0	0	0	0	0	0
Acrolein	0	0	0	0	33	26	0	0	0	0
Aluminum	9	0	6	0	10	0	9	0	9	0
Ammonia as N	0	0	0	0	0	0	0	0	0	0
Aniline	0	0	0	0	9	0	0	0	0	0
Anthracene	0	0	0	0	64	29	0	0	0	0
Biphenyl	0	0	0	0	9	0	0	0	0	0
Butyl benzyl phthalate	0	0	0	0	0	0	0	0	0	0
Cadmium	9	0	6	0	9	6	9	0	9	0
Carbon disulfide	0	0	0	0	0	0	0	0	0	0
Chromium	0	0	0	0	7	0	0	0	0	0
Cobalt	0	0	0	0	0	0	0	0	0	0
Copper	276	267	273	267	241	69	276	9	276	9
Cyanide	0	0	0	0	0	0	0	0	0	0
Di-n-butyl phthalate	0	0	0	0	0	0	0	0	0	0
Di-n-octyl phthalate	0	0	0	0	0	0	0	0	0	0
Dibenzofuran	0	0	0	0	0	0	0	0	0	0
Dibenzothiophene	0	0	0	0	0	0	0	0	0	0
Dimethylphenanthrene, 3,6-	0	0	0	0	0	0	0	0	0	0
Dinitrophenol, 2,4-	0	0	0	0	9	9	0	0	0	0
Dinitrotoluene, 2,6-	0	0	0	0	0	0	0	0	0	0
Diphenyl Ether	0	0	0	0	0	0	0	0	0	0
Fluoranthene	0	0	0	0	21	21	0	0	0	0
Fluorene	0	0	0	0	21	21	0	0	0	0
Fluoride	0	0	0	0	0	0	0	0	0	0
Iron	0	0	0	0	0	0	0	0	0	0
Isopropylnaphthalene, 2-	0	0	0	0	0	0	0	0	0	0

Table I.12: Summary of Pollutants Estimated to Exceed Aquatic Life Based Acute AWQC (National Basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Lead	18	9	15	9	9	6	18	0	18	0
Magnesium	21	21	21	21	0	0	21	21	21	0
Manganese	9	0	6	0	0	0	9	0	9	0
Methylfluorene, 1-	0	0	0	0	0	0	0	0	0	0
Methylnaphthalene, 2-	0	0	0	0	0	0	0	0	0	0
Methylphenanthrene, 1-	0	0	0	0	0	0	0	0	0	0
Molybdenum	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0
Nickel	9	9	9	9	23	0	9	0	9	0
Phenanthrene	0	0	0	0	9	9	0	0	0	0
Phenol	0	0	0	0	0	0	0	0	0	0
Pyrene	0	0	0	0	0	0	0	0	0	0
Selenium	0	0	0	0	12	12	0	0	0	0
Silver	64	56	61	56	60	12	64	23	64	23
Styrene	0	0	0	0	0	0	0	0	0	0
Sulfide	0	0	0	0	0	0	0	0	0	0
Tin	0	0	0	0	0	0	0	0	0	0
Titanium	0	0	0	0	0	0	0	0	0	0
Vanadium	0	0	0	0	0	0	0	0	0	0
Zinc	9	0	6	0	85	33	9	0	9	0
Total Exceedances	423	362	402	362	631	254	423	53	423	32

[a] Base = Baseline discharge level

[b] PC = Post-Compliance discharge level.

Source: U.S. EPA analysis.

I.4.3 POTW Effects

EPA evaluated the effects of indirect MP&M dischargers on POTW operations for the final and alternative options. 788 sample MP&M facilities discharge 132 pollutants to 572 POTWs. Of these, EPA evaluated 89 pollutants for potential inhibition of POTW operations and eight pollutants for potential sludge contamination. The 788 indirect sample MP&M facilities discharge 52.8 million pounds per year of priority and nonconventional pollutants to the receiving POTWs. The final MP&M rule does not regulate indirect dischargers and thus will not reduce the baseline MP&M loadings to receiving POTWs.

a. Biological inhibition

EPA estimated inhibition of POTW operations by comparing predicted POTW influent concentrations to available inhibition levels for 89 pollutants. EPA's analysis shows that 51 POTWs had influent concentrations that exceed the biological inhibition values for one of the four following pollutants silver, cadmium, chromium and copper under the baseline conditions corresponding to the Final Option and the 433 Upgrade Options (see Table I.13). Both of the 433 Upgrade Options would eliminate influent concentrations in excess of POTW inhibition criteria at 21 POTWs. Under the baseline conditions corresponding to the Proposed/NODA Option, 293 POTWs had influent concentrations in excess of the biological inhibition criteria. The Proposed/NODA Option would eliminate influent concentrations in excess of the biological inhibition criteria at 156 POTWs.

Table I.13: National Summary of Projected Inhibition and Sludge Contamination Problems

Category	Biological Inhibition (# of POTWs)			Sludge Contamination (# of POTWs)		
	POTWs (No.)	Pollutants (No.)	Total Exceedances	POTWs (No.)	Pollutants (No.)	Total Exceedances
Selected Option: Traditional Extrapolation						
Baseline	51	4	139	1,020	7	2,702
Post-Compliance	51	4	139	1,020	7	2,702
Selected Option: Post-Stratification Extrapolation						
Baseline	51	4	139	1,020	7	2,702
Post-Compliance	51	4	139	1,020	7	2,702
Proposed/NODA Option						
Baseline	293	12	885	5,328	8	14,493
Post-Compliance	137	8	410	5,259	8	14,321
Directs + 413 to 433 Upgrade						
Baseline	51	4	139	1,020	7	2,702
Post-Compliance	30	4	115	1,005	7	2,626
Directs + All to 433 Upgrade						
Baseline	5	4	139	1,020	7	2,702
Post-Compliance	30	4	115	1,005	7	2,562

Source: U.S. EPA analysis.

Table I.14 presents MP&M pollutants that are estimated to upset POTW operations and contaminate sewage sludge.

Table I.14: Summary of Pollutants Estimated to Impact POTW Operations (National basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Biological Inhibition (# of POTWs)										
Acrolein	0	0	0	0	77	65	0	0	0	0
Arsenic	0	0	0	0	75	65	0	0	0	0
Benzoic acid	0	0	0	0	68	0	0	0	0	0
Bromo-2-chlorobenzene, 1-	0	0	0	0	48	48	0	0	0	0
Bromo-3-chlorobenzene, 1-	0	0	0	0	48	48	0	0	0	0
Chromium	30	30	30	30	81	7	30	27	30	27
Copper	27	27	27	27	142	0	27	27	27	27
Iron	0	0	0	0	65	32	0	0	0	0
Lead	39	39	39	39	150	81	39	30	39	30
Nickel	0	0	0	0	50	0	0	0	0	0
Silver	42	42	42	42	65	65	42	30	42	30
Zinc	0	0	0	0	16	0	0	0	0	0
Total Exceedances	139	139	139	139	885	410	139	115	139	115
Sludge Contamination (# of POTWs)										
Lead	234	234	234	234	2,829	2,790	234	234	234	234
Mercury	0	0	0	0	118	118	0	0	0	0
Nickel	763	763	763	763	2,371	2,325	763	751	763	687
Arsenic	84	84	84	84	1,686	1,683	84	84	84	84
Cadmium	754	754	754	754	1,877	1,871	754	739	754	739
Copper	534	534	534	534	1,874	1,835	534	500	534	500
Zinc	224	224	224	224	2,132	2,132	224	209	224	209
Selenium	109	109	109	109	1,567	1,567	109	109	109	109

[a] Base = Baseline discharge level

[b] PC = Post-Compliance discharge level.

Source: U.S. EPA analysis.

b. Sewage sludge

EPA estimated that baseline concentrations of seven metals at the national level fail to meet Land Application-High limits for sludge disposal at 1,020 POTWs under the final regulatory alternatives. These concentrations were compared with the relevant metals concentration limits for the following sewage sludge management options: Land Application-High (Concentration Limits), Land Application-Low (Ceiling Limits), and Surface Disposal.

The Agency estimates that the final regulation will not eliminate metal concentrations in excess of sludge contamination criteria at any of these 1,020 POTWs, since indirect dischargers are exempted from the final rule. EPA estimated that 15 POTWs would be able to upgrade their sewage sludge disposal practices by meeting Land Application-High sludge concentration limits under the 433 Upgrade Options. Under the Proposed/NODA Option, 69 POTWs would be able to upgrade their sewage sludge disposal practices to Land Application-High.

GLOSSARY

action levels: the existence of a contaminant concentration in the environment high enough to warrant implementation of drinking water treatment technology.

acute toxicity (AT): the ability of a substance to cause severe biological harm or death soon after a single exposure or dose. Also, any poisonous effect resulting from a single short-term exposure to a toxic substance (See also: chronic toxicity). (http://www.epa.gov/OCEPAterms/aterms.html)

adsorption: removal of a pollutant from air or water by collecting the pollutant on the surface of a solid material; an advanced method of treating waste in which activated carbon removes organic matter from wastewater. (http://www.epa.gov/OCEPAterms/aterms.html)

adsorption coefficient (K_{oc}): represents the ratio of the target chemical adsorbed per unit weight of organic carbon in the soil or sediment to the concentration of that same chemical in solution at equilibrium.

alkalinity: the capacity of bases to neutralize acids (e.g., adding lime to lakes to decrease acidity). (http://www.epa.gov/OCEPAterms/aterms.html)

ambient water quality criteria (AWQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

atm/m^3-mole: atmosphere per cubic meter mole (see also: mole).

benthic: relating to the bottom of a body of water; living on, or near, the bottom of a water body. (http://www.ucmp.berkeley.edu/glossary/gloss5ecol.html)

bioconcentration factor (BCF): indicator of the potential for a chemical dissolved in the water column to be taken up by aquatic biota across external surface membranes, usually gills.

BIODEG: a web-based biodegradation database developed by Syracuse Research Corporation. (http://esc.syrres.com/efdb/biodgsum.htm)

biodegradation: a process whereby organic molecules are broken down by microbial metabolism.

biodegradation half-life: represents the number of days a compound takes to be degraded to half of its starting concentration under prescribed laboratory conditions.

biological oxygen demand (BOD): the amount of dissolved oxygen consumed by microorganisms as they decompose organic material in an aquatic environment.

cancer potency slope factors (SFs): a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.

carcinogens: chemicals that EPA believes can cause or have the potential to cause tumors or cancers in humans, either directly or indirectly.

CHEMFATE: a web-based chemical fate database developed by Syracuse Research Corporation. (http://esc.syrres.com/efdb/Chemfate.htm)

chronic toxicity (CT): the capacity of a substance to cause long-term toxic or poisonous health effects in humans, animals, fish, and other organisms (see also: acute toxicity). (http://www.epa.gov/OCEPAterms/cterms.html)

critical dilution factors (CDFs): express the relationship between a point source loading and the resulting concentration at the edge of the mixing zone. Typically, this is expressed as a ratio of parts receiving water to one part effluent.

dissolved concentration potentials (DCPs): represents the concentration of a nonreactive dissolved substance under well-mixed, steady-state conditions given an annual load of 10,000 tons.

dry metric tons (DMT): dry measure is a system of units for measuring dry commodities. 1 DMT=1,000 kilogram.

EC1: the concentration at which one percent of the test organisms show a significant sub-lethal response.

EC5: the concentration at which five percent of the test organisms show a significant sub-lethal response.

Environmental Research Laboratory-Duluth fathead minnow database: a database developed by EPA's Mid-Continent Ecology Division (MED) which provides data on the acute toxicity of hundreds of industrial organic compounds to the fathead minnow. (http://www.eoa.gov/med/databases/fathead_minnow.html)

GAGE: a U.S. Geological Survey stream flow database. The database contains stream flow data and drainage area measurement from all U.S. Geological Survey flow gages.

hazardous air pollutant (HAP): air pollutants that are not covered by ambient air quality standards but which, as defined in the Clean Air Act, may present a threat of adverse human health effects or adverse environmental effects (e.g., beryllium, mercury, ethylbenzene, chloroethane, and doxane). (http://www.epa.gov/OCEPAterms/hterms.html)

Health Effects Assessment Summary Tables (HEAST): a comprehensive listing of provisional human health risk assessment data relative to oral and inhalation routes for chemicals of interest to EPA. Unlike data in IRIS, HEAST entries have received insufficient review to be recognized as high quality, Agency-wide consensus information (U.S. EPA. 1997. Health Effects Assessment Table; FY 1997 Update. EPA-540-R-97-036).

Henry's Law (H): chemical law stating that the amount of a gas that dissolves in a liquid is proportional to the partial pressure of the gas over the liquid, provided no chemical reaction takes place between the liquid and the gas. The law is named after William Henry (1774 1836), the English chemist who first reported the relationship. (www.infoplease.com)

human health-based water quality criteria (WQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/wterms.html)

Integrated Risk Information System (IRIS): IRIS is an electronic database with information on human health effects of various chemicals. IRIS provides consistent information on chemical substances for use in risk assessments, decision-making, and regulatory activities.

LC50 (Lethal Concentration): a standard measure of toxicity that tells how much of a substance is needed to kill half of a group of experimental organisms in a given time (see also: LD 50). (http://www.epa.gov/OCEPAterms/lterms.html)

LD50 (Lethal Dose): the dose of a toxicant or microbe that will kill 50 percent of the test organisms within a designated period. The lower the LD 50, the more toxic the compound.

l/kg: liter per kilogram

Lowest Observed Effect Concentration (LOEC): the lowest level of pollutant concentration that causes statistically and biologically significant differences in test samples as compared to other samples subjected to no stressor. (http://www.epa.gov/OCEPAterms)

Maximum Allowable Toxicant Concentration (MATC): for a given ecological effects test, the range (or geometric mean) between the No Observable Adverse Effect Level and the Lowest Observable Adverse Effects Level. (http://www.epa.gov/OCEPAterms/mterms.html)

maximum contaminant levels (MCLs): the maximum permissible level of a contaminant in water delivered to any user of a public system. MCLs are enforceable standards. (http://www.epa.gov/OCEPAterms/mterms.html)

mg/kg: milligram per kilogram

µg/l: microgram per liter

mole: the amount of substance that contains Avogardo's number of atoms, molecules or other elementary units.

National Estuarine Inventory (NEI): The National Estuarine Inventory is a series of inter-related activities that define, characterize, and assess the nation's estuarine systems. NEI data are compiled in a systematic and consistent manner that enables the nation's estuaries to be compared and assessed according to their environmental quality, economic values, and resource uses. A principal feature of the NEI is the determination of the physical dimensions and hydrologic features of estuarine systems of the United States which are primary determinants of estuarine processes and ultimately affect the ecology of a system.

National Oceanic and Atmospheric Administration (NOAA): organization within the Bureau of Commerce that conducts research and gathers data about the global oceans, atmosphere, space, and sun.

No Observed Effect Concentration (NOEC): exposure level at which there are no statistically or biologically significant differences in the frequency or severity of any effect in the exposed or control populations. (http://www.epa.gov/OCEPAterms/nterms.html)

oil and grease (O&G): organic substances that may include hydrocarbons, fats, oils, waxes, and high-molecular fatty acids. Oil and grease may produce sludge solids that are difficult to process. (http://www.epa.gov/owmitnet/reg.htm)

organic carbon (OC): carbon in compounds derived from living organisms.

partition factor: a chemical-specific value representing the fraction of the load expected to partition to sewage sludge during wastewater treatment.

Permit Compliance System (PCS): a computerized database of information on water discharge permits, designed to support the National Pollutant Discharge Elimination System (NPDES). (http://www.epa.gov/ceisweb1/ceishome/ceisdocs/pcs/pcs-exec.htm)

pH: an expression of the intensity of the basic or acid condition of a liquid; natural waters usually have a pH between 6.5 and 8.5. (http://www.epa.gov/OCEPAterms/pterms.html)

pollutants of concern (POCs): the 150 contaminants identified by EPA as being of potential concern for this rule and which are currently being discharged by MP&M facilities.

Premanufacture Notices (PMN): a notice, required by Section 5 of TSCA, that must be submitted to EPA by anyone who plans to manufacture or import a new chemical substance for a non-exempt commercial distribution. The notice must be submitted at least 90 days prior to the manufacture or import of the chemical. (http://www.epa.gov/oppt/newchems/index.htm)

priority pollutant (PP): 126 individual chemicals that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater, or soil samples. These chemicals are also known as toxic pollutants.

quantitative structure-activity relationship (QSAR): an expert system that uses a large database of measured physicochemical properties, such as melting point, vapor pressure, and water solubility, to estimate the fate and effect of a specific chemical based on its molecular structure. (http://www.epa.gov/med/databases/aster.html)

reference doses (RfDs): RfDs represent chemical concentrations - expressed in mg of pollutant/kg body weight/day - which, if not exceeded, are expected to protect an exposed population, including sensitive groups such as young children or pregnant women.

Secondary Maximum Contaminant Levels (SMCLs): non-enforceable water treatment levels applying to public water systems and specifying the maximum contamination levels that, in the judgment of EPA, are required to protect the public welfare. These treatment levels apply to any contaminants that may adversely affect the odor or appearance of such water and consequently may cause people served by the system to discontinue its use.

suspended solids: small particles of solid pollutants that float on the surface of, or are suspended in, sewage or other liquids. They resist removal by conventional means.

Superfund Chemical Data Matrix (SCDM): a source for factor values and benchmark values applied when evaluating potential National Priorities List (NPL) sites using the Hazard Ranking System (HRS). (http://www.epa.gov/superfund/resources/scdm/index.htm)

systemic toxicants: chemicals that EPA believes can cause significant non-carcinogenic health effects when present in the human body above chemical-specific toxicity thresholds.

total Kjeldahl nitrogen (TKN): TKN is defined as the total of organic and ammonia nitrate. It is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

total organic carbon (TOC): a measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids" (see also: suspended solids).

total petroleum hydrocarbons (TPH): a general measure of the amount of crude oil or petroleum product present in an environmental media (e.g. soil, water, or sediments). While it provides a measure of the overall concentration of petroleum hydrocarbons present, TPH does not distinguish between different types of petroleum hydrocarbons.

total suspended particles (TSP): method of monitoring airborne particulate matter by total weight. (http://www.epa.gov/OCEPAterms/tterms.html)

total suspended solids (TSS): a measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids" (see also: suspended solids).

United States Geological Survey (USGS): a governmental organization that provides reliable scientific information to: describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. (www.noaa.gov)

volatilization: a process whereby chemicals dissolved in water escape into the air.

ACRONYMS

AQUIRE: AQUatic Information REtrieval System
ASTER: ASsessment Tools for the Evaluation of Risk
AT: acute toxicity
AWQC: ambient water quality criteria
BCF: bioconcentration factor
BOD: biological oxygen demand
CDF: critical dilution factor
CT: chronic toxicity
DCP: dissolved concentration potential
DMT: dry metric tons
H: Henry's Law
HAP: hazardous air pollutant
HEAST: Health Effects Assessment Summary Tables
IRIS: Integrated Risk Information System
K_{oc}: adsorption coefficient
LOEC: Lowest Observed Effect Concentration
MATC: Maximum Allowable Toxicant Concentration
MCL: maximum contaminant level
NEI: National Estuarine Inventory
NOAA: National Oceanic and Atmospheric Administration
NOEC: No Observed Effect Concentration
O&G: oil and grease
OC: organic carbon
PCS: Permit Compliance System
PMN: Premanufacture Notices
POC: pollutant of concern
PP: priority pollutant
QSAR: quantitative structure-activity relationship
RBC: EPA's Region III Risk-Based Concentration Table
RfD: reference dose
SCDM: Superfund Chemical Data Matrix
SF: cancer potency slope factor
SMCL: Secondary Maximum Contaminant Level
TKN: total Kjeldahl nitrogen
TOC: total organic carbon
TPH: total petroleum hydrocarbons
TSP: total suspended particulates
TSS: total suspended solids
USGS: United States Geological Survey
WQC: water quality criteria

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Appendix J: Spacial Distribution of MP&M Facilities and Recreational User Populations

INTRODUCTION

This appendix compares the national distribution of all MP&M facilities by state and the national distribution of recreational participants by state (see Table J.1 and Figure J.1).

APPENDIX CONTENTS

EPA based the distribution of MP&M facilities by state on Census data on total numbers of facilities in the SICs that make up the MP&M industries, not just water dischargers. This comparison assumes that the state distribution of water-discharging MP&M facilities is the same as the overall distribution of MP&M facilities.

EPA based the distribution of recreational participants by state and by type of recreation activity on information provided by the National Demand Study data. This comparison suggests that the reaches that benefit from the final rule are also those where a very large percentage of all recreational participants reside and recreate.

Table J.1: Distribution of MP&M Facilities and Participants of Water-based Recreation by State

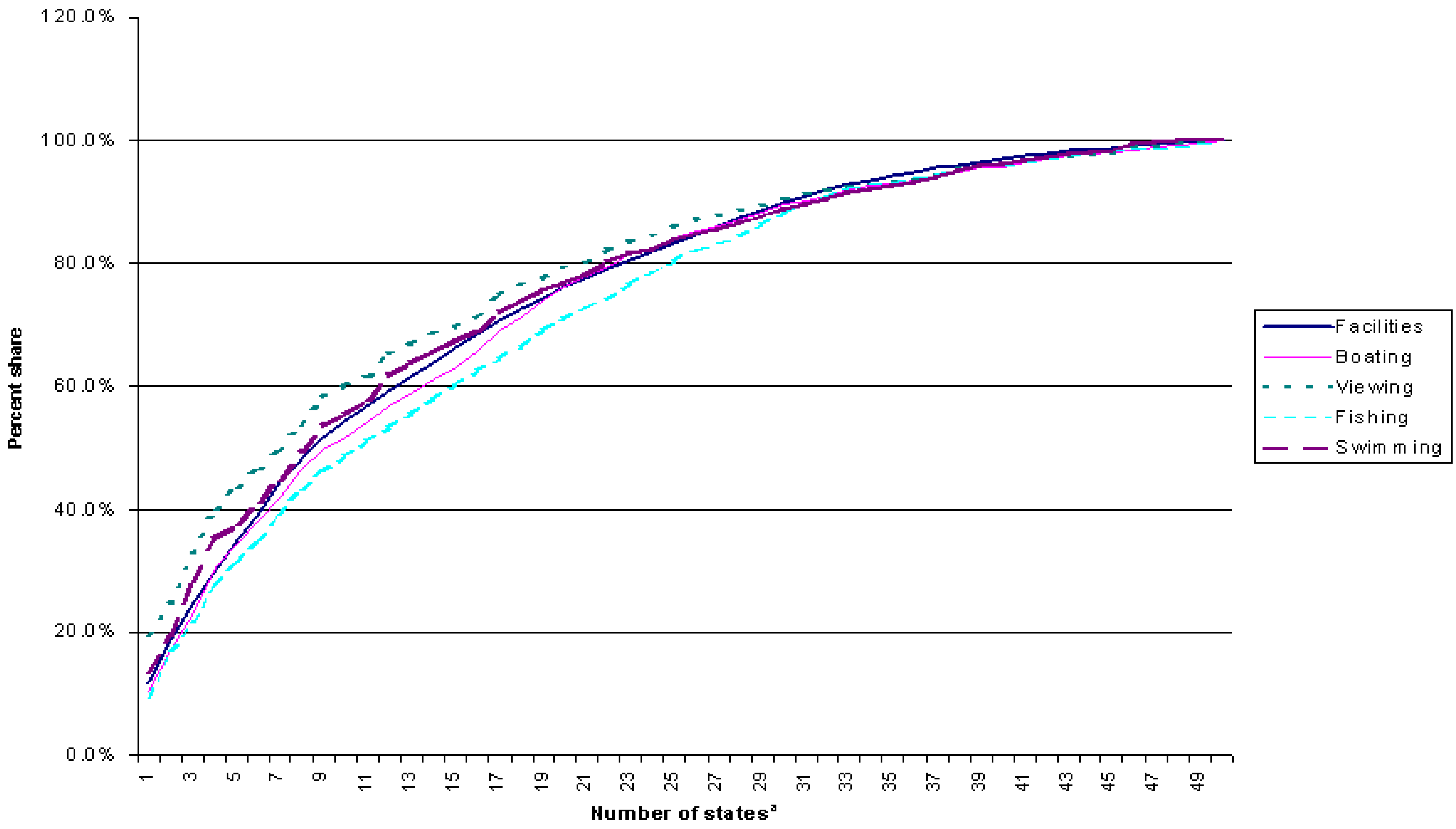
State	Percent of State Population Participating by Activity				Average # of Per-Person Trips per Season by Activity				Total State Pop. (1990) (Millions)	Potential (Extrapolated) # Participants Based on State Population				Nat.'l # of MP&M Facilities	State % of National Facilities	Cum. ST % of Facilities	Cumulative Percent Distribution of Participants by State			
	Boat	View	Fish	Swim	Boat	View	Fish	Swim		Boat	View	Fish	Swim				Boat	View	Fish	Swim
CA	11.7%	36.9%	13.6%	20.1%	5.4	14	7.1	11.7	29.8	3,490,513	10,992,849	4,057,154	5,983,736	68,359	11.9%	11.9%	10.3%	19.5%	9.4%	13.8%
TX	12.8%	16.4%	18.9%	14.5%	7.2	5	10.6	6.5	17.0	2,171,791	2,792,303	3,205,978	2,456,192	38,176	6.6%	18.5%	16.7%	24.5%	16.8%	19.4%
NY	12.4%	25.6%	11.2%	20.5%	7.9	5.7	9.2	8.7	18.0	2,231,374	4,602,209	2,022,183	3,695,714	36,329	6.3%	24.8%	23.3%	32.6%	21.5%	27.9%
FL	18.7%	32.6%	20.5%	24.2%	10.1	17.9	17.1	15.4	12.9	2,423,418	4,221,438	2,657,943	3,126,991	30,198	5.2%	30.0%	30.5%	40.1%	27.7%	35.1%
IL	11.8%	17.2%	14.6%	9.4%	9.6	9	13.7	5.7	11.4	1,349,105	1,962,335	1,667,985	1,079,284	28,343	4.9%	34.9%	34.5%	43.6%	31.5%	37.6%
OH	11.5%	15.8%	14.2%	14.0%	8	8.2	13.1	8.8	10.8	1,251,590	1,718,851	1,535,284	1,518,596	26,460	4.6%	39.5%	38.2%	46.6%	35.1%	41.1%
PA	10.5%	14.4%	15.2%	13.7%	9.4	7.4	10.9	8	11.9	1,249,014	1,713,391	1,809,469	1,633,326	26,237	4.6%	44.1%	41.9%	49.7%	39.3%	44.8%
MI	16.0%	24.8%	18.4%	20.8%	8.6	9.4	12	8.5	9.3	1,484,665	2,307,687	1,710,593	1,936,520	23,662	4.1%	48.2%	46.3%	53.8%	43.2%	49.3%
NJ	15.9%	32.3%	15.9%	23.9%	10.9	6.4	6.3	7.3	7.7	1,225,246	2,495,046	1,225,246	1,849,008	19,805	3.4%	51.6%	49.9%	58.2%	46.1%	53.5%
NC	8.8%	17.9%	16.5%	13.5%	7.7	5.2	13.6	7.4	6.6	586,317	1,188,920	1,091,201	895,762	15,158	2.6%	54.3%	51.6%	60.3%	48.6%	55.6%
IN	14.3%	15.0%	20.3%	16.3%	7.7	9	11.8	5.5	5.5	794,663	831,624	1,127,312	905,546	14,656	2.5%	56.8%	54.0%	61.8%	51.2%	57.7%
MA	15.7%	30.9%	15.7%	28.9%	8.7	11.6	14.3	9.5	6.0	942,332	1,860,501	942,332	1,739,689	13,915	2.4%	59.2%	56.8%	65.1%	53.4%	61.7%
WI	15.7%	22.1%	18.1%	19.7%	10	6.1	11.5	6.2	4.9	768,940	1,079,788	883,463	965,266	13,845	2.4%	61.6%	59.0%	67.0%	55.4%	63.9%
GA	11.5%	13.9%	16.6%	11.5%	11.4	4.1	10.3	7.4	6.5	746,819	903,129	1,076,808	746,819	13,747	2.4%	64.0%	61.2%	68.6%	57.9%	65.6%
MO	13.0%	12.6%	18.8%	15.2%	5.2	4	5	8	5.1	665,035	646,562	960,606	775,874	13,395	2.3%	66.3%	63.2%	69.8%	60.1%	67.4%
VA	13.4%	17.0%	16.2%	13.4%	9	4.2	8.4	6.1	6.2	827,102	1,049,783	1,002,066	827,102	12,829	2.2%	68.6%	65.7%	71.6%	62.5%	69.3%
WA	25.0%	39.2%	18.8%	25.9%	5.8	11.7	18.2	5.8	4.9	1,216,673	1,907,623	916,260	1,261,735	11,991	2.1%	70.6%	69.3%	75.0%	64.6%	72.2%
MN	17.6%	19.6%	19.6%	17.6%	5.4	16.5	11.5	6.8	4.4	767,875	857,162	857,162	767,875	11,272	2.0%	72.6%	71.5%	76.5%	66.6%	73.9%
TN	17.9%	13.5%	22.6%	14.5%	7.5	3.7	15.1	6.7	4.9	873,280	659,079	1,103,957	708,510	10,808	1.9%	74.5%	74.1%	77.7%	69.1%	75.6%
MD	14.8%	18.7%	17.1%	12.1%	8.8	12.1	13.2	8.4	4.8	706,988	893,037	818,617	576,753	8,993	1.6%	76.0%	76.2%	79.3%	71.0%	76.9%
AL	14.7%	11.9%	20.6%	13.8%	7.5	9.2	18.6	10.6	4.0	593,114	481,905	834,066	556,044	8,825	1.5%	77.6%	77.9%	80.1%	72.9%	78.2%
CT	16.4%	37.1%	14.5%	27.0%	7.7	6.8	7.7	12.3	3.3	537,516	1,219,747	475,495	888,969	8,593	1.5%	79.1%	79.5%	82.3%	74.0%	80.2%
LA	16.4%	15.3%	27.0%	13.8%	4	3.4	13.4	4.4	4.2	692,165	647,509	1,138,723	580,525	8,500	1.5%	80.5%	81.6%	83.4%	76.7%	81.5%
CO	6.6%	13.2%	25.9%	11.3%	17.2	14.8	13.1	5.2	3.3	217,554	435,109	854,678	372,950	8,231	1.4%	82.0%	82.2%	84.2%	78.7%	82.4%
OR	20.3%	37.8%	24.9%	23.0%	8.8	7.2	13.2	7.4	2.8	576,323	1,074,057	707,306	654,913	7,978	1.4%	83.3%	83.9%	86.1%	80.3%	83.9%
KY	11.9%	12.3%	22.4%	10.0%	6.5	3	9.4	17.5	3.7	437,524	454,352	824,564	370,212	7,822	1.4%	84.7%	85.2%	86.9%	82.2%	84.8%
AZ	7.3%	11.2%	11.8%	10.7%	7.2	8	8.3	5.7	3.7	267,685	411,823	432,415	391,232	7,799	1.4%	86.1%	86.0%	87.7%	83.2%	85.7%
IA	13.5%	16.4%	18.7%	13.5%	5	4.4	13.8	2.7	2.8	373,482	454,673	519,627	373,482	7,661	1.3%	87.4%	87.1%	88.5%	84.4%	86.5%
OK	11.2%	12.6%	25.2%	14.0%	4.9	3.4	14.6	4.2	3.1	351,954	395,948	791,896	439,942	6,972	1.2%	88.6%	88.2%	89.2%	86.2%	87.5%

Table J.1: Distribution of MP&M Facilities and Participants of Water-based Recreation by State

State	Percent of State Population Participating by Activity				Average # of Per-Person Trips per Season by Activity				Total State Pop. (1990) (Millions)	Potential (Extrapolated) # Participants Based on State Population				Nat.'l # of MP&M Facilities	State % of National Facilities	Cum. ST % of Facilities	Cumulative Percent Distribution of Participants by State			
	Boat	View	Fish	Swim	Boat	View	Fish	Swim		Boat	View	Fish	Swim				Boat	View	Fish	Swim
SC	13.8%	19.9%	26.0%	15.5%	9.8	8.5	16.2	7.5	3.5	481,589	693,488	905,387	539,380	6,907	1.2%	89.8%	89.6%	90.4%	88.3%	88.8%
KS	6.7%	17.0%	18.5%	13.3%	17.6	9	12.9	6.2	2.5	165,172	422,105	458,810	330,343	6,370	1.1%	90.9%	90.1%	91.1%	89.4%	89.5%
AR	14.1%	12.5%	28.1%	18.0%	4.6	10.2	13.3	7.3	2.4	330,571	293,841	661,141	422,396	5,825	1.0%	91.9%	91.1%	91.7%	90.9%	90.5%
MS	13.6%	12.1%	23.6%	15.7%	6.3	24.2	17.4	12.9	2.6	349,222	312,462	606,544	404,363	5,165	0.9%	92.8%	92.1%	92.2%	92.3%	91.4%
NE	10.7%	15.5%	10.7%	15.5%	3.9	2.1	13.9	3.9	1.6	169,113	244,274	169,113	244,274	4,424	0.8%	93.6%	92.6%	92.7%	92.7%	92.0%
UT	8.1%	17.1%	13.5%	12.6%	6.6	3.5	3.6	6.8	1.7	139,691	294,902	232,818	217,296	3,633	0.6%	94.2%	93.0%	93.2%	93.3%	92.5%
WV	9.5%	10.3%	18.3%	15.9%	6.6	4.6	17.2	6.7	1.8	170,807	185,041	327,381	284,679	3,442	0.6%	94.8%	93.5%	93.5%	94.0%	93.1%
RI	15.8%	40.4%	19.3%	36.8%	6.9	4.6	8.3	7	1.0	158,442	404,907	193,651	369,697	3,106	0.5%	95.3%	94.0%	94.2%	94.5%	94.0%
ME	22.2%	44.4%	27.8%	37.5%	7.6	5.7	10.5	10.3	1.2	272,873	545,746	341,091	460,473	2,980	0.5%	95.9%	94.8%	95.2%	95.3%	95.1%
NH	18.8%	31.2%	14.1%	34.4%	3.3	14.9	13.2	15.7	1.1	207,985	346,641	155,989	381,305	2,960	0.5%	96.4%	95.4%	95.8%	95.6%	95.9%
NM	6.7%	8.6%	12.4%	9.5%	3.7	5.6	9.8	3.8	1.5	101,005	129,863	187,580	144,292	2,927	0.5%	96.9%	95.7%	96.0%	96.1%	96.3%
ID	24.1%	25.3%	20.5%	20.5%	5.8	4.3	13.4	9.5	1.0	242,590	254,720	206,202	206,202	2,572	0.4%	97.3%	96.4%	96.5%	96.5%	96.7%
NV	17.3%	21.3%	13.3%	12.0%	4.8	7.3	15.4	6.3	1.2	208,318	256,391	160,244	144,220	2,406	0.4%	97.7%	97.0%	96.9%	96.9%	97.1%
MT	14.5%	20.0%	34.5%	29.1%	7.8	15.6	20.7	8.3	0.8	116,228	159,813	276,041	232,455	2,204	0.4%	98.1%	97.4%	97.2%	97.5%	97.6%
SD	16.7%	21.4%	16.7%	21.4%	2.3	1.8	6	7	0.7	116,001	149,144	116,001	149,144	2,049	0.4%	98.5%	97.7%	97.5%	97.8%	97.9%
ND	15.0%	15.0%	25.0%	15.0%	3.7	3	4.5	11.5	0.6	95,820	95,820	159,700	95,820	1,749	0.3%	98.8%	98.0%	97.7%	98.2%	98.2%
HI	16.4%	58.2%	18.2%	47.3%	6.7	33.9	6.6	15.5	1.1	181,347	644,788	201,496	523,890	1,677	0.3%	99.1%	98.5%	98.8%	98.7%	99.4%
VT	20.6%	17.6%	8.8%	20.6%	7.1	5.5	8.7	10.4	0.6	115,862	99,310	49,655	115,862	1,488	0.3%	99.3%	98.9%	99.0%	98.8%	99.6%
DE	15.7%	41.2%	15.7%	13.7%	6.4	11	11.5	6.9	0.7	104,497	274,305	104,497	91,435	1,379	0.2%	99.6%	99.2%	99.5%	99.0%	99.8%
WY	19.4%	16.1%	48.4%	6.5%	6.3	4.6	8.1	8	0.5	87,791	73,159	219,478	29,264	1,309	0.2%	99.8%	99.4%	99.6%	99.5%	99.9%
AK	34.5%	41.4%	37.9%	6.9%	5.4	7.1	17.4	2	0.6	189,670	227,604	208,637	37,934	1,156	0.2%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Information on total MP&M facilities by state is from Census data; information on where recreating people live is from NDS data.

Figure J.1: Cumulative Distribution of Facilities and Participants



[a] The numbers refer to states in the order they appear in the above table. Therefore, 1 is California, 2 is Texas, 3 is New York, etc.

Sources: Information on total MP&M facilities by state is from Census data; information on where recreating people live is from NDS data.

Appendix K: Selecting WTP Values for Benefits Transfer

INTRODUCTION

EPA identified eight surface water evaluation studies that quantified the effects of water quality improvements on various water-based recreational activities. As noted in Chapter 15 of this report, the Agency selected these studies based on technical criteria for evaluating study transferability (Desvousges et al., 1987; Desvousges et al., 1992; and Boyle and Bergstrom, 1992), including the following:

- The environmental change valued at the study site must be the same as the environmental quality change caused by the rule (e.g., changes in toxic contamination vs. changes in nutrient concentrations);
- The populations affected at the study site and at the policy site must be the same (e.g., recreational users vs nonusers);
- The assignment of property rights at both the study and policy sites must lead to the same theoretically-appropriate welfare measure (e.g., ***willingness-to-pay*** **(WTP)** vs. willingness-to-accept compensation); and
- The candidate studies should be based on defensible research methods. Six of the eight studies are published in peer reviewed journals. One study, Tudor et al. (2002), was presented at the annual American Agricultural Economic Association and the Northeastern Resource and Environmental Economic meetings.[1] The eighth study, Lyke (1993), is an unpublished Ph.D. dissertation.

In addition to the above criteria, the Agency considered authors' recommendations regarding the robustness and theoretical soundness of various estimates in selecting point estimates for benefits transfer.

The rest of this appendix presents welfare estimates from seven studies used in estimating recreational benefits from the final regulation and provides EPA's reasons for selecting specific values from each study. The study by Tudor et al. (2002) is discussed in detail in Chapter 21. All welfare estimates from that study are eligible for use in benefits transfer, because the study is based on the policy scenarios specific to the MP&M regulation.

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[1] Preliminary results of this study were presented at the annual American Agricultural Economic Association meeting (L. Tudor et al., 1999a) and at the annual Northeastern Agricultural and Resource Economic Association meeting (L. Tudor et al., 1999b). EPA subjected this study to a formal peer review by experts in the natural resource valuation field. The peer review concluded that EPA had done a competent job, especially given the available data. This study can be found in Chapter 21. The peer review report is in the docket for the rule.

K.1 DESVOUSGES ET AL., 1987. OPTION PRICE ESTIMATES FOR WATER QUALITY IMPROVEMENTS: A CONTINGENT VALUATION STUDY FOR THE MONONGAHELA RIVER

This study used findings from a ***contingent valuation (CV)*** survey to estimate WTP for improved recreational fishing from enhanced water quality in the Pennsylvania portion of the Monongahela River. In a hypothetical market, each survey respondent was asked to provide an option price for different water quality changes, such as "raising the water quality from suitable for boating (hereafter, 'boatable' water) to a level where gamefish would survive (hereafter, 'fishable' water)." Table K.1 lists water quality changes evaluated in the study and the corresponding WTP estimates. The following discussion provides justification for selecting the point estimates EPA used in the benefits transfer analysis in Chapter 15.

Table K.1: Changes in the Resource Value from a Specified Water Quality Improvement from Desvousges et al. (1987)

Water Quality Change Valued	Adjusted to 2001$ [b]			Original Estimates (1981$)		
	User	Nonuser	Combined	User	Nonuser	Combined
Iterative Bidding: $25 starting point						
Unsuitable to Boatable	$53.4	$57.8	$56.4	$27.4	$29.7	$29.0
Boatable to Fishable[a]	**$36.8**	$28.3	$30.9	**$18.9**	$14.5	$15.9
Fishable to Swimmable	$23.0	$14.0	$16.9	$11.8	$7.2	$8.7
Boatable to Swimmable	$62.5	$42.2	$48.9	$32.1	$21.7	$25.1
Unsuitable to Swimmable	$115.9	$100.0	$105.3	$59.5	$51.4	$54.1
Iterative Bidding: $125 starting point						
Unsuitable to Boatable	$184.4	$75.6	$111.7	$94.7	$38.8	$57.4
Boatable to Fishable	$113.1	$51.2	$71.9	$58.1	$26.3	$36.9
Fishable to Swimmable	$64.4	$22.5	$36.6	$33.1	$11.6	$18.8
Boatable to Swimmable	$194.1	$78.9	$117.3	$99.7	$40.5	$60.2
Unsuitable to Swimmable	$378.5	$154.2	$229.0	$194.4	$79.2	$117.6
Direct Question: no payment card						
Boatable to Unsuitable	$88.2	$27.6	$47.7	$45.3	$14.2	$24.5
Boatable to Fishable	$60.9	$21.0	$34.2	$31.3	$10.8	$17.6
Fishable to Swimmable	$39.3	$16.6	$24.1	$20.2	$8.5	$12.4
Boatable to Swimmable	$103.0	$39.5	$60.7	$52.9	$20.3	$31.2
Unsuitable to Swimmable	$191.2	$67.2	$108.4	$98.2	$34.5	$55.7
Direct Question: payment card						
Boatable to Unsuitable	$91.1	$103.2	$99.3	$46.8	$53.0	$51.0
Boatable to Fishable	$88.2	$42.6	$57.1	$45.3	$21.9	$29.3
Fishable to Swimmable	$44.5	$15.0	$24.3	$22.9	$7.7	$12.5
Boatable to Swimmable	$138.6	$58.3	$83.6	$71.2	$29.9	$42.9
Unsuitable to Swimmable	$229.6	$161.3	$182.8	$117.9	$82.8	$93.9

Location:	Pennsylvania portion of the Monongahela River
Estimating Approach:	CV
Survey Population :	Recreational Users and Nonusers

[a] The value selected for benefits transfer is given in bold.

[b] WTP values from the original study are adjusted to 2001$ based on the Consumer Price Index (CPI).

Source: Desvousges et al., 1987.

EPA judged that only one value from this study met the requirements for the quality of research methods and was compatible with the environmental changes and population characteristics considered in the analysis of recreational benefits from the MP&M rule. EPA selected this value for the following reasons:

- **Environmental quality change.** The Desvousges et al. (1987) study derived WTP values for five different changes in water quality, as shown in Table K.1 above. EPA judged that only one of these improvements, from "boatable" to "fishable," is compatible with the changes in water quality expected under the MP&M rule. Streams unsuitable for recreational activities such as boating are likely to be affected by multiple environmental stressors from many sources, including many that are not related to MP&M discharges (e.g., severe oxygen depletion.) In these cases, it is reasonable to assume that changes in concentrations of MP&M pollutants would reduce or eliminate one of the stressors on the reach, but would be unlikely to change the designation of the reach.

  The analysis in Chapter 15 assumes that reaches with ***ambient water quality criteria (AWQC)*** exceedances under the baseline conditions are boatable and likely to support rough fishing, but may not be clean enough to support gamefishing. AWQC are set at a level below which pollutant concentrations are not expected to cause significant harm to human health or aquatic life. Exposure to pollutant concentrations above the AWQC levels are expected to have a harmful effect. Therefore, by definition, water with pollutant levels that exceed criteria set to protect human health or aquatic life are not suitable waters for sensitive aquatic species or ideal as a sources of fish for consumption.

  Removing AWQC exceedances is therefore comparable to shifting water quality from "boatable"to "fishable." The Agency did not use the boatable to swimmable designation because a more limited number of reaches are suitable for swimming nationally due to reasons not related to MP&M discharges (e.g., amenities, pathogens). Determining national level locations affected by MP&M pollutants that are suitable for swimming required more resources than were available for the national analysis.

- **Research methods.** The authors used four different payment vehicles in their CV study. For the recreational benefits analysis, EPA decided to use the WTP estimates derived from the "***iterative bidding***" ***(IB)*** payment vehicle, because it is universally preferred to the "***direct question/open-ended***" format for eliciting option price bids.

  Survey respondents in the direct question format are asked to state the most that they would be willing to pay for the program or policy. This format confronts respondents with an unfamiliar choice. Studies that use this approach usually have high non-response rates.

  Respondents in the IB format are asked whether they would be willing to pay a given amount. If the answer is yes, then this amount is raised in pre-set increments until the respondent says that he or she will not pay the last amount given. If the answer is no, then the amount is decreased until the respondent indicates WTP the stated amount. Some studies found that the respondent's final WTP amount depends on the initial amount offered. This problem is referred to in economic literature as starting point bias. The Agency selected the WTP estimates derived using the $25 starting point IB process to avoid upward starting point bias. Table K.1 shows that the selected estimates are the most conservative among all the payment vehicles used.

- **Population characteristics.** The user population considered in this study matches the user population characteristics considered in EPA's analysis (i.e., recreational anglers, boaters, and wildlife viewers).

K.2 FARBER AND GRINER, 2000. VALUING WATERSHED QUALITY IMPROVEMENTS USING CONJOINT ANALYSIS

Farber and Griner (2000) used a CV study to estimate changes in water resource values to users from various improvements in Pennsylvania's water quality. The study defines water quality as "polluted," "moderately polluted," and "unpolluted" based on a water quality scale developed by EPA Region III. "Polluted" streams are unable to support aquatic life, "moderately polluted" streams are somewhat unable to support aquatic life, and "unpolluted" streams adequately support aquatic life. Farber and Griner developed WTP estimates for water quality improvements for the following three water quality changes:

- from "moderately polluted" to "unpolluted,"
- from "severely polluted" to "moderately polluted," and

- from “severely polluted” to “unpolluted.”

The authors used six different model variations to estimate the WTP for the three improvements scenarios for various population groups (e.g., users, nonusers, and a mix of users and nonusers). Table K.2 presents the estimated WTP values. The following discussion provides EPA’s reasons for selecting point estimates for the use in benefits transfer.

Table K.2: Estimate WTP for Specified Water Quality Improvements from Farber and Griner (2001$)

Water Quality Change Valued	Binary Choice Model			Intensity of Preference Model		
	User	Nonuser	Combine	User	Nonuser	Combine
Basic						
Moderately Polluted to Unpolluted	$49.7	$6.3	$40.4	$56.2	$14.0	$54.2
Severely Polluted to Moderately Polluted	$66.9	$5.8	$55.6	$73.8	$51.4	$70.9
Severely Polluted to Unpolluted	$117.3	$44.9	$95.7	$129.6	$57.7	$116.8
Interactive						
Moderately Polluted to Unpolluted	$48.2	$3.2	$38.0	$56.9	$13.3	$54.6
Severely Polluted to Moderately Polluted	$65.2	$1.5	$52.7	$75.1	$50.6	$71.9
Severely Polluted to Unpolluted	$115.5	$41.3	$92.9	$133.1	$57.6	$119.5
Fixed Effects						
Moderately Polluted to Unpolluted [a]	**$24.5**	$16.4	$28.3	**$41.8**	$5.5	$41.0
Severely Polluted to Moderately Polluted	$42.4	$10.6	$38.2	$63.4	$30.3	$59.0
Severely Polluted to Unpolluted	$86.6	$48.4	$80.4	$110.5	$31.0	$98.6

Location:	Lower Allegheny Watershed in Western Pennsylvania
Estimating Approach:	Conjoint Analysis
Survey Population:	Recreational users and nonusers

[a] Values selected for the use in benefits transfer are given in bold.

[b] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Farber and Griner, 2000.

The Agency selected only two values from this study based on their compatibility with the environmental changes and population characteristics considered in both the original study and the analysis of recreational benefits from the MP&M rule. The following discussion summarizes EPA’s reasons used in the selection process:

- **Environmental quality change.** EPA judged that only one water quality improvement scenario change from “moderately polluted” to “unpolluted” is compatible with the environmental quality change expected from the final regulation

  AWQC are set at a level below which pollutant concentrations have not been demonstrated to cause significant harm to human health or aquatic life. Exposure to pollutant concentrations above the AWQC levels are expected to have a harmful effect. Therefore, by definition, water with pollutant levels that exceed criteria set to protect human health or aquatic life are polluted waters.

  EPA chose the case where the policy variable changed from moderately polluted to unpolluted because this is likely to be the most frequently occurring scenario for reaches with MP&M discharges. Streams unable to support any aquatic life (i.e., “severely polluted”) are likely to be affected by numerous environmental stressors, in addition to MP&M discharges. Eliminating MP&M-related AWQC exceedences would eliminate or reduce one of the stressors, but is unlikely to change the quality of the water from severely polluted to unpolluted. It is more realistic to assume that most streams affected by MP&M facility discharges are moderately polluted, i.e., these streams support some aquatic life; but sensitive species are adversely affected by MP&M pollutants exceeding AWQC values protective of aquatic life. Removing all AWQC exceedances would make such streams unpolluted.

- **Research methods.** EPA considered only two of the six versions of the benefits transfer model based on the authors’ recommendations. The authors appear to prefer the “fixed effects” versions of both the ***binary choice***

(BC) and ***intensity of preference (IP)*** models. Specifically, they note that "A likelihood ratio test, with degrees of freedom being the number of individuals in the estimating sample, can be used to test the superiority of the fixed effects model. Such a test shows the fixed effects model to be a statistical improvement over either the basic or interactive models" (see Table K.2). In addition, they state that, "the purpose of estimating a fixed effects model was to account for the possibility that some respondents may approve of all changes, regardless of price and quality. If this behavior existed in the sample, not controlling for it would result in overestimates of marginal valuations for each type of quality change. This expectation is supported by the fact that the fixed effects valuation estimates are lower than the others."

- **Population characteristics.** The user population considered in this study matches the user population characteristics considered in EPA's analysis (i.e., recreational anglers, boaters, and wildlife viewers).

K.3 JAKUS ET AL., 1997. DO SPORTFISH CONSUMPTION ADVISORIES AFFECT RESERVOIR ANGLERS' SITE CHOICE?

Jakus et al. (1997) used a repeated discrete choice ***travel cost (TC)*** model to examine the impacts of ***fish consumption advisories (FCA)*** in eastern and middle Tennessee. The estimated consumer surplus from recreational fishing in middle and east Tennessee is $26.02 and $52.57 per angler per day, respectively, under the baseline water quality conditions. The estimated welfare gain from removing FCAs is $2.04 and $3.16 per angler per day , respectively. Table K.3 summarizes the study's estimates.

Table K.3:Consumer Surplus from Recreational Fishing from Jakus et al. (1997)[a]

Water Quality Change Valued	Consumer Surplus Adjusted to 2001$	Consumer Surplus ($1997)
Site Choice Model -- multinomial logit		
Average surplus per trip in middle TN (baseline water quality	$26.02	$23.60
Benefit per trip from removing all advisories in middle TN	**$2.04**	**$1.85**
Average surplus per trip in East TN (baseline water quality conditions)	$52.57	$47.67
Benefit per trip from removing all advisories in east TN	**$3.16**	**$2.86**
Benefit per trip from removing Watts Bar advisory	$1.75	$1.59
Repeated Discrete Choice Model -- repeated nested logit model		
Seasonal benefit from removing all advisories in middle TN	$24.22	$21.96
Seasonal benefit from removing all advisories in east TN	$52.27	$47.40
Seasonal benefit from removing Watts Bar advisory	$30.43	$27.60

Location:	Tennessee
Estimating Approach:	TC
Survey Population:	Tennessee residents; anglers and non-anglers

[a] Values selected for the use in benefits transfer are given in bold.

[b] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Jakus et al, 1997.

EPA selected two values from this study for use in benefits transfer, based on their compatibility with the environmental quality change and population characteristics at both the original study and policy sites, for the following reason:

- **Environmental quality change.** FCAs are usually triggered by the presence of toxic pollutants in fish tissue. EPA expects the final regulation to reduce discharges of toxic pollutants, including those linked to FCAs (e.g., mercury and lead). The Agency therefore assumed that the removal of FCAs is compatible with water quality improvements expected from the final regulation.

The recreational benefits analysis uses consumer surplus estimates for both regions studied by the authors, because MP&M facilities are located in these regions as well as throughout heavily populated regions of the U.S. EPA did not include the value corresponding to the Watts Bar lake in the benefits transfer analysis because this lake is included in the set of fishing areas for east Tennessee.

K.4 LANT AND ROBERTS, 1990. GREENBELTS IN THE CORNBELT: RIPARIAN WETLANDS, INTRINSIC VALUES, AND MARKET FAILURE

Lant and Roberts (1990) used a CV study to estimate the recreational and nonuse benefits of improved water quality in selected Iowa and Illinois river basins. River quality was defined by means of an interval scale of “poor,” “fair,” “good,” and “excellent.” The authors defined the four water quality intervals as follows:

- “poor” water quality is inadequate to support any recreation activity,
- “fair” water quality is adequate for boating and rough fishing,
- “good” water quality is adequate for gamefishing, and
- “excellent” is adequate to support swimming and exceptional fishing.

Table K.4 summarizes WTP values for specified water quality improvements from this study.

Table K.4: WTP Values for a Specified Water Quality Improvement from Lant and Roberts (1990)

Water Quality Change Valued	Adjusted to 2001$		Original Study Values 1987$	
	Use Value	Nonuse Value	Use Value	Nonuse Value
Poor to fair	$47.5	$58.6	$30.50	$37.61
Fair to good[a]	**$57.8**	$73.5	**$37.10**	$47.16
Good to excellent	$64.7	$67.3	$41.51	$43.22

Location:	Selected Iowa and Illinois river basins
Estimating Approach:	CV
Survey Population:	Recreational users and nonusers

[a] The values given in bold were selected for the use in benefits transfer.

[b] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Lant and Roberts, 1990.

The Agency judged that only one value from this study is compatible with the environmental changes and population characteristics considered in the analysis of recreational benefits from the MP&M rule, for the following reasons:

- **Environmental quality change.** The Agency judged that only one of the three possible water quality changes considered in this study “fair” to “good” was compatible with the water quality change expected under the MP&M rule. EPA assumed in its analysis of recreational benefits expected from the MP&M rule that reaches with AWQC exceedances under the baseline conditions may support rough fishing, but may not be clean enough to support more sensitive species such as those desired for game fishing. Removing AWQC exceedances will shift water quality from “fair“ to “good.”
- **Population characteristics.** The user population considered in this study matches the population characteristics considered in EPA’s analysis (i.e., recreational anglers, boaters, and wildlife viewers).

K.5 AUDREY LYKE, 1993. DISCRETE CHOICE MODELS TO VALUE CHANGES IN ENVIRONMENTAL QUALITY: A GREAT LAKES CASE STUDY

Lyke's (1993) study of the Wisconsin Great Lakes open water sport fishery showed that anglers may place a significantly higher value on a contaminant-free fishery than on one with some level of contamination. Lyke estimated the value of the fishery to Great Lakes trout and salmon anglers if it was improved enough to be "completely free of contaminants that may threaten human health." The author also estimated various policy scenarios that affect the value of recreational fishing in the Wisconsin Great Lakes, including reducing the daily bag limit for lake trout and restoring naturally reproducing populations of lake trout. Table K.5 presents welfare estimates from this study.

Table K.5: WTP Estimates for Specified Water Quality Improvements from Lyke (1993)[a]

Water Quality Change Valued	Adjusted to 2001$ [b]		Original Study Value	
	Value of WI Fishing	Change in Value	Value of WI Fishing	Change in Value
CV -- linear logit model				
1990 fishing conditions remain the same as 1989	**$95,062,744**		**$66,600,000**	
WI daily bag limit for lake trout reduced to one a day	$43,962,951	($51,099,793	$30,800,000	($35,800,000
Great Lakes fish are free of pollutants affecting human health	$105,625,27	**$10,562,527**	$74,000,000	**$7,400,000**
Restoring naturally reproducing populations of lake trout	$17,271,159	$17,271,159	$12,100,000	$12,100,000
WI inland fishing conditions remain the same as 1989	$964,330,17		$675,600,00	
Restoring naturally reproducing populations of lake trout in WI waters of Great Lakes (inland anglers only)	$0	$0	$0	$0
CV -- constant elasticity of substitution model (mean)				
1990 fishing conditions remain the same as 1989	**$118,899,79**		**$83,300,000**	
Great Lakes fish are free of pollutants affecting human health	$156,011,38	**$37,111,581**	$109,300,00	**$26,000,000**
CV -- constant elasticity of substitution model (median)				
1990 fishing conditions remain the same as 1989	$26,834,528		$18,800,000	
Great Lakes fish are free of pollutants that affect human health	$40,537,266	$13,702,738	$28,400,000	$9,600,000

Location:	Wisconsin
Estimating Approach:	TC and CV
Survey Population:	Wisconsin Great Lakes and inland anglers

[a] The values selected for the use in benefits transfer are given in bold.
[b] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Lyke, 1993.

EPA selected two WTP values from this study for use in benefits transfer for the following reasons:

- **Environmental quality change.** EPA judged that only one policy scenario Great Lakes fish that are free from contaminants harmful to human health is compatible with water quality improvements associated with removal of all AWQC exceedances. Other scenarios, such as reducing daily bag limit for lake trout to one per day and restoring naturally reproducing populations of lake trout, are irrelevant to the MP&M regulation. The Agency used estimates from the "1990 fishing conditions remain the same as 1989 conditions" scenario as an estimate of the baseline value of recreational fishing in Wisconsin.

- **Research methods.** The Agency did not consider estimates from the TC model because the author noted that "the nested logit travel cost model results seem too high."

K.6 Montgomery and Needelman, 1997. The Welfare Effects of Toxic Contamination in Freshwater Fish

Montgomery and Needelman (1997) estimated benefits from removing “toxic” contamination from lakes and ponds in New York State. They used a binary variable as their primary water quality measure, which indicates whether the New York Department of Environmental Conservation considers water quality in a given lake to be impaired by toxic pollutants. Their model controls for major causes of impairments other than “toxic” pollutants, to separate the effects of various pollution problems that affect the fishing experience. Table K.6 lists environmental quality changes considered in the study and the WTP values corresponding to a specified water quality change.

Table K.6: Welfare Estimates from Montgomery and Needelman (1997)

Water Quality Change Valued	Compensating Variation per Capita per Season (2001$)[b]	Compensating Variation per Capita per Season (1989$)
Eliminate toxic contamination in all lakes[a]	**$90.28**	**$63.25**
All toxic lakes are closed to fishing	$124.31	$87.09
Raise pH in acidic lakes (none are threatened or impaired)	$19.73	$13.82
Close all acidic lakes to fishing	$21.20	$14.85
Eliminate toxic contamination and raise pH in acidic lakes	$113.39	$79.44

Location:	New York State
Estimating Approach:	TC -- Repeated discrete choice model
Survey Population:	New York State residents; anglers and non-anglers

[a] The values selected for the use in benefits transfer are given in bold.

[b] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Montgomery and Needelman, 1997.

The Agency selected only one value from this study for use in the benefits transfer based on its compatibility with environmental quality changes at both the original study and the MP&M sites, for the following reason:

- **Environmental quality change.** Only one of the five policy scenarios considered eliminate toxic contamination in all lakes is directly compatible with the potential changes brought about by the MP&M rule. The MP&M rule is unlikely to significantly affect the acidity in lakes and streams affected by MP&M discharges. The last three policy scenarios in Table K.6 involve changes in pH levels, and are therefore not included in the benefits transfer. The Agency also did not consider the estimate from the second scenario in Table K.6 closing all toxic lakes to fishing in benefits transfer, because it does not consider water quality improvement per se.

K.7 Phaneuf et al., 1998. Valuing Water Quality Improvements Using Revealed Preference Methods When Corner Solutions are Present

Phaneuf et al. (1998) studied angling in Wisconsin Great Lakes. They estimated changes in recreational fishing values resulting from a 20 percent reduction of toxin levels in lake trout flesh. The study uses a TC model to value water quality improvements when ***corner solutions*** are present in the data. Corner solutions arise when consumers visit only a subset of the available recreation sites, setting their demand to zero for the remaining sites. Phaneuf et al. found that improved industrial and municipal waste management results in general water quality improvement. Table K.7 presents findings from this study based on two policy scenarios and four different model specifications.

Table K.7: Welfare Estimates from Phaneuf et al. (1998)

Water Quality Change Valued	**Adjusted to 2001$[a]**				**Study Values (1989$)**			
	RNL	**RPRN**	**KT**	**System**	**RNL**	**RPRN**	**KT**	**System**
20% reduction in toxins	$41.62	$12.53	**$166.21**	$15.69	$29.16	$8.78	**$116.45**	$10.99
Loss of South Lake Michigan	$232.19	$140.37	$12,119	$441.36	$162.67	$98.34	$849.09	$309.21

Location:	Wisconsin Great Lakes
Estimating Approach:	TC models, including: RNL: Repeated Nested Logit model; RPRNL: Random Parameters Repeated Nested Logit model; KT: Kuhn-Tucker model; and System: Systems of Demands model
Survey Population:	Wisconsin anglers; Great Lakes and inland anglers

[a] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Phaneuf et al, 1998.

The Agency selected only one value for use in benefits transfer for the following reasons:

- **Environmental quality change.** Only one policy scenario evaluated in this study a 20 percent reduction in the toxin levels in fish tissue is compatible with the water quality changes expected from the MP&M regulation (i.e., removal of aquatic life-based AWQC exceedances. The second scenario loss of South Lake Michigan fishing sites is irrelevant to the final regulation.

- **Research methods.** Phaneuf et al. estimated four different models and provided WTP estimates based on each of them. The authors indicated, however, that "the KT model comes closest to matching the ideal theoretical model" (see authors conclusions, page 1030). Other models either rely on more restrictive assumptions or require additional research. The Agency chose the value from the KT model based on the authors' recommendation, which is one of the selection criteria for values used in benefits transfer.

GLOSSARY

ambient water quality criteria (AWQC): Levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

binary choice (BC): offers respondents to a contingent valuation survey specific dollars and cents choices, for example, "Would you be willing to pay between $10 and $20 per year to improve visibility at the Grand Canyon?"

conjoint analysis: "any decompositional method that estimates the structure of consumer's preferences given his or her overall evaluations of a set of alternatives that are prespecified in terms of levels of different attributes. Price typically is included as an attribute." (Green and Srinivasan, 1990).

contingent valuation (CV): a method used to determine a value for a particular event, where people are asked what they are willing to pay for a benefit and/or are willing to receive in compensation for tolerating a cost. Personal valuations for increases or decreases in the quantity of some good are obtained contingent upon a hypothetical market. The aim is to elicit valuations or bids that are close to what would be revealed if an actual market existed. (http://www.damagevaluation.com/glossary.htm)

corner solutions: a corner solution arises when a consumer who has a choice of two goods, x_1 and x_2, chooses to consume no x_1 at the utility maximum.

direct question/open-ended (OE): in the OE approach, respondents are asked the most they would be willing to pay for the program or policy. This approach has a virtue of not providing any hints about what might be a reasonable value. This approach, however, confronts respondents with an unfamiliar choice (i.e., placing a price on environmental commodities). Studies that use the OE approach have high item non-response rates.

fish consumption advisory (FCA): an official notification to the public about specific areas where fish tissue samples have been found to be contaminated by toxic chemicals which exceed FDA action limits or other accepted guidelines. Advisories may be species specific or community wide.

intensity of preference (IP): an experimental design that allows individuals to state an intensity of preferences for or against the alternative to the status quo. For example, the individual designates they would "probably yes" or "definitely yes" prefer the alternative to the status quo.

iterative bidding (IB): with IB, respondents are asked whether they would be WTP a given amount. If the answer is yes, this amount is raised in pre-set increments until the respondent says that he or she will not pay the last amount given. If the answer is no, then the amount is decreased until the respondent indicates a willingness-to-pay the stated amount.

starting point bias: when survey interviewers suggest a first bid this can influence the respondent's answer and cause the respondent to agree too readily with bids in the vicinity of the initial bid. (http://www.damagevaluation.com/glossary.htm)

travel cost (TC): method to determine the value of an event by evaluating expenditures of participants. Travel costs are used as a proxy for price in deriving demand curves for a recreation site. (http://www.damagevaluation.com/glossary.htm)

willingness-to-pay (WTP): maximum amount of money one would be willing to pay or give up to buy some good. (http://www.damagevaluation.com/glossary.htm)

ACRONYMS

AWQC: ambient water quality criteria
BC: binary choice
CV: contingent valuation
FCA: fish consumption advisory
IB: iterative bidding”
IP: intensity of preference
TC: travel cost
WTP: willingness-to-pay

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Appendix L: Parameters Used in the IEUBK Model

INTRODUCTION

This appendix contains a comprehensive list of model parameters that are used in the IEUBK model for lead in children.

APPENDIX CONTENTS

The remainder of this appendix is a reproduction of *Appendix B: Description of Parameters In the IEUBK Lead Model,* taken from the *Technical Support Document for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (v0.99d) (December 1994).*

APPENDIX B: DESCRIPTION OF PARAMETERS IN THE IEUBK LEAD MODEL

TABLE B-1. DESCRIPTION OF PARAMETERS IN THE IEUBK LEAD MODEL

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
ABSD	Total absorption for dust at low saturation	0.3	0-84	E	Based on US EPA (1989a).	unitless	U-1c, U-2
ABSF	Total absorption for food at low saturation	0.5	0-84	E	Based on US EPA (1989a).	unitless	U-1a,U-2
ABSO	Total absorption for other ingested lead at low saturation	0.0	0-84	E	Based on the default condition that there is no other source of lead ingestion in the household.	unitless	U-1d,U-2
ABSS	Total absorption for soil at low saturation	0.3	0-84	E	Based on US EPA (1989a).	unitless	U-1e,U-2
ABSW	Total absorption for water at low saturation	0.5	0-84	E	Based on US EPA (1989a).	unitless	U-1b,U-2
air_absorb(t)	Net percentage absorption of air lead	32 32 32 32 32 32 32	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Deposition efficiencies of airborne lead particles were estimated by U S EPA (1989a). A respiratory deposition/absorption rate of 25% to 45% is reported for young children living in non-point source areas while a rate of 42% is calculated for those living near point sources. An intermediate value of 32% was chosen.	%	U-4
air_concentration(t)	Outdoor air lead concentration	0.1 0.1 0.1 0.1 0.1 0.1 0.1	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Based on the lower end of the range 0.1 - 0.3 µg Pb/m^3 that is reported for outdoor air lead concentration in U.S. cities without lead point sources (US EPA 1989)	µg/m^3	E-1,2,11

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
AVF, AVW, AVD, AVO, AVS	Bioavailability	1	0-84	I	Parameter added for later flexibility in describing the absorption process; has no effect in current algorithm.	unitless	U-1a-U-1e
AVINTAKE	Available intake	U-2	0-84	I	The amount of Pb that is available for intake	µg	U-1a,b,c,d,e
can_fruit(t)	Lead intake from canned fruit when fruit is consumed only in canned form	1.811 1.063 1.058 0.999 0.940 0.969 1.027	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-5d
can_veg(t)	Lead intake from canned vegetables when vegetable is consumed only in canned form	0.074 0.252 0.284 0.295 0.307 0.291 0.261	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-5b
contrib_percent	Ratio of indoor dust lead concentration to soil lead concentration	0.70	0-84	E	Analysis of soil and dust data from 1983 East Helena study (US EPA, 1989)	g/g per g/g	E-11
CONRBC	Maximum lead concentration capacity of red blood cells	1200	0-84	I	Based on Marcus (1983) reanalysis of infant baboon data from Mallon (1983). See Marcus (1985a) for assessment of form of relationship and estimates from data on human adults [data from deSilva (1981a,b), Manton and Malloy (1983), and Manton and Cook (1984)] and infant and juvenile baboons (Mallon, 1983).	µg/dL	B-2.5
constant_soil_conc(t)	Soil lead concentration	200 200 200 200 200 200 200	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Air Quality Criteria Document for Lead. (US EPA, 1986)	µg/g	E-8

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
constant_water_conc	Water lead concentration	4.0	0-84	E	Based on analysis of data from the American Water Works Service Co. (Marcus, 1989)	µg/L	E-6a
CRBONEBL(t)	Ratio of lead concentration (µg/kg) in bone to blood lead concentration (µg/L)	B-4c	0-84	I	Data in Barry (1981) were used. Bone lead concentration was calculated as an arithmetic average of the concentrations in the rib, tibia, and calvaria. The blood lead concentrations were taken directly from the study. Concentrations in each of the following eight age groups were considered: stillbirths, 0-12 days, 1-11 mos, 1-5 yrs, 6-9 yrs, 11-16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	L/kg	B-1h
CRKIDBL(t)	Ratio of lead concentration (µg/kg) in kidney to blood lead concentration (µgL)	B-4a	0-84	I	Data in Barry (1981) were used. Lead concentrations in kidney (combined values for cortex and medulla) and blood were taken directly from the study. Concentrations in each of the following eight age groups were considered: stillbirths, 0-12 days, 1-11 mos, 1-5 yrs, 6-9 yrs, 11-16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	L/kg	B-2h
CRLIVBL(t)	Ratio of lead concentration (µg/kg) in liver to blood lead concentration (µg/l)	B-4b	0-84	I	Data in Barry (1981) were used. Lead concentrations in liver and blood were taken directly from the study. Concentrations in each of the following eight age groups were considered: stillbirths, 0-12 days, 1-11 mos, 1-5 yrs, 6-9 yrs, 11-16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	L/kg	B-2e,2f

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
CROTHBL(t)	Ratio of lead concentration (µg/kg) in other soft tissue to blood lead concentration (µg/L)	B-4d	0-84	I	Data in Barry (1981) were used. Lead concentration ratio for soft tissues was calculated as a weighted arithmetic average of concentration ratios for muscle (53.8%), fat (24.0%), skin (9.4%), dense connective tissue (4.4%), brain (2.7%), GI tract (2.3%), lung (1.9%), heart (0.7%), spleen (0.3%), pancreas (0.2%), and aorta (0.2%), where the weights applied are given in parentheses. The weight associated with each soft tissue component was equal to the weight of the component (kg) divided by weight of all soft tissues (kg). These weights were estimated from Schroeder and Tipton (1968) and are assumed to apply in the range 0-84 months of age. Concentrations in each of the following eight age groups were considered: stillbirths, 0-12 days, 1-11 mos, 1-5 yrs, 6-9 yrs, 11-16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	L/kg	B-2n,2o
DAYCARE(t)	Dust lead intake at daycare	E-12c	0-84	I	Simple combination of the total amount of dust ingested daily, fraction of total dust ingested as daycare dust, and dust lead concentration at daycare.	µg/day	E-9d
DaycareConc	Dust lead concentration at daycare	200	0-84	E	Based on the assumption that default daycare dust concentrations are the same as default residence dust concentrations.	µg/g	E-12c
DaycareFraction	Fraction of total dust ingested daily as daycare dust	0	0-84	E	Based on the default assumption that the child does not attend daycare.	unitless	E-9.5,12c
diet_intake(t)	User-specified diet lead intake	5.53 5.78 6.49 6.24 6.01 6.34 7.00	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-4a
DietTotal(t)	Total Dietary Intake	E-4b	0.84	I	Summation of all dietary sources; same as INDIET(t)	µg/day	E-4b
DustTotal(t)	Daily amount of dust ingested	E-10	0-84	I	Simple combination of total amount soil and dust ingested daily and fraction of this combined ingestion that is dust alone.	g/day	E-9c,12a-12e

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
EXAIR(t)	Air lead intake	E-3	0-84	I	Simple combination of average air lead concentration and ventilation rate.	µg/day	U-4
f_fruit(t)	Lead intake from fresh fruit if no home-grown fruit is consumed	0.039 0.196 0.175 0.175 0.179 0.203 0.251	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-5e
f_veg(t)	Lead intake from fresh vegetables if no home-grown vegetables are consumed	0.148 0.269 0.475 0.466 0.456 0.492 0.563	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-5c
FirstDrawConc	First Draw water lead concentration	4.0	0-84	E	Based on analysis of data from the American Water Works Service Co. (Marcus, 1989)	µg/L	E-6b
FirstDrawFraction	Fraction of total water consumed daily as first draw	0.5	0-84	E	In the absence of appropriate data, a conservative value corresponding to consumption largely after four fours stagnation time was used, e.g. early morning or late afternoon.	unitless	E-6b,7
FountainConc	Fountain water lead concentration	10	0-84	E	Default assumption is that the drinking fountain has a lead-lined reservoir, but that consumption is not always first draw. Therefore, a value was selected from the range of 5-25 g/L.	µg/L	E-6b
FountainFraction	Fraction of total water consumed daily from fountains	0.15	0-84	E	A default value was based on 4-6 trips to the water fountain at 40-50 ml per trip.	none	E-6b,7
fruit_all(t)	Daily amount of all frults consumed	38.481 169.000 63.166 61.672 61.848 67.907 80.024	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	g/day	E-5f

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
HomeFlushedConc	Home flushed water lead concentration	1.0	0-84	E	Based on analysis of data from the American Water Works Service Co. (Marcus, 1989)	µg/L	E-6b
HCT0	Hematocrit at birth	0.45	0	I	Data from Silve et al. (1987); also Spector (1956) and Altman and Ditmer (1973)	decimal percent	B-7b,d
InCanFruit(t)	Lead intake from canned fruit	E-5d	0-84	I	Simple combination of the fraction of non-home grown fruits consumed daily, and lead intake from canned fruits when fruits are consumed only in canned form.	µg/day	E-4b
InCanVeg(t)	Lead intake from canned vegetables	E-5b	0-84	I	Simple combination of the fraction of vegetables consumed daily as non-home grown, and lead intake from canned vegetables when vegetables are consumed only in canned form.	µg/day	E-4b
INDIET(t)	Diet lead intake	E-4a *or* E-4b	0-84	I	Two options are provided. Default option - Considers composite diet lead intake. Alternate option - Combines lead intake from several individual components of diet.	µg/day	U-1a, U-2
IndoorConc(t)	Indoor air lead concentration	E-1	0-84	I	Algebraic expression of relationship	µg/m^3	E-2
indoorpercent	Ratio of indoor dust lead concentration to corresponding outdoor concentration	30	0-84	E	Based on homes near lead point sources. The default value is reported in OAQPS (USEPA 1989, pp A-1) and is estimated by Cohen and Cohen (1980).	%	E-1
INDUST(t)	Household dust lead intake	E-9a *or* E-9c	0-84	I	Two options are provided. Default option - Assumes that all dust lead exposure is from the household. Alternate option - Considers dust lead exposure from several alternative sources as well.	µg/day	U-1-c, U-2

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
INDUSTA(t)	Lead intake from alternate dust sources	E-9b *or* E-9d	0-84	I	Two options are provided. Default option - Assumes that lead intake from alternate sources is zero. Alternate option - Combines lead intake from several alternate sources.	µg/day	U-1.5c, U-2
InFish(t)	Lead intake from fish	E-5h	0-84	I	Simple combination of total meat consumed daily, fraction of meat consumed as fish, and lead concentration in fish.	µg/day	E-4b
InFrFruit(t)	Lead intake from non-home grown fresh fruits	E-5e	0-84	I	Simple combination of the fraction of fruits consumed daily as non-home grown and lead intake from fresh fruits.	µg/day	E-4b
InFrVeg(t)	Lead intake from non-home grown fresh vegetables	E-5c	0-84	I	Simple combination of the fraction of vegetables consumed daily as non-home grown and lead intake from fresh vegetables.	µg/day	E-4b
InGame(t)	Lead intake from game animal meat	E-5i	0-84	I	Simple combination of total meat consumed daily, fraction of meat consumed as game animal meat, and lead concentration in game animal meat.	µg/day	E-4b
InHomeFruit(t)	Lead intake from home grown fruits	E-5f	0-84	I	Simple combination of total amount of fruit consumed daily, fraction of fruit consumed as home grown, and lead concentration in home grown fruit.	µg/day	E-4b
InHomeVeg(t)	Lead intake from home grown vegetables	E-5g	0-84	I	Simple combination of total amount of vegetable consumed daily, fraction of vegetables consumed as home grown, and lead concentration in home grown vegetables.	µg/day	E-4b
InMeat(t)	Lead intake from non-game and non-fish meat	E-5a	0-84	I	Simple combination of total amount of meat consumed daily, fraction of meat consumed as non-game and non-fish meat, and lead concentration in non-game and non-fish meat.	µg/day	E-4b
InOtherDiet(t)	Combined lead intake from dairy food, juice, nuts, beverage, pasta, bread, sauce, candy, infant and formula food	3.578 3.506 3.990 3.765 3.545 3.784 4.215	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Sum of the amounts of lead ingested in food items not substituted by the calculation of exposure to lead in home grown fruits and vegetables, wild game or fish. Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-4b, E-4c

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
INOTHER(t)	Combined other sources of ingested lead, such as paint chips, ethnic medicines, etc.	0	0-84	E	Assumes no other sources of ingested lead	g/day	U-1d, U-2
INSOIL(t)	Soil lead intake	E-8	0-84	I	Simple combination of total amount of soil and dust ingested daily, fraction of this combined ingestion that is soil alone, and lead concentration in soil.	µg/day	U-1e,U-2
INWATER(t)	Water lead intake	E-6a *or* E-6b	0-84	I	Two options are provided. Default option - Simple combination of water consumed daily and a constant water lead concentration. Alternate option - Water lead concentration depends on contribution from several individual sources of water.	µg/day	U-1b, U-2
MCORT(t)	Mass of lead in cortical bone	B-7e *and* B-9f	0 *and* 0-84	I	0 months - Simple combination of an assumed bone to blood lead concentration ratio, blood lead concentration, and weight of cortical bone. Basis for value of bone to blood lead concentration ratio was human autopsy data (Barry, 1981). 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3). Both cases above assume that the cortical bone to blood lead concentration ratio is equal to the bone (composite) to blood lead concentration ratio.	µg	B-6b,6i,6.5b, 6.5i,8a,9f
meat_all(t)	Daily amount of meat (including fish and game) consumed	29.551 87.477 95.700 101.570 107.441 111.948 120.961	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	g/day	E-5h

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
meat(t)	Lead intake from meat if no game meat or fish is consumed	0.226 0.630 0.811 0.871 0.931 1.008 1.161	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg /day	E-5a
MKIDNEY(t)	Mass of lead in kidney	B-7f *and* B-9c	0 *and* 0-84	I	0 months - Simple combination of an assumed kidney to blood lead concentration ratio, blood lead concentration, and weight of kidney. Basis for the value of the kidney to blood lead concentration ratio was human autopsy data (Barry, 1981). 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	µg	B-6b,6f,6.5b,6.5f,8d,9c
MLIVER(t)	Mass of lead in liver	B-7g *and* B-9b	0 *and* 0-84	I	0 months - Simple combination of an assumed liver to blood lead concentration ratio, blood lead concentration, and weight of the liver. Basis for the value of the liver to blood lead concentration ratio was human autopsy data (Barry, 1981). 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	µg	B-6b,6e,6.5b,6.5e,8d,9b
MOTHER(t)	Mass of lead in soft tissues	B-7h *and* B-9d	0 *and* 0-84	I	0 months - Simple combination of an assumed soft tissue to blood lead concentration ratio, blood lead concentration, and weight of the soft tissues at birth. Basis for the value of soft tissue to blood lead concentration ratio was human autopsy data (Barry et al., 1981), using total lead and total weight of other tissue. 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	µg	B-6b,6g,6.5b,6.5g,8d,9d
MPLASM(t)	Mass of lead in plasma pool	B-7d *and* B-9g	0 *and* 0-84	I	0 months - Simple combination of the mass of lead in blood and red blood cells. 0-84 months - Based on the assumption that the lead concentration in plasma-ECF is equal to the lead concentration in the plasma.	µg	B-10a

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
MPLECF(t)	Mass of lead in plasma-extra-cellular fluid (plasma-ECF)	B-7b *and* B-8a	0 *and* 0-84	I	0 months - Based on two assumptions. (1) masses of lead in plasma-ECF and red blood cells are in kinetic quasi-equilibrium, and (2) lead concentration in the plasma-ECF is equal to lead concentration in the plasma. 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	µg	B-6a,6c-6i,6.5a, 6.5c-6.5i,8a,9a-9g
MRBC(t)	Mass of lead in red blood cells	B-7c *and* B-9a	0 *and* 0-84	I	0 months - Based on the assumption that the masses of lead in plasma-ECF and red blood cells are in kinetic quasi-equilibrium. 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	µg	B-6a,6d,6.5a,6.5d,8d,9a,10a
MTRAB(t)	Mass of lead in trabecular bone	B-7i *and* B-9e	0 *and* 0-84	I	0 months - Simple combination of an assumed bone to blood lead concentration ratio, blood lead concentration, and weight of trabecular bone. Basis for the value of bone to blood lead concentration ratio was human autopsy data (Barry, 1981). 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3). Both cases above assume that trabecular bone to blood lead concentration ratio is equal to bone (composite) to blood lead concentration ratio.	µg	B-6b,6h,6.5b,6.5h,8d,9e
multiply_factor	Ratio of indoor dust lead concentration to air lead concentration	100	0-84	E	Analyses of the 1983 East Helena study in (USEPA 1989, Appendix B-8) suggest about 267 µg/g increment of lead in dust for each µg /m^3. lead in air. A much smaller factor of 100 µg/g PbD per µg/m^3 is assumed for non-smelter community exposure.	µg /g per µg/m^3	E-11
OCCUP(t)	Dust lead intake from secondary occupation	E-12a	0-84	I	Simple combination of amount of dust ingested, fraction of the total dust ingested as secondary occupational dust, and lead concentration in secondary occupational dust	µg/day	E-9d
OccupConc	Secondary occupational dust lead concentration	1200	0-84	E	Air Quality Criteria Document for Lead. (US EPA, 1986)	µg/g	E-12a

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
OccupFraction	Fraction of total dust ingested as secondary occupation dust	0	0-84	E	The default condition is that there is no adult in the residence who works at a lead-related job.	unitless	E-9.5,12a
PAINT(t)	Dust lead intake from lead based home paint	E-12e	0-84	I	Simple combination of amount of dust ingested daily, fraction of the total dust ingested as lead-based home paint, and lead concentration in lead-based home paint.	µg/day	E-9d
PaintConc	Leadconcentration in housedust containing lead based paint	1200	0-84	E	Air Quality Criteria Document for Lead. (US EPA, 1986)	µg/g	E-12e
PAF	Fraction of total absorption as passive absorption at low dose	0.20	0-84	E	Based on in vitro everted rat intestine data (Aungst and Fung, 1981), reanalyses (Marcus, 1994) of infant baboon data (Mallon, 1983) and infant duplicate diet study (Sherlock and Quinn, 1986)	unitless	U-1a thru U-1f
PaintFraction	Fraction of total dust ingested that results from lead based home paint	0	0-84	E	The default is that there is no lead-based paint in the home.	unitless	E-12e
PBBLDMAT	Maternal blood lead concentration	2.5	adult	E	Based in part on Midvale 1989 study. The default value of 2.5 g/dL has little influence of the early post natal exposure of the child.	µg/dL	B-7a
PBBLD0	Lead concentration in blood	B-7a	0	I	Based on 85% of maternal blood lead concentration (US EPA 1989)	µg/dL	B-7b, 7c, 7e-7i
PBBLOODEND(t)	Lead concentration in blood	B-10a	0-84	I	Simple combination of the blood lead concentrations determined in each iteration in the solution algorithm between the previous month and that month.	µg/dL	B-10c
RATBLPL	Ratio of lead mass in blood to lead mass in plasma-ECF	100	0-84	I	Based on the lower end of the 50-500 range for the red cell/plasma lead concentration ratio recommended in Diamond and O'Flaherty (1992a).	unitless	B-2b-2d,2g,2i,2k,2m

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
RATFECUR	Ratio of endogenous fecal lead elimination rate to urinary lead elimination rate	0.75	0-84	I	Assume child ratio is larger than the adult ratio; values derived from a reanalysis of data from Ziegler et al. (1978) and Rabinowitz and Wetherill (1973).	unitless	B-1f
RATOUTFEC	Ratio of elimination rate via soft tissues to endogenous fecal lead elimination rate	0.75	0-84	I	Within the range of values derived from a reanalysis of data from Ziegler et al. (1978) and Rabinowitz and Wetherill (1973).	unitless	B-1g
SATINTAKE(t)	Half saturation absorbable lead intake	U-3	0-84	I	Assumed proportional to the weight of body . The coefficient of proportionality is assumed to depend on the estimate of the parameter for a 24 month old and the corresponding body weight.	µg/day	U-1a thru U-1e
SATINTAKE24	Half saturation absorbable lead intake for a 24 month old	100	0-84	E	Extrapolated from reanalysis of human infant data (Sherlock and Quinn, 1986) and infant baboon data (Mallon, 1983)	µg/day	U-3
SCHOOL(t)	Dust lead intake from school	E-12b	0-84	I	Simple combination of amount of dust ingested daily, the fraction of total dust ingested daily as school dust, and lead concentration in dust at school	µg/day	E-9d
SchoolConc	Dust lead concentration at school	200	0-84	E	By default, this dust lead concentration is set to the same as the residential dust lead concentration.	µg/g	E-12b
SchoolFraction	Fraction of total dust ingested daily as school dust	0	0-84	E	Based on the default assumption that children are not in school.	unitless	E-9c,E-9.5,12b
SECHOME(t)	Dust lead intake at secondary home	E-12d	0-84	I	Simple combination of amount of dust ingested daily, fraction of dust ingested daily as secondary home dust, and lead concentration in dust at the secondary home.	µg/day	E-9d
SecHomeConc	Secondary home dust lead concentration	200	0-84	E	Based on the assumption that dust lead concentration in a secondary home is the same as the default dust lead concentration in the primary home.	µg/g	E-12d

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
SecHomeFraction	Fraction of total dust ingested daily as secondary home dust	0	0-84	E	Based on the default assumption that the child does not spend a significant amount of time in a secondary home.	unitless	E-9b,12d
soil_indoor(t)	Indoor household dust lead concentration	E-11	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Under alternate dust sources model, based on assumption that both soil and outdoor air contribute to indoor dust lead.	µg/g	E-9c
soil_ingested(t)	Soil and dust (combined) consumption	0.085 0.135 0.135 0.135 0.100 0.090 0.085	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Based on values reported in OAQPS report (USEPA 1989, pp. A-16). The values reported were estimated for children, ages 12-48 mos, by several authors such as Binder et al. (1986) and Clausing et al. (1987). Sedman (1987) extrapolated these estimates to those for children, ages 0-84 mos.	g/day	E-8-9a,10
TBLBONE(t)	Lead transfer time from blood to bone	1 *and* B-1e	24 *and* 0-84	I	24 months - Initialization is keyed to the two year old child, based in part on information from Heard and Chamberlain, (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this parameter, within a wide range of possible values, has little effect on the blood lead value. 0-84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the parameter for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on Mordenti (1986).	days	B-1h,2i,2k
TBLFEC(t)	Lead transfer time from blood to feces	B-1f	0-84	I	Simple combination of an assumed ratio of urinary lead elimination rate to endogenous fecal lead elimination rate, and lead transfer time from blood to urine (See RATFECUR). The ratio of of elimination rates was estimated for adults using Chamberlain et al. (1978), and Chamberlain (1985) and is assumed to apply to ages 0-84 months.	days	B-1g,2e,2f

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
TBLKID(t)	Lead transfer time from blood to kidney	10 *and* B-1d	24 *and* 0-84	I	24 months - Initialization is keyed to the two year old child, based in part on information from Heard and Chamberlain, (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this parameter, within a wide range of possible values, has little effect on the blood lead value. 0-84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the parameter for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on (Mordenti, 1986).	days	B-2g,2h
TBLLIV(t)	Lead transfer time from blood to liver	10 *and* B-1b	24 *and* 0-84	I	24 months - Initialization is keyed to the two year old child, based in part on information from Heard and Chamberlain, (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this parameter, within a wide range of possible values, has little effect on the blood lead value. 0-84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the parameter for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on (Mordenti, 1986).	days	B-2d,2e
TBLOTH(t)	Lead transfer time from blood to other soft tissue	10 *and* B-1c	24 *and* 0-84	I	24 months - Initialization is keyed to the two year old child, based in part on information from Heard and Chamberlain, (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this parameter, within a wide range of possible values, has little effect on the blood lead value. 0-84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the parameter for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on (Mordenti, 1986).	days	B-2m,2n
TBLOUT(t)	Lead transfer time from blood to elimination pool via soft tissue	B-1g	0-84	I	Simple combination of an assumed ratio of elimintion rate via soft tissues to endogenous fecal lead elimination rate, times the lead transfer time from blood to feces (See RATOUTFEC).	days	B-2n,2o

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
TBLUR(t)	Lead transfer time from blood to urine	20 *and* B-1a	24 *and* 0-84	I	24 months - Assumed proportional to body surface area. The coefficient of proportionality is assumed to depend on an adult estimate for the parameter and the corresponding body surface area. The adult estimate of 39 days was obtained using Araki et al (1986a, 1986b, 1987), Assenato et al (1986), Campbell et al (1981), Carton et al (1987), Chamberlain et al. (1978), Folashade et al (1991), Heard and Chamberlain (1981), He et al (1988), Kawaii et al (1983), Kehoe (1961), Koster et al (1989), Manton and Malloy (1983), Rabinowitz and Wetherill (1973), Rabinowitz et al (1976), and Yokoyama et al (1985). 0-84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the parameter for a 24 month old and the corresponding body surface area. Both cases above assume that (a) body surface area varies as 1/3 power of weight of body based on (Mordenti, 1986) and (b) respectively, 70 kg and 12.3 kg are standard adult and 2 year old body weights based on Spector (1956). Since glomerular filtration rate (GFR) is proportional to body surface area for ages 24 months based on (Weil, 1955), surface area scaling is equivalent to scaling by GFR for ages 24 months.	days	B-1f,2c
TBONEBL(t)	Lead transfer time from bone to blood	B-1h	0-84	I	Based on the assumption that masses of lead in bone and blood are in kinetic quasi-equilibrium.	days	B-2j,2l
TCORTPL(t)	Lead transfer time from cortical bone to plasma-ECF	B-2l	0-84	I	Based on the assumption that the cortical and trabecular bone pools have similar lead kineticsfor children younger than 84 months.	days	B-6b,6i,6.5b, 6.5i,8d,9f
time_out(t)	Time spent outdoors	1 2 3 4 4 4 4	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Values are reported in the OAQPS staff report (USEPA 1989, pp. A-2) and the TSD (USEPA 1990a). The values have been derived from a literature review (Pope, 1985).	hrs/day	E-2

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
TimeStep	Length of time-step in solution algorithm	1/6	0-84	E	This user-selectable parameter is available mainly for adjusting the model run time to the speed of the computer. Newer, faster computers can run the model at the shortest TimeStep (15 min) in less than one minute. The default value, 4 hours, is based on a tradeoff between numerical accuracy of results and computer run-time. Except in the case of extreme exposure scenarios, there is no difference in the numerical accuracy at any user selectable value for TimeStep.	day	B-6.5a,6.5d-6.5i,7b,7c, 8a,d,9a-9f,10a-10b
TKIDPL(t)	Lead transfer time from kidney to plasma-ECF	B-2h	0-84	I	Based on the assumption that the lead transfer time from kidney to blood is equal to the lead transfer time from kidney to plasma-ECF.	days	B-6b,6f,6.5b,6.5f,8d,9c
TLIVFEC(t)	Lead transfer time from liver to feces	B-2f	0-84	I	Based on the assumption that the masses of lead in liver and blood are in kinetic quasi-equilibrium.	days	B-6e,6.5e, 8c,d,9b
TLIVPL(t)	Lead transfer time from liver to plasma-ECF	B-2e	0-84	I	Based on the assumption that the lead transfer time from liver to blood is equal to the lead transfer time from liver to plasma-ECF.	days	B-6b,6e,6.5b,6.5e,8c,d, 9b
TOTHOUT(t)	Lead transfer time from soft tissues to elimination pool	B-2o	0-84	I	Based on the assumption that the masses of lead in soft tissues and blood are in kinetic quasi-equilibrium.	days	B-6g,6.5g, 8c,d,9h
TOTHPL(t)	Lead transfer time from soft tissues to plasma-ECF	B-2n	0-84	I	Based on the assumption that the lead transfer time from soft tissues to blood is equal to the lead transfer time from soft tissues to plasma-ECF.	days	B-6c,6g,6.5c,6.5g,8c,d, 9h
TPLCORT(t)	Lead transfer time from plasma-ECF to cortical bone	B-2k	0-84	I	Based on the following assumptions: The rate at which lead leaves the plasma-ECF to reach the bone is proportional to the rate which lead leaves the blood to reach the same pool. The cortical and trabecular bone pools have similar lead kinetics for children younger than 84 months. The cortical bone is 80% of the weight of bone based on Leggett et al. (1982).	days	B-6c,6i,6.5c, 6.5i,8b,c,9f

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
TPLKID(t)	Lead transfer time from plasma-ECF to kidney	B-2g	0-84	I	Based on the assumption that the rate at which lead leaves the plasma-ECF to reach the kidney is proportional to the rate at which lead leaves the blood to reach the same pool.	days	B-6c,6f,6.5c,6.5f,8b,c,9c
TPLLIV(t)	Lead transfer time from plasma-ECF to liver	B-2d	0-84	I	Based on the assumption that the rate at which lead leaves the plasma-ECF to reach the liver is proportional to the rate at which lead leaves the blood to reach the same pool.	days	B-6c,6e,6.5c,6.5e,8b,c, 9b
TPLOTH(t)	Lead transfer time from plasma-ECF to soft tissues	B-2m	0-84	I	Based on the assumption that the rate at which lead leaves the plasma-ECF to reach the soft tissues is proportional to the rate which lead leaves the blood to reach the same pool.	days	B-6c,6g,6.5c,6.5g,8b,c, 9d
TPLRBC	Lead transfer time from plasma-ECF to red blood cells	0.1	0-84	I	Initialization value of 0.1 was assigned as plausible nominal value reflecting best professional judgement on appropriate time scale for composite process of transfer of lead through the red blood cell membrane to lead binding components.	days	B-2b,2.5,7b, 7c
TPLRBC2(t)	Lead transfer time from plasma-ECF to red blood cells constrained by the maximum capacity of red blood cell lead concentration	B-2.5	0-84	I	Simple combination of the lead transfer time from plasma-ECF to red blood cells, and the ratio of red blood cell lead concentration to the corresponding maximum concentration. Based on Marcus (1985a) and reanalysis of infant baboon data.	days	B-6a,6d,6.5a,6.5d,8b,9a
TPLTRAB(t)	Lead transfer time from plasma-ECF to trabecular bone	B-2i	0-84	I	Based on the following assumptions: The rate at which lead leaves the plasma-ECF to reach the bone is proportional to the rate which lead leaves the blood to reach the same pool. The cortical and trabecular bone pools have similar lead kinetics. The trabecular bone is 20% of the weight of bone based on Leggett et al. (1982).	days	B-6c,6h,6.5c,6.5h,8b,c, 9e
TPLUR(t)	Lead transfer time from plasma-ECF to urine	B-2c	0-84	I	Based on the assumption that the rate at which lead leaves the plasma-extra-cellular fluid to reach the urine pool is proportional to the rate at which lead leaves the blood to reach the same pool.	days	B-6c,6.5c,8a

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
TRBCPL	Lead transfer time from red blood cells to plasma-ECF	B-2b	0-84	I	Based on the assumption that the transfer time out of RBC is similar at all ages, since mean red cell value is similar.	days	B-6b,6d,6.5b,6.5d,7b,7c, 8c,d,9a
TTRABPL(t)	Lead transfer time from trabecular bone to plasma-extra-cellular fluid	B-2j	0-84	I	Based on the assumption that the cortical and trabecular bone pools have similar lead kinetics for children younger than 84 months.	days	B-6b,6h,6.5b,6.5h,8c,d, 9e
TWA(t)	Time weighted average air lead concentration	E-2	0-84	I	Simple combination of outdoor and indoor air lead concentrations and the number of hours spent outdoors.	µg/m^3	E-3
UPAIR(t)	Air lead uptake	U-4	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-5
UPDIET(t)	Diet lead uptake	U-1a	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-1f
UPDUST(t)	Dust lead uptake	U-1c	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-1f
UPDUSTA(t)	Dust lead uptake rate from alternate sources	U-1.5c	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-1f
UPGUT(t)	Total gut uptake	U-1f	0-84	I	Sum of all gastrointestinal uptake.	µg/day	U-5
UPOTHER(t)	Uptake of other ingested lead	U-1d	0-84	I	Assumes no other gut lead intake	µg/day	U-1f
UPSOIL(t)	Soil lead uptake	U-1e	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-1f
UPTAKE(t)	Total lead uptake	U-5	0-84	I	Simple combination of the media-specific daily lead uptake rates, translated to a monthly rate.	µg/mo	B-6a,6.5a,8a
UPWATER(t)	Water lead uptake	U-1b	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-1f

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
UserFishConc	Lead concentration in fish	0	0-84	E	Based on the assumption that only commercially available fish are consumed.	µg/g	E-5h
userFishFraction	Fraction of total meat consumed as fish	0	0-84	E	Based on the assumption that only commercially available fish are consumed.	unitless	E-5a,5h
UserFruitConc	Lead concentration in home grown fruits	0	0-84	E	Based on the assumption that only commercially available fruits are consumed.	µg/g	E-5f
userFruitFraction	Fraction of total fruits consumed as home grown fruits	0	0-84	E	Based on the assumption that only commercially available fruits are consumed.	unitless	E-5d,5e,5f
UserGameConc	Lead concentration in game animal meat	0	0-84	E	Based on the assumption that only commercially available meat is consumed.	µg/g	E-5i
userGameFraction	Fraction of total meat consumed as game animal meat excluding fish	0	0-84	E	Based on the assumption that only commercially available meat is consumed.	unitless	E-5a,5i
UserVegConc	Lead concentration in home grown vegetables	0	0-84	E	Based on the assumption that only commercially available vegetables are consumed.	µg/g	E-5g
userVegFraction	Fraction of total vegetables consumed as home grown vegetables	0	0-84	E	Based on the assumption that only commercially available vegetables are consumed.	unitless	E-5b,5c,5g

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
veg_all(t)	Daily amount of all vegetables consumed	56.84 106.50 155.75 157.34 158.93 172.50 199.65	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	g/day	E-5g
vent_rate(t)	Ventilation rate	2 3 5 5 5 7 7	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Values are reported in the OAQPS report (USEPA 1989, pp. A-3) and the TSD (USEPA 1990a). These estimates are based on body size in combination with smoothed data from Phalen et al., (1985).	m^3/day	E-3
VOLBLOOD(t)	Volume of blood	B-5a	0-84	I	Statistical fitting of data from Silve et al (1987); also Spector (1956) and Altman and Ditmer (1973)	µg/dL	B-1h,2e,2f,2h,2n,2o,5d, 5e,5m,10a
VOLECF(t)	Volume of extra-cellular fluid (ECF)	B-5d	0-84	I	The volume of extracellular fluid that exchanges rapidly with plasma is estimated 73% of the blood volume based on Rabinowitz (1976). This additional volume of distribution is assumed to be the volume the extra-cellular fluid pool, which is the difference between the volume of the distribution and the blood volume.	dL	B-9g
VOLPLASM(t)	Volume of plasma	B-5c	0-84	I	Statistical fit to VOLBLOOD(t) - VOLRBC(t)	dL	B-7b,7c,9g
VOLRBC(t)	Volume of red blood cells	B-5b	0-84	I	Statistical fit to hematocrit × blood volume	dL	B-2.5
water_consumption(t)	Daily amount of water consumed	0.20 0.50 0.52 0.53 0.55 0.58 0.59	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Exposure Factors Handbook (US EPA, 1989b)	L/day	E-6a,6b

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
weight_soil	Percentage of total soil and dust ingestion that is soil	45	0-84	E	Guidance Manual, Section 2.3 (US EPA, 1994)	%	E-8,10
WTBLOOD(t)	Weight of blood	B-5m	0-84	I	Based on an blood density of 1.056 kg/l (Spector 1956).	kg	B-5l
WTBODY(t)	Weight of body	B-5f	0-84	I	Statistical fitting of data from Silve et al. (1987); also Spector (1956) and Altman and Ditmer (1973). Also, body weight of 24 month old is assumed to be 12.3 kg (Spector 1956).	kg	B-1a-1e,5f,5g,5l
WTBONE(t)	Weight of bone	B-5g	0-84	I	12-84 months - Based on child skeletal ash data in Harley and Kneip (1984) and the following assumptions. $\text{WTBONE} = (\text{WTBONE}_{\text{ADULT}} / \text{WTSKEL\_ASH}_{\text{ADULT}}) * \text{WTSKEL\_ASH}$ where $\text{WTBONE}_{\text{ADULT}} = 10$ kg $\text{WTSKEL\_ASH}_{\text{ADULT}} = 2.91$ kg 0-12 months - Assumed to be 11% of the weight of the body. The ratio of weight of bone to weight of body (11%) is based on the 12-month estimate for WTBONE from the above equation, and an estimate for WTBODY at the same age.	kg	B-5h,5i
WTCORT(t)	Weight of cortical bone	B-5i	0-84	I	Assumed to be 80% of the weight of the bone based on Leggett et al. (1982).	kg	B-1h,5l,7e
WTECF(t)	Weight of extra-cellular fluid (ECF)	B-5e	0-84	I	Based on an assumed ECF density approximately the same as water, of 1.0 kg/L.	kg	B-5l
WTKIDNEY(t)	Weight of kidney	B-5j	0-84	I	Statistical fitting of data from Silve et al. (1987); also Spector (1956) and Altman and Ditmer (1973). Also, body weight of 24 month old is assumed to be 12.3 kg (Spector 1956).	kg	B-5j,5l,7f
WTLIVER(t)	Weight of liver	B-5k	0-84	I	Statistical fitting of data from Silve et al. (1987); also Spector (1956) and Altman and Ditmer (1973). Also, body weight of 24 month old is assumed to be 12.3 kg (Spector 1956).	kg	B-2e,2f,5l,7g
WTOTHER(t)	Weight of soft tissues	B-5l	0-84	I	Simple combination of the weight of body and the weights of kidney, liver, bone, blood and extra-cellular fluid.	kg	B-2n,2o,7h

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
WTTRAB(t)	Weight of trabecular bone	B-5h	0-84	I	Assumed to be 20% of the weight of the bone based on Leggett et al. (1982).	kg	B-1h, 5l,7i

Appendix M: Sensitivity Analysis of Lead-Related Benefits

INTRODUCTION

APPENDIX CONTENTS

The methodology for estimating lead-related benefits for the MP&M regulation is discussed in Chapter 14. In its main analysis, EPA uses a three percent discount rate to value benefits associated with reductions in exposure to lead. OMB, however, frequently recommends the use of a seven percent discount rate in benefit-cost analyses for government regulations. This appendix therefore presents a sensitivity analysis of the results for lead-related benefits estimated using a seven percent discount rate and compares them with estimated lead-related benefits in the main (three percent) analysis. Because EPA found that the final rule will not yield any lead-related health benefits to either children or adults, the analysis in this appendix is limited only to the two Upgrade Options considered as alternatives to the final rule, and the Proposed/NODA Option.

M.1 VALUES FOR QUANTIFIED LEAD-RELATED HEALTH EFFECTS

Table M.1 below compares per-case values for lead-related health effects estimated using a three percent discount rate and a seven percent discount rate. Values for some health effect categories do not change for the following two reasons:

- Discounting is not used in estimating a specific value. For example, the cost of treating hypertension used in this analysis is the estimate of *annual* medical costs and lost work time associated with this condition.
- The original study did not provide sufficient information for estimating the cost of illness value based on a seven percent discount rate. Taylor et al. (1996) used a five percent discount rate to estimate the expected lifetime cost of a stroke. The authors do not provide sufficient information to recalculate the value based on a different discount rate. Therefore, EPA did not revise this value in the main analysis to reflect discounting at a three percent rate.

Table M.1: Comparison of Per-Case Values for Lead-Related Health Effects (2001 $)

Health Category	Value/Cost @ 3% Discount Rate	Value/Cost @ 7% Discount Rate
Lead-Related Health Effects for Children		
Value of an IQ point [A-(B+C)]	$9,419	$1,817
(A) Wage loss per IQ point	$10,675	$2,427
(B) Cost of additional education per IQ point	$511	$247
(C) Opportunity cost of lost income while in school	$746	$363
Additional education cost for children with IQ < 70	$58,012	$36,831
Additional education cost for children with PbB > 20 µg/dL	$16,485	$12,169
Value of preventing neonatal mortality[a]	$6,500,000	$6,500,000
Lead-Related Health Effects for Adults		
Hypertension (male & female)[b]	$1,141	$1,141
CHD (male & female)	$76,347	$74,115
Stroke (male)[c]	$335,135	$335,135
Stroke (female)[c]	$251,351	$251,351
Mortality (male & female)[a]	$6,500,000	$6,500,000

[a] Value of a Statistical Life (VSL) is taken from U.S. EPA's Guidelines for Preparing Economic Analyses. The recommended value was not adjusted in the main analysis.
[b] Annual cost of treatment. No discounting is required.
[C] Values based on Taylor et al. (1996) which uses a five percent discount rate to estimate the expected lifetime cost of a stroke. EPA used this value in the main analysis presented in Chapter 14 of this report.

Source: U.S. EPA analysis.

M.2 LEAD-RELATED BENEFIT RESULTS

This section presents lead-related benefits of the alternative regulatory options – the 433 Upgrade Options and the Proposed/NODA Option – based on a seven percent discount rate.

M.2.1 Preschool Age Children Lead-Related Benefits

Table M.2 summarizes lead-related benefits for children estimated for the 433 Upgrade Options based on a three percent and a seven percent discount rate. As shown in Table M.2, using a seven percent discount rate results in a 19 percent reduction in the total monetary value of lead-related benefits for preschool children compared to the value of benefits estimated based on a three percent discount rate. Changes in the monetary values associated with individual benefit categories range from zero percent (neonatal mortality) to 81 percent (avoided IQ loss).

Table M.2: Comparison of the Monetary Value of Lead-Related Benefits to Children (2001$) Based on Alterantive Discount Rates – 433 Upgrade Options

	Directs + 413 to 433 Upgrade				Directs + All to 433 Upgrade			
		Mean Benefit Value (2001$)				Mean Benefit Value (2001$)		
Category	Reduced Cases or IQ Points	3% DR	7% DR	% Change	Reduced Cases or IQ Points	3% DR	7% DR	% Change
Neonatal mortality	0.15	$995,630	$995,630	0%	0.17	$1,109,294	$1,109,294	0%
Avoided IQ Loss	31.99	$301,323	$58,128	81%	36.19	$340,845	$65,752	81%
Reduced IQ < 70	0.11	$6,637	$4,213	37%	0.13	$7,501	$4,762	37%
Reduced PbB > 20 µg/L	0.00	$0	$0	0%	0.00	$0	$0	0%
Total Benefits		$1,305,590	$1,057,970	19%		$1,457,640	$1,179,808	19%

Source: U.S. EPA analysis.

Table M.3 summarizes lead-related benefits for children estimated for the Proposed/NODA Option based on a three percent and a seven percent discount rate. As shown in Table M.3, using a seven percent discount rate results in a 40 percent reduction in the total monetary value of lead-related benefits for preschool children compared to the value of benefits estimated based on a three percent discount rate. Changes in the monetary values associated with individual benefit categories range from zero percent (neonatal mortality) to 81 percent (avoided IQ loss).

Table M.3: Comparison of the Monetary Value of Lead-Related Benefits to Children (2001$) Based on Alterantive Discount Rates – Proposed/NODA Option

		Benefit Value (2001$)		
Category Category	Reduced Cases or IQ Points	3% DR	7% DR	% Change
Neonatal Mortality	1.60	$10,417,781	$10,417,781	0%
Avoided IQ Loss	1,078.38	$10,157,286	$1,959,421	81%
Reduced IQ < 70	3.72	$216,007	$137,140	37%
Reduced PbB > 20 µg/L	0.00	$0	$0	0%
Total Benefits		$20,791,073	$12,514,342	40%

Source: U.S. EPA analysis.

M.2.2 Adult Lead-Related Benefits

Table M.4 presents lead-related benefits for adults for the 433 Upgrade Options based on a three percent and a seven percent discount rate. Under both 433 Upgrade Options the difference between the total monetary value of benefits to adults estimated based on a three percent and a seven percent discount rate is negligible (less than 0.1 percent). The reduction in total benefits is marginal between the two discount rate scenarios because the monetary value of only one lead-related benefit category for adults (i.e., CHD) is affected by the discount rate.

Table M.4: Comparison of the Monetary Value of Lead-Related Benefits to Adults (2001$) Based on Alterantive Discount Rates – 433 Upgrade Options

Category		Directs + 413 to 433 Upgrade			Directs + All to 433 Upgrade		
			Mean Value of Benefits			Mean Value of Benefits	
		Reduced Cases	3% DR	7% DR	Reduced Cases	3% DR	7% DR
Men	Hypertension	53.47	$61,004	$61,004	59.58	$67,982	$67,982
	CHD	0.05	$4,155	$4,033	0.06	$4,631	$4,495
	CBA	0.02	$5,698	$5,698	0.02	$6,350	$6,350
	BI	0.01	$3,226	$3,226	0.01	$3,596	$3,596
	Mortality	0.07	$474,735	$474,735	0.08	$529,125	$529,125
Women	CHD	0.02	$1,662	$1,614	0.02	$1,853	$1,799
	CBA	0.01	$2,417	$2,417	0.01	$2,694	$2,694
	BI	0.01	$1,487	$1,487	0.01	$1,658	$1,658
	Mortality	0.02	$150,190	$150,190	0.03	$167,417	$167,417
Total Benefits			$704,574	$704,404		$785,304	$785,115

Source: U.S. EPA analysis.

Table M.5 summarizes lead-related benefits for adults for the Proposed/NODA Option based on a three percent and a seven percent discount rate. For this option, the estimated total monetary values of benefits drop from $7,048,025 under the three percent discount rate to $7,046,328 under the seven percent discount rate (i.e., a decrease of less than 0.1 percent). This marginal difference in the total value of benefits based the three percent and the seven percent discount rate is due to the fact that only one benefit category (i.e., CHD) is affected by the discount rate.

Table M.5: Comparison of the Monetary Value of Lead-Related Benefits to Adults (2001$) Based on Alterantive Discount Rates – Proposed/NODA Option

Category		Reduced Cases	Mean Value of Benefits	
			3% DR	7% DR
Men	Hypertension	545.25	$622,126	$622,126
	CHD	0.54	$41,564	$40,349
	CBA	0.17	$56,907	$56,907
	BI	0.10	$32,197	$32,197
	Mortality	0.73	$4,750,132	$4,750,132
Women	CHD	0.22	$16,472	$15,991
	CBA	0.10	$23,928	$23,928
	BI	0.06	$14,714	$14,714
	Mortality	0.23	$1,489,984	$1,489,984
Total Benefits			$7,048,025	$7,046,328

Source: U.S. EPA analysis.

Appendix N: Analysis of the National Demand for Water-Based Recreation Survey

INTRODUCTION

This appendix presents EPA's analysis of the National Demand for Water-based Recreation Survey (NDS). The objective of this analysis is to determine the number of people who participate in water-based recreation and their total number of recreation trips, characterize participation and number of trips taken by water body type, and provide more detailed information on specific recreation activities (e.g., fish species targeted on fishing trips) and expenditures associated with various activities.

APPENDIX CONTENTS

N.1 BACKGROUND INFORMATION

U.S. EPA cooperated with the National Forest Service and several other federal agencies and interested groups to collect data on the outdoor recreation activities of Americans. The 1993 NDS collected data on demographic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over. Respondents reported on water-based recreation trips taken within the past 12 months, including the primary purpose of their trips (i.e., fishing, boating, swimming, and viewing), and number of trips, trip length, distance to the recreation site(s), number of participants, their trip expenditures, and detailed trip allocation information on the last trip taken for each recreation type. For example, respondents reported:

- where fishing was the primary purpose of a trip, the number of fish caught and the species targeted (i.e., coldwater, warmwater, anadromous, or marine);
- the type of water body (e.g., lake, river, ocean, wetland); and
- where boating was the primary purpose of trip, the type of boating (i.e., motorboating, sailing, canoeing, rowing, rafting, and other floating).

EPA used NDS data to characterize water-based recreation activities nationwide, including:

- percent of state population participating in water-based recreation by recreation activity and trip length (i.e., single-day vs. multiple-day trips);
- average number of water-based recreation trips per person by recreation activity and trip length;
- allocation of single- or multiple-day trips among different water body types by recreation type;
- mean one-way distance traveled to the site visited on last trip;
- total expenditures per person for last single-day or multiple-day trip;
- distribution of total expenditures among various expenditure categories for single- and multiple-day trips (e.g., lodging, boat rental, and entrance fee);
- allocation of fishing trips by target species; and
- allocation of boating trips by boating type.

N.2 DATA ANALYSIS

The NDS used a random digit dialed population-based sample (aged 16 and over) of the nation. For simple random sampling, estimates of the sample mean and total are consistent estimates of the population mean and total. EPA therefore treats sample-based estimates as being representative of the population-based estimates. For example, the percent of survey respondents participating in a given water-based recreation activity is theoretically consistent with the percent of the state population (aged 16 and over) that participates in that activity. The estimated percentages can be applied to the state population (aged 16 and over) to derive the number of participants in various water-based recreation activities in each state.

The survey database cannot be used to characterize subsistence fishing because subsistence fishermen's behavior differs significantly from recreational fishermen's behavior. In addition, this population subgroup is likely to be under-represented in the survey database due to various factors. First, subsistence fishermen constitute a relatively small portion of the total fisherman population. They also tend to have a lower education level. Some of them may lack long-distance telephone services and/or have language barriers. These factors are likely to result in inadequate representation of this subgroup in the survey data.

N.3 PARTICIPATION IN WATER-BASED RECREATION BY ACTIVITY TYPE

This analysis estimates the percent and the number of state residents who participated in water-based recreation by activity type and trip length (i.e., single-day vs. multiple-day). Participants in each activity in a given state include state residents who took at least one single-day and/or multiple-day trip for each respective activity during the previous 12 months. Because some participants took both single-day and multiple-day trips, the percent and the number of state residents participating in all trips does not equal the sum of the single-day plus multiple-day percentages or number of participants. The analysis also estimates the average number of recreation trips per person per year, by recreational activity, trip length (single-day vs. multiple-day trips), and state of residence. Tables N.1, N.2, N.3, and N.4 characterize participation in boating, fishing, swimming, and viewing, respectively.

1. ***Estimating the percent of state population participating in each of the four water-based recreation activities.*** The total percent of state residents participating in each activity equals the total number of respondents who took at least one single-day and/or multiple-day trip divided by the state's sample size. Similarly, the percent participating in single-day or multiple-day trips for each respective activity equals the respective number of sample respondents who took either single-day or multiple-day trips, respectively, divided by the state's sample size.

2. ***Estimating the number of state residents participating in each of the four water-based recreation activities.*** EPA calculated the total number of participants in each state by multiplying the percent of sample respondents who took at least one single-day and/or multiple-day trip by each state's actual population 16 years of age and older. Similarly, the total number of participants in single-day or multiple-day trips for each respective activity equals the respective percent of sample respondents who took either single-day or multiple-day trips, respectively, times the state's population 16 years of age and older.

3. ***Estimating the average number of trips per person per year.*** EPA estimated the average number of recreation trips per person per year by dividing the total number of trips taken for each activity by state residents by the total number of participants in this activity. Similarly, dividing the number of single-day trips or multiple-day trips by the respective number of participants provided the average number of single-day and multiple-day trips per person, respectively. Tables N.1-N.4 also show the mean trip length for the last multiple-day trip.

For comparison purposes, Tables N.2 and N.4 also present estimates of the total percent and the number of state residents participating in recreational fishing and wildlife viewing based on the U.S. Fish and Wildlife Service's (USFWS) 1996 National Survey of Fishing Hunting and Wildlife Associated Recreation. The table shows that the two surveys yield similar results. NDS estimates, however, are slightly higher than USFWS estimates for some states. NDS fishing and viewing participation estimates are higher for 47 and 30 states, respectively. This discrepancy may be due to the difference in the year when the respective surveys were conducted.

Table N.1: Participation in Boating

State	State Pop. 16 and Up	NDS Sample Size	Sample Weight	Total Participation in Boating				Participation in Single-Day Trips			Participation in Multiple-Day Trips			
				Percent Population	# People	Avg # Trips per Person per Year	Days per Year	Percent Population	Number of People	Avg # of Trips per Person per Year	Percent Population	Number of People	Avg # of Trips per Person per Year	Mean Trip Length (days)
AK	457,728	29	15,784	48%	219,709	5.1	5.7	45%	205,978	5.1	14%	64,082	1.2	2.5
AL	3,451,586	218	15,833	18%	621,285	7.9	10.6	16%	552,254	7.1	6%	207,095	5.5	2.3
AR	2,072,622	128	16,192	20%	414,524	6.4	24.1	16%	331,620	5.0	7%	145,084	6.9	8.3
AZ	3,907,526	178	21,952	12%	468,903	7.3	10.8	9%	351,677	7.3	6%	234,452	3.3	3.2
CA	25,599,275	1,313	19,497	20%	5,119,855	5.3	11.3	14%	3,583,898	5.1	11%	2,815,920	3.3	4.2
CO	3,322,455	212	15,672	13%	431,919	10.6	14.0	8%	265,796	14.6	7%	232,572	2.6	3.5
CT	2,651,452	159	16,676	20%	530,290	8.7	18.3	18%	477,261	7.9	7%	185,602	5.2	6.2
DC	468,575	35	13,388	11%	51,543	2.0	2.7	9%	42,172	2.3	3%	14,057	1.0	3.0
DE	610,269	51	11,966	20%	122,054	10.6	13.3	18%	109,848	10.8	8%	48,822	2.2	4.0
FL	12,741,821	662	19,247	23%	2,930,619	10.3	16.6	20%	2,548,364	9.8	5%	637,091	7.0	5.3
GA	6,250,708	373	16,758	18%	1,125,127	10.9	19.0	15%	937,606	10.4	9%	562,564	5.2	4.0
HI	949,184	55	17,258	20%	189,837	7.6	9.5	18%	170,853	6.6	2%	18,984	18.0	2.0
IA	2,281,002	171	13,339	19%	433,390	6.6	13.3	17%	387,770	4.7	5%	114,050	8.3	4.1
ID	969,166	83	11,677	30%	290,750	5.8	8.1	25%	242,292	5.6	8%	77,533	4.0	3.2
IL	9,530,327	466	20,451	18%	1,715,459	8.3	15.9	13%	1,238,943	9.0	8%	762,426	4.9	4.3
IN	4,682,392	300	15,608	21%	983,302	9.3	18.3	15%	702,359	7.5	8%	374,591	9.3	3.6
KS	2,058,489	135	15,248	13%	267,604	13.9	27.1	9%	185,264	14.2	9%	185,264	6.6	3.8
KY	3,161,283	219	14,435	16%	505,805	6.2	9.0	13%	410,967	6.4	5%	158,064	2.6	4.7
LA	3,394,854	189	17,962	20%	678,971	4.2	6.2	18%	611,074	4.1	5%	169,743	2.0	5.0
MA	5,008,007	249	20,112	23%	1,151,842	11.8	11.7	18%	901,441	8.1	8%	400,641	4.2	3.7
MD	4,085,342	257	15,896	19%	776,215	9.1	18.2	17%	694,508	8.9	6%	245,121	4.1	7.9
ME	1,010,273	72	14,032	33%	333,390	7.1	18.2	26%	262,671	6.7	13%	131,335	4.7	7.0
MI	7,628,170	576	13,243	24%	1,830,761	9.3	17.4	19%	1,449,352	9.0	11%	839,099	5.0	4.5
MN	3,782,817	245	15,440	24%	907,876	5.9	8.8	20%	756,563	5.9	7%	264,797	4.1	3.3
MO	4,331,937	277	15,639	22%	953,026	6.0	11.4	16%	693,110	5.3	12%	519,832	3.5	3.9
MS	2,160,165	140	15,430	18%	388,830	10.0	14.9	16%	345,626	7.1	6%	129,610	10.3	2.5
MT	701,423	55	12,753	22%	154,313	5.8	7.9	15%	105,213	7.8	7%	49,100	1.8	4.7
NC	6,291,182	407	15,457	14%	880,765	7.5	12.1	12%	754,942	7.2	6%	377,471	4.0	3.5
ND	502,176	40	12,554	28%	140,609	4.2	13.8	18%	90,392	3.9	13%	65,283	3.8	6.4
NE	1,314,974	84	15,654	20%	262,995	5.2	13.3	13%	170,947	3.8	10%	131,497	5.8	3.8
NH	960,593	64	15,009	23%	220,936	3.7	8.4	22%	211,330	3.2	5%	48,030	3.3	7.3
NJ	6,545,471	347	18,863	18%	1,178,185	10.1	12.2	17%	1,112,730	10.5	3%	196,364	2.7	5.1

Table N.1: Participation in Boating

State	State Pop. 16 and Up	NDS Sample Size	Sample Weight	Total Participation in Boating				Participation in Single-Day Trips			Participation in Multiple-Day Trips			
				Percent Population	# People	Avg # Trips per Person per Year	Days per Year	Percent Population	Number of People	Avg # of Trips per Person per Year	Percent Population	Number of People	Avg # of Trips per Person per Year	Mean Trip Length (days)
NM	1,370,134	105	13,049	19%	260,325	3.8	8.9	10%	137,013	3.5	11%	150,715	3.4	3.6
NV	1,537,896	75	20,505	23%	353,716	10.1	18.4	21%	322,958	6.8	9%	138,411	8.9	3.5
NY	14,797,284	774	19,118	18%	2,663,511	6.5	9.2	13%	1,923,647	7.5	5%	739,864	3.0	4.5
OH	8,789,530	650	13,522	17%	1,494,220	7.0	10.6	13%	1,142,639	7.5	7%	615,267	3.3	3.6
OK	2,665,966	143	18,643	20%	533,193	4.5	8.3	13%	346,576	4.9	8%	213,277	3.2	3.9
OR	2,673,283	217	12,319	26%	695,054	8.4	12.2	22%	588,122	8.9	9%	240,595	2.7	4.9
PA	9,693,987	742	13,065	15%	1,454,098	9.2	16.1	12%	1,163,278	9.1	5%	484,699	5.6	4.7
RI	827,474	57	14,517	16%	132,396	8.0	N/A	16%	132,396	6.9	2%	16,549	10.0	N/A
SC	3,115,130	181	17,211	19%	591,875	9.0	16.5	15%	467,270	8.9	7%	218,059	4.5	5.8
SD	577,391	42	13,747	26%	150,122	6.5	24.1	21%	121,252	4.8	10%	57,739	7.0	7.5
TN	4,445,987	296	15,020	23%	1,022,577	7.9	10.3	20%	889,197	7.7	6%	266,759	4.5	3.1
TX	15,618,097	657	23,772	18%	2,811,257	8.2	14.7	15%	2,342,715	7.4	7%	1,093,267	5.7	3.9
UT	1,598,531	111	14,401	20%	319,706	4.5	9.6	11%	175,838	5.6	13%	207,809	2.3	4.4
VA	5,529,436	389	14,214	19%	1,050,593	9.9	17.4	15%	829,415	8.6	6%	331,766	8.1	4.2
VT	479,265	34	14,096	24%	115,024	7.1	12.4	21%	100,646	7.1	9%	43,134	2.3	7.0
WA	4,552,631	324	14,051	35%	1,593,421	6.0	10.4	29%	1,320,263	5.7	14%	637,368	3.4	4.2
WI	4,156,609	299	13,902	22%	914,454	10.3	14.7	19%	789,756	10.0	7%	290,963	4.5	4.2
WV	1,455,370	126	11,551	13%	189,198	5.1	8.3	10%	145,537	6.6	2%	29,107	2.3	9.0
WY	381,882	31	12,319	26%	99,289	5.5	6.2	23%	87,833	5.7	6%	22,913	2.0	2.5

N/A - Not Available

Source: NDS.

Table N.2: Participation in Recreational Fishing

				Total Participation in Fishing					Single-Day Trips			Multiple-Day Trips			
State	Pop. 16 and Up	NDS Sample Size	Sample Weight	Percent Pop. (NDS-based)	Percent Pop. (USFWS-based)	Number of People	Avg # of Trips per Person per Year	Days per Year	% Pop.	# People	Avg # of Trips per Person per Year	% Pop.	# People	Avg # of Trips per Person per Year	Mean trip length (days)
AK	457,728	29	15,784	59%	41%	270,060	13.8	18.3	55%	251,750	12.8	24%	109,855	4.3	3.7
AL	3,451,586	218	15,833	25%	21%	862,896	16.8	19.5	21%	724,833	18.5	6%	207,095	5.0	3.2
AR	2,072,622	128	16,192	37%	26%	766,870	11.9	16.2	31%	642,513	12.5	12%	248,715	4.1	4.3
AZ	3,907,526	178	21,952	20%	14%	781,505	8.1	16.5	15%	586,129	7.0	11%	429,828	5.4	3.8
CA	25,599,275	1,313	19,497	22%	12%	5,631,840	6.5	13.1	16%	4,095,884	6.6	10%	2,559,928	3.8	4.8
CO	3,322,455	212	15,672	38%	23%	1,262,533	12.0	19.5	30%	996,736	12.2	17%	564,817	5.1	4.3
CT	2,651,452	159	16,676	18%	14%	477,261	6.9	8.0	16%	424,232	7.1	4%	106,058	2.1	3.6
DC	468,575	35	13,388	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DE	610,269	51	11,966	20%	19%	122,054	10.3	16.0	18%	109,848	10.8	4%	24,411	3.0	10.5
FL	12,741,821	662	19,247	25%	18%	3,185,455	15.3	17.4	21%	2,675,782	16.6	5%	637,091	4.7	3.7
GA	6,250,708	373	16,758	23%	18%	1,437,663	8.8	12.6	19%	1,187,635	9.8	8%	500,057	2.9	4.6
HI	949,184	55	17,258	20%	14%	189,837	6.1	6.2	18%	170,853	6.6	2%	18,984	1.0	3.0
IA	2,281,002	171	13,339	24%	23%	547,440	11.9	16.7	19%	433,390	13.4	7%	159,670	3.8	5.4
ID	969,166	83	11,677	40%	32%	387,666	12.3	19.4	33%	319,825	10.8	20%	193,833	6.0	3.5
IL	9,530,327	466	20,451	20%	18%	1,906,065	13.7	27.4	16%	1,524,852	14.2	7%	667,123	7.8	5.9
IN	4,682,392	300	15,608	26%	19%	1,217,422	11.0	14.6	23%	1,076,950	11.1	8%	374,591	3.8	4.0
KS	2,058,489	135	15,248	28%	19%	576,377	11.3	18.8	21%	432,283	12.2	13%	267,604	4.8	4.3
KY	3,161,283	219	14,435	30%	23%	948,385	9.0	13.9	25%	790,321	9.2	12%	379,354	3.9	4.0
LA	3,394,854	189	17,962	34%	26%	1,154,250	15.0	18.9	29%	984,508	15.3	8%	271,588	7.8	3.2
MA	5,008,007	249	20,112	22%	12%	1,101,762	15.3	24.0	18%	901,441	13.3	6%	300,480	14.1	3.4
MD	4,085,342	257	15,896	21%	15%	857,922	12.2	15.7	18%	735,362	12.9	6%	245,121	2.9	5.7
ME	1,010,273	72	14,032	31%	21%	313,185	9.9	11.2	28%	282,876	10.5	6%	60,616	2.0	4.5
MI	7,628,170	576	13,243	27%	20%	2,059,606	10.5	16.4	20%	1,525,634	11.3	10%	762,817	5.0	4.3
MN	3,782,817	245	15,440	34%	31%	1,286,158	10.3	18.7	24%	907,876	10.9	19%	718,735	4.5	4.4
MO	4,331,937	277	15,639	26%	23%	1,126,304	5.8	10.5	20%	866,387	5.5	9%	389,874	4.3	4.2
MS	2,160,165	140	15,430	27%	21%	583,245	17.0	19.3	25%	540,041	16.8	7%	151,212	5.8	2.5
MT	701,423	55	12,753	42%	24%	294,598	19.5	26.2	36%	252,512	19.7	20%	140,285	4.9	4.0
NC	6,291,182	407	15,457	25%	20%	1,572,796	11.2	15.1	20%	1,258,236	12.5	12%	754,942	3.2	3.4

Table N.2: Participation in Recreational Fishing

				Total Participation in Fishing					Single-Day Trips			Multiple-Day Trips			
State	Pop. 16 and Up	NDS Sample Size	Sample Weight	Percent Pop. (NDS-based)	Percent Pop. (USFWS-based)	Number of People	Avg # of Trips per Person per Year	Days per Year	% Pop.	# People	Avg # of Trips per Person per Year	% Pop.	# People	Avg # of Trips per Person per Year	Mean trip length (days)
ND	502,176	40	12,554	33%	24%	165,718	4.5	6.3	30%	150,653	3.9	10%	50,218	3.0	3.0
NE	1,314,974	84	15,654	20%	19%	262,995	11.9	24.8	14%	184,096	13.2	12%	157,797	4.3	6.0
NH	960,593	64	15,009	16%	18%	153,695	14.9	23.6	14%	134,483	13.2	8%	76,847	6.0	4.0
NJ	6,545,471	347	18,863	19%	13%	1,243,639	5.9	7.0	16%	1,047,275	6.1	4%	261,819	3.1	2.8
NM	1,370,134	105	13,049	22%	19%	301,429	8.7	12.3	16%	219,221	8.5	12%	164,416	4.2	2.7
NV	1,537,896	75	20,505	21%	17%	322,958	11.9	15.2	17%	261,442	13.5	5%	76,895	3.8	4.8
NY	14,797,284	774	19,118	15%	11%	2,219,593	8.8	16.2	12%	1,775,674	9.1	5%	739,864	4.4	6.0
OH	8,789,530	650	13,522	19%	13%	1,670,011	14.6	23.2	16%	1,406,325	14.0	7%	615,267	7.6	4.1
OK	2,665,966	143	18,643	32%	31%	853,109	13.0	12.9	28%	746,470	13.4	1%	26,660	4.1	9.0
OR	2,673,283	217	12,319	36%	21%	962,382	11.4	15.2	29%	775,252	11.8	13%	347,527	4.6	3.5
PA	9,693,987	742	13,065	21%	15%	2,035,737	10.8	16.1	17%	1,647,978	11.1	8%	775,519	5.0	3.7
RI	827,474	57	14,517	21%	14%	173,770	7.8	7.5	19%	157,220	8.3	2%	16,549	2.0	N/A
SC	3,115,130	181	17,211	29%	24%	903,388	16.1	20.4	27%	841,085	15.6	7%	218,059	6.8	3.6
SD	577,391	42	13,747	26%	31%	150,122	8.2	13.7	24%	138,574	7.7	12%	69,287	2.6	5.5
TN	4,445,987	296	15,020	26%	17%	1,155,957	15.1	19.0	24%	1,067,037	14.8	6%	266,759	5.2	4.4
TX	15,618,097	657	23,772	29%	18%	4,529,248	10.2	16.6	23%	3,592,162	10.1	13%	2,030,353	5.3	3.6
UT	1,598,531	111	14,401	23%	21%	367,662	5.6	17.9	15%	239,780	4.1	11%	175,838	5.9	5.4
VA	5,529,436	389	14,214	26%	18%	1,437,653	8.2	13.0	19%	1,050,593	8.7	10%	552,944	4.3	4.0
VT	479,265	34	14,096	9%	19%	43,134	12.0	8.7	9%	43,134	8.7	3%	14,378	10.0	N/A
WA	4,552,631	324	14,051	27%	22%	1,229,210	14.9	21.3	22%	1,001,579	16.1	12%	546,316	4.6	4.0
WI	4,156,609	299	13,902	29%	25%	1,205,417	10.4	18.4	22%	914,454	11.1	14%	581,925	4.5	4.6
WV	1,455,370	126	11,551	25%	18%	363,842	17.0	22.4	22%	320,181	16.3	8%	116,430	6.9	3.7
WY	381,882	31	12,319	58%	31%	221,492	12.9	46.0	52%	198,579	8.2	32%	122,202	10.0	7.0

N/A - Not Available

Source: U.S. Fish and Wildlife Service's (USFWS) 1996 National Survey of Fishing Hunting and Wildlife Associated Recreation.

Table N.3: Participation in Recreational Swimming

State	State Pop. 16 and Up	NDS Sample Size	Sample Weight	Total Participation in Swimming				Participation in Single-Day Trips			Participation in Multiple-Day Trips			
				Percent Pop.	Number of People	Avg # Trips per Person per Year	Days per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Mean Trip length (days)
AK	457,728	29	15,784	7%	32,041	2.0	N/A	7%	32,041	2.0	3%	13,732	1.0	N/A
AL	3,451,586	218	15,833	23%	793,865	7.7	11.5	17%	586,770	9.3	7%	241,611	3.3	4.6
AR	2,072,622	128	16,192	23%	476,703	8.5	20.1	21%	435,251	6.8	9%	186,536	5.9	6.0
AZ	3,907,526	178	21,952	19%	742,430	4.5	7.6	13%	507,978	5.3	7%	273,527	1.9	5.6
CA	25,599,275	1,313	19,497	29%	7,423,790	9.5	13.0	22%	5,631,840	11.0	9%	2,303,935	3.1	4.9
CO	3,322,455	212	15,672	17%	564,817	4.0	6.4	12%	398,695	5.0	6%	199,347	1.7	4.8
CT	2,651,452	159	16,676	41%	1,087,095	11.0	19.8	33%	874,979	11.3	18%	477,261	4.4	5.5
DC	468,575	35	13,388	17%	79,658	2.5	6.4	9%	42,172	2.0	9%	42,172	3.3	3.0
DE	610,269	51	11,966	22%	134,259	5.3	8.5	14%	85,438	6.9	6%	36,616	2.7	5.8
FL	12,741,821	662	19,247	33%	4,204,801	13.3	17.9	26%	3,312,873	14.9	8%	1,019,346	5.2	4.9
GA	6,250,708	373	16,758	29%	1,812,705	5.3	11.0	15%	937,606	6.6	13%	812,592	3.6	4.8
HI	949,184	55	17,258	58%	550,527	19.2	27.6	56%	531,543	16.5	24%	227,804	8.3	3.4
IA	2,281,002	171	13,339	18%	410,580	2.4	4.0	13%	296,530	2.7	4%	91,240	1.3	6.8
ID	969,166	83	11,677	25%	242,292	8.9	11.1	23%	222,908	8.8	8%	77,533	3.1	3.0
IL	9,530,327	466	20,451	21%	2,001,369	4.0	8.0	12%	1,143,639	5.4	8%	762,426	2.2	5.9
IN	4,682,392	300	15,608	22%	1,030,126	5.0	8.9	17%	796,007	5.4	8%	374,591	2.3	5.5
KS	2,058,489	135	15,248	19%	391,113	5.5	9.3	14%	288,188	6.0	7%	144,094	3.0	4.4
KY	3,161,283	219	14,435	17%	537,418	11.0	13.2	11%	347,741	15.7	5%	158,064	1.8	5.5
LA	3,394,854	189	17,962	24%	814,765	4.3	9.3	16%	543,177	4.7	11%	373,434	2.8	4.9
MA	5,008,007	249	20,112	41%	2,053,283	9.4	17.8	34%	1,702,722	8.9	14%	701,121	6.1	5.0
MD	4,085,342	257	15,896	27%	1,103,042	5.6	11.4	14%	571,948	7.8	12%	490,241	3.2	5.1
ME	1,010,273	72	14,032	46%	464,726	14.5	29.7	40%	404,109	12.8	15%	151,541	9.9	5.8
MI	7,628,170	576	13,243	30%	2,288,451	8.5	16.3	24%	1,830,761	8.6	10%	762,817	4.7	6.0
MN	3,782,817	245	15,440	24%	907,876	5.4	6.5	18%	680,907	6.6	5%	189,141	2.2	3.4
MO	4,331,937	277	15,639	22%	953,026	6.4	10.9	16%	693,110	7.7	9%	389,874	2.5	5.1
MS	2,160,165	140	15,430	21%	453,635	10.5	12.8	17%	367,228	11.9	6%	129,610	2.5	4.4
MT	701,423	55	12,753	40%	280,569	6.9	10.1	33%	231,470	7.6	16%	112,228	2.0	4.8
NC	6,291,182	407	15,457	23%	1,446,972	5.7	10.8	15%	943,677	7.0	10%	629,118	2.4	6.0
ND	502,176	40	12,554	25%	125,544	8.0	N/A	15%	75,326	11.5	13%	65,283	2.4	N/A
NE	1,314,974	84	15,654	19%	249,845	3.5	10.7	15%	197,246	3.9	6%	78,898	1.6	15.0

Table N.3: Participation in Recreational Swimming

State	State Pop. 16 and Up	NDS Sample Size	Sample Weight	Total Participation in Swimming				Participation in Single-Day Trips			Participation in Multiple-Day Trips			
				Percent Pop.	Number of People	Avg # Trips per Person per Year	Days per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Mean Trip length (days)
NH	960,593	64	15,009	42%	403,449	15.8	56.5	38%	365,025	14.5	16%	153,695	7.2	15.8
NJ	6,545,471	347	18,863	39%	2,552,734	6.2	12.7	28%	1,832,732	6.9	16%	1,047,275	3.1	6.1
NM	1,370,134	105	13,049	15%	205,520	2.7	4.2	10%	137,013	3.8	5%	68,507	1.4	3.7
NV	1,537,896	75	20,505	19%	292,200	6.3	13.2	12%	184,548	6.3	9%	138,411	4.6	4.2
NY	14,797,284	774	19,118	33%	4,883,104	7.6	15.0	25%	3,699,321	8.1	11%	1,627,701	4.5	6.0
OH	8,789,530	650	13,522	23%	2,021,592	7.3	15.6	15%	1,318,430	8.7	6%	527,372	4.7	8.1
OK	2,665,966	143	18,643	28%	746,470	3.4	5.7	16%	426,555	4.1	8%	213,277	2.9	4.1
OR	2,673,283	217	12,319	34%	908,916	6.7	12.7	27%	721,786	7.1	12%	320,794	3.2	6.4
PA	9,693,987	742	13,065	28%	2,714,316	5.7	10.4	17%	1,647,978	7.5	12%	1,163,278	2.7	5.1
RI	827,474	57	14,517	40%	330,990	6.9	N/A	37%	306,165	7.0	11%	91,022	2.5	N/A
SC	3,115,130	181	17,211	22%	685,329	6.0	9.4	17%	529,572	6.9	5%	155,756	3.0	6.0
SD	577,391	42	13,747	24%	138,574	7.3	9.2	24%	138,574	7.2	7%	40,417	1.0	7.0
TN	4,445,987	296	15,020	23%	1,022,577	5.8	9.7	17%	755,818	6.7	8%	355,679	2.5	5.4
TX	15,618,097	657	23,772	24%	3,748,343	5.1	7.7	16%	2,498,896	6.0	9%	1,405,629	2.3	4.3
UT	1,598,531	111	14,401	20%	319,706	5.9	10.4	15%	239,780	6.2	10%	159,853	2.5	4.5
VA	5,529,436	389	14,214	28%	1,548,242	4.9	11.1	17%	940,004	5.5	13%	718,827	3.2	5.2
VT	479,265	34	14,096	26%	124,609	12.3	19.6	24%	115,024	11.6	6%	28,756	8.5	4.5
WA	4,552,631	324	14,051	35%	1,593,421	5.4	10.7	28%	1,274,737	5.7	14%	637,368	2.4	6.3
WI	4,156,609	299	13,902	27%	1,122,284	5.5	8.9	22%	914,454	6.1	7%	290,963	2.1	7.0
WV	1,455,370	126	11,551	25%	363,842	6.5	12.7	18%	261,967	6.4	9%	130,983	5.1	4.4
WY	381,882	31	12,319	6%	22,913	8.0	N/A	6%	22,913	8.0	3%	11,456	1.0	N/A

N/A - Not Available

Source: NDS.

Table N.4: Participation in Wildlife Viewing (Near-Water Recreation)

State	Pop. 16 and Up	NDS Sample Size	Sample Weight	Total Participation in Near-Water Recreation					Single-Day Trips			Multiple-Day Trips			
				Percent Pop. (NDS-based)	Percent Pop. (USFWS-based)	Number of People	Avg # of Trips per Person per Year	Days per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Mean trip length
AK	457,728	29	15,784	48%	50%	219,709	7.2	8.4	41%	187,668	7.1	7%	32,041	8.0	2.0
AL	3,451,586	218	15,833	36%	30%	1,242,571	4.4	8.2	12%	414,190	9.2	24%	828,381	1.9	4.0
AR	2,072,622	128	16,192	28%	34%	580,334	6.4	15.0	13%	269,441	10.2	16%	331,620	3.3	5.5
AZ	3,907,526	178	21,952	25%	31%	976,882	4.7	8.7	11%	429,828	8.0	13%	507,978	2.1	4.7
CA	25,599,275	1,313	19,497	51%	25%	13,055,630	11.2	14.3	37%	9,471,732	14.0	16%	4,095,884	3.2	4.2
CO	3,322,455	212	15,672	25%	42%	830,614	8.6	11.7	13%	431,919	14.8	10%	332,246	1.9	5.4
CT	2,651,452	159	16,676	60%	31%	1,590,871	5.3	8.8	38%	1,007,552	6.7	20%	530,290	3.1	4.4
DC	468,575	35	13,388	51%	N/A	238,973	3.9	30.7	23%	107,772	2.4	31%	145,258	4.6	10.5
DE	610,269	51	11,966	57%	34%	347,853	9.9	16.6	41%	250,210	11.0	24%	146,465	4.7	4.5
FL	12,741,821	662	19,247	44%	25%	5,606,401	14.2	18.2	32%	4,077,383	17.9	13%	1,656,437	3.7	4.7
GA	6,250,708	373	16,758	36%	29%	2,250,255	3.1	9.4	14%	875,099	4.1	21%	1,312,649	2.6	5.2
HI	949,184	55	17,258	64%	14%	607,478	30.3	30.7	56%	531,543	33.9	9%	85,427	1.8	4.0
IA	2,281,002	171	13,339	32%	38%	729,921	2.9	7.1	16%	364,960	4.4	15%	342,150	1.2	9.0
ID	969,166	83	11,677	43%	40%	416,741	3.2	7.0	24%	232,600	4.2	23%	222,908	1.5	5.6
IL	9,530,327	466	20,451	31%	35%	2,954,401	5.9	10.6	17%	1,620,156	9.0	13%	1,238,943	2.2	6.1
IN	4,682,392	300	15,608	31%	35%	1,451,542	5.4	11.2	15%	702,359	9.0	14%	655,535	2.4	6.3
KS	2,058,489	135	15,248	33%	32%	679,301	5.8	12.8	17%	349,943	9.0	14%	288,188	2.5	7.7
KY	3,161,283	219	14,435	28%	32%	885,159	2.4	9.1	12%	379,354	3.0	15%	474,192	2.0	7.3
LA	3,394,854	189	17,962	34%	27%	1,154,250	3.2	8.5	15%	509,228	3.4	19%	645,022	3.1	4.0
MA	5,008,007	249	20,112	50%	35%	2,504,004	9.8	21.0	31%	1,552,482	11.5	22%	1,101,762	5.9	5.3
MD	4,085,342	257	15,896	46%	34%	1,879,257	6.3	12.7	18%	735,362	12.1	29%	1,184,749	2.4	5.2
ME	1,010,273	72	14,032	54%	46%	545,547	5.4	6.6	44%	444,520	5.7	11%	111,130	3.5	2.8
MI	7,628,170	576	13,243	44%	36%	3,356,395	6.3	10.3	24%	1,830,761	9.4	16%	1,220,507	2.7	5.2
MN	3,782,817	245	15,440	33%	38%	1,248,330	10.5	15.2	19%	718,735	16.5	14%	529,594	2.4	5.5
MO	4,331,937	277	15,639	32%	40%	1,386,220	2.7	8.1	13%	563,152	4.0	17%	736,429	2.1	5.8
MS	2,160,165	140	15,430	29%	23%	626,448	11.3	15.2	12%	259,220	24.2	14%	302,423	1.8	5.7
MT	701,423	55	12,753	33%	47%	231,470	10.1	12.9	20%	140,285	15.6	15%	105,213	1.2	6.0
NC	6,291,182	407	15,457	45%	35%	2,831,032	4.1	11.5	18%	1,132,413	5.2	29%	1,824,443	3.2	4.5
ND	502,176	40	12,554	25%	23%	125,544	2.6	3.4	15%	75,326	3.0	5%	25,109	4.0	2.0
NE	1,314,974	84	15,654	25%	35%	328,744	1.8	5.9	14%	184,096	2.1	8%	105,198	1.7	8.6
NH	960,593	64	15,009	42%	44%	403,449	12.2	21.5	31%	297,784	14.9	9%	86,453	5.2	9.5

Table N.4: Participation in Wildlife Viewing (Near-Water Recreation)

State	Pop. 16 and Up	NDS Sample Size	Sample Weight	Total Participation in Near-Water Recreation					Single-Day Trips			Multiple-Day Trips			
				Percent Pop. (NDS-based)	Percent Pop. (USFWS-based)	Number of People	Avg # of Trips per Person per Year	Days per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Mean trip length
NJ	6,545,471	347	18,863	54%	26%	3,534,554	5.5	11.8	32%	2,094,551	6.3	23%	1,505,458	3.7	5.0
NM	1,370,134	105	13,049	29%	29%	397,339	2.6	7.8	9%	123,312	5.6	18%	246,624	1.4	6.9
NV	1,537,896	75	20,505	35%	21%	538,264	6.2	11.0	21%	322,958	7.2	23%	353,716	2.6	3.8
NY	14,797,284	774	19,118	45%	23%	6,658,778	4.3	9.9	25%	3,699,321	5.7	18%	2,663,511	2.2	7.5
OH	8,789,530	650	13,522	36%	33%	3,164,231	4.7	11.1	16%	1,406,325	8.2	19%	1,670,011	1.9	7.3
OK	2,665,966	143	18,643	34%	35%	906,428	1.9	5.3	12%	319,916	3.4	17%	453,214	1.5	5.4
OR	2,673,283	217	12,319	59%	42%	1,577,237	6.4	12.4	38%	1,015,848	7.2	33%	882,183	3.3	4.3
PA	9,693,987	742	13,065	39%	37%	3,780,655	3.9	9.4	14%	1,357,158	7.4	24%	2,326,557	1.9	5.7
RI	827,474	57	14,517	56%	32%	463,385	4.0	9.2	40%	330,990	4.6	9%	74,473	4.6	8.0
SC	3,115,130	181	17,211	45%	29%	1,401,808	5.3	10.9	20%	623,026	8.3	25%	778,782	2.8	4.7
SD	577,391	42	13,747	29%	30%	167,443	2.1	7.9	21%	121,252	1.8	5%	28,870	4.5	8.5
TN	4,445,987	296	15,020	41%	37%	1,822,855	2.1	6.1	13%	577,978	3.7	25%	1,111,497	1.4	5.7
TX	15,618,097	657	23,772	33%	25%	5,153,972	3.6	7.6	16%	2,498,896	5.0	16%	2,498,896	2.2	4.8
UT	1,598,531	111	14,401	31%	30%	495,545	2.4	4.6	17%	271,750	3.5	11%	175,838	1.2	5.9
VA	5,529,436	389	14,214	41%	37%	2,267,069	3.4	11.4	17%	940,004	4.2	25%	1,382,359	2.7	5.7
VT	479,265	34	14,096	47%	48%	225,255	5.6	9.6	18%	86,268	5.5	32%	153,365	2.5	4.3
WA	4,552,631	324	14,051	58%	39%	2,640,526	9.2	13.4	40%	1,821,052	11.6	29%	1,320,263	2.6	4.1
WI	4,156,609	299	13,902	38%	42%	1,579,511	4.6	8.8	22%	914,454	6.1	16%	665,057	2.3	5.4
WV	1,455,370	126	11,551	27%	31%	392,950	4.3	16.1	10%	145,537	4.6	17%	247,413	3.9	5.8
WY	381,882	31	12,319	29%	39%	110,746	3.1	4.5	16%	61,101	4.6	13%	49,645	1.2	3.5

N/A - Not Available

Source: U.S. Fish and Wildlife Service's (USFWS) 1996 National Survey of Fishing Hunting and Wildlife Associated Recreation.

N.4 ALLOCATION OF TRIPS BY WATER BODY TYPE

This analysis assesses the allocation of trips by water body type, recreation activity, and state of residence. EPA determined the number of trips taken to each water body type based on the water body type visited on the last single- or multiple-day trip for each recreation activity. Dividing the total number of trips taken in a state to a given water body type for a given activity by the total number of trips taken for that activity in the state provided estimates of the percent taken to the various water body types. The NDS distinguishes four general water body types:

- Lakes:
  - lakes,
  - ponds, and
  - reservoirs;
- Streams:
  - rivers,
  - streams, and
  - canals;
- Oceans:
  - oceans,
  - bays, and
  - sounds; and
- Other:
  - wetlands, and
  - unknown water body types.

Note that respondents in several states apparently provided inaccurate information. For example, Montana residents are unlikely to take single-day trips to the ocean. The data indicate, however, that five, six, and eleven percent of participants reported that they took single-day fishing, swimming, and viewing trips to the ocean, respectively. This inconsistency may arise due to the following two factors:

- respondents traveled to other states for multi-purpose multiple-day trips and participated in the given activity on only one day per trip; and
- response errors (e.g., some respondents identified water body types incorrectly).

Tables N.5 and N.6 show allocation of single- and multiple-day trips by water body type for boating, fishing, swimming, and viewing.

Table N.5: Allocation of Single-Day Trips by Water Body Type

State	Boating (%)				Fishing (%)				Swimming (%)				Viewing (%)			
	Lake	Stream	Ocean[a]	Other[b]	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other
AK	30%	20%	50%	0%	9%	45%	45%	0%	100%	0%	0%	0%	18%	18%	64%	0%
AL	50%	44%	6%	0%	56%	29%	16%	0%	57%	13%	30%	0%	25%	15%	55%	5%
AR	78%	22%	0%	0%	78%	22%	0%	0%	78%	17%	0%	4%	38%	38%	23%	0%
AZ	100%	0%	0%	0%	76%	19%	5%	0%	63%	32%	5%	0%	50%	11%	33%	6%
CA	38%	8%	51%	2%	43%	16%	40%	1%	28%	9%	61%	2%	11%	2%	86%	1%
CO	79%	21%	0%	0%	65%	33%	2%	0%	83%	4%	8%	4%	65%	15%	19%	0%
CT	38%	27%	35%	0%	35%	22%	43%	0%	33%	5%	60%	2%	20%	9%	69%	2%
DC	0%	33%	67%	0%	N/A	N/A	N/A	N/A	67%	0%	33%	0%	0%	50%	50%	0%
DE	25%	0%	75%	0%	25%	38%	38%	0%	0%	0%	100%	0%	18%	6%	76%	0%
FL	15%	27%	56%	1%	24%	24%	52%	1%	13%	9%	79%	0%	4%	5%	90%	1%
GA	79%	12%	9%	0%	60%	21%	18%	2%	67%	7%	23%	2%	53%	2%	44%	0%
HI	22%	0%	78%	0%	10%	0%	90%	0%	0%	0%	100%	0%	0%	0%	93%	7%
IA	43%	52%	0%	4%	59%	38%	0%	3%	70%	17%	9%	4%	60%	28%	8%	4%
ID	65%	35%	0%	0%	47%	53%	0%	0%	59%	35%	6%	0%	44%	44%	6%	6%
IL	55%	40%	5%	0%	74%	22%	4%	0%	93%	7%	0%	0%	76%	11%	9%	4%
IN	88%	12%	0%	0%	82%	13%	5%	0%	92%	4%	2%	2%	78%	15%	5%	2%
KS	100%	0%	0%	0%	96%	4%	0%	0%	94%	6%	0%	0%	71%	10%	14%	5%
KY	77%	23%	0%	0%	73%	24%	2%	0%	64%	18%	18%	0%	58%	25%	13%	4%
LA	45%	45%	10%	0%	39%	43%	14%	4%	38%	27%	27%	8%	32%	16%	48%	4%
MA	21%	36%	44%	0%	49%	21%	31%	0%	33%	4%	63%	0%	15%	8%	76%	2%
MD	13%	34%	53%	0%	30%	32%	39%	0%	23%	19%	58%	0%	10%	18%	70%	3%
ME	63%	19%	19%	0%	65%	15%	20%	0%	67%	4%	30%	0%	19%	6%	74%	0%
MI	80%	14%	5%	0%	73%	20%	8%	0%	92%	3%	5%	0%	81%	8%	8%	3%
MN	77%	23%	0%	0%	90%	10%	0%	0%	84%	7%	7%	2%	95%	5%	0%	0%
MO	53%	42%	3%	3%	73%	21%	4%	2%	52%	36%	7%	5%	60%	30%	7%	3%
MS	47%	42%	11%	0%	76%	15%	9%	0%	50%	36%	14%	0%	38%	13%	50%	0%
MT	75%	25%	0%	0%	42%	53%	5%	0%	63%	31%	6%	0%	78%	11%	11%	0%
NC	61%	19%	19%	0%	52%	24%	24%	0%	36%	15%	42%	7%	22%	14%	63%	2%
ND	100%	0%	0%	0%	80%	20%	0%	0%	83%	17%	0%	0%	100%	0%	0%	0%
NE	89%	11%	0%	0%	100%	0%	0%	0%	77%	23%	0%	0%	64%	27%	9%	0%

Table N.5: Allocation of Single-Day Trips by Water Body Type

State	Boating (%)				Fishing (%)				Swimming (%)				Viewing (%)			
	Lake	Stream	Ocean[a]	Other[b]	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other
NH	58%	25%	17%	0%	44%	44%	11%	0%	55%	0%	41%	5%	25%	0%	75%	0%
NJ	24%	11%	65%	0%	31%	13%	55%	2%	20%	2%	77%	0%	9%	4%	86%	1%
NM	43%	43%	14%	0%	38%	62%	0%	0%	50%	30%	20%	0%	25%	38%	38%	0%
NV	92%	0%	8%	0%	60%	40%	0%	0%	100%	0%	0%	0%	85%	0%	8%	8%
NY	47%	18%	35%	0%	53%	21%	26%	0%	43%	7%	49%	1%	40%	9%	50%	1%
OH	83%	11%	5%	1%	84%	13%	2%	1%	86%	4%	7%	3%	71%	9%	18%	2%
OK	88%	13%	0%	0%	94%	3%	3%	0%	80%	15%	0%	5%	87%	7%	7%	0%
OR	41%	36%	23%	0%	31%	56%	13%	0%	50%	26%	22%	2%	11%	13%	77%	0%
PA	46%	32%	19%	3%	54%	27%	18%	2%	53%	19%	26%	2%	37%	10%	51%	2%
RI	11%	22%	67%	0%	36%	18%	45%	0%	29%	5%	67%	0%	4%	0%	96%	0%
SC	64%	20%	12%	4%	66%	13%	19%	2%	68%	4%	29%	0%	31%	7%	62%	0%
SD	100%	0%	0%	0%	57%	43%	0%	0%	89%	11%	0%	0%	75%	13%	13%	0%
TN	75%	17%	8%	0%	63%	34%	3%	0%	72%	23%	5%	0%	48%	18%	33%	0%
TX	74%	8%	18%	0%	64%	13%	23%	0%	62%	16%	20%	2%	41%	10%	48%	1%
UT	78%	0%	22%	0%	87%	13%	0%	0%	64%	36%	0%	0%	89%	6%	6%	0%
VA	31%	35%	35%	0%	27%	38%	35%	0%	23%	17%	58%	2%	16%	13%	70%	2%
VT	100%	0%	0%	0%	67%	33%	0%	0%	71%	14%	14%	0%	80%	0%	20%	0%
WA	38%	27%	33%	1%	36%	30%	34%	0%	63%	25%	12%	0%	21%	11%	67%	1%
WI	66%	30%	4%	0%	78%	20%	2%	0%	80%	10%	5%	5%	73%	13%	7%	7%
WV	83%	8%	8%	0%	43%	57%	0%	0%	55%	35%	10%	0%	55%	18%	27%	0%
WY	83%	0%	17%	0%	73%	27%	0%	0%	100%	0%	0%	0%	100%	0%	0%	0%

[a] Note that respondents in several states apparently provided inaccurate information because some states at great distances from the ocean report individuals taking single-day trips to the ocean.

[b] Other includes wetlands and unknown water body types.

N/A - Not Available

Source: NDS.

Table N.6: Allocation of Multiple-Day Trips by Water Body Type

State	Boating (%)				Fishing (%)				Swimming (%)				Viewing (%)			
	Lake	Stream	Ocean	Other[a]	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other
AK	75%	0%	25%	0%	33%	0%	67%	0%	0%	0%	0%	0%	33%	0%	33%	33%
AL	43%	0%	43%	14%	40%	0%	40%	20%	19%	0%	62%	19%	7%	0%	72%	21%
AR	71%	14%	0%	14%	45%	36%	0%	18%	0%	17%	67%	17%	30%	0%	43%	26%
AZ	63%	13%	25%	0%	73%	13%	7%	7%	7%	7%	50%	36%	7%	11%	52%	30%
CA	49%	23%	25%	3%	58%	17%	11%	13%	19%	12%	41%	29%	13%	6%	52%	29%
CO	85%	8%	0%	8%	48%	36%	12%	4%	33%	0%	25%	42%	30%	4%	41%	26%
CT	33%	33%	33%	0%	60%	0%	40%	0%	14%	5%	73%	9%	10%	0%	60%	30%
DC	0%	0%	100%	0%	N/A	N/A	N/A	N/A	0%	0%	67%	33%	8%	0%	75%	17%
DE	100%	0%	0%	0%	50%	0%	50%	0%	0%	0%	100%	0%	0%	8%	83%	8%
FL	11%	25%	43%	21%	21%	11%	36%	32%	9%	2%	52%	38%	7%	3%	53%	36%
GA	46%	19%	27%	8%	24%	12%	40%	24%	15%	5%	62%	18%	8%	2%	70%	20%
HI	0%	0%	50%	50%	0%	0%	100%	0%	0%	0%	83%	17%	0%	0%	40%	60%
IA	78%	0%	11%	11%	78%	22%	0%	0%	14%	0%	57%	29%	21%	7%	52%	21%
ID	80%	20%	0%	0%	56%	38%	0%	6%	75%	25%	0%	0%	50%	11%	28%	11%
IL	58%	23%	10%	10%	70%	7%	11%	11%	33%	8%	25%	35%	23%	7%	36%	34%
IN	68%	16%	5%	11%	69%	6%	13%	13%	35%	0%	24%	41%	17%	4%	57%	23%
KS	100%	0%	0%	0%	100%	0%	0%	0%	63%	0%	25%	13%	30%	9%	39%	22%
KY	78%	22%	0%	0%	71%	18%	0%	12%	25%	19%	38%	19%	5%	0%	78%	16%
LA	57%	0%	14%	29%	31%	15%	31%	23%	11%	0%	79%	11%	8%	5%	67%	21%
MA	42%	11%	32%	16%	53%	0%	20%	27%	7%	0%	63%	30%	16%	3%	52%	29%
MD	18%	9%	55%	18%	44%	33%	11%	11%	15%	5%	69%	10%	9%	5%	71%	15%
ME	63%	13%	13%	13%	50%	50%	0%	0%	50%	0%	17%	33%	25%	0%	25%	50%
MI	76%	10%	10%	4%	65%	8%	6%	20%	50%	6%	22%	22%	40%	2%	22%	36%
MN	63%	6%	6%	25%	83%	9%	0%	9%	50%	0%	6%	44%	44%	2%	30%	23%
MO	75%	17%	4%	4%	52%	29%	5%	14%	30%	10%	25%	35%	20%	5%	42%	32%
MS	50%	33%	17%	0%	60%	0%	20%	20%	14%	0%	57%	29%	8%	4%	67%	21%
MT	25%	25%	25%	25%	50%	50%	0%	0%	50%	0%	17%	33%	33%	11%	33%	22%
NC	52%	19%	19%	10%	11%	8%	72%	8%	3%	3%	79%	16%	2%	2%	82%	13%

Table N.6: Allocation of Multiple-Day Trips by Water Body Type

State	Boating (%)				Fishing (%)				Swimming (%)				Viewing (%)			
	Lake	Stream	Ocean	Other[a]	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other
ND	100%	0%	0%	0%	100%	0%	0%	0%	25%	0%	0%	75%	25%	0%	0%	75%
NE	75%	25%	0%	0%	75%	13%	13%	0%	33%	0%	33%	33%	40%	10%	30%	20%
NH	0%	33%	67%	0%	0%	0%	100%	0%	40%	0%	60%	0%	14%	0%	71%	14%
NJ	0%	0%	67%	33%	18%	18%	18%	45%	4%	0%	83%	13%	9%	3%	58%	30%
NM	85%	8%	0%	8%	70%	20%	10%	0%	33%	17%	0%	50%	27%	0%	50%	23%
NV	75%	0%	25%	0%	33%	17%	17%	33%	20%	20%	40%	20%	31%	0%	62%	8%
NY	41%	17%	22%	20%	50%	17%	20%	13%	22%	0%	62%	16%	12%	5%	55%	28%
OH	68%	18%	9%	6%	70%	13%	7%	10%	14%	5%	59%	21%	20%	2%	59%	19%
OK	62%	8%	8%	23%	50%	10%	10%	30%	30%	10%	25%	35%	21%	6%	38%	35%
OR	38%	31%	15%	15%	42%	33%	8%	17%	9%	17%	30%	43%	8%	5%	72%	16%
PA	42%	9%	36%	12%	53%	16%	22%	9%	17%	3%	64%	16%	12%	4%	65%	20%
RI	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	100%	11%	11%	33%	44%
SC	56%	0%	33%	11%	17%	17%	50%	17%	0%	8%	67%	25%	2%	2%	81%	15%
SD	75%	0%	0%	25%	25%	75%	0%	0%	100%	0%	0%	0%	25%	0%	25%	50%
TN	50%	14%	21%	14%	33%	33%	11%	22%	15%	4%	65%	15%	11%	1%	71%	16%
TX	53%	6%	26%	15%	53%	10%	25%	12%	16%	16%	42%	26%	17%	2%	57%	24%
UT	85%	0%	0%	15%	70%	10%	0%	20%	50%	25%	0%	25%	25%	0%	38%	38%
VA	35%	15%	45%	5%	24%	19%	43%	14%	12%	2%	71%	16%	4%	3%	78%	15%
VT	100%	0%	0%	0%	0%	0%	0%	0%	50%	0%	50%	0%	55%	0%	45%	0%
WA	27%	27%	36%	9%	29%	32%	25%	14%	29%	19%	39%	13%	12%	9%	68%	11%
WI	78%	11%	11%	0%	73%	15%	3%	9%	43%	9%	30%	17%	34%	4%	38%	25%
WV	20%	20%	0%	60%	25%	50%	0%	25%	9%	9%	55%	27%	9%	9%	70%	13%
WY	100%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	50%

[a] Other includes wetlands and unknown water body types.
N/A - Not Available

Source: NDS.

N.5 ONE-WAY TRAVEL DISTANCE

This analysis estimates the average one-way distance to sites by trip duration (i.e., single day versus multi-day trips), trip length, recreation activity, and state of residence. EPA estimated the mean one-way distance traveled based on the distance reported for the last single- or multiple-day trip for each activity. As shown in Table N.7, some respondents indicated traveling to the ocean across long distances on single-day trips. These values are likely to be due to the following two factors:

- respondents traveled long distances for multi-purpose multiple-day trips and participated in the given activity on only one day on the trip; and

- response errors.

EPA estimated the average travel distance traveled after dropping outliers because these outliers may provide undue influence on sample means.

Table N.7: Average One-Way Distance

State	Miles to Single-Day Site				Miles to Multiple-Day Site			
	Boating	Fishing	Swimming	Viewing	Boating	Fishing	Swimming	Viewing
AK	41	47	32	39	76	193	N/A	43
AL	31	29	35	53	93	218	230	214
AR	52	38	19	222	215	246	282	394
AZ	54	45	44	117	205	323	413	383
CA	32	40	26	31	233	316	272	226
CO	41	56	15	69	372	260	548	894
CT	30	41	36	49	168	161	194	330
DC	46	N/A	417	85	1000[a]	N/A	165	688
DE	36	32	50	189	1,625	1,700	85	248
FL	21	23	20	24	317	381	154	237
GA	34	52	42	46	199	283	261	336
HI	37	13	14	13	3	80	32	45
IA	60	25	26	49	314	321	228	1,354
ID	35	48	101	54	228	146	100	507
IL	52	34	30	29	255	368	213	707
IN	47	29	50	64	295	378	368	813
KS	42	22	52	68	151	177	272	861
KY	55	32	46	106	151	143	391	697
LA	30	27	39	53	132	76	244	245
MA	22	25	30	29	136	154	144	398
MD	36	40	56	38	581	199	200	263
ME	44	24	30	23	436	148	152	31
MI	31	33	25	32	192	249	234	387
MN	45	55	16	16	354	185	132	552
MO	42	40	39	71	195	265	200	628
MS	11	27	36	39	72	122	203	483
MT	43	172	31	102	588	154	352	500
NC	42	49	45	67	153	182	264	262
ND	69	55	35	75	154	130	45	120
NE	70	29	71	56	125	603	400	152
NH	27	24	28	34	186	248	108	712
NJ	49	31	41	41	483	179	227	476
NM	76	50	71	252	161	191	207	1,315
NV	108	46	43	53	48	401	254	565

Table N.7: Average One-Way Distance

State	Miles to Single-Day Site				Miles to Multiple-Day Site			
	Boating	Fishing	Swimming	Viewing	Boating	Fishing	Swimming	Viewing
NY	32	26	25	37	202	195	194	692
OH	63	38	30	45	265	262	498	778
OK	62	50	46	47	189	244	232	542
OR	31	36	33	51	398	200	97	143
PA	40	38	36	57	296	228	210	391
RI	10	26	18	26				433
SC	15	33	40	60	713	132	200	250
SD	43	35	19	46	352	143	400	740
TN	29	27	24	84	61	888	493	481
TX	40	38	38	65	190	187	261	442
UT	43	66	44	68	235	122	207	598
VA	37	30	39	69	407	159	256	303
VT	41	20	33	50	70		78	334
WA	23	28	20	41	154	198	205	277
WI	34	30	30	33	289	303	104	545
WV	86	30	95	158	338	278	328	429
WY	69	46	32	47	73	56		230

[a] Based on one observation only.
N/A - Not Available

Source: NDS.

N.6 INDIVIDUAL EXPENDITURES PER TRIP

This analysis estimates the mean total expenditures per person by trip length, recreation activity, and state of residence. Total expenditures for single-day boating, fishing, and viewing trips consist of transportation, entrance fee, and boat rental. Total expenditures for multiple-day boating, fishing, and viewing trips include expenses for transportation, entrance fees, boat rental, and lodging. Transportation includes expenses for plane, train, bus, or ship only, and do not reflect costs associated with operating a car. Expenditures on single-day and multiple-day swimming trips do not include boat rental. Expenditures on single-day and multiple-day trips for all activities do not include bait, tackle, recreational clothing and equipment (e.g., photographic supply and binoculars), boat ownership, or food. Results of the analysis are presented below in Table N.8.

Table N.8: Individual Expenditures per Trip

State	Average Expenditures per Person on Single-day Trips (1993$ per trip)				Average Expenditures per Person on Multiple-day Trips (1993$ per trip)			
	Boating	Fishing	Swimming	Viewing	Boating	Fishing	Swimming	Viewing
AK	$16	$10	$0	$12	$66	$98	$0	$70
AL	$14	$15	$2	$5	$23	$421	$153	$261
AR	$18	$24	$1	$1	$59	$48	$361	$399
AZ	$16	$5	$7	$3	$41	$84	$184	$126
CA	$53	$22	$5	$3	$454	$220	$455	$328
CO	$49	$11	$3	$18	$320	$235	$248	$325
CT	$19	$12	$35	$7	$387	$114	$330	$505
DC[a]	$17	N/A	$2	$3	$2,000	N/A	$200	$354
DE	$6	$18	$2	$2	$43	$63	$325	$120
FL	$22	$22	$2	$4	$376	$852	$234	$375
GA	$19	$17	$8	$28	$147	$275	$279	$249
HI	$22	$7	$0	$0	$110	$0	$118	$75
IA	$8	$2	$1	$2	$119	$662	$340	$488
ID	$21	$0	$1	$1	$54	$29	$63	$118
IL	$37	$9	$2	$1	$342	$333	$241	$495
IN	$18	$10	$3	$14	$299	$321	$175	$661
KS	$19	$3	$2	$2	$89	$175	$178	$518
KY	$18	$2	$35	$18	$340	$180	$117	$298
LA	$50	$14	$1	$1	$186	$58	$251	$245
MA	$19	$13	$18	$3	$89	$197	$309	$274
MD	$49	$51	$2	$36	$116	$178	$300	$288
ME	$2	$2	$1	$2	$329	$44	$143	$22
MI	$26	$7	$2	$4	$227	$125	$379	$255
MN	$10	$6	$2	$1	$198	$160	$99	$261
MO	$26	$11	$2	$9	$164	$122	$278	$352
MS	$14	$26	$1	$1	$52	$169	$181	$329

Table N.8: Individual Expenditures per Trip

State	Average Expenditures per Person on Single-day Trips (1993$ per trip)				Average Expenditures per Person on Multiple-day Trips (1993$ per trip)			
	Boating	Fishing	Swimming	Viewing	Boating	Fishing	Swimming	Viewing
MT	$8	$23	$1	$0	$25	$95	$542	$86
NC	$13	$26	$24	$3	$165	$132	$393	$227
ND	$14	$2	$0	$0	$53	$3	$0	$0
NE	$3	$4	$85	$2	$24	$310	$150	$237
NH	$16	$7	$3	$0	$127	$0	$955	$342
NJ	$32	$44	$13	$7	$360	$168	$631	$414
NM	$15	$3	$22	$32	$73	$78	$41	$218
NV	$25	$1	$1	$4	$104	$25	$554	$116
NY	$25	$29	$5	$8	$242	$76	$298	$459
OH	$26	$15	$8	$22	$403	$239	$560	$465
OK	$11	$22	$2	$3	$173	$314	$137	$268
OR	$15	$5	$22	$1	$429	$51	$543	$248
PA	$23	$21	$19	$9	$275	$310	$275	$399
RI	$23	$16	$3	$2	$0	$0	$0	$240
SC	$27	$12	$2	$7	$576	$201	$731	$265
SD	$5	$6	$0	$2	$248	$54	$10	$715
TN	$26	$4	$0	$14	$458	$49	$329	$315
TX	$152	$12	$2	$3	$151	$138	$324	$349
UT	$25	$2	$4	$13	$164	$10	$117	$419
VA	$10	$23	$1	$243	$175	$116	$317	$319
VT	$6	$1	$6	$2	$100	$0	$22	$372
WA	$11	$19	$13	$1	$266	$170	$217	$165
WI	$10	$5	$3	$8	$425	$135	$468	$308
WV	$46	$2	$14	$3	$250	$275	$209	$356
WY	$5	$5	$0	$22	$85	$17	$0	$114

[a] Average boating expenditures in Washington, D.C. are based on a single observation.
N/A - Not Available

Source: NDS.

N.7 DISTRIBUTION OF DIRECT COSTS FOR SINGLE-DAY TRIPS

This analysis estimates the percent of total expenditures for single-day and multiple-day trips spent on each component of total expenditures. Total expenditures for single-day boating, fishing, and viewing trips consist of:

- transportation,
- entrance fee, and
- boat rental.

Lodging is not included in single-day expenditures. Swimming trip expenditures do not include boat rental. Transportation includes expenses for:

- plane,
- train,
- bus, or
- ship only

and do not include automobile travel costs.

EPA determined the percent of total expenditures for each category by dividing the total amount spent on each category by the total expenditures in a state for a given activity.

Tables N.9 and N.10 present results for single- and multiple-day trips, respectively.

Table N.9: Distribution of Direct Costs for Single-Day Trips

State	Boating (% of total expenditures)			Fishing (% of total expenditures)			Swimming[a] (% of total expenditures)		Viewing (% of total expenditures)		
	Trans[b]	Enter Fee	Boat Rental	Trans	Enter Fee	Boat Rental	Trans	Enter Fee	Trans	Enter Fee	Boat Rental
AK	0%	3%	97%	0%	5%	95%	N/A	N/A	0%	27%	73%
AL	0%	12%	88%	4%	28%	68%	0%	100%	0%	61%	39%
AR	0%	8%	92%	36%	41%	23%	0%	100%	0%	100%	0%
AZ	0%	6%	94%	0%	25%	75%	0%	100%	83%	17%	0%
CA	45%	13%	42%	15%	21%	65%	37%	63%	50%	34%	16%
CO	0%	9%	91%	57%	17%	25%	0%	100%	84%	16%	0%
CT	0%	9%	91%	0%	3%	97%	0%	100%	0%	100%	0%
DC	0%	35%	65%	N/A	N/A	N/A	0%	100%	0%	73%	27%
DE	0%	30%	70%	0%	52%	48%	0%	100%	0%	17%	83%
FL	0%	10%	90%	1%	12%	87%	0%	100%	0%	26%	74%
GA	0%	7%	93%	0%	29%	71%	66%	34%	83%	11%	5%
HI	62%	0%	38%	0%	18%	82%	N/A	N/A	N/A	N/A	N/A
IA	0%	3%	97%	0%	0%	100%	0%	100%	0%	63%	37%
ID	0%	5%	95%	0%	0%	100%	0%	100%	0%	100%	0%
IL	4%	13%	82%	0%	13%	87%	0%	100%	6%	80%	13%
IN	0%	2%	98%	0%	24%	76%	0%	100%	53%	41%	6%
KS	0%	24%	76%	0%	51%	49%	0%	100%	0%	55%	45%
KY	0%	2%	98%	0%	27%	73%	96%	4%	82%	9%	9%
LA	0%	68%	32%	0%	46%	54%	0%	100%	0%	100%	0%
MA	0%	43%	57%	4%	28%	68%	88%	12%	0%	78%	22%
MD	31%	17%	52%	0%	2%	98%	0%	100%	17%	82%	1%
ME	0%	23%	77%	0%	0%	100%	0%	100%	0%	94%	6%
MI	0%	8%	92%	0%	10%	90%	0%	100%	0%	65%	35%
MN	0%	17%	83%	0%	65%	35%	0%	100%	0%	20%	80%
MO	0%	25%	75%	0%	20%	80%	0%	100%	1%	92%	7%
MS	0%	36%	64%	0%	44%	56%	0%	100%	0%	100%	0%
MT	0%	8%	92%	96%	4%	0%	0%	100%	N/A	N/A	N/A
NC	0%	23%	77%	0%	12%	88%	0%	100%	40%	41%	19%
ND	0%	30%	70%	0%	32%	68%	0%	100%	N/A	N/A	N/A
NE	0%	0%	100%	0%	0%	100%	0%	100%	0%	5%	95%
NH	0%	48%	52%	0%	61%	39%	0%	100%	0%	100%	0%
NJ	15%	10%	74%	8%	48%	44%	26%	74%	35%	47%	18%
NM	0%	8%	92%	0%	49%	51%	91%	9%	98%	2%	0%
NV	0%	19%	81%	0%	67%	33%	0%	100%	0%	32%	68%
NY	23%	29%	48%	5%	36%	58%	44%	56%	5%	76%	19%

Table N.9: Distribution of Direct Costs for Single-Day Trips

State	Boating (% of total expenditures)			Fishing (% of total expenditures)			Swimming[a] (% of total expenditures)		Viewing (% of total expenditures)		
	Trans[b]	Enter Fee	Boat Rental	Trans	Enter Fee	Boat Rental	Trans	Enter Fee	Trans	Enter Fee	Boat Rental
OH	28%	6%	66%	7%	14%	79%	0%	100%	43%	11%	46%
OK	0%	27%	73%	58%	9%	33%	0%	100%	0%	0%	100%
OR	0%	17%	83%	0%	25%	75%	0%	100%	0%	87%	13%
PA	0%	11%	89%	0%	22%	78%	94%	6%	49%	41%	10%
RI	0%	0%	100%	0%	1%	99%	0%	100%	0%	100%	0%
SC	0%	66%	34%	0%	10%	90%	0%	100%	95%	2%	3%
SD	0%	19%	81%	0%	39%	61%	0%	100%	0%	100%	0%
TN	26%	0%	73%	0%	22%	78%	0%	100%	98%	2%	0%
TX	0%	2%	98%	0%	20%	80%	0%	100%	0%	33%	67%
UT	0%	42%	59%	0%	60%	40%	0%	100%	0%	84%	16%
VA	9%	25%	66%	0%	25%	75%	0%	100%	20%	80%	0%
VT	0%	8%	92%	0%	0%	100%	0%	100%	0%	100%	0%
WA	0%	18%	82%	45%	16%	39%	0%	100%	17%	56%	28%
WI	0%	19%	81%	1%	20%	79%	2%	98%	48%	36%	16%
WV	0%	33%	67%	0%	0%	100%	78%	22%	88%	6%	6%
WY	0%	47%	53%	0%	53%	48%	N/A	N/A	0%	16%	84%

[a] Swimming expenditures do not include boat rental.

[b] Transportation expenses include expenditures on plane, train, bus, or ship taken on the trip only and do not reflect travel costs.

N/A - Not Available

Source: U.S. EPA analysis.

Table N.10: Distribution of Direct Costs for Multiple-Day Trips

State	Boating (% of total expenditures)				Fishing (% of total expenditures)				Swimming[a] (% of total expenditures)			Viewing (% of total expenditures)			
	Trans[b]	Enter Fee	Lodging[c]	Boat Rental	Trans	Enter Fee	Lodging	Boat Rental	Trans	Enter Fee	Lodging	Trans	Enter Fee	Lodging	Boat Rental
AK	0%	2%	15%	84%	0%	3%	77%	20%	N/A	N/A	N/A	0%	0%	71%	29%
AL	0%	0%	20%	80%	0%	0%	37%	63%	4%	0%	96%	0%	0%	99%	1%
AR	0%	1%	51%	48%	0%	7%	73%	20%	0%	0%	100%	8%	8%	84%	0%
AZ	0%	5%	55%	40%	0%	10%	65%	24%	31%	0%	69%	29%	1%	69%	1%
CA	28%	6%	53%	13%	12%	16%	58%	14%	23%	2%	76%	20%	11%	63%	5%
CO	0%	7%	77%	16%	20%	0%	69%	10%	12%	2%	87%	23%	1%	72%	3%
CT	22%	0%	16%	63%	0%	1%	95%	4%	17%	1%	83%	11%	0%	88%	0%
DC	100%	0%	0%	0%	N/A	N/A	N/A	N/A	0%	0%	100%	22%	6%	42%	30%
DE	0%	0%	77%	23%	0%	0%	100%	0%	8%	0%	92%	0%	1%	99%	0%
FL	10%	1%	71%	18%	0%	2%	16%	81%	0%	2%	98%	7%	5%	88%	0%
GA	14%	7%	51%	28%	8%	4%	69%	19%	0%	0%	99%	9%	9%	77%	5%
HI	0%	0%	91%	9%	N/A	N/A	N/A	N/A	0%	0%	100%	0%	0%	100%	0%
IA	0%	21%	63%	16%	0%	0%	64%	36%	18%	0%	82%	26%	1%	71%	1%
ID	0%	1%	92%	7%	0%	8%	78%	15%	0%	3%	97%	20%	14%	65%	1%
IL	18%	6%	41%	35%	14%	2%	79%	5%	33%	4%	63%	21%	1%	74%	3%
IN	8%	3%	58%	31%	7%	5%	81%	7%	17%	57%	26%	20%	37%	42%	1%
KS	0%	2%	30%	68%	0%	1%	74%	25%	24%	0%	76%	16%	0%	82%	1%
KY	0%	3%	12%	85%	21%	3%	48%	27%	0%	0%	100%	14%	0%	86%	0%
LA	0%	3%	81%	16%	0%	31%	62%	8%	9%	0%	91%	1%	3%	94%	2%
MA	0%	1%	38%	61%	0%	14%	78%	9%	19%	0%	81%	21%	5%	73%	0%
MD	0%	0%	56%	44%	0%	0%	98%	2%	12%	0%	88%	13%	2%	83%	2%
ME	0%	72%	22%	6%	0%	15%	80%	6%	0%	4%	96%	0%	6%	94%	0%
MI	9%	6%	58%	26%	5%	4%	83%	8%	17%	6%	77%	33%	3%	63%	2%
MN	17%	0%	78%	5%	0%	0%	73%	27%	0%	1%	99%	44%	0%	54%	2%
MO	0%	3%	74%	23%	0%	6%	64%	30%	30%	0%	70%	24%	8%	67%	1%
MS	0%	1%	65%	34%	0%	0%	69%	31%	0%	0%	100%	0%	2%	97%	1%
MT	0%	0%	100%	0%	0%	0%	92%	8%	5%	0%	95%	0%	5%	95%	0%
NC	12%	8%	55%	25%	18%	4%	69%	9%	8%	0%	92%	7%	0%	93%	0%
ND	0%	0%	16%	84%	0%	0%	100%	0%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NE	0%	6%	66%	28%	30%	6%	64%	0%	0%	0%	100%	60%	0%	40%	0%
NH	0%	13%	0%	87%	N/A	N/A	N/A	N/A	9%	0%	91%	0%	0%	100%	0%
NJ	34%	0%	60%	6%	0%	37%	25%	39%	20%	0%	79%	21%	2%	76%	1%
NM	0%	7%	52%	41%	0%	5%	83%	12%	0%	18%	82%	17%	1%	82%	1%
NV	0%	3%	37%	60%	0%	0%	100%	0%	45%	2%	53%	7%	1%	92%	1%

Table N.10: Distribution of Direct Costs for Multiple-Day Trips

State	Boating (% of total expenditures)				Fishing (% of total expenditures)				Swimming[a] (% of total expenditures)			Viewing (% of total expenditures)			
	Trans[b]	Enter Fee	Lodging[c]	Boat Rental	Trans	Enter Fee	Lodging	Boat Rental	Trans	Enter Fee	Lodging	Trans	Enter Fee	Lodging	Boat Rental
NY	20%	13%	58%	8%	0%	5%	75%	20%	9%	1%	90%	16%	0%	82%	1%
OH	8%	2%	49%	41%	5%	1%	79%	15%	6%	24%	70%	17%	0%	79%	4%
OK	16%	0%	62%	22%	0%	81%	19%	0%	18%	4%	78%	30%	1%	68%	2%
OR	4%	1%	43%	52%	0%	2%	87%	11%	41%	0%	59%	5%	3%	91%	1%
PA	37%	4%	36%	23%	1%	1%	61%	37%	19%	1%	81%	9%	0%	89%	1%
RI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20%	0%	79%	0%
SC	10%	0%	24%	67%	0%	10%	87%	3%	0%	0%	100%	21%	1%	76%	1%
SD	0%	0%	96%	4%	0%	12%	69%	18%	0%	0%	100%	28%	0%	72%	0%
TN	0%	0%	53%	46%	0%	0%	38%	63%	12%	0%	88%	7%	0%	91%	2%
TX	6%	5%	56%	33%	6%	5%	70%	19%	21%	8%	72%	20%	1%	76%	3%
UT	0%	0%	66%	34%	0%	60%	40%	0%	0%	1%	99%	34%	0%	66%	0%
VA	54%	3%	30%	14%	0%	10%	60%	31%	2%	1%	97%	8%	2%	90%	1%
VT	0%	50%	50%	0%	N/A	N/A	N/A	N/A	0%	0%	100%	60%	0%	40%	0%
WA	10%	4%	46%	40%	57%	0%	18%	25%	23%	4%	73%	24%	1%	73%	1%
WI	9%	4%	35%	52%	26%	21%	48%	6%	13%	0%	87%	18%	1%	81%	0%
WV	0%	0%	80%	20%	0%	3%	97%	0%	0%	0%	100%	0%	13%	87%	0%
WY	0%	0%	71%	29%	0%	4%	96%	0%	N/A	N/A	N/A	0%	10%	90%	0%

[a] Swimming expenditures do not include boat rental.

[b] Transportation expenses include expenditures on plane, train, bus, or ship taken on the trip only and do not reflect travel costs.

[c] Total expenses for multiple-day trips include lodging, while total expenditures for single-day trips do not.

N/A - Not Available

Source: NDS; U.S. EPA analysis.

N.8 PROFILE OF BOATING TRIPS

This analysis provides a profile of sample boater characteristics by state of residence. Table N.11 shows distribution of boaters by type of boating in which they participated on their last trip and the source of the boat used on their most recent boating trip.

Boating types include:

- motorboating;
- sailing;
- white water kayaking and canoeing;
- other kayaking or canoeing;
- rowing, rafting, tubing, or floating;
- wind surfing; and
- other.

Boat sources include:

- boaters who used their own boat, including those who indicated using either their own boat or one belonging to someone in their immediate family on their last trip;
- boat renters, including those who either rented or chartered a boat on their last trip; and
- other, including respondents who did not indicate either using their own boat or renting a boat.

Dividing the number of respondents who participated in each boating type on their last trip by the total sample of boaters provided an estimate of the percent participating in each type.

Table N.11: Profile of Boating Trips

State	Total Number of Boaters		Source Boat Used on Last Trip[a] (Percent of Boaters)			Type of Boating on Last Trip[b] (Percent of Boaters)							
	NDS Sample	Sample Weighted	Own	Rent	Other	Motor	Sail	White Water Kayak	Other Kayak	Row	Raft	Wind Surf	Other
AK	14	220,972	36%	36%	29%	71%	0%	21%	7%	0%	0%	0%	0%
AL	39	617,486	51%	21%	28%	79%	0%	8%	0%	0%	3%	0%	10%
AR	25	404,809	48%	20%	32%	88%	0%	0%	0%	0%	4%	0%	8%
AZ	21	461,000	57%	14%	29%	67%	14%	0%	10%	10%	0%	0%	0%
CA	269	5,244,634	31%	23%	46%	66%	14%	2%	1%	1%	4%	0%	11%
CO	27	423,143	44%	22%	33%	70%	4%	4%	4%	4%	7%	4%	4%
CT	32	533,626	41%	34%	25%	50%	22%	6%	9%	0%	6%	0%	6%
DC	4	53,551	0%	50%	50%	50%	50%	0%	0%	0%	0%	0%	0%
DE	10	119,661	60%	10%	30%	80%	10%	10%	0%	0%	0%	0%	0%
FL	152	2,925,614	31%	32%	37%	74%	8%	3%	5%	1%	1%	0%	7%
GA	69	1,156,297	30%	32%	38%	77%	9%	7%	0%	0%	3%	0%	4%
HI	11	189,837	9%	36%	55%	36%	36%	9%	9%	0%	0%	0%	9%
IA	32	426,854	25%	31%	44%	81%	3%	9%	3%	0%	0%	0%	3%
ID	25	291,917	56%	12%	32%	72%	4%	0%	4%	4%	16%	0%	0%
IL	86	1,758,816	34%	28%	38%	66%	5%	2%	6%	0%	6%	0%	15%
IN	62	967,694	35%	26%	39%	84%	10%	2%	0%	0%	0%	0%	5%
KS	18	274,465	44%	22%	33%	83%	0%	0%	6%	11%	0%	0%	0%
KY	35	505,228	54%	17%	29%	89%	0%	0%	3%	0%	3%	0%	6%
LA	38	682,563	47%	18%	34%	87%	3%	3%	0%	3%	0%	0%	5%
MA	58	1,166,524	28%	45%	28%	53%	19%	9%	12%	0%	0%	0%	7%
MD	49	778,917	20%	47%	33%	65%	10%	4%	0%	2%	8%	2%	8%
ME	24	336,758	21%	46%	33%	63%	8%	8%	13%	0%	0%	0%	8%
MI	141	1,867,312	30%	43%	26%	76%	9%	4%	3%	1%	1%	1%	6%
MN	59	910,964	39%	29%	32%	83%	2%	2%	3%	0%	0%	0%	10%
MO	60	938,326	38%	28%	33%	75%	3%	5%	12%	0%	0%	0%	5%
MS	25	385,744	36%	32%	32%	80%	12%	0%	8%	0%	0%	0%	0%
MT	12	153,038	67%	0%	33%	42%	0%	17%	17%	0%	8%	0%	17%
NC	57	881,075	30%	30%	40%	70%	9%	7%	2%	2%	5%	0%	5%
ND	11	138,098	55%	27%	18%	82%	0%	0%	0%	0%	0%	9%	9%
NE	17	266,126	18%	12%	71%	88%	0%	12%	0%	0%	0%	0%	0%
NH	15	225,139	13%	53%	33%	80%	7%	13%	0%	0%	0%	0%	0%
NJ	64	1,207,234	17%	53%	30%	70%	13%	0%	5%	2%	0%	0%	11%
NM	20	260,978	55%	10%	35%	65%	5%	0%	15%	0%	10%	0%	5%
NV	17	348,590	41%	12%	47%	82%	0%	6%	0%	6%	0%	6%	0%
NY	137	2,619,158	21%	50%	28%	64%	11%	1%	6%	4%	2%	0%	12%

Table N.11: Profile of Boating Trips

State	Total Number of Boaters		Source Boat Used on Last Trip[a] (Percent of Boaters)			Type of Boating on Last Trip[b] (Percent of Boaters)							
	NDS Sample	Sample Weighted	Own	Rent	Other	Motor	Sail	White Water Kayak	Other Kayak	Row	Raft	Wind Surf	Other
OH	109	1,473,937	30%	37%	33%	75%	7%	6%	3%	0%	3%	0%	6%
OK	29	540,650	21%	34%	45%	66%	7%	7%	3%	0%	0%	3%	14%
OR	57	702,199	49%	21%	30%	70%	9%	0%	4%	2%	9%	0%	7%
PA	111	1,450,179	28%	40%	32%	72%	6%	1%	4%	2%	1%	1%	14%
RI	9	130,654	33%	56%	11%	33%	44%	0%	11%	11%	0%	0%	0%
SC	34	585,163	53%	21%	26%	71%	3%	6%	9%	0%	0%	0%	12%
SD	11	151,221	18%	36%	45%	82%	0%	9%	0%	0%	0%	0%	9%
TN	67	1,006,355	45%	25%	30%	84%	6%	0%	0%	1%	0%	0%	9%
TX	118	2,805,077	41%	20%	39%	80%	5%	1%	3%	2%	2%	0%	8%
UT	22	316,826	59%	9%	32%	86%	0%	0%	0%	0%	0%	0%	14%
VA	72	1,023,443	36%	43%	21%	57%	22%	1%	8%	0%	1%	0%	10%
VT	8	112,768	50%	50%	0%	50%	13%	13%	13%	0%	13%	0%	0%
WA	114	1,601,852	37%	26%	37%	70%	11%	0%	6%	3%	4%	0%	6%
WI	65	903,611	42%	38%	20%	68%	8%	5%	15%	2%	3%	0%	0%
WV	17	196,359	47%	6%	47%	59%	0%	6%	6%	0%	0%	0%	29%
WY	8	98,550	38%	0%	63%	63%	0%	13%	13%	0%	13%	0%	0%

[a] Own includes those who used their own boat or one belonging to someone in their immediate family.
Rent includes those who rented or chartered a boat.
Other includes those who did not indicate either using own boat or renting a boat.

[b] Kayak includes kayak or canoe; raft includes rafting, tubing, or floating; other includes other or type not indicated.
N/A - Not Available

Source: U.S. EPA analysis; NDS.

N.9 PROFILE OF FISHING TRIPS

This analysis provides a profile of fishing trips, including angling success rate, average catch, and type of fisheries targeted on the last trip by state of residence. The success rate equals the total number of fishermen who report catching at least one fish on their last trip divided by the total number of fishermen in each state. The average catch equals the total fish caught by all fishermen divided by the total number of fishermen in the state. Average catch therefore includes those who did not indicate catching any fish. Similarly, the percent of fishermen who fished from a boat equals the total number of fishermen who reported fishing from a boat on their last trip, divided by the total number of fishermen. Finally, the percent of fishermen who participated in each type of fishing equals the total number of fishermen who reported fishing in either cold, warm, salt, anadromous, or other water divided by the total number of fishermen. Other includes both those who indicated other and missing values. Results of the analysis are presented below in Table N.12.

Table N.12: Profile of Fishing Trips

State	Sample Weighted Number of Fishermen	Fish Catch on Last Trip[a]		Fished from a Boat on Last Trip (% of fishermen)	Type of Water Fished on Last Trip[b]				
		Average Number of Fish Caught	Success Rate (% of fishermen)		Cold (% of fishermen)	Warm (% of fishermen)	Salt (% of fishermen)	Anadromous (% of fishermen)	Other (% of fishermen)
AK	268,323	9	65%	65%	41%	0%	53%	6%	0%
AL	870,813	7	67%	71%	22%	45%	20%	2%	11%
AR	761,041	7	85%	62%	36%	60%	0%	0%	4%
AZ	790,286	4	67%	39%	44%	47%	3%	3%	3%
CA	5,556,583	5	73%	47%	47%	14%	28%	5%	6%
CO	1,253,757	4	65%	16%	79%	13%	5%	0%	4%
CT	466,922	3	71%	50%	29%	21%	43%	7%	0%
DC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DE	119,661	6	70%	50%	20%	20%	60%	0%	0%
FL	3,156,584	5	70%	57%	14%	23%	50%	4%	9%
GA	1,457,940	6	74%	47%	32%	33%	24%	0%	10%
HI	189,837	21	91%	36%	0%	18%	82%	0%	0%
IA	546,907	7	76%	37%	51%	41%	0%	0%	7%
ID	385,331	3	73%	21%	85%	0%	0%	9%	6%
IL	1,942,878	5	74%	44%	38%	45%	4%	2%	11%
IN	1,201,814	6	74%	45%	39%	47%	4%	1%	9%
KS	579,427	6	74%	39%	21%	74%	0%	0%	5%
KY	952,715	5	76%	39%	26%	65%	2%	3%	5%
LA	1,149,580	8	80%	56%	19%	47%	25%	2%	8%
MA	1,086,074	4	72%	43%	39%	19%	30%	2%	11%
MD	842,502	5	77%	62%	38%	17%	38%	0%	8%
ME	308,695	3	68%	55%	64%	18%	18%	0%	0%
MI	2,052,719	6	75%	61%	54%	28%	3%	7%	9%
MN	1,281,526	5	70%	63%	53%	34%	0%	2%	11%
MO	1,141,630	4	74%	37%	51%	36%	3%	3%	8%
MS	586,331	8	82%	55%	24%	58%	13%	0%	5%
MT	293,322	3	78%	22%	87%	9%	4%	0%	0%
NC	1,592,117	10	77%	42%	27%	22%	42%	4%	5%
ND	163,207	4	69%	46%	54%	46%	0%	0%	0%
NE	266,126	9	88%	41%	41%	53%	0%	0%	6%
NH	150,093	2	40%	60%	50%	30%	10%	10%	0%
NJ	1,244,960	5	73%	45%	18%	21%	48%	2%	11%
NM	300,125	3	61%	22%	74%	17%	4%	0%	4%

Table N.12: Profile of Fishing Trips

State	Sample Weighted Number of Fishermen	Fish Catch on Last Trip[a]		Fished from a Boat on Last Trip (% of fishermen)	Type of Water Fished on Last Trip[b]				
		Average Number of Fish Caught	Success Rate (% of fishermen)		Cold (% of fishermen)	Warm (% of fishermen)	Salt (% of fishermen)	Anadromous (% of fishermen)	Other (% of fishermen)
NV	328,084	4	75%	13%	63%	19%	6%	0%	13%
NY	2,236,799	4	80%	49%	46%	19%	26%	2%	7%
OH	1,649,727	5	72%	48%	41%	45%	4%	3%	7%
OK	857,583	6	70%	33%	26%	57%	9%	0%	9%
OR	960,904	3	51%	40%	62%	8%	13%	12%	6%
PA	2,064,218	4	61%	44%	51%	25%	16%	3%	5%
RI	174,205	5	50%	50%	33%	17%	33%	0%	17%
SC	912,165	8	81%	60%	32%	34%	25%	6%	4%
SD	151,221	7	64%	45%	73%	27%	0%	0%	0%
TN	1,141,537	4	76%	46%	36%	51%	5%	3%	5%
TX	4,564,193	5	66%	55%	23%	45%	24%	1%	7%
UT	360,030	3	56%	16%	84%	8%	0%	0%	8%
VA	1,421,449	7	73%	46%	28%	21%	39%	3%	9%
VT	42,288	5	100%	33%	33%	67%	0%	0%	0%
WA	1,250,568	2	56%	60%	49%	8%	22%	15%	6%
WI	1,209,448	9	69%	59%	57%	34%	0%	1%	7%
WV	358,067	6	58%	16%	68%	26%	0%	0%	6%
WY	221,738	4	72%	28%	89%	6%	0%	0%	6%

[a] Missing values for fish catch were included as zero in both the mean and the median.

[b] Other includes both those that indicated other and missing values.

N/A - Not Available

Source: NDS; U.S. EPA analysis.