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DRAFT

THE NATIONAL COSTS TO DEVELOP TMDLs

July 31, 2001

Prepared for:

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EXECUTIVE SUMMARY

The 1972 Clean Water Act created the TMDL (Total Daily Maximum Load) program in section 303(d) of the Act, providing a mechanism to restore waterbodies still impaired after the most obvious water pollution problems have been addressed by other provisions of the Act. The TMDL program has three sets of ongoing activities, in which States[1] must:

- ***List Impaired Waterbodies*:** identify specific impaired waterbody segments and the causes of impairment, and periodically submit the resulting list to EPA;
- ***Develop TMDLs*:** for each pollutant cause of impairment for each listed waterbody, develop specific plans (i.e., "TMDLs") to restore the uses of the waterbody; and
- ***Implement TMDLs:*** take the actions needed to carry out the plan for each TMDL.

In their 1998 303(d) lists, States identified nearly 22,000 waterbodies impaired by nearly 42,000 causes of various types. Over 36,000[2] of these causes of impairment are pollutants, which must be addressed by TMDLs. Recognizing the importance and potential magnitude of this effort, EPA initiated this study to estimate the administrative cost of developing TMDLs and a companion study[3] to estimate the cost to dischargers of complying with TMDLs. More recently, the Congress directed EPA, as part of the Omnibus Appropriations Act for FY 2001 (Public Law 106-554), to prepare a report (called *The National Costs of the Total Maximum Daily Load Program* hereinafter referred to as *The Summary Report*) addressing the question of how to identify and correct the remaining water pollution problems throughout the country in the most cost effective manner, including the TMDL program.

This study provides the basis for the estimates in *The Summary Report* regarding the national cost of developing all of the required TMDLs associated with the 1998 303(d) lists starting in 2000. We also assess the potential workload associated with developing the TMDLs for waterbodies that might be included on future 303(d) lists. The administrative costs of listing impaired waterbodies, the costs of additional monitoring to develop TMDLs, and the administrative costs of implementing TMDLs are not estimated in this study — however, the costs of listing and monitoring are addressed in *The Summary Report*.

This executive summary is organized as follows:

A. overview of results,
B. overview of the State TMDL-related activities covered in this analysis,
C. overview of the approach used, and
D. organization of this report.

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[1] In this report, we use the term "States" to refer to all 50 States plus the District of Columbia, Puerto Rico, the Virgin Islands, American Samoa, Guam, the Commonwealth of the Northern Marianas, and authorized Tribes.

[2] TMDLs for about 1,000 pollutant causes have already been developed prior to 2000, and these are not included in the estimate of 36,225 pollutant causes still requiring TMDLs as discussed in detail in Chapter II.

[3] Environomics and Tetra Tech, Inc., *The National Costs to Implement TMDLs*, prepared for the U.S. EPA, Office of Wetlands, Oceans and Watersheds, draft July, 2001.

A. Overview of Results

This study covers all of the tasks associated with developing TMDLs, including those mandated by the July 2000 revisions to the Water Quality Planning and Management (WQPM) Regulation[4]. To the extent that the development of TMDLs require additional monitoring, this added cost is not estimated in this study but is included in *The Summary Report*. Finally, we note that while States will have the primary responsibility for developing TMDLs, EPA will undertake a portion of this workload.

In summary, the results of this analysis regarding the national undiscounted cost of developing the TMDLs for the 1998 303(d) lists are:

- the total cost is estimated to be about $1 billion, and
- the yearly cost is estimated to initially be about $27-29 million in the year 2000, increasing over a few years (as States expand their capacity to develop TMDLs) to perhaps $63-$75 million per year until all of the TMDLs are completed in 2015.

This overview summarizes in greater detail the total and annual national costs for developing TMDLs for the 1998 303(d) lists. These estimates are provided on both an undiscounted and discounted basis. In addition, we discuss the national average unit cost and associated typical range of unit costs of developing TMDLs for a single cause of impairment, for a waterbody that requires multiple TMDLs, and for a group of waterbodies in a watershed. Finally, we discuss the potential workload that might be associated with developing TMDLs that are identified in future lists.

1. Total undiscounted national cost of developing TMDLs for the 1998 303(d) Lists

The national total undiscounted cost starting in the year 2000 to develop the estimated 36,225 TMDLs for the pollutant causes of impairment identified in the 1998 303(d) lists is estimated to be about $1 billion, with a likely range of about $0.97 to $1.06 billion[5]. The range reflects a 5-10 year transition period over which we assumed that States would fully achieve the cost efficiencies that can be realized by clustering waterbodies and causes for TMDL development. The cost might be 10% lower than this range if States are able to adopt efficient practices for developing TMDLs more rapidly than assumed in this report; alternatively, the total costs could be 10% higher or more to the extent that States require a longer transition period to employ the most efficient practices for developing TMDLs.

The national total cost estimate is based on the unit costs of typical TMDLs, with perhaps only 2-5% of the TMDLs nationally requiring costs in excess of the unit costs used in this analysis. We do not anticipate that the cost of these outliers will significantly affect the estimate for national total cost.

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[4] The TMDL development costs for this subset of tasks represent less than 10% of the total cost estimated in this report, and were previously estimated in: Environomics and Tetra Tech, Inc., *Analysis of the Incremental Cost of Final Revisions to the Water Quality Planning and Management Regulation and the National Pollution Discharge Elimination System Program*, prepared for the U.S. EPA, Office of Wetlands, Oceans and Watersheds. July 7, 2000.

[5] Perhaps $27-29 million of this cost (i.e., $0.03 billion) was incurred in the year 2000.

However, to the extent that these outliers have sufficiently higher unit costs than used in this analysis, they may result in increasing the national total costs estimated in this report by perhaps 10 to 20%.

2. Annual undiscounted national cost of developing TMDLs for the 1998 303(d) lists

When submitting their 1998 303(d) lists, the States committed to schedules that would result in developing virtually all of these TMDLs by 2013. However, the recent revisions to the TMDL regulation would allow States to complete these TMDLs by 2015. Therefore, in this report, we assumed that the States would use the additional time allowed by the regulation and would develop TMDLs at a roughly uniform rate over the sixteen year period from 2000 through 2015. Therefore, the average annual national cost for developing TMDLs would be about $63-$69 million. As in the case for total cost, the range reflects a 5-10 year transition period over which we assumed that States would fully achieve the cost efficiencies that can be realized by clustering waterbodies and causes for TMDL development.

However, the pace at which States would actually develop TMDLs over this period is unclear. A roughly uniform annual pace over the 16-year period through 2015 would imply the development of about 2,350 TMDLs per year. It is apparent that the actual initial pace of TMDL development is lower. We estimate that about 1,000 TMDLs were developed prior to 2000 for causes identified on the 1998 303(d) lists, and that perhaps another 1,000 TMDLs were developed in 2000. Therefore, it appears that States are in the process of building up their capacity to develop TMDLs. In addition, the revisions to the TMDL regulation encourage States to take advantage of the cost savings that can result from coordinating the development of TMDLs on a watershed basis, and in order to accomplish this, more of the TMDLs may be developed in the latter years relative to a strictly uniform national rate over the entire period. For example, a "transition" pace might steadily increase from 1,000 TMDLs per year in the year 2000 to about 2,550 TMDLs by the year 2005 and remain at that rate through the year 2015 to complete all 36,225 TMDLs; this would result in a yearly cost starting at about $27-$29 million in the year 2000 which would steadily increase to about $68-$75 million in 2005 and remain at that level through 2015.

We note that both the uniform and transition paces are consistent with the schedules for TMDL development required in the court orders that resulted from citizens suits regarding timely establishment of TMDLs. We also note that the pace of TMDL development for individual States may differ markedly from the overall national average pace assumed in this report. For example, when submitting their 1998 303(d) lists, twenty of the States indicated that they would complete their TMDLs by 2008; and in response to citizen law suits, a number of States have agreed in consent decrees to develop TMDLs and thereby may be committed to developing TMDLs rates that may be more rapid than the national average pace assumed in this report. As discussed in Appendix A, States that wish to apply the national estimates and methodology of this report should make appropriate State-specific adjustments.

3. Discounted national cost of developing TMDLS for the 1998 303(d) lists

The present value of developing the 36,225 TMDLs for the 1998 303(d) lists at a uniform pace through 2015 is about $598 - $658 million at a 7% discount rate and $776-$853 million at a 3% discount rate. The associated annualized cost over the period 2000 to 2015 is $60-66 million. However, since we anticipate that the actual pace of TMDL development will be relatively slower in the initial years and greater in the latter years, the actual present value and annualized costs would likely be lower. For the previous example, in which the annual pace of development starts at 1,000 TMDLs in the year 2000 to gradually rise to 2,500 in the year 2005 remaining at the level through 2015, the discounted national costs would be 2-4% lower depending on the discount rate.

4. Typical unit cost of developing TMDLs at different levels of aggregation

The cost of developing TMDLs can be viewed at different levels of aggregation in addition to the national total. Accordingly, we estimated the average cost and the associated typical range of cost of developing TMDLs for 1) a single cause of impairment, 2) a waterbody that requires multiple TMDLs, and 3) a submission that may range from a single TMDL for a single waterbody to many TMDLs for all of the waterbodies in a watershed. These estimates are shown in Exhibit ES-1 and are reflected in the estimated total undiscounted cost of $1 billion discussed previously.

As summarized in Exhibit ES-1, the cost per cause is estimated to be about $28,000 on average nationally, but can typically range from about $6,000 to $154,000. The lower end of the range reflects the typical cost associated with TMDLs that are of the least difficulty and which also are developed subsequent to other related TMDLs (for example, the second nutrient-related pollutant for a waterbody). The higher end of the range represents the typical cost associated with TMDLs that are most difficult to develop, and for which there isn't the benefit of related work done on other TMDLs. Note that the range of $6,000 to $154,000 per TMDL broadly represents the typical cost of developing TMDLs, with perhaps only 2-5% of the TMDLs nationally exceeding the costs in this range.[6]

Exhibit ES-1
Average and Typical Range for the Cost of Developing TMDLs at Different Levels of Aggregation Reflected in the Estimate of Total Undiscounted Cost of $1 Billion

Level of Aggregation	National Average Cost* (thousands 2000 $)	Typical Range for Cost (thousands 2000 $)
Cost per single Cause of Impairment (for single TMDL)	$27 - $29	$6 - $154
Cost per single Waterbody (for single TMDLs to multiple TMDLs)	$49 - $54	$26 - over $500
Cost per Submission (for single waterbodies to multiple waterbodies)	$136 - $165	$26 - over $1,000

**Ranges reflect a 5-10 year transition period over which States are assumed to fully achieve the cost efficiencies that can be realized by clustering waterbodies and causes when developing TMDLs.*

The cost per waterbody can vary widely. Although most waterbodies have only one cause of impairment requiring a TMDL, nearly 40% of the waterbodies have two or more causes ranging to over thirty causes for a single waterbody. The national average cost of developing TMDLs per waterbody is estimated to be about $52,000 on average, but can typically range from under $26,000 to over $500,000 depending on the number of TMDLs and their level of difficulty.

States will combine the development of TMDLs into logical, efficient groups and submit them together in a single submission. Submissions may range from a single TMDL for a waterbody to many TMDLs for all of the waterbodies in a watershed. The cost of a submission (which typically may cover 5-

[6] See Chapter III, Section B.2.c for additional detail.

6 TMDLs but could have fewer or far more TMDLs) is estimated to be about $150,000 on average nationally, but may typically range from including a single TMDL for a cost of under $26,000 per submission to cases that include a cluster of many waterbodies and/or TMDLs at higher levels of difficulty that exceed $1,000,000 per submission.

In this analysis, we focused on the ranges of cost for "typical" TMDLs (as reflected in Exhibit ES-1) in order to develop an estimate of the total national cost. We did not include consideration of the most inexpensive TMDLs or the most expensive TMDLs because these "outliers" are not representative of the bulk of the national TMDL development workload. We believe that the range of costs used in this report are appropriate for developing an estimate for total national cost. However, to the extent that there are a significant number of outliers with sufficiently higher costs, the national total cost estimate in this report may under-estimate total cost. There are two primary reasons why some TMDLs may be outliers:

- They may be more resource intensive because they are more difficult technically, they require greater public participation and outreach, or both; and/or

- Their spacial scale may be significantly larger. We have not attempted in this report to reflect or make adjustments for large-scale waterbodies. In this regard, some States may have broadly defined some impaired waterbodies to include all of the interconnected impaired segments in a watershed. In effect, an impaired waterbody defined in this way is actually a "cluster" or a "submission" in this report, and the appropriate unit TMDL development costs should be applied to each of the segments composing the waterbody. For this report, however, we have not attempted to reflect or adjust for such differences in the way that States may have defined impaired waterbodies.

For perspective, if the potential outliers exceed the maximum cost of $154,000 per TMDL by an average of $100,000 per outlier TMDL then the national total cost estimated in this report would be understated by perhaps10-20% – note that the average additional cost of $100,000 per outlier represents a range for the additional cost that includes up to $1,000,000 per outlier TMDL over and above $154,000.[7]

It is important to note that the typical TMDL development costs for individual States may be substantially higher or lower than the national average. States that wish to apply the national average estimates and methodology to estimate the cost of developing TMDLs for their State, should make the appropriate State-specific adjustments as detailed in Appendix A. In particular, the distribution for the level of difficulty may be very different across States, and it may be especially important for some States to include explicit consideration of "outliers". In addition, States that broadly define a single impaired waterbody to include all of the interconnected impaired segments in a watershed (or otherwise identified large-scale waterbodies) should consider whether it is appropriate to apply the unit TMDL development costs to the segments composing the impaired waterbody. Finally, the State's ability to achieve efficiencies in developing TMDLs can importantly affect cost, and there are a number of factors to consider when evaluating the potential to achieve such efficiencies, especially in the near term, as discussed in Appendix G.

[7] See Chapter III. Section B.2.c. for a detailed discussion.

5. The cost of developing TMDLs for causes identified in the future

Additional waterbodies requiring TMDLs will likely be identified in the future, though it is unclear how many. EPA, believes that the bulk of the water quality problems have already been identified, as do the States.[8] EPA also anticipates that new causes will be identified gradually over an extended period of time, in part because States have already focused on those areas most likely to be impaired and so it will take longer to find new impairments, and in part because some waterbodies may not become impaired until some time in the future (for example, waters that are currently "threatened" but not impaired).

There is little basis for forecasting the rate at which additional impairments will be identified in future listings. From 1972 to 1992, very few States submitted 303(d) lists. By 1996, in response to law suits and increased effort by EPA, all of the States had submitted lists, although these varied in their comprehensiveness. In 1998, in response to the growing number of law suits, most of the States did a thorough job of listing their impaired waterbodies. The increase in the number of pollutant causes in the 1998 303(d) lists as compared to the 1996 303(d) lists was 4,536 causes. The 1998 lists grew significantly in some States because authorities wanted to minimize the potential for litigation and listed causes for which TMDLs would ultimately not be required (some States are planning on submitting additional information in future listings that will allow them to de-list causes that were previously identified in the 1996 or 1998 listings). The increase of 4,536 causes from the 1996 to the 1998 303(d) lists thus is likely to be significantly larger than the rate at which new pollutant causes will be identified in future listings. In fact, if States do delist TMDLs in the future, some future listings may actually reduce the TMDL workload rather than increase it.

In this report, we provide some perspective on the potential workload associated with new causes that will be identified in the future. To do so, we estimate the cost for a plausible, but hypothetical, scenario based on the following assumptions regarding 1) the rate at which new pollutant causes will be identified, 2) the period over which new causes will be identified, 3) the rate at which TMDLs will be developed for these causes and 4) the characteristics of the TMDLs that will need to be developed:

- On average, we assume that 1,000 new pollutant causes might be identified in each future listing. However, since a number of States appear to be preparing to de-list causes, we assume that there will not be a net increase in the number of causes in the 2002 listing, and that net new causes will be added starting in the 2006 listing.

- We assume that 1,000 new pollutant causes will be identified for perhaps nine listings, with few remaining causes to be identified after 2038. This amounts to a total of 9,000 new pollutant causes, which is equivalent to about 25% of the current TMDL development workload for the 1998 303(d) lists.

- We assume that the TMDLs for newly identified causes will be developed uniformly over a 10-year period from being listed – for 1,000 newly listed causes this would result in 100 TMDLs per year. With the last set of new causes listed in 2038 and this pace of development, the TMDLs for all of the future causes would be developed by 2050.

[8] U.S General Accounting Office, *Identification and Remediation of Polluted Waters Impeded by Data Gaps*,GAO/T-RCED-00-131, page 4.

- We assume that the characteristics of the TMDLs for future causes will be similar to causes already identified, that by the time these TMDLs are developed it will be possible to employ the most efficient approaches, and that the unit costs to develop TMDLs will remain unchanged (we have not estimated the extent to which these unit costs might decline over the next few decades).

For this scenario, a total of 9,000 TMDLs will be developed at a total undiscounted cost of $216 million at a typical undiscounted yearly cost of about $5-7 million[9] over most of the period through 2050. Because the identification (and associated TMDL development) of these additional waterbodies is assumed to be spread over a longer period of time (i.e., perhaps through 2050) relative to the 1998 303(d) lists, the present value is lowered. Consequently, the present value cost for this hypothetical workload (amounting to 1/4 of the current workload for the 1998 303(d) lists) is about $43 - $101 million, reflecting discount rates of 3%-7%.

If the total number of new causes, the pace of identifying them, the difficulty of developing TMDLs for them, the pace of TMDL development, and the unit cost per TMDL differs from this hypothetical scenario, then these costs will increase or decrease accordingly.

B. Overview of the TMDL-Related Activities Covered in this Analysis

This analysis estimates the full cost of developing TMDLs, beginning with those tasks associated with the initiation of TMDL development and ending with the submission of the TMDL to EPA for approval. This analysis includes those additional tasks mandated by the July 2000 Water Quality Planning and Management Regulation. This represents the full cost of developing TMDLs, whether these activities are undertaken in full or in part by States, EPA or other entities.

The cost of special monitoring requirements for developing TMDLs is not included in this study, but is addressed in *The Summary Report* as discussed earlier. *The Summary Report* also includes the States' costs associated with developing 303(d) lists.[10] This analysis has not addressed the costs associated with implementing TMDLs (for example, outreach efforts or permitting efforts beyond those needed to reissue NPDES permits to sources that discharge to impaired waterbodies).

The cost of TMDL program activities to EPA is not addressed in this analysis, but is estimated in *The Summary Report*, including the grants that EPA issues to States for implementing Clean Water Act programs, including the TMDL program. We assumed in this analysis that information that is routinely provided by other governmental units, such as the U.S. Department of Agriculture, will continue to be provided, and have not estimated this cost. We recognize that there may be increased demand for technical assistance as a result of the TMDL program, but have not estimated the cost attributable to additional

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[9] Since the workload for different listing periods would overlap (due to a four-year listing cycle and a ten-year period to develop the TMDLs), the overall pace of development would start at 100 TMDLs per year, working up to about 200-300 TMDLs per year and stay at that rate for most of the period, and then wind down.

[10] The cost of listing was also estimated in EPA's approved ICR Number 1560.05 and in the *Analysis of the Incremental Cost of Final Revisions to the Water Quality Planning and Management Regulation and the National Pollution Discharge Elimination System Program*, prepared by Environomics for the U.S. EPA, Office of Wetlands, Oceans and Watersheds. July 7, 2000.

technical assistance that other governmental units may provide for TMDL development or for TMDL implementation.

C. OVERVIEW OF THE APPROACH

The methodology for this analysis was developed in consultation with State, EPA and contractor representatives experienced in performing the tasks needed to develop TMDLs. The data sources and the approach used are summarized below, and described in far greater detail later in this report.

1. Data sources

Data and estimates were needed for three types of information:

a. Data regarding the existing TMDL program,

b. Estimates of the level of effort associated with developing TMDLs, and

c. Data and estimates of the potential for clustering.

The sources for these data and estimates are described in Appendix A and summarized briefly below.

<u>a. Data regarding the existing TMDL program</u>

The data describing the current TMDL program were obtained by extracting data and developing summary statistics from the Agency's 1998 303(d) TMDL Tracking System Database (Version dated 2/19/00), reviewing and describing selected characteristics of the State 1998 303(d) list submissions, and reviewing the content of a sample of 1,096 TMDLs (these include a comprehensive sampling of TMDLs recently reviewed and approved by EPA.

<u>b. Data and estimates regarding the level of effort associated with the TMDL program</u>

A variety of sources provide estimates regarding the level of effort associated with all of the federal requirements associated with developing TMDLs:

- The unit estimates of the staff burden (hours) were obtained through discussions with several State representatives and experts on TMDL development from an EPA contractor (Tetra Tech), and prior analyses of these topics.

- The estimated cost for developing TMDLs using the unit cost estimates in this report was compared with the actual costs for a broad range of 131 TMDLs which were developed by an EPA Region and an EPA contractor (Tetra Tech).

- The Agency's Gap Analysis Effort, and its State Water Quality Management Resource Needs Model provided important input regarding typical fully-loaded labor rates for State efforts, as well as perspective in assessing the magnitude and reasonableness of the estimates for TMDL-development related tasks.

- Additional important perspective is provided by published State workload models such as those prepared by Washington State.

<u>c. Data and estimates of the potential for clustering</u>

- U.S. Geologic Survey hydrologic units (at the sub-basins level, as defined by 8-digit HUCs) provided an initial basis for organizing waterbodies into groups for more detailed analysis to identify the extent to which they might be clustered for TMDL development.

- U.S. EPA Reach File 3 was used to identify the interconnected impaired waterbodies and the isolated impaired waterbodies within the sub-basins

- Additional important perspective is provided by a published State workload model prepared by Washington State, as well as the extent to which clustering occurred for the sample of 1,096 recently submitted TMDLs.

2. Estimating unit burden and the associated unit costs

The first step in the analysis was to estimate the unit burden (i.e., the hours of effort needed) to develop a TMDL. Eight basic tasks were defined to encompass the full range of activities needed for developing TMDLs. These tasks reflect the long-established requirements of the Water Quality Planning and Management Regulation, as well as the two new requirements found in revisions finalized on July 11, 2000. The level of effort to accomplish each task was estimated for each of three levels of difficulty to reflect the fact that some TMDLs will be relatively simple to develop, while other TMDLs will involve far more effort. Multiplying the resulting burden by the fully loaded labor cost per hour of $38.89 for State staff[11] results in the estimated cost to develop TMDLs representing the three levels of difficulty. These costs are for a single TMDL (i.e., for a single cause of impairment) for a single waterbody, with none of the cost efficiencies that might be realized by coordinating the development of multiple TMDLs. These are referred to as "Type A" TMDLs in this report.

The second step in the analysis was to estimate the well-recognized efficiencies that can be obtained when the development efforts for multiple TMDLs are coordinated. These cost reductions can be realized in two cases:

- ***Standard efficiencies*** can be realized when coordinating the development of multiple TMDLs, either for a single waterbody or for a cluster of multiple interconnected waterbodies in a watershed (these are referred to as "Type B" TMDLs in this report). Examples of tasks that will experience such efficiencies include watershed characterization, holding a joint public hearing and reusing parts of the TMDL document (or providing a single submission for all of the TMDLs).

[11] In this analysis, we use the consensus estimate developed for the Gap Analysis Effort's State Water Quality Management Resource Needs Model Version 5.1 (January, 2001) for the average fully loaded labor rate for State staff (these estimates were for March 2000, originally appearing in Version 3.0). This rate includes all labor-related costs including: direct salary paid, paid or accrued vacation, paid or accrued sick leave, cost of other fringe benefits (e.g., health, pension, etc.), general training, indirect expenses such as professional support (e.g., clerical, accounting and supervisory), office space, utilities, telephone service, and equipment (e.g., fax machines, basic computing needs such as hardware and software, etc.).

- *Additional modeling-related efficiencies* (over and above standard efficiencies) can be realized if the causes of impairment are for similar pollutants (these are referred to as "Type C" TMDLs in this report). For example, such efficiencies can be realized when modeling related pollutants, whether within a waterbody with multiple TMDLs or across waterbodies in a cluster of multiple interconnected waterbodies in a watershed. Once the analysis has been performed for a pollutant or pollutant type (such as a several metals or several nutrients), the additional effort to perform the analysis for additional pollutants of that type is a fraction of the initial effort. Similar efficiencies can be realized for allocating load reductions and for developing implementation plans.

Accordingly, we estimated an additional set of unit burdens and associated costs to represent the standard efficiencies associated with coordinating the development of multiple TMDLs (Type B), and another for the added efficiencies in cases where the causes are for similar pollutants (Type C). It should be noted that efficiencies for some tasks can be realized even if the TMDLs are not prepared in the same time frames – for example, significant portions of the watershed characterizations, the TMDL documents and the implementation plans from previously developed TMDLs can typically be applied.

In total, nine sets of typical unit burden were developed, representing each combination of three different levels of difficulty and three different levels of efficiency, as shown in Exhibit ES-2. For each type of TMDL, these estimates represent the typical burden for the middle 50% of the TMDLs nationally – for example, about 25% of the Level 3, Type A TMDLs might be expected to have a lower burden than 2,396 hours and 25% of the Level 3, Type A TMDLs might be expected to have a greater burden than 3,954 hours. We used the averages for these nine estimated ranges of burden to develop national estimates. State-specific refinements would be necessary to apply these estimates of unit burden to estimate the workloads for specific States (these adjustments are described in Appendix A).

Exhibit ES-2
Summary of the Typical Unit Burden to Develop a TMDL Taking Efficiencies Into Account

Extent to Which Efficiencies Are Realized	Level 1 (hours)	Level 2 (hours)	Level 3 (hours)
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster	666 - 1,200	1,200 - 2,396	2,396 - 3,954
B. TMDLs with standard efficiencies: subsequent causes for a water body/clustered waters	195 - 420	420 - 1,059	1,059 - 1,859
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	164 - 288	288 - 583	583 - 965

3. Validating the estimates of unit burden and cost

Data for selected TMDLs already developed and existing estimates of projected costs were generally available on either a burden (hours) basis or on a cost basis, but not both. We validated our estimates by comparing the estimated burden or costs developed in this report to the actual or estimated burden or costs as appropriate. We made the following comparisons:

- Comparison of estimated vs actual costs for 131 TMDLs
- Comparison with the Washington State Workload Model
- Comparison with the May 1996 EPA Report containing 14 case studies of TMDL cost
- Comparison with the Gap State Water Quality Management Resource Needs Model
- Comparison with commonly cited high-cost TMDLs

Overall, these comparisons tend to indicate that this report's estimates of the national cost of developing TMDLs are reasonable and are more likely to overestimate the actual cost than to underestimate it. Each of these is addressed in the body of this report and in greater detail in Appendices B-F.

4. Estimating the characteristics of the TMDL workload

The following summarizes how we estimated the characteristics of the workload associated with the 1998 303(d) lists and the workload that might be associated with future lists.

a. Workload associated with the 1998 303(d) lists

To estimate the national cost of developing TMDLs for the 1998 303(d) lists, it was necessary to estimate several key aspects of the overall TMDL workload including: total number of TMDLs, the distribution of TMDLs by level of difficulty, the extent to which efficiencies will occur, and the overall pace of TMDL development. Our approach for estimating each of these important factors is summarized below, and described in greater detail in the body of this report:

- The total number of TMDLs to be developed for the 1998 303(d) lists was estimated using the Agency's 303(d) TMDL Tracking System Database (Version dated 2/19/00).

- The distribution of TMDLs by level of effort (i.e., the percentage of TMDLs that will be of Level 1 difficulty, Level 2 difficulty, and Level 3 difficulty) was based on expert judgment. These judgements result in a greater percentage of more difficult, higher cost TMDLs than reflected in 1) the default judgements in the Gap State Water Quality Management Resource Needs Model and the Washington State Workload Model. Therefore, we consider the judgements in this report to provide a somewhat conservative estimate of the overall difficulty, and therefore cost, of developing TMDLs.

- Estimates for the extent to which efficiencies will occur are based on an analysis of the potential extent to which efficiencies can be realized as well as the extent to which such efficiencies are currently being realized.

    - Estimates for the potential to cluster waterbodies and TMDLS to realize efficiencies were based on identifying those waterbodies on the 1998 303(d) lists that are interconnected within watersheds, and the extent to which waterbodies with multiple TMDLs or clustered waterbodies have similar causes. This analysis was performed for 77% of the waterbodies on the 1998 303(d) lists, representing 70% of the causes of impairment nationally. Based on this analysis, if States cluster waterbodies to the maximum potential extent, 80% of the impaired waterbodies (and a larger percentage of the TMDLs) can realize the associated efficiencies associated with clustering.

    - Estimates for the extent to which efficiencies have been realized to date are based on a sample of 1,096 TMDLs reviewed by EPA headquarters – for this sample 26% of the waterbodies realized efficiencies from clustering, and over 50% of the TMDLs realized some efficiencies. This was augmented by additional information, such as the extent to which States are using or starting to use basin planning and the extent to which clustering occurs in State workload models that coordinate the development of multiple TMDLs.

For this analysis, we assumed that over a 5-10 year period, States would gradually increase their practice of clustering waterbodies (from the current level of 26% clustering to the potential of 80% clustering) ultimately achieving the maximum cost efficiencies that clustering affords.

- For a 5-year transition period, on average 70% of the waterbodies would realize efficiencies for TMDL development from being clustered

- For a 10-year transition period, on average 60% of the waterbodies would realize efficiencies for TMDL development from being clustered

The resulting workload (number of TMDLs) is summarized in Exhibit ES-3a and ES-3b.

Exhibit ES-3a
TMDL Workload (number of TMDLs) for the 1998 303(d) List - 60% Clustering

Description of the Submission	Total 100%	Level 1 45%	Level 2 30%	Level 3 25%
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster	7,844	3,529	2,353	1,962
B. TMDLs with standard efficiencies: subsequent causes for a waterbody or cluster	5,113	2,300	1,533	1,280
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	23,268	10,470	6,980	5,818
Total Number	36,225	16,299	10,868	9,060

Exhibit ES-3b
TMDL Workload (number of TMDLs) for the 1998 303(d) List - 70% Clustering

Description of the Submission	Total 100%	Level 1 45%	Level 2 30%	Level 3 25%
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster	5,883	2,647	1,764	1,472
B. TMDLs with standard efficiencies: subsequent causes for a waterbody or cluster	5,467	2,460	1,640	1,367
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	24,875	11,193	7,462	6,220
Total Number	36,225	16,300	10,866	9,059

b. Workload associated with future lists

To provide perspective for the potential national workload for developing TMDLs for impaired waterbodies identified in future listings (i.e., the listings in 2002, 2006, 2010, etc.), we estimated the cost for a hypothetical, but plausible, scenario based on a number of assumptions regarding the rate at which new causes will be listed, the number of listings, and the pace and characteristics of TMDL development.

5. Estimating national cost

For the TMDLs for the 1998 303(d) lists, the unit costs were combined with the characteristics of the 1998 303(d) TMDL workload to estimate total national cost. The total national cost of developing TMDLs depends significantly on the extent to which States cluster waterbodies when developing TMDLs. If States cluster waterbodies to the maximum extent feasible, then TMDLs for 80% of the waterbodies would realize efficiencies for TMDL development. For this analysis, we assumed that the States would work toward achieving these efficiencies over a 5-10 year period for the 1998 303(d) lists, resulting in a range for the average cluster efficiency of 60%-70% over the period 2000 to 2015.

To estimate the year-by-year cost of developing TMDLs, it was necessary to assume a pace of development. Even though States have committed to developing the TMDLs for their 1998 303(d) lists by 2013, we assumed that the States would use the additional time allowed by the recent revisions to the TMDL rule. Therefore, we assumed that States would complete these TMDLs by 2015, and would develop them at a roughly uniform rate over this period. We note that it appears that States appear to building their capacity to develop TMDLs, and therefore are starting at a slower pace in the initial years relative to a uniform pace, and therefore are likely to steadily increase their pace of development over a transition period (for example through 2005) and then develop TMDLs at a steady pace until the workload is completed.

For the TMDLs for future 303(d) lists, the unit costs were combined with an estimate of the future workload to estimate the total and year-by-year undiscounted national costs for developing these additional TMDLs. We assumed that by the time these TMDLs must be developed, States will be able to realize the full efficiencies that can be attained through clustering waterbodies.

The present value of the costs associated with developing TMDLs was estimated using a 3% and 7% discount rate. The costs were annualized using a 3% and 7% discount rate over the period that the TMDLs would be developed.

D. ORGANIZATION OF THIS REPORT

The remainder of this report is organized as follows:

Chapter I: Unit Burden and Costs for Developing TMDLs

Chapter II: Characteristics of the TMDL Development Workload

Chapter III: National Costs to Develop TMDLs

Supporting detail is provided in the following appendices:

Appendix A: Data Sources, Applicability to States & Limitations

Appendix B: Comparison of Estimated vs Actual Costs for 131 TMDLs

Appendix C:	Comparison with the GAP State Water Quality management Resource Needs Model
Appendix D:	Comparison with the Washington State Workload Model
Appendix E:	Evaluation of EPA's 1996 Report - Case Studies of 14 TMDLs
Appendix F:	Comparison with Commonly Cited High-Cost TMDLs
Appendix G:	Potential for Clustering
Appendix H:	Description of Causes and Sources of Impairment
Appendix I:	Present Value and Annualized Costs

I. UNIT BURDEN AND COSTS FOR DEVELOPING TMDLs

The methodology used in this analysis was developed in consultation with State, EPA and contractor representatives and was validated by comparing the resulting estimated costs with the known actual costs for 131 TMDLs as well as other TMDLs for which costs have been documented. This chapter is organized as follows:

A. Framework for estimating TMDL development burden and costs

B. Unit burden estimates

C. Unit cost estimates

D. Comparison of estimated costs with actual costs and with other estimates

A. FRAMEWORK FOR ESTIMATING TMDL DEVELOPMENT BURDEN AND COSTS

There are two key considerations for accurately estimating the unit burden and unit costs for any task associated with developing TMDLs:

- unit burden and costs can vary widely across TMDLs, and
- there are efficiencies associated with developing multiple TMDLs at once.

Each of these is discussed below:

1. Reflecting the wide variability in unit burden and costs

For this analysis, estimates of the unit burden and costs for developing TMDLs are based upon the judgment of EPA, State and contractor personnel familiar with the tasks involved. However, it can be difficult to estimate an average burden for any given TMDL development task, because the effort associated with developing a TMDL spans a large range for a number of reasons, including: the size of the geographic area and type of waterbody, the number and type of sources, the types of pollutants, the sophistication of the modeling and analysis tools used, the level of public interest, etc. Rather than attempt to estimate a single appropriate average that takes all of this into account, it was easier and more accurate to develop estimates of typical unit burdens for three categories of TMDLs representing three different levels of difficulty:

- *Level 1* represents relatively simple TMDLs with limited public interest,
- *Level 2* represents mid-range TMDLs, and
- *Level 3* represents TMDLs requiring detailed and sophisticated analysis as well as being the subject of greater public interest.

This approach facilitates developing more accurate estimates, communication of the estimates, and their validation. The approach of categorizing TMDLs by three levels of difficulty was also adopted by the Gap State Water Quality Management Resource Needs Model's TMDL workload module.

Using this approach requires that three unit burden estimates be developed for any task. In addition, to apply this approach to estimate national cost, it was necessary to estimate the portion of the overall national TMDL workload represented by each of the three levels of difficulty.

2. Reflecting the efficiencies associated with developing multiple TMDLs at once

States can reduce the cost of developing TMDLs by logically grouping causes, whether for the causes in a single waterbody or for all the causes in a cluster of waterbodies. In this report, "clustered" waterbodies always refers to a grouping of waterbodies that are interconnected within a watershed (as discussed later in this report and in detail in Appendix G). In some cases, savings result because a task can be performed at the same time for all of the causes or waterbodies, while in other cases savings result because the work performed for the first cause or waterbody can be applied to subsequent causes or waterbodies. We refer to the cost savings that can be realized when TMDLs are grouped as "standard efficiencies" and the additional cost savings that can be realized when the pollutant causes are also similar as "modeling-related efficiencies." The circumstances that lead to reductions in the burden and cost of developing TMDLs through standard efficiencies and modeling-related efficiencies are discussed below.

<u>a. Standard efficiencies</u>

Standard efficiencies from clustering can be obtained in two cases:

- *Submissions for a single waterbody involving multiple TMDLs.* Increasingly, States are coordinating or developing together all of the TMDLs for a waterbody that requires more than one TMDL. These may be clustered together into a single submission, although this is not necessary to realize efficiencies. To estimate this efficiency, we assumed that there are no efficiencies for the first TMDL in a cluster, but that there are efficiencies for the remaining TMDLs for the waterbody. Examples of tasks that will experience efficiencies include watershed characterization, holding a joint public hearing and reusing parts of the TMDL document (or providing a single submission for all of the TMDLs).

- *Submissions with multiple TMDLs involving more than one waterbody:* Increasingly, States use a watershed approach to developing TMDLs, in which the development of TMDLs is coordinated for logical groupings of waterbodies. These may be clustered together into a single submission, although this is not necessary to realize efficiencies. To estimate this efficiency, we assumed that there are no efficiencies for the first TMDL in a cluster, but that there are for the remaining TMDLs. Examples of tasks that will experience efficiencies include characterizing the watershed, holding a joint public hearing, and reusing parts of the TMDL document (or providing a single submission for all of the waterbodies).

It should be noted that efficiencies for some tasks can be realized even if the TMDLs are not prepared in the same time frames – for example, significant portions of the watershed characterization and the TMDL documents from previously developed TMDLs can typically be applied. Further, the efficiencies can be realized even if the TMDLs are submitted separately, rather than in a single submission.

We have assumed that the first TMDL for a waterbody or for a cluster of waterbodies does not benefit whatsoever from any efficiencies and is developed at full cost -- we call these "Type A" TMDLs. We have termed the remaining TMDLs which are developed at reduced cost because of the standard clustering efficiencies described above as "Type B" TMDLs. However, as discussed next, some of these clustered Type B TMDLs can realize yet additional efficiencies because some or all of the pollutant causes are related.

b. Additional modeling-related efficiencies

In addition to the standard efficiencies that can be realized for clustered TMDLs, modeling-related efficiencies can also be realized for those TMDLs that have related pollutant causes:

- *Multiple TMDLs for a waterbody involving related pollutants*. For multiple TMDLs for a waterbody, further efficiencies can be realized when modeling related pollutants such as metals (e.g., lead, nickel, and cadmium) and nutrient-related pollutants (e.g,, nutrients, dissolved oxygen, organic enrichment, algae and ammonia) since similar models, analytical techniques, and chemical and biological processes are considered. Once the analysis has been performed for a pollutant type, the additional effort to perform the analysis for additional pollutants of that type is a fraction of the initial effort. Similarly, additional efficiencies can be realized for allocating load reductions and for developing implementation plans.

- *Multiple TMDLs for a cluster of interconnected waterbodies involving related or the same pollutants*. As above, for multiple TMDLs for a cluster of interconnected waterbodies, further efficiencies can be realized when modeling related pollutants such as metals and nutrient-related pollutants since similar models, analytical techniques, and chemical and biological processes are considered. However, for a cluster of waterbodies, efficiencies can also be realized for the same pollutant (e.g, fecal coliforms) present in more than one of the waterbodies in the cluster. Once the analysis has been performed for a pollutant or pollutant type, the additional effort to perform the analysis for additional pollutants of that type is a fraction of the initial effort. Similarly, additional efficiencies can be realized for allocating load reductions and for developing implementation plans.

As for standard efficiencies, the modeling-related efficiencies for some tasks can be realized even if the TMDLs are not prepared in the same time frames – for example, significant portions of the implementation plans from previously developed TMDLs can typically be applied. Further, the efficiencies can be realized even if the TMDLs are submitted separately, rather than in a single submission.

When estimating modeling-related efficiencies, we assumed that there are no added efficiencies for the first pollutant (or related pollutant) in the cluster, but that there are added modeling-related efficiencies for subsequent related TMDLs. We have termed these as "Type C" TMDLs.

B. Unit Burden and Cost Estimates

This section describes:

1. the definitions of the tasks and levels of difficulty for developing TMDLs,
2. the unit burden for developing TMDLs when there are no efficiencies,
3. the unit burden when there are efficiencies, and

4. the associated unit cost.

1. Tasks and levels of difficulty for developing TMDLs

To facilitate estimating the burden associated with developing TMDLs, the overall effort is broken down into eight tasks for three levels of difficulty as discussed below.

a. Eight tasks that include all of the effort associated with developing TMDLs

The tasks associated with developing TMDLs can be broken down in many ways. For this analysis, our primary considerations were : 1) to facilitate making judgements regarding the burden associated with the tasks and 2) to facilitate comparison of our estimates with available actual costs for these tasks for selected TMDLs. The eight tasks described in Exhibit I-1 represent all of the effort associated with developing TMDLs, as discussed previously in the Executive Summary (ES.B.).

Exhibit I-1
Tasks for Developing TMDLs

Task	Title	Description
1	Watershed Characterization	Compile available information, create database or electronic files, review the available information, select the technical approach.
2	Modeling and Analysis	Select final model, model setup and calibration. Evaluate existing conditions.
3	Allocation Analysis	Evaluate allocation scenarios and select final allocation.
4	Develop TMDL document for public review	Prepare technical report documenting analysis & assumptions. Document the TMDL (i.e. WLA, LA, loading capacity, margin of safety, seasonality). Prepare administrative record.
5	Public Outreach	Public meetings and dissemination of information prior to TMDL submittal
6	Formal public participation & response	Announcement of the TMDL, formal public meeting, prepare response to comments
7	Tracking, planning, legal support, etc.	Miscellaneous tasks needed to support TMDL development
8	Implementation Plan	Develop an implementation plan

b. Three levels of difficulty

The characteristics and complexity of TMDLs vary tremendously. Considerations include:

- general source type (i.e., point source, non-point source, or mix),
- specific source type (e.g., agriculture, forestry, urban runoff),
- waterbody type (i.e., rivers, lakes/reservoirs, estuaries/coastal),
- pollutant type (e.g., nutrients, metals, toxic organics, pesticides, etc.)
- number of pollution sources,
- spatial scale (e.g., reach length, contributing area),
- flow or critical conditions (e.g., steady, event driven),
- data availability,
- past studies or ongoing activities,

- stakeholder interest (number and level of concern), and
- management implications (e.g., cost, feasibility, responsibility).

Ideally, the burden estimates for each of the 8 tasks should be developed separately for different combinations of key factors such as source type, waterbody type, pollutant type, etc.. However, this level of detail was not feasible within the time constraints for this report. Instead, this variation is accounted for by estimating ranges of costs for each of the three different levels of complexity for each task.

As evident in Exhibit I-2, we made the simplifying assumption that TMDLs which require more complex modeling would typically also require correspondingly higher levels of effort for the other tasks (i.e., watershed characterization, preparing the TMDL document, public outreach, developing the implementation plan, etc.). Admittedly, tasks could conceivably be undertaken at different levels: a particular TMDL that uses a Level 1 modeling and allocation analysis may have a very high level of public interest; a TMDL that uses a Level 3 modeling and analysis may have only limited public interest. However, this simplifying assumption is believed to be a reasonable generality for the purpose of estimating national costs using the methodology applied in this report – from the standpoint of developing national costs, it is only necessary to estimate the total number of Levels 1, 2, and 3 tasks and not how they actually combine for specific TMDLs.

Exhibit I-2
Levels of Difficulty

Level	Analysis	Other Tasks
1	Simplified TMDL analysis using "spreadsheet" calculations Models and analysis tools used are empirical.* No formal calibration is performed although the predictions are compared to best available data. The watershed is typically analyzed as a single unit. Load allocations are typically expressed as a single value (i.e., gross allotments). The receiving water is analyzed as a single unit or several larger segments. Time variability is limited. Analysis includes average annual value or selected design flow conditions	limited
2	Mid-Range Analysis Models and analysis include some process-based analysis. Some calibration and testing is performed. Watersheds may be segmented into subwatersheds. Load allocations may include several categories, including background conditions. The receiving water may be segmented. Some time variability is considered. Time scale may be daily or monthly. Typical models include: QUAL2E, GWLF, BATHTUB and more simplified applications of SWMM and WASP5.* Some mid-range TMDLs use a combination of mass-balance analyses and statistics to estimate allocations.	mid-range
3	Detailed Analysis Models and analysis are more detailed and include a more explicit description of the physical, chemical, and biological processes. Due to the more complex nature of the analysis, more data processing and data preparation is required. A higher level of calibration is expected. Watershed and receiving water are segmented into smaller analysis units. Time steps are hourly or smaller. Some of the more detailed models typically used in TMDL development include: HSPF, SWMM, WASP5, and CE-QUAL-W2.*	high

** For additional discussion of model types and general levels of complexity, see the EPA Model Compendium (U.S. EPA, 1997, Compendium of Models for TMDL Development and Watershed Assessment. EPA841-B-97-007)*

When estimating ranges for the eight tasks for each level of difficulty, we established ground rules designed to facilitate the development of a realistic national estimate. As a general matter, this meant limiting consideration of unusual circumstances that might bias the national estimate:

- Ranges should generally represent the 25th to 75th percentiles, with the midpoint of the range representative of the average or typical cost. Ranges should not include costs that are at the very low or the very high extremes.

- Ranges should neither consider the initial learning curve cost of "coming up to speed" for the first TMDLs done by a State, nor the eventual learning curve efficiencies that result as staff become more experienced and methods improve.

- Ranges should represent typical costs over the period of analysis, which at the time the estimates were made was 2000 to 2013. While some initial TMDLs in a category would include a significant level of effort for training, software development, and alternative methods, they should not be used to derive representative cost estimates. Similarly, the ranges should not include the cost of developing or testing new methodologies.

Finally, the ground rules for estimating ranges include the requirement that where the TMDL development is associated with a large watershed planning and restoration effort (e.g., NEP, Long Island Sound, etc.), the TMDL costs should be limited to the incremental effort to develop the TMDL. It was not deemed appropriate to attribute the entire cost of such watershed planning and restoration efforts as resulting solely from TMDL development.

2. The unit burden when there are no efficiencies

The resulting estimates for the burden to accomplish each of the 8 tasks at the 3 levels of difficulty are shown in Exhibit I-3. These estimates assume no efficiencies whatsoever, and apply to the first TMDL for a submission (i.e., the TMDL for the first cause of impairment), whether for a waterbody or for a cluster of interconnected waterbodies. Later in this report (Section I.D.), we show that these estimates of unit costs are reasonably close to the actual costs for a significant sample of TMDLs.

To estimate national burden, we used the average burden associated with each of the 3 levels of difficulty: 933 hours for Level 1; 1,798 hours for Level 2; and 3,175 hours for Level 3 TMDLs.

3. Efficiencies associated with coordinating the development of multiple TMDLs

Exhibit I-4 summarizes the standard efficiencies and the modeling-related efficiencies that we estimated for each of the 8 tasks. The exhibit is based on the convention that the first TMDL for a submission bears the full burden (i.e., 100%) for all of the tasks associated with developing that TMDL, as shown in Exhibit I-3. Tasks for any successive TMDLs (e.g., a TMDL for a second cause of impairment for a waterbody or for a cluster of interconnected waterbodies) can be achieved with less effort. As shown in the second column, Type B TMDLs receive standard efficiencies only for Tasks 1, 4, 5, 6, 7 and 8. As shown in the third column, Type C TMDLs not only receive the standard efficiencies, they also receive the additional modeling-related efficiencies for Tasks 2, 3, and 8. Later in this report (Section I.D.), we show that these estimates are reasonably close to the actual costs for a significant sample of TMDLs.

Exhibit I-3
Hours of Effort to Develop a <u>Type A</u> TMDL at 3 Levels of Difficulty
No Efficiencies: i.e. the first TMDL for a waterbody or a cluster of waterbodies

Task	Level 1		Level 2		Level 3	
	Low	High	Low	High	Low	High
1. Watershed Characterization	160	200	200	240	240	320
2. Modeling and Analysis	24	80	80	480	480	960
3. Allocation Analysis	8	40	40	80	80	120
4. Develop TMDL Doc for Public Review	160	240	240	480	480	640
5. Public Outreach	160	240	240	320	320	480
6. Formal public participation/response	50	120	120	320	320	680
7. Tracking, planning, legal support, etc.	84	160	160	316	316	514
8. Implementation Plan	20	120	120	160	160	240
Total for Range	666	1,200	1,200	2,396	2,396	3,954
Total for Average	933 hrs		1,798 hrs		3,175 hrs	

Exhibit I-4
Incremental Unit Effort of Successive TMDLs Where Efficiencies Exist

Tasks	% of Unit Effort of Initial Full-Cost TMDL	
	Type B ***Standard Efficiencies*** **<u>Grouping</u>** **Multiple TMDLs for a Waterbody or Cluster of Waterbodies**	***Type C*** ***Model-Related Efficiencies*** **<u>plus Similar Pollutants</u>** **Within a Waterbody or Cluster of Waterbodies**
1. watershed characterization	25%	25%
2. modeling & analysis	100%	25%
3. allocation analysis	100%	25%
4. develop TMDL document	25%	25%
5. public outreach	25%	25%
6. formal public participation	25%	25%
7. tracking, planning, legal support, etc	25%	25%
8. implementation plan	50%	15%

Specific examples follow:

- *For three TMDLs that are developed for a single waterbody or for a cluster of three waterbodies:* Focusing only on the implementation plan task, the first TMDL bears the full burden (i.e. 100%) of the preparation of the implementation plan, but the burden for each of the next two implementation plans is 50% of the full burden. The resulting total burden is equivalent to the burden of 2 plans (100% + 50% +50%) instead of 3 plans, and the resulting savings overall for preparing implementation plans for all of the TMDLs for the waterbody in this example is 33%.

- *For three TMDLs (1 nutrient and 2 metals) that are developed for a single waterbody or for a cluster of two waterbodies:* Focusing only on the implementation plan, the nutrient TMDL bears the full burden (i.e. 100%) of the preparation of the plan, but the burden for the first metal is 50% of the full burden and the burden for the second metal is 15% of the full cost. The resulting total burden is equivalent to 1.65 plans (100% + 50% + 15%), saving 45% overall.

- *For three TMDLs for unrelated pollutants for a single waterbody or for a TMDL that is developed for each of three waterbodies clustered together:* Focusing only on the modeling and analysis task, the first TMDL bears the full burden (i.e. 100%) for modeling and analysis, as do the remaining two TMDLs. In the case of this particular task, there are no efficiencies associated with clustering waterbodies or for clustering TMDLs for unrelated pollutants for a waterbody and, therefore, no savings.

- *For three TMDLs (1 nutrient and 2 metals) that are developed for a single waterbody or for a cluster of two waterbodies:* Focusing only on the modeling and analysis task, the nutrient TMDL bears the full burden (i.e. 100%) as does the first metal. However, the burden for the second metal is 25% of the full burden. The resulting total burden is equivalent to 2.25 modeling efforts (100% + 100% + 25%), with a resulting overall savings of 25%.

Exhibits I-5 and I-6 combine the efficiencies shown in Exhibit I-4 with the full unit burden shown in Exhibit I-3 to yield the resulting burden for successive TMDLs developed for a group of causes and/or waterbodies.

Exhibit I-5
Percent of Full Effort (Hours) Needed to Develop a Type B TMDL at 3 Levels of Difficulty
When There Are Standard Efficiencies for Multiple TMDLs for a Waterbody or a Cluster of Waterbodies

Task	% of Full Cost	Level 1		Level 2		Level 3	
		Low	High	Low	High	Low	High
1. Watershed Characterization	25%	40	50	50	60	60	80
2. Modeling and Analysis	100%	24	80	80	480	480	960
3. Allocation Analysis	100%	8	40	40	80	80	120
4. Develop TMDL Doc for Public Review	25%	40	60	60	120	120	160
5. Public Outreach	25%	40	60	60	80	80	120
6. Formal public participation/response	25%	12	30	30	80	80	170
7. Tracking, planning, legal support, etc.	25%	21	40	40	79	79	129
8. Implementation Plan	50%	10	60	60	80	80	120
	Total for Range	195	420	420	1,059	1,059	1,859
	Total for Average	308 hrs		740 hrs		1,459 hrs	

Exhibit I-6
Percent of Full Effort (Hours) Needed to Develop a Type C TMDL at 3 Levels of Difficulty
When There Are Also Efficiencies for Similar Pollutants within a Waterbody or Across Clustered Waterbodies

Task	% of Full Cost	Level 1		Level 2		Level 3	
		Low	High	Low	High	Low	High
1. Watershed Characterization	25%	40	50	50	60	60	80
2. Modeling and Analysis	25%	6	20	20	120	120	240
3. Allocation Analysis	25%	2	10	10	20	20	30
4. Develop TMDL Doc for Public Review	25%	40	60	60	120	120	160
5. Public Outreach	25%	40	60	60	80	80	120
6. Formal public participation/response	25%	12	30	30	80	80	170
7. Tracking, planning, legal support, etc.	25%	21	40	40	79	79	129
8. Implementation Plan	15%	3	18	18	24	24	36
	Total for Range	164	288	288	583	583	965
	Total for Average	226 hrs		436 hrs		774 hrs	

The average burden for each level of difficulty and the extent to which efficiencies are realized from Exhibits I-3, I-5 and I-6 are summarized below in Exhibit I-7.

Exhibit I-7
Summary of the Total Average Unit Burden to Develop a TMDL Taking Efficiencies Into Account

Extent to Which Efficiencies Are Realized	Level 1 (hrs)	Level 2 (hrs)	Level 3 (hrs)
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster	933	1,798	3,175
B. TMDLs with standard efficiencies: subsequent causes for a water or clustered waters	308	740	1,459
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	226	436	774

Following are several additional examples of how the average burdens summarized in Exhibit I-7 apply to different situations. To simplify comparison among the examples, all pertain to groups of Level 2 TMDLs that are developed for a single submission.

- *Single Level 2 TMDL:* The total effort is 1,798 hours.
- *5 TMDLs for a cluster of 5 waterbodies, each with a single Level 2 TMDL, all unrelated pollutants:* The combined effort is 4,758 hours (1,798 + 4 x740).
- *5 TMDLs for a cluster of 2 waterbodies, one waterbody with 3 Level 2 TMDLs and one waterbody with 2 Level 2 TMDLs, all unrelated pollutants:* The combined effort is 4,758 hours (1,798 + 4 x 740).
- *5 TMDLs for a waterbody with 5 Level 2 TMDLs, no related pollutants:* The combined effort is 4,758 hours (1,798 + 4 x 740).
- *5 TMDLs for a waterbody with 5 Level 2 TMDLs, all for metals (or all for nutrients or nutrient-related pollutants):* The combined effort is 3,542 hours (1,798 + 4 x436).
- *5 TMDLs for a cluster of 5 waterbodies, each with 1 Level 2 TMDL, all for metals (or all for nutrients/nutrient-related pollutants, or the same pollutant):* The combined effort is 3,542 hours (1,798 + 4 x436).
- *5 TMDLs for a waterbody with 5 Level 2 TMDLs, composed of 1 pollutant with no efficiencies, 2 metals-related pollutants, and 2 nutrient-related pollutants:* The combined effort is 4,150 hours (1,798 + 740 + 436 + 740 + 436).
- *5 TMDLs for a cluster for 5 waterbodies, each with 1 Level 2 TMDL, composed of 1 pollutant with no efficiencies, 2 metals-related pollutants, and 2 nutrient-related pollutants:* The combined effort is 4,150 hours (1,798 + 740 + 436 + 740 + 436).

C. RESULTING UNIT COSTS ESTIMATES

To estimate the cost of developing TMDLs, we estimated the fully loaded labor cost per hour and applied this result to the burden per TMDL estimated in Exhibit I-7, as discussed below.

1. Fully loaded labor rate per hour

The Gap State Water Quality Management Resource Needs Model (the Gap Model) consensus estimate[12] for the average, median, or typical fully loaded cost for a year of labor for a State is $70,000. The Gap Model's corresponding typical working hours for a State for the $70,000 annual cost is 1,800 hours. The resulting fully loaded hourly rate is $38.89/hour ($70,000/1,800 hours). This fully loaded labor rate includes all of the following labor-related costs:[13]

- direct salary paid,
- paid or accrued vacation and sick leave,
- cost of other fringe benefits (e.g., health, pension, etc.),
- general training,
- indirect expenses such as professional support (e.g., clerical, accounting & supervisory),
- office space, utilities, and telephone service, and
- equipment (e.g., fax machines, basic computing needs such as hardware & software, etc.)

For this report, we used the consensus estimate for the typical fully loaded cost in the Gap Model to estimate the national cost associated with the burden to develop TMDLs. As described in Appendix A, when estimating State- specific costs, the labor costs for the States should be used instead of the average.

2. Unit cost estimates

Applying the loaded hourly labor cost of $38.89 to the burden summarized in Exhibit I-7 results in the following estimates of cost in Exhibit I-8.

[12] Version 5.1 (January, 2001) based on consensus default estimates dated March, 2000. See Appendix A (Section A.2.) for a list of the 18 States and the 8 associations that participated in the Gap Analysis Effort.

[13] It should be noted that this rate, while comprehensive, does not include an allowance for computer maintenance or periodic upgrades of hardware or software.

Exhibit I-8
Summary of the Total Average Unit Cost to Develop a TMDL Taking Efficiencies Into Account

Extent to Which Efficiencies Are Realized	Level 1 (2000 $)	Level 2 (2000 $)	Level 3 (2000 $)
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster	$36,284	$69,924	$123,476
B. TMDLs with standard efficiencies: subsequent causes for a waterbody or cluster	$11,978	$28,779	$56,741
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	$8,789	$16,956	$30,101

Applying these average unit costs to the same examples described previously in conjunction with Exhibit I-7, the following shows how the costs summarized in Exhibit I-8 apply to different situations.

- *Single Level 2 TMDL:* The total cost is $69,924 as shown in Exhibit I-8.

- *5 TMDLs for a cluster of 5 waterbodies, each with a single Level 2 TMDL:* The combined cost is $185,040 ($69,924 + 4 x$28,779).

- *5 TMDLs for a cluster of 2 waterbodies: one waterbody with 3 Level 2 TMDLs and one waterbody with 2 Level 2 TMDLs, no related pollutants:* The combined cost is $185,440 ($69,924 + 4 x $28,779).

- *5 TMDLs for a waterbody with 5 Level 2 TMDLs, no related pollutants:* The combined cost is $185,440 ($69,924 + 4 x $28,779).

- *5 TMDLs for a waterbody with 5 Level 2 TMDLs, all for metals (or all for nutrients or nutrient-related pollutants):* The combined cost is $137,748 ($69,924 + 4 x$16,956).

- *5 TMDLs for a cluster of 5 waterbodies, each with 1 Level 2 TMDL, all for metals (or all for nutrients or nutrient-related pollutants):* The combined cost is $137,748 ($69,924 + 4 x$16,956).

- *5 TMDLs for a waterbody with 5 Level 2 TMDLs, composed of 1 pollutant with no efficiencies, 2 metals-related pollutants, and 2 nutrient-related pollutants:* The combined cost is $161,394 ($69,924 + $28,779 + $16,956 + $28,779 + $16,956).

- *5 TMDLs for a cluster of 5 waterbodies, each with 1 Level 2 TMDLs, composed of 1 pollutant with no efficiencies, 2 metals-related pollutants, and 2 nutrient-related pollutants:* The combined cost is $161,394 ($69,924 + $28,779 + $16,956 + $28,779 + $16,956).

As illustrated above, the unit burden in Exhibit I-7 and the associated unit costs in Exhibit I-8 provide a building-block basis for estimating the total burden and costs associated with a TMDL submission, which can comprise multiple TMDLs for multiple waterbodies. Using this approach, it should be apparent that the total cost associated with a submission for a group of TMDLs can far exceed the costs for a single

TMDL as represented in Exhibit I-8. For example, using the methodology applied in this report, single submissions composed of Level 3 TMDLs for many waterbodies, or waterbodies with many Level 3 TMDLs can have combined TMDL development costs in excess of $1,000,000.

D. Comparison of Estimated Costs with Actual Costs and Other Estimates

For selected TMDLs already developed or for other projections of future costs, information was generally available on either a burden (hours) basis or on a cost basis, but not both. We validated our estimates by comparing our estimated burden or costs to the actual or estimated burden or costs as appropriate. We made the following comparisons:

1. Comparison of estimated versus actual costs for 131 TMDLs

2. Comparison with the Washington State Workload Model

3. Comparison with the May 1996 EPA Report containing 14 case studies of TMDL cost

4. Comparison with the Gap State Water Quality Management Resource Needs Model

5. Comparison with commonly cited high-cost TMDLs

Each of these is summarized below and discussed in detail in Appendices B-H.

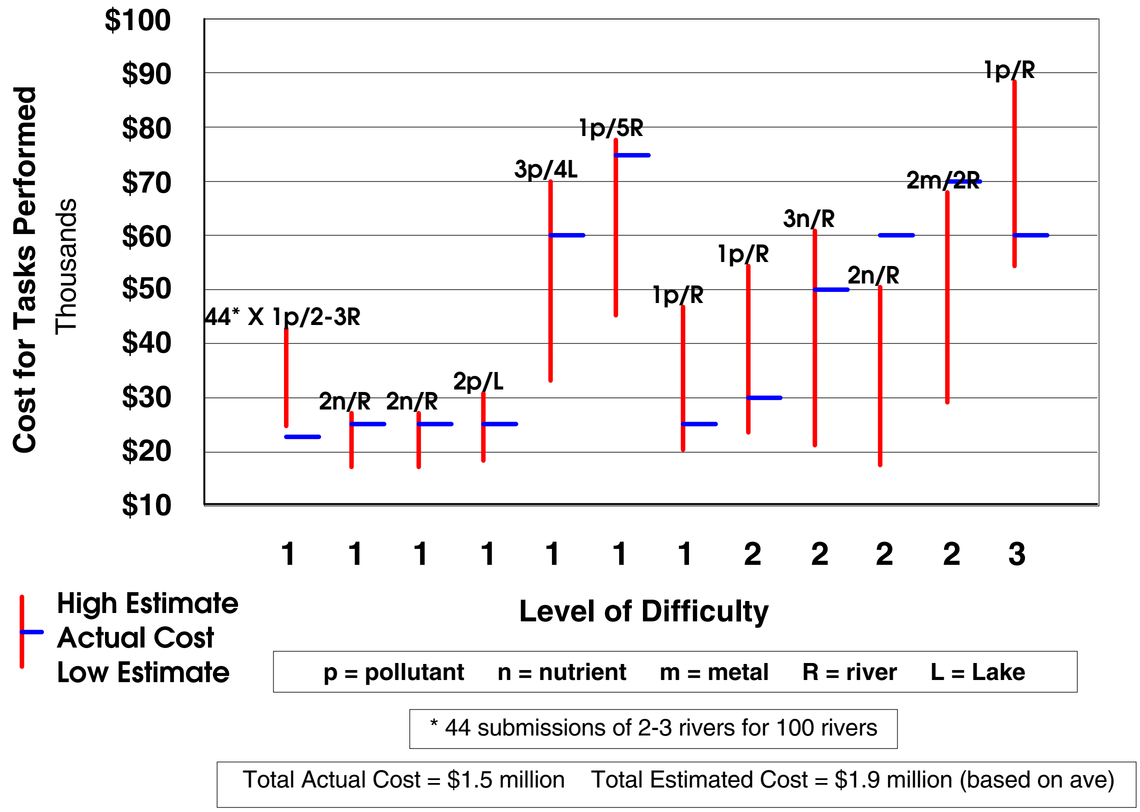
1. Comparison of estimated vs actual costs for 131 TMDLs

The nine sets of unit costs (shown in Exhibit I-8) were validated primarily by comparing the TMDL development costs that result from applying the estimated costs with the known TMDL development costs for 131 TMDLs. These 131 TMDLs, which were developed by an EPA Region and an EPA contractor, represent a variety of pollutants in 8 States across 5 EPA Regions, and include all three levels of difficulty and both types of efficiencies. For each of the 131 TMDLs, we identified which of the 8 specific tasks were performed by the contractor, state and/or the EPA Region, and the actual cost associated with these tasks. We then developed cost estimates for these tasks using the “low” and “high” unit cost estimates found in Exhibits I-3, I-5 and I-6, taking into consideration the level of difficulty, whether the waterbodies were clustered, whether there were multiple causes for waterbodies, and whether modeling efficiencies could be realized. The comparison of the estimated cost with the actual cost is summarized in Exhibit I-9. Each vertical line represents the range of costs that we estimated for a submission using the appropriate unit costs from Exhibits I-3, I-5 or I-6 for each of the tasks performed, adjusted as appropriate to reflect the level of difficulty of the analysis, standard efficiencies and modeling efficiencies. The actual cost is seen on the chart as a horizontal tick. The exhibit provides additional information for each submission including the level of difficulty, the number of pollutants, whether the pollutants are related, and the number and type of waterbodies in the submission. The first bar is different from the others in that it represents 44 submissions – each submission consisted of Level 1 TMDLs for one pollutant in a cluster of 2-3 rivers.

As can be seen from the Exhibit, the actual costs for each of the case studies tend to be either below or well within the range of costs estimated in this chapter. Further, the total actual cost for all 131 TMDLs is $1.5 million, which compares favorably with an estimated average cost of $1.9 million in a range of $1.4 - $2.5 million based on the unit burden in Exhibits I-3, I-5 and I-6. This shows that the unit

Exhibit I-9

Actual vs Estimated Costs For 131 TMDLs
In 55 Submissions for 119 Waterbodies
For Subsets of Tasks For Developing TMDLs



costs estimated in this report, including those representing efficiencies in TMDL development, are reasonably accurate for the purpose of estimating national cost. This comparison is described in detail in Appendix B.

2. Comparison with the Washington State Workload Model

As detailed in Appendix D, we were able to evaluate the methodology developed in this report by comparing its results to the estimates from a detailed workload model developed by the Washington State Department of Ecology for its expected cost to implement Section 303(d).[14] About 1/3 of the total effort estimated by Washington State is associated with the cost of developing TMDLs as specifically defined in

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[14] *Total Maximum Daily Loads Workload Model, Program Definition and Cost, Implementing Section 303(d) of the federal Clean Water Act in Washington State*, Dept of Ecology, Ecology Publication #98-26, July 1998

this report, and the remaining 2/3 is associated with listing and implementing TMDLs. Overall, the basic methodology and the unit burden estimates developed in this report provide similar results to the more detailed State-specific assessment developed by Washington State.

In the absence of taking State-specific factors into account, applying all of the national average estimates in this report to Washington State's workload results in a cost estimate that substantially exceeds that estimated by the Washington State Model. To focus on the validity of the national average unit burdens in Exhibit I-7, we modified the national model to take into account key state-specific factors, including Washington State's: more aggressive efforts to cluster waterbodies than we assumed for the national average, relatively lower percentage of more-difficult TMDLs than we assumed nationally (22% for Levels 2 and 3 combined for Washington State versus the 75% we assumed nationally), and higher average salary rate than we assumed for the national average. When adjusted for these state-specific factors, the resulting estimates are reasonably close to Washington State's estimates, but still exceed them by 4%-20%.[15] Therefore, based on this comparison, this report's average unit costs and general methodology regarding efficiencies appear to be reasonably accurate, and may be more likely to over-estimate cost than to under-estimate cost.

3. Comparison with the 1996 EPA report containing 14 case studies of TMDL cost

In 1996, to begin to develop an understanding of the costs associated with developing TMDLs, EPA prepared an initial analysis, *TMDL Development Cost Estimates: Case Studies of 14 TMDLs* (May, 1996), which, for convenience, we refer to as the "1996 Report." While the 1996 Report provided a helpful start in understanding this topic, the results of that study cannot be directly applied to the purpose of estimating either the average cost or the national cost of developing TMDLs for several reasons:

- the costs in that study are probably not representative of current costs,[16]
- the 14 cases are not representative of the national TMDL workload,
- the costs include monitoring and implementation costs, not just TMDL development, and
- the costing methodology is inconsistent across the 14 cases.

Therefore, the results of the 1996 Report cannot be used directly. Instead, each case in the 1996 Report requires careful evaluation and adjustment to extract information that could be helpful for estimating the average cost of developing TMDLs or the national cost of developing TMDLs.

As discussed in detail in Appendix E, once the useful information from the 1996 Report is properly extracted, adjusted and evaluated, the results tend to be consistent with the conclusions of this analysis:

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[15] The reason for this range is that the Washington State workload model estimated a range for the cost of developing its TMDLs

[16] The cases represent experience in developing TMDLs as of 1995 or earlier. Much has been learned since then regarding more efficient approaches for developing TMDLs. In addition, some of the cases represent costs associated with learning how to develop TMDLs or are forecasts of costs for TMDLs that were about to be developed made by staff that had little experience in actually developing TMDLs.

- the range for the unit costs for developing TMDLs as estimated in this report encompasses the costs in the 1996 Report, and

- applying the costs extracted from the 1996 Report in a manner that reflects the national TMDL workload to estimate a national average cost of developing TMDLs results in an average cost that is similar to that estimated in this analysis (the costs from the 1996 Report result in an average cost per TMDL that is only about 10% higher, which would be expected since the 1996 Report likely overstates today's TMDL development costs.).

Therefore, we conclude that the data in the 1996 Report tend to validate the results of this analysis.

4. Comparison with the Gap State Water Quality Management Resource Needs Model

We attempted to compare the unit burdens (shown in Exhibit I-7) with those estimated in the Gap State Water Quality Management Resource Needs Model (version 5.1, January 2001). The Gap Model includes a module for the cost associated with developing TMDLs, which adopts the same approach of using three levels of difficulty to represent a range of costs for developing TMDLs as used in this report. The Gap Model is designed to allow States to enter their specific circumstances, but includes consensus-based default estimates judged to be representative of the typical State.

However, as described in Appendix C, we are unable to directly compare the unit burdens in this report to the consensus default estimates in the Gap Model for two reasons:

- the model's consensus estimates combine the consideration of a number of factors to an unspecified degree (such the potential magnitude and incidence of efficiencies – in particular, no explicit provision is made for estimating the unit costs for Type B or Type C TMDLs); and

- some of the model's tasks for developing TMDLs may include some effort that would be for implementation rather than for development as defined in this report.

Therefore, we could not compare the unit burdens in this report with those of the Gap Model.

We note that this report adopted the Gap Models' typical fully loaded labor cost, and as shown in Chapter II, we assume that the difficulty of the TMDL workload will be greater than the Gap Model's default estimates.

5. Comparison with commonly cited high-cost TMDLs

We also considered a number of the commonly-cited high-cost TMDLs:

- Long Island Sound

- Dissolved oxygen TMDL for Tallahala Creek in Jones Count, Mississippi

- Phosphorous TMDL for the Bosque watershed in Texas

- TMDLs in Florida

- TMDL for the Waccamaw River in South Carolina

As discussed in Appendix F, we found that in nearly all of these cases, the cited costs include costs for activities that are not specifically part of the TMDL development activities evaluated in this report, such as monitoring costs and implementation costs. While these costs may be appropriate to estimate the total costs borne to achieve water quality, they do not represent the activities we addressed. Further, in a number of cases the cited costs are simply not relevant because they are outdated, representing early efforts to develop TMDLs without the benefit of prior experience and or now available advances in the state-of-the-art. Finally, some of these cases are very complex and/or have unusually large spatial extent, and the cost of developing TMDLs for them is not representative of the effort typically (i.e. nationally) needed to develop TMDLs.

II. CHARACTERISTICS OF THE TMDL DEVELOPMENT WORKLOAD

The TMDL workload analyzed in this report results from the pollutant causes identified in the 1998 303(d) lists. This chapter provides an overview of the 1998 303(d) list and useful perspective on both the magnitude of the workload associated with the 1998 list and several key characteristics that can affect the cost of developing TMDLs. As explained previously, these characteristics include the extent to which waterbodies are likely to be clustered for TMDL development or the extent to which individual waterbodies require multiple TMDLs.

As discussed in detail in this chapter, several additional factors should be considered when estimating the total TMDL development workload:

- pollutant causes of impairment in the 1998 303(d) list that are subsequently delisted,
- pollution causes of impairment in the 1998 303(d) list that are subsequently found to be caused by pollutants (therefore requiring TMDLs be developed for them),
- TMDLs already developed for the 1998 303(d) list by the start of the study period,
- the extent to which efficiencies in developing TMDLs are realized, and
- new pollutant causes identified in future lists (i.e., 2002, 2006, 2010, etc.).

For this analysis, we considered the extent to which some TMDLs for the 1998 list have already been developed prior to 2000, the extent to which pollution causes of impairment might eventually be found to be caused by pollutants, the extent to which efficiencies in developing TMDLs might be realized, and the extent to which new pollutant causes might be identified in future lists. However, we did not consider the extent to which previously identified causes will be delisted in the future.

This chapter is organized as follows:

A. Overview of the TMDLs required for the 1998 303(d) Lists
B. TMDL workload for the 1998 303(d) Lists
C. TMDL development trends for the 1998 303(d) Lists
D. TMDL workload for impaired waterbodies identified in future lists

A. OVERVIEW OF THE TMDLS REQUIRED FOR THE 1998 303(D) LISTS

This section describes four key characteristics of the 1998 303(d) lists:

1. number of waterbodies affected and number of TMDLs to be developed,
2. distribution of the number of causes by waterbody,
3. number of waterbodies that have several similar causes, and
4. expected level of difficulty.

As discussed earlier, these are important characteristics because they generally affect the cost of developing TMDLs.

1. Number of waterbodies affected and TMDLs to be developed

The 1998 303(d) lists identify 21,851 waterbodies that are not attaining water quality standards as a result of 41,881 causes of impairment of various types.[17] It is important to remember that these causes include both "pollution" and "pollutant" causes, and that only pollutant causes are required to have TMDLs developed for them. Of the 41,881 reported causes, 5,656 causes are for pollution[18] so that TMDLs are required for 36,225 causes. Detail regarding the sources and causes of impairment is provided in Appendix H. Of the 21,851 listed waterbodies, 2,240 are listed solely due to pollution causes for which TMDLs are not required. The remaining 19,611 waterbodies each have at least one pollutant cause and, therefore, at least one TMDL required for them.

2. Distribution of the number of causes by waterbody

While most of the waterbodies in the 1998 303(d) lists have only one pollutant cause, 42% of the waterbodies have more than one cause, and over 20% have three or more causes; Over 2/3 of the causes are for waterbodies that have two or more causes. This is important because, as discussed in Chapter I, the development costs for successive TMDLs for a waterbody will be less due to both the availability of readily applicable information from the first TMDL that was developed and the opportunity to jointly perform some TMDL development tasks for several TMDLs at the same time. Additional information regarding the distribution of number of causes across waterbodies is provided in Appendix H. Of course, this does not reflect the additional efficiencies that can be achieved when causes for multiple waterbodies are clustered together in a submission.

3. Number of similar causes for waterbodies with multiple pollutants

In addition to realizing those efficiencies that result when developing multiple TMDLs for a waterbody, about 24% of the pollutant causes will also realize modeling-related efficiencies because they are similar to other causes that are being modeled (e.g., multiple nutrients, multiple metals, etc.). As discussed further later in this chapter (II.C TMDL Development Trends for the 1998 303(d) Lists), far greater modeling-related efficiencies can be achieved across waterbodies when waterbodies are clustered.

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[17] Note that 337 of the 21,851 waterbodies did not have any causes specified for them, and we did not feel it appropriate to attribute "zero" causes to these 337 waterbodies. Therefore, we assumed that these 337 waterbodies had either 1, 2, or 3 causes in the same proportion as the rest of the waterbodies (we felt this to be representative since about 85% of the 21,851 waterbodies have either 1, 2 or 3 causes associated with them). Applying this procedure results in an estimate of 550 causes for the 337 waterbodies, and this amount is included in the total of 41,881causes. Further, we assumed that all 550 causes were "pollutant" causes requiring the development of TMDLs, even though about 15% of all reported causes are for "pollution" and would not require TMDLs.

[18] It is possible that a portion of the pollution causes may be found to be the result of pollutant causes, requiring TMDLs be developed for them. This is accounted for in this analysis as described in II.B. TMDL Development Workload for the 1998 303(d) Lists.

4. Level of difficulty

Generally, we anticipate that there will be more TMDLs nationally at Level 1 than Level 2, and more TMDLs at Level 2 than Level 3. For this analysis, we assumed the following national distribution:

Exhibit II-1
National Distribution of Level of Difficulty for Developing TMDLs

Difficulty Level	% of Pollutant Causes
1	45%
2	30%
3	25%

This national estimate is generally consistent with the Gap State Water Quality Management Resource Needs Model. The Gap Model's estimated defaults for the number of Level 1, 2 and 3 TMDLs for the first five years (rather than for the entire 1998 303(d) lists as was estimated for this report) are:

		Yr 1	Yr 5	Yr 1-5
Level 1	80%	42%	60%	
Level 2	15%	42%	30%	
Level 3	5%	16%	10%	

Relative to the default estimates in the Gap Model, it would appear that the distribution assumed in this report may overestimate the number of Level 3 TMDLs. However, the Gap Model defaults may simply reflect the possibility that States may be targeting the less difficult TMDLs in the near term.

The national estimate appears very conservative when compared to the distribution of difficulty reflected in the Washington State Workload Model for its 1996 303(d) list, in which (as discussed in Appendix D) about 78% are Level 1, about 7% are Level 2, and 15% are Level 3 TMDLs.

B. TMDL Development Workload for the 1998 303(d) Lists

This section describes the factors affecting the total workload, the resulting estimated workload associated with the 1998 303(d) lists, and the distribution of the workload over time.

1. Factors affecting the total workload for the 1998 303(d) lists

The number of TMDLs is one of the most important estimates affecting the expected cost of developing TMDLs. The key factors to consider when estimating the number of TMDLs to be developed for the 1998 303(d) lists include the number of:

i. pollutant causes identified in the 1998 303(d) list,
ii. pollution causes subsequently identified as due to pollutants,
iii. TMDLs already developed for the 1998 303(d) list, and the
iv. pollutant causes in the 1998 303(d) list that are subsequently delisted.

Each of these is discussed below.

i. Pollutant causes identified in the 1998 303(d) list

For the causes identified in the 1998 303(d) list, only those 36,225 causes that are due to pollutants and that do not already have TMDLs are relevant for this analysis (these are termed "Part 1" listings). Among causes that do not result in additional effort for developing TMDLs: those due to "pollution" ("Part 2" listings), those resolved without a TMDL by the next listing cycle ("Part 4" listings), and those already having a TMDL ("Part 3" listings).

ii. Pollution causes that are due to pollutants

There were 5,656 pollution causes identified in the 1998 303(d) lists, of which 1,439 were due to impaired biological communities and 963 were identified as due to noxious aquatic plants, taste and odor and debris. A portion of these 2,402 pollution causes may be found to be the result of pollutant causes, requiring that TMDLs be developed for them. For this analysis, we assumed that perhaps 1,000 of these 2,402 impairments would be found to be due to pollutant causes, requiring an additional 1,000 TMDLs. Therefore, we assume there will be 4,546 pollution causes. We further assumed that these cases would most likely occur for waterbodies for which other pollutant causes had already been identified.[19]

iii. TMDLs already developed for the 1998 303(d) list prior to 2000

Some portion of the TMDLs resulting from the 1998 303(d) list will have been developed and approved prior to 2000 (Part 3 listings, which include any previously listed cause for which TMDLs have been developed, but attainment not yet achieved) and fall outside an analysis of cost that starts in 2000. From October 1999 through early February 2000, EPA had approved over 600 TMDLs[20] while about 1000 TMDLs had been approved prior to October 1999 (a portion of these were approved prior to the 1998 303(d) lists and would not have been included on the 1998 lists). We assumed that perhaps 1,000 TMDLs included on the 1998 303(d) list were developed by February 2000. Therefore, these TMDLs are deducted from the total workload to estimate one that starts in 2000.

i*v. Pollutant causes in the 1998 303(d) list that do not require TMDLs*

These are pollutant causes of impairment in the 1998 303(d) listing that future monitoring eventually prove to show that a TMDL is not required. States have often listed waterbodies conservatively, choosing to list waterbodies even though the information suggesting that it is impaired is very limited. Subsequent monitoring may find that the waterbody is not impaired. In addition, some pollutant causes may be listed under Part 4, for which no TMDLs are required because WQS will be achieved by other means by the next listing submission. We have not estimated either of these cases in this analysis. To the

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[19] Therefore, we only increase the number of TMDLs that need to be developed. Alternatively, if we had assumed that these cases also included waterbodies that were identified as being impaired by pollution only, then it would be appropriate to also increase the number of waterbodies affected.

[20] Testimony of J. Charles Fox, Assistant Administrator for Water, U.S. Environmental Protection Agency before the Subcommittee on Water Resources and Environment of the Committee on Transportation and Infrastructure, U.S. House of Representatives, February 10, 2000.

extent delisting or listing under Part 4 occurs, this analysis overstates the national cost of developing TMDLs.

2. Resulting total workload

Applying the four factors in the previous section to all of the causes of impairment identified in the 1998 303(d) lists results in a total remaining TMDL workload (as of the beginning of 2000) for the 1998 303(d) lists of 36,625 TMDLs as shown in Exhibit II-2 below.

Exhibit II-2
Total TMDL Workload for the 1998 303(d) Lists as of 2000

i & ii	**Total causes of impairment identified in the 1998 303(d) lists**	**41,881**
	Less pollution causes identified in the 1998 303(d) lists	4,656
	Subtotal: Total pollutant causes in the 1998 303(d) lists	37,225
iii	Less TMDLs for the 1998 303(d) causes developed prior to 2000	(1,000)
iv	Less pollutant causes listed in the 1998 303(d) lists found not to require TMDLs	not estimated
	Total number of TMDLs for the 1998 303(d) lists analyzed in this report	**36,225***

*Of these 36,225 TMDLs, perhaps 1,000 were developed during 2000.

C. TMDL Development Trends for the 1998 303(d) Lists

This section describes the current program in terms of:

1. the extent to which States are clustering TMDL development to capture efficiencies, and

2. the pace of TMDL development.

1. Extent that clustering for TMDL development is expected

As described in this section, States are already beginning to aggressively manage their TMDL workloads to garner the cost savings that results when coordinating the development of multiple TMDLs. The extent to which States realize these efficiencies is likely to increase in the future as States establish plans and set TMDL development priorities with these cost savings in mind. For the 1998 303(d) lists, we estimated the maximum potential for realizing efficiencies from clustering. In addition, we identified current trends based on the characteristics of a comprehensive sample of 1,096 recent TMDL submittals to EPA, State workload models, and other information regarding general trends. We used this information to estimate the extent to which States will employ clustering when developing TMDLs. The maximum potential for realizing clustering efficiencies, current trends, and the resulting estimates used in this analysis are described below.

a. Maximum Potential for Achieving Clustering Efficiencies

We estimated the maximum potential for realizing efficiencies from clustering through a detailed analysis for all of the 1998 303(d) impaired waterbodies for which adequate data were available. Adequate data were available for 15,012 waterbodies including 25,494 pollutant causes, representing 77% of the waterbodies and 70% of the pollutant causes for the 1998 303(d) lists.[21]

As described in detail in Appendix G, we began by grouping the listed waterbodies that were located in the same watershed as defined by the 8-digit hydrologic unit code (HUC)[22]. We then identified those waterbodies within the watershed that were interconnected – i.e. those waterbodies that flowed into one another. Each set of waterbodies that were interconnected within watersheds was considered to be associated in a potential "cluster" for which standard (Type B) efficiencies could be realized. In addition, for each cluster (group of associated waterbodies), we identified the extent to which modeling-related (Type C) efficiencies could also be realized because the waterbodies shared similar pollutant causes.

The results of the analysis reveal that the 15,012 waterbodies could be grouped into 2,995 clusters, so that 12,017 of the waterbodies (80%) could realize standard clustering efficiencies. From the analysis described in Appendix G we could determine that modeling efficiencies could be realized for 18,445 of the pollutant causes.[23] Thus, the sample of 25,494 pollutant causes would be grouped as follows:

Exhibit II-3
Maximum Efficiencies for the Sample of 25,494 Pollutant Causes

Description of the Submission	Total
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster	2,995
B. TMDLs with standard efficiencies: subsequent causes for a waterbody or clustered waterbodies	4,054
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	18,445

[21] As discussed in Appendix G, there was inadequate data available to analyze the waterbodies in Region X. Since the waterbodies in Region X represent 23% of the waterbodies but 30% of the pollutant causes, this might imply that even greater clustering efficiencies might be realized for Region X than for the waterbodies analyzed.

[22] The U.S. Geologic Survey divides the nation into successively smaller hydrologic units: 21 major regions, which are then subdivided into 222 subregions which include areas drained by a river system, a reach of river and its tributaries in that reach, a closed basin(s) or a group of streams forming a coastal drainage area. A third level of classification subdivides the subregions into 352 units that nest within the subregions. The fourth, smallest unit in the hierarchy, is the cataloging unit which represents part or all of a surface drainage basin, a combination of drainage basins or a distinct hydrologic feature. The hydrologic units are identified with a unique code ranging from 2 to 16 digits – the more digits, the smaller the size of the unit. The 6 digit HUCs are generally referred to as basins and the 8 digit HUCs are generally referred to as sub-basins. There are 2,262 8-digit HUCs in the U.S. Although many states have defined smaller watersheds, the 8-digit level is the smallest watershed delineation uniformly available throughout the United States and is an appropriate size for planning and for larger scale assessment.

[23] Of the 18,445 pollutant causes that can realize modeling efficiencies, 3,624 of the pollutant causes realize efficiencies because they are similar pollutants within the same waterbody, while 14,821 of the pollutant causes realize modeling efficiencies because they are similar pollutants across waterbodies in a cluster (the waterbodies in a cluster flow into one another within a watershed, and therefore can benefit from modeling efficiencies).

Total Number	25,494

According to the convention developed in Chapter I, the first TMDL for a cluster requires the full cost (i.e., realizes no efficiencies), so that there are 2,995 Type A TMDLs. Therefore, the remaining 22,499 TMDLs receive some type of clustering efficiencies (Type B or Type C). We evaluated each of the 2,995 clusters to determine that 18,455 of these 22,499 pollutant causes (i.e., 82%) would receive maximum (Type C) efficiencies, so that the remaining 4,054 TMDLs would receive only standard (Type B) cluster efficiencies.

Therefore, substantial efficiencies can potentially be realized if waterbodies are clustered for TMDL development. The extent to which waterbodies have been clustered and current trends are discussed next.

b. Recent Clustering Efficiencies – Sample of 1,096 TMDLs

A comprehensive sample of 1,096 TMDLs recently submitted to EPA provides the basis for assessing the extent to which efficiencies in TMDL development are already being realized. As explained previously, a TMDL represents an individual pollutant and waterbody combination (e.g., a waterbody with two pollutants requires two TMDLs). A submittal is one document that can contain many TMDLs, as might be the case for a waterbody with multiple pollutants and/or for a watershed with multiple waterbodies. This sample is a compilation of submittals to EPA over the period April 1998 through September 2000 (nearly all of these submittals were approved by EPA, with the remainder still under review). The 1,096 TMDLs represent 496 submittals for 668 waterbodies by 35 States in 9 EPA Regions for over 60 different types of causes

Overall, 429 of the waterbodies were in single-waterbody submissions; 239 of the waterbodies were clustered together in 67 multiple-waterbody submissions. Therefore, about 36% of the waterbodies were in clustered submissions (239/668), so that about 26% of the waterbodies (239-67) benefitted from clustering efficiencies. The sample of 1,096 TMDLs shows further substantial evidence of the use of efficient methods for developing TMDLs:

- About 45% of the 496 submissions realized some form of efficiency.
- About 55% of the 1,096 TMDLs realized some form of efficiency.
- About 54% of the 668 waterbodies realized some form of efficiency.

Appendix G provides additional detail regarding these results.

As discussed below, there is substantial additional evidence that States are already applying techniques for achieving efficiencies and are likely to increase their use in the future.

c. State Workload Models

States with basin approaches to planning have built in the efficiencies associated with clustering. In other cases, States have planned their workload based on clustering TMDLs. For example, Washington State's published TMDL Workload Model (dated July, 1998), uses "projects" as the unit of analysis, which Washington State defines as "....a grouping of individual waterbody segments and/or parameters of concern. A project likely contains many individual TMDLs." Washington State also groups the projects into several categories representing the difficulty of developing TMDLs for them. Accordingly, Washington State grouped its TMDLs into 173 projects comprising 672 waterbodies with 1,560 causes of impairment. This averages to about 4 waterbodies with about 9 TMDLs per project. Overall, 74% of the waterbodies were planned to achieve clustering efficiencies (499/672) and 89% of the causes of impairment were planned to achieve clustering efficiencies (1,387/1,560). Additional detail regarding the Washington State workload model is provided in Appendix D.

d. General Trends

States develop TMDLs in accordance with their priority ranking and schedule as submitted in their periodic 303(d) lists. The revised TMDL rule explicitly encourages States to consider basin planning when developing their priority ranking and schedule for TMDL development in order to take advantage of the efficiencies this provides. As States develop more TMDLs, they increasingly cluster waterbodies for the sake of concurrent TMDL development because they recognize that watershed-based clustering presents cost savings for all tasks. Watershed-based clustering is also consistent with internal State management. Twenty-five States already use a basin planning approach to address monitoring, evaluation, public meetings and permitting efforts. Some States and EPA Regions are under consent decree to develop TMDLs under a court mandated schedule, and nearly half of these identify a basin planning approach for development of TMDLs.

The general trend is clearly in the direction of increasing clustering to take advantage of efficiencies in developing TMDLs.

e. Clustering Efficiency Assumed For This Analysis

States are likely to strive to achieve as much cost efficiencies as possible when developing TMDLs. However, as discussed in Appendix G, there are a number of factors that could make it difficult to achieve the maximum cluster efficiency of 80%, especially in the near term for the 1998 303(d) lists. For this analysis, we assume that States will make steady progress in taking advantage of the cost savings that can be realized by clustering waterbodies for TMDL submissions. If States steadily increase their use of clustering over 10 years to then achieve the maximum clustering efficiency, the overall clustering efficiency for the 1998 303(d) lists would average 60%. If States are able to adopt the use of clustering more rapidly, perhaps achieving maximum clustering efficiency over 5 years, the overall clustering efficiency for the 1998 303(d) lists would average 70%.

For this analysis, we estimate a range for the cost of developing TMDLs for the 1998 303(d) lists based on the assumption that national clustering efficiencies will average 60%-70%. For causes identified in future lists, we assume that TMDLs for them will be developed with the maximum clustering efficiency of 80%. The resulting distribution of workload by type of TMDL for the 1998 303(d) lists is shown in Exhibit II-4:

Exhibit II-4
National TMDL Workload (number of TMDLs) for the 1998 303(d) Lists for Two Scenarios for Clustering

Description of the Submission	% Waterbodies Clustered	
	60%	70%
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster of waters	7,844	5,883
B. TMDLs with standard efficiencies: subsequent causes for a waterbody or cluster of waterbodies	5,113	5,467
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	23,268	24,875
Total Number	36,225	36,225

2. Distribution of the TMDL development workload over time

When States submitted their 1998 303(d) lists, they committed to overall schedules for completing the TMDLs that would be needed to achieve water quality standards for these impaired waterbodies. Based on the States' commitments, virtually all TMDLs (over 99.5%) would be developed by 2013, with only perhaps 100 of the 36,225 TMDLs for the 1998 303(d) lists scheduled to be completed over the period 2014-2018. However, the recent revisions to the TMDL regulation would allow States to complete these TMDLs by 2015. Therefore, in this report, we assumed that the States would use the additional time allowed by the regulation and would complete the development of the TMDLs for the 1998 303(d) lists by 2015.

However, the pace at which States would actually develop TMDLs over this period is unclear. For simplicity, we assumed in this report that the States would develop TMDLs at a roughly uniform rate over the sixteen year period from 2000 to 2015, yielding about 2,350 TMDLs per year.

Current indications are that States are initially developing TMDLs at a slower rate than assumed in this report. We estimate that about 1,000 TMDLs were developed prior to 2000 for causes identified on the 1998 303(d) lists, and that perhaps another 1,000 TMDLs were developed in 2000. Therefore, it appears that States are in the process of building up their capacity to develop TMDLs. In addition, the revisions to the TMDL regulation encourage States to take advantage of the cost savings that can result from coordinating the development of TMDLs on a watershed basis, and in order to accomplish this, more of the TMDLs may be developed in the latter years relative to a uniform national rate.

Exhibit II-5 illustrates the uniform national pace of developing TMDLs assumed in this report, as well as an alternative "transition" pace in which States start at the current rate of about 1,000 TMDLs in the year 2000 and steadily increase the pace each year to about 2,550 in the year 2005 and remain at that rate to fully complete the workload of 36,225 TMDLs by 2015. We note that both the uniform and transition paces are consistent with the schedules for TMDL development required in the court orders that resulted from citizens suits regarding timely establishment of TMDLs.

Exhibit II-5
Example Alternative National Paces for Developing the TMDLs for the 1998 303(d) List

Year of Completion	# TMDLs Completed	
	Uniform Pace	Transition Pace
2000	1,000	1,000
2001	2,350	1,310
2002	2,350	1,620
2003	2,350	1,930
2004	2,350	2,230
2005	2,350	2,550
2006	2,350	2,550
2007	2,350	2,550
2008	2,350	2,550
2009	2,350	2,550
2010	2,350	2,550
2011	2,350	2,550
2012	2,350	3,550
2013	2,350	3,550
2014	2,350	3,550
2015	2,325	3,635
Total	36,225	36,225

D. TMDL Workload for Impaired Waterbodies Added By Future Lists

This section provides perspective on the total number of new causes that might be identified in the future, the rate at which these new causes might be listed, and the resulting distribution of this workload over time. While this discussion is necessarily speculative, it does provide an indication of the additional workload and its timing.

1. Perspective on the total number of new causes that might be added in the future

To date, States have monitored or assessed only a portion of their waterbodies. In the future, there will likely be new listings each cycle (e.g., 2002, 2006, 2010, 2014, 2018). These new listings might identify the need to develop additional TMDLs beyond those identified in the 1998 303(d) listing. Based on the National Water Quality Inventory Report for Congress for 1998,

- 23% of the Nation's river and stream miles have been assessed; 35% of these do not fully support water quality standards or uses and an additional 10% are threatened.
- 32% of the estuary acres have been assessed; 44% of these do not fully support water quality standards or uses and an additional 9% are threatened.

- 42% of lake, pond and reservoir acres (not including the Great Lakes) have been assessed; 45% of these do not fully support water quality standards or uses and an additional 9% are threatened.

- 90% of the Great Lakes shoreline miles have been assessed, and 96% of the shoreline miles are not fully supporting water quality standards and uses, and an additional 2% are threatened.

Thus, about 1/3 of the Nation's waters have been assessed, leaving 2/3 to be assessed.

As assessment and monitoring efforts expand to cover more of the Nation's waterbodies, more impaired waterbodies needing TMDLs will likely be found. A portion of the causes for the impaired waterbodies that will be identified in the future will have TMDLs developed for them. In addition, a portion of the waterbodies that have already been assessed that are not currently impaired, may be found to be impaired in the future (perhaps a portion of the currently "threatened" waterbodies).

However, the magnitude of the water quality problems yet to be discovered is likely to be far less than might be suggested by only cursory consideration of the above statistics for three reasons:

- ***Many of the unassessed waterbodies are extremely unlikely to be impaired.*** For example, a significant fraction of the unassessed waterbodies are located in areas that are for the most part considered to be pristine (for example, Alaska alone represents over 10% of the unassessed river miles and about half of the unassessed lake acres.) In addition, the reported total river miles doubled from the 1992 to the 1996 305(b) lists to include nonperennial waterbodies (intermittent streams, canals and ditches), which are generally unlikely to be considered impaired[24] and these comprise over 75% of the unassessed river miles.

- ***State monitoring efforts have been focused on waterbodies most likely to be impaired.*** Therefore, it is likely that most major water quality problems have already been identified. This is consistent with the results of a recent report by the General Accounting Office, in which "the state officials we interviewed said they feel confident that they have identified most of their serious water quality problems.[25]. This suggests that the rate of impairment for unassessed waters will be far lower than for assessed waters.

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[24] Many States do not have specific designated uses assigned to nonperennial waters and therefore the States' numeric water quality criteria do not apply (only the narrative criteria apply). Therefore, it is much less likely that States will list these intermittent streams because the issue of use support is not as clear.

[25] U.S. General Accounting Office, *Identification and Remediation of Polluted Waters Impeded by Data Gaps*, GAO/T-RCED-00-131, page 4, March 2000.

- ***Future impairment of currently assessed waters is not likely to be significant.*** If all threatened waters became impaired, then this might increase the current number of TMDLs by perhaps 20%-30%. However, only a portion of these might become actually become impaired because current programs, such as technology-based requirements, and steps taken be States to address threatened waterbodies can potentially prevent a significant portion of threatened waterbodies from becoming impaired.

Overall, it is anticipated that although additional impaired waterbodies will be identified in future listings, it does not appear likely that this will result in a significant increase relative to the current workload for the 1998 303(d) lists.

2. Perspective on the rate at which new causes might be identified in the future

There is little basis for forecasting the rate at which additional impairments will be identified in future listings. From 1972 to 1992, very few States submitted 303(d) lists. By 1996, in response to law suits and increased effort by EPA, all of the 56 States had submitted lists, although these varied in their comprehensiveness. In 1998, in response to the growing number of law suits, most of the 56 States did a thorough job of listing their impaired waterbodies. The increase in the number of pollutant causes in the 1998 303(d) list as compared to the 1996 303(d) list was 4,536 causes. The 1998 lists grew significantly in some States because authorities wanted to minimize the potential for litigation and listed causes for which TMDLs would ultimately not be required (some States are planning on submitting additional information in future listings that will allow them to de-list causes that were previously identified in the 1996 or 1998 listings). The increase of 4,536 causes from the 1996 to the 1998 303(d) lists (about 2,000 causes per year) thus likely overstates the extent to which new pollutant causes will be identified in future listings. In fact, if States do delist TMDLs in the future, some future listings may actually reduce the TMDL workload rather than increase it.

Further, current State monitoring resources are largely committed for waterbodies that have already been assessed and identified as impaired, as well as other monitoring requirements associated with ongoing water program activities. Until the TMDLs for the 1998 303(d) lists are developed, implemented and successful in achieving water quality standards, it seems likely that there will be limited discretionary monitoring resources available for States to assess additional waterbodies. Even then, newly identified impaired waterbodies could also require additional monitoring. Thus, the workload associated with newly identified impaired waterbodies is likely to be spread out over a long period.

Finally, EPA anticipates that new causes will be identified gradually over an extended period of time, in part because States have already focused on those areas most likely to be impaired and so it will take longer to find new impairments, and in part because some waterbodies may not become impaired until some time in the future (for example, waterbodies that are currently “threatened” but not impaired).

3. Hypothetical scenario for perspective on the potential workload for new causes

In this report, we provide some perspective on the potential workload associated with new causes that will be identified in the future. To do so, we estimate the cost for a plausible, but hypothetical, scenario based on the following assumptions regarding 1) the rate at which new pollutant causes will be identified, 2) the period over which new causes will be identified, 3) the rate at which TMDLs will be developed for these causes, 4) the characteristics of the TMDLs that will need to be developed, and 5) the unit costs for developing TMDLs:

- On average, we assume that 1,000 new pollutant causes might be identified in each future listing. However, since a number of States appear to be preparing to de-list causes, we assume that there will not be a net increase in the number of causes in the 2002 listing, and that net new causes will be added starting in the 2006 listing.

- We assume that 1,000 new pollutant causes will be identified for perhaps nine listings, with few remaining causes to be identified after 2038, for a total of 9,000 new causes, which is equivalent to about 25% of the current TMDL development workload for the 1998 303(d) lists.

- We assume that the TMDLs for newly identified causes will be developed uniformly over a 10-year period from being listed. – for 1,000 newly listed causes this would result in 100 TMDLs per year. With the last set of new causes listed in 2038 and this pace of development, the TMDLs for all of the future causes would be developed by 2050.

- We assume that the characteristics of the TMDLs for future causes will be similar to causes already identified, and that by the time these TMDLs are developed it will be possible to do employ the most efficient approaches.

- We assume that the unit costs to develop TMDLs for newly identified causes will be the same as for the 1998 303(d) lists – this assumption tends to overstate costs because we anticipate that with the experience of developing TMDLs for the 1998 303(d) lists, State staff will be increasingly more effective and efficient, and that new methods and technology will become available to further lower TMDL development costs. However, we did not attempt in this report to estimate the extent to which such cost savings would occur over the next five decades, and so relied upon the rather conservative assumption that the unit costs for TMDL development would remain constant in real terms.

This scenario represents a total of 9,000 TMDLs or about 25% of the current workload for the 1998 303(d) lists.

III. NATIONAL COST TO DEVELOP TMDLS

This chapter estimates the national burden and cost associated with developing TMDLs for all of the impaired waterbodies that have already been identified or will be identified in the future, as follows:

- ***Cost of TMDLs for the 1998 303(d) lists***. To estimate the national burden and cost associated with developing all of the remaining TMDLs for the 1998 303(d) lists starting in 2000, we used the unit burdens and costs developed in Chapter I in combination with the estimates in Chapter II regarding the number of TMDLs to be developed, the extent to which submissions will cluster waterbodies, the extent to which multiple TMDLs will be developed for individual waterbodies, the extent to which modeling efficiencies will occur, and the pace of TMDL development. In this chapter, we first summarize the unit burden costs from Chapter I and the TMDL workload from Chapter II, and then combine them to estimate the national cost of developing all of the remaining TMDLs for the 1998 303(d) lists.

- ***Perspective on the potential cost of TMDLs for future 303(d) lists.*** To estimate the national burden and cost associated with developing TMDLs for impaired waterbodies identified in future 303(d) lists, we apply the same unit TMDL development costs used for the 1998 303(d) lists to the hypothetical scenario described in Chapter II.

This chapter is organized as follows:

A. Summary of the National TMDL Workload for the 1998 303(d) lists

B. National Burden and Cost of Developing TMDLs for the 1998 303(d) lists

C. National Burden and Cost of Developing TMDLs for newly listed causes

D. Applicability of These Results to Specific States

E. Potential Future Improvements

A. SUMMARY OF THE UNIT COSTS AND TMDL WORKLOAD FOR THE 1998 303(D) LISTS

Chapter I developed the unit burden and costs for developing TMDLs. Chapter II provided a detailed description of the characteristics of the TMDL development workload for the 1998 303(d) lists starting in 2000. This section reviews the key statistics and estimates that were derived in these Chapters that will be combined to estimate the national cost of developing TMDLs.

1. Review of national average TMDL unit burden and costs

Chapter I developed the national average unit burden (Exhibit I-7) and unit costs (Exhibit I-8) for Type A, Type B and Type C TMDLs. For the reader's convenience, this information is repeated below in Exhibits III-1a and III-1b.

Exhibit III-1a
Summary of the Average Unit Burden to Develop a TMDL Taking Efficiencies Into Account

Extent to Which Efficiencies Are Realized	Level 1 (hrs)	Level 2 (hrs)	Level 3 (hrs)
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster	933	1,798	3,175
B. TMDLs with standard efficiencies: subsequent causes for a water or clustered waters	308	740	1,459
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	226	436	774

Exhibit III-1b
Summary of the Average Unit Cost to Develop a TMDL Taking Efficiencies Into Account

Extent to Which Efficiencies Are Realized	Level 1 (2000 $)	Level 2 (2000 $)	Level 3 (2000 $)
A. TMDLs requiring full cost: the only or first cause for a waterbody /cluster	$36,284	$69,924	$123,476
B. TMDLs with standard efficiencies: subsequent causes for a water or clustered waters	$11,978	$28,779	$56,741
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	$8,789	$16,956	$30,101

2. Review of the national TMDL workload

Chapter II estimated the distribution of TMDLs by level of difficulty (Exhibit II-1) and the TMDL workload by TMDL efficiency based on a range of 60%-70% clustering (Exhibit II-4). Combining the estimates for level of difficulty with the estimates for the TMDL workload yields the number of TMDLs by efficiency type and level of difficulty in Exhibit III-2a (for 60% clustering) and in Exhibit III-2b (for 70% clustering).

Exhibit III-2a
National TMDL Workload (number of TMDLs) for the 1998 303(d) List - 60% Clustering

Description of the Submission	Total 100%	Level 1 45%	Level 2 30%	Level 3 25%
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster	7,844	3,529	2,353	1,962
B. TMDLs with standard efficiencies: subsequent causes for a waterbody or cluster	5,113	2,300	1,533	1,280
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	23,268	10,470	6,980	5,818
Total Number	36,225	16,299	10,868	9,060

Exhibit III-2b
National TMDL Workload (number of TMDLs) for the 1998 303(d) List - 70% Clustering

Description of the Submission	Total 100%	Level 1 45%	Level 2 30%	Level 3 25%
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster	5,883	2,647	1,764	1,472
B. TMDLs with standard efficiencies: subsequent causes for a waterbody or cluster	5,467	2,460	1,640	1,367
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	24,875	11,193	7,462	6,220
Total Number	36,225	16,300	10,866	9,059

B. NATIONAL BURDEN AND COST OF DEVELOPING TMDLS FOR THE 1998 303(d) LISTS

Applying the unit burden (hours/TMDL) to the total TMDL workload (number of TMDLs) provides the national burden for developing TMDLs (total hours). Multiplying the national burden (hours) by the labor rate (cost/hour) provides the national undiscounted cost of developing TMDLs. Using the pace of TMDL development and discount rates of 3% - 7% we can estimate the associated present value and annualized cost. These estimates are provided below.

1. National burden for developing TMDLs for the 1998 303(d) lists starting in 2000

Combining the unit burden per TMDL in Exhibit III-1a with the distribution of TMDLs in Exhibits III-2 provide the total hours burden of 24.9-27.4 million hours associated with the 1998 303(d) list as shown in Exhibit III-3a (60% clustering) and Exhibit III-3b (70% clustering).

Exhibit III-3a
Total Hours for Developing 36,225 TMDLs for the 1998 303(d) list - 60% Clustering

Description of the Submission	Total (hours)	Level 1 (hours)	Level 2 (hours)	Level 3 (hours)
A. TMDLs requiring full cost: the only or first cause for a waterbody/cluster	13,752,601	3,292,557	4,230,694	6,229,350
B. TMDLs with standard efficiencies: subsequent causes for a waterbody/cluster	3,710,340	708,400	1,134,420	1,867,520
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	9,912,632	2,366,220	3,043,280	4,503,132
Total Hours	27,375,573	6,367,177	8,408,394	12,600,002

Exhibit III-3b
Total Hours for Developing 36,225 TMDLs for the 1998 303(d) list - 70% Clustering

Description of the Submission	Total (hours)	Level 1 (hours)	Level 2 (hours)	Level 3 (hours)
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster	10,314,923	2,469,651	3,171,672	4,673,600
B. TMDLs with standard efficiencies: subsequent causes for a waterbody/cluster	3,965,733	757,680	1,213,000	1,994,453
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	10,597,330	2,529,618	3,253,432	4,814,280
Total Hours	24,877,986	5,756,949	7,638,704	11,482,333

The associated average burden per TMDL is estimated to be 687-756 hours and the average burden per waterbody is estimated to be 1,269-1,396 hours (for 19,611 waterbodies).

Since the number of submissions with multiple waterbodies and TMDLs can be represented by the number of clusters (which is the same number as the number of Type A TMDLs), the associated national average burden per submission is estimated to be 3,490-4,229 hours. However, the range for the burden associated with submissions is from a single waterbody with a single Level 1 TMDL resulting in a burden of 666 hours (low end of the Level 1 range from Exhibit I-3) to over 25,000 hours for submissions with many clustered waterbodies and/or many TMDLs, especially if they are of higher difficulty.[26]

2. National undiscounted cost of developing all TMDLs for the 1998 303(d) lists

The undiscounted cost may be the most appropriate estimate from the perspective of budgeting resources for developing TMDLs. The present value cost, which is a more appropriate estimate from a social cost standpoint, is discussed in the next section.

a. National total undiscounted cost.

Combining the national burden in Exhibit III-3 with the fully loaded hourly State labor rate of $38.89 from Section I.B.3 provides the total undiscounted cost of $0.97-$1.06 billion associated with the 1998 303(d) list as shown in Exhibit III-4a (60% clustering) and Exhibit III-4b (70% clustering). The cost might be 10% lower than this range if States are able to adopt efficient practices for developing TMDLs more rapidly than assumed in this report; alternatively, the total costs could be 10% higher or more to the extent that States require a longer transition period to employ efficient practices for developing TMDLs. (see Appendix I for more detail).

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[26] For example, these could be submissions for many waterbodies even at lower levels of difficulty (e.g., a single submission could include dozens of waterbodies). Alternatively there could be smaller numbers of waterbodies in a submission but a higher number of TMDLs per waterbody at Level 3 difficulty (e.g., 944 waterbodies have 5 or more causes ranging up to 31 causes per waterbody, and a cluster of 5 waterbodies each with 5 Level 3 causes even with substantial efficiencies could easily exceed 25,000 hours). Finally, it is possible that a single waterbody with many TMDLs could also require a significant total effort, especially if they are at Level 2 or Level 3 difficulty (note that over 50 waterbodies have 10 to 31 causes of impairment, as shown in Appendix H).

Exhibit III-4a
Total Undiscounted Cost for Developing All 36,225 TMDLs for the 1998 303(d) List - 60% Clustering
(Thousands of March 2000 dollars)

Description of the Submission	Total ('000 $)	Level 1 ('000 $)	Level 2 ('000 $)	Level 3 ('000 $)
A. TMDLs at full cost: only or first cause for a waterbody or cluster	$534,839	$128,047	$164,532	$242,259
B. TMDLs at partial cost: subsequent causes for a waterbody/cluster	$144,295	$27,550	$44,118	$72,628
C. TMDLs with additional modeling efficiencies for related causes	$385,502	$92,023	$118,352	$175,127
Total Cost	$1,064,636	$247,620	$327,002	$490,014

Exhibit III-4b
Total Undiscounted Cost for Developing All 36,225 TMDLs for the 1998 303(d) List - 70% Clustering
(Thousands of March 2000 dollars)

Description of the Submission	Total ('000 $)	Level 1 ('000 $)	Level 2 ('000 $)	Level 3 ('000 $)
A. TMDLs requiring full cost: only or first cause for a waterbody or cluster	$401,148	$96,045	$123,346	$181,757
B. TMDLs with standard efficiencies: subsequent causes for a waterbody or cluster	$154,227	$29,466	$47,197	$77,564
C. TMDLs with additional modeling efficiencies: subsequent related causes	$412,130	$98,377	$126,526	$187,227
Total Cost	$967,505	$223,889	$297,069	$446,548

b. National annual undiscounted cost

When submitting their 1998 303(d) lists, the States committed to schedules that would result in developing virtually all of these TMDLs by 2013. However, the recent revisions to the TMDL regulation would allow States to complete these TMDLs by 2015. Therefore, in this report, we assumed that the States would use the additional time allowed by the regulation and would develop TMDLs at a roughly uniform rate over the sixteen year period from 2000 through 2015. Therefore, the average annual national cost for developing TMDLs would be about $63-$69 million. As in the case for total cost, the range reflects a 5-10 year transition period over which we assumed that States would fully achieve the cost efficiencies that can be realized by clustering waterbodies and caused for TMDL development.

However, as discussed previously, the pace at which States would actually develop TMDLs over this period is unclear. A roughly uniform annual pace over the 16-year period through 2015 would imply the development of about 2,350 TMDLs per year. As discussed earlier, it is clear that the actual initial pace of TMDL development is lower. We estimate that about 1,000 TMDLs were developed prior to 2000 for causes identified on the 1998 303(d) lists, and that perhaps another 1,000 TMDLs were developed in the year 2000. Therefore, it appears that States are in the process of building up their capacity to develop TMDLs. In addition, the revisions to the TMDL regulation encourage States to take advantage of the cost savings that can result from coordinating the development of TMDLs on a watershed basis, and in order to accomplish this, more of the TMDLs may be developed in the latter years relative to a uniform national rate. Thus, in the early years the annual cost would be lower than average and in the latter years it would be higher than average. For example, a "transition" pace might steadily increase from 1,000 TMDLs per year in the year 2000 to about 2,550 TMDLs by the year 2005 and remain at that rate through the year 2015 to complete all 36,225 TMDLs, resulting in a yearly cost that would start at about \$27-\$29 million in the year 2000 and steadily increase to about \$68-\$75 million in 2005 and remain at that level through 2015.

c. Typical unit costs of developing TMDLs at different levels of aggregation

The cost of developing TMDLs can be viewed at different levels of aggregation in addition to the national total. Accordingly, we estimated the average cost and the associated typical range of cost of developing TMDLs for 1) a single cause of impairment, 2) a waterbody that requires multiple TMDLs, and 3) a submission that may range from a single TMDL for a single waterbody to many TMDLs for all of the waterbodies in a watershed. These estimates are shown in Exhibit III-5 and are reflected in the estimated total cost undiscounted cost of \$1 billion in Exhibit III-4.

Exhibit III-5
Average and Typical Range for the Cost of Developing TMDLs at Different Levels of Aggregation

Level of Aggregation	National Average Cost* (thousands 2000 \$)	Typical Range for Cost (thousands 2000 \$)
Cost per single Cause of Impairment (for single TMDL)	\$27 - \$29	\$6 - \$154
Cost per single Waterbody (for single TMDLs to multiple TMDLs)	\$49 - \$54	\$26 - over \$500
Cost per Submission (for single waterbodies to multiple waterbodies)	\$136 - \$165	\$26 - over \$1,000

**Ranges reflect a 5-10 year transition period over which States are assumed to fully achieve the cost efficiencies that can be realized by clustering waterbodies and causes when developing TMDLs.*

Overall, the associated average cost per TMDL is estimated to be about \$27,000 - \$29,000 but may typically range from \$6,000 to \$154,000 (from the low end of the range in Exhibit I-6 for Level 1 Type C TMDLs to the high end of the range in Exhibit I-3 for Level 3 Type A TMDLs). Note that this range broadly represents the typical cost of developing TMDLs, with perhaps only 2-5% of the TMDLs nationally exceeding the costs in this range:

- *Minimum Estimate*. From Exhibit III-2a, we estimate that there may be 1,962 Type A Level 3 TMDLs, whose costs we estimated to typically range from \$93,000 to \$154,000 (combining the range for level of effort from Exhibit ES-2 and the hourly cost of \$38.89 from Section I.C.1). We expect 25% of these TMDLs to be lower than this range, and 25% to be higher, implying that perhaps 491 TMDLs (25% x 1,962) might exceed a cost of \$154,000, representing 1.4% of all TMDLs (491/36,225). Thus, a minimum estimate for the portion of TMDLs that might exceed \$154,000 in cost might be about 2%.

- *Maximum Estimate*. It is plausible, although not likely, that some of the Type A Level 2, Type B Level 2, and Type B Level 3 TMDLs might also exceed \$154,000.[27] The total

[27] \$154,000 already represents a substantial "margin of safety" over the high-end cost applied for these TMDLs, amounting to: 165% of the high-end cost for Type A Level 2 TMDLs; 373% of the high end cost for Type

number of the TMDLs in these categories, including the Type A Level 3 TMDLs is 7,128 (from Exhibit III-2a: 2,353 + 1,962 + 1,533 + 1,280), and a total of about 1,782 of these (25% x 7,128) might exceed the high end of the costs we estimated. In the rather unlikely event that the cost of virtually every one of these TMDLs exceeds $154,000 then this would represent 4.9% of all TMDLs (1,782/36,225).

The cost per waterbody can also vary widely. Although most waterbodies have only one cause of impairment requiring a TMDL, nearly 40% of the waterbodies have two or more causes ranging to over thirty causes for a single waterbody. The average burden per waterbody, often requiring several TMDLs, is estimated to be about $49,000 - $54,000, but can typically range from under $26,000 to over $500,000 depending on the number of TMDLs and their level of difficulty.

States will combine the development of TMDLs into logical, efficient groups and submit them together in a single submission, which may range from including a single TMDL for a waterbody to many TMDLs for all of the waterbodies in a watershed. Since the number of submissions can be represented by the number of clusters (i.e., the Type A TMDLs), the associated national average burden per submission is estimated to be about $136,000-$165,000 (which typically may cover 5-6 TMDLs, but could have fewer or far more TMDLs. However, the typical burden associated with a submission ranges from a single waterbody with a single Level 1 TMDL, resulting in a cost of about $26,000 (at the low end of the range in Exhibit I-3), to over $1,000,000 for submissions with many clustered waterbodies and/or many TMDLs, especially if they are of higher difficulty and diverse pollutant types.

In this analysis, we focused on the ranges of cost for "typical" TMDLs (as reflected in Exhibit III-5) in order to develop an accurate estimate of the total national cost. We did not include consideration of the most inexpensive TMDLs or the most expensive TMDLs because these "outliers" are not representative of the bulk of the national TMDL development workload. We believe that the range of costs used in this report are appropriate for developing an estimate for total national cost. However, to the extent that there are a significant number of outliers with sufficiently higher costs, the national total cost estimate in this report may under-estimate total cost. There are two primary reasons why some TMDLs may be outliers:

- They may be more resource intensive because they are more difficult technically, they require greater public participation and outreach, or both; and/or
- Their spacial scale may be significantly larger.[28] We have not attempted in this report to reflect or make adjustments for large-scale waterbodies. In this regard, some States may have broadly defined some impaired waterbodies to include all of the interconnected impaired segments in a watershed. In effect, an impaired waterbody defined in this way is actually a "cluster" or a "submission" in this report, and the appropriate unit TMDL development costs should be applied to each of the segments composing the waterbody. For this report, however, we have not attempted to reflect or adjust for such differences in the way that States may have defined impaired waterbodies.

B Level 2 TMDLs; and 213% of the high-end cost for Type B Level 3 TMDLs.

[28] This does not, however, include the full cost of large watershed planning and restoration efforts, such as the Long Island Sound, which would be undertaken in the absence of the requirement to develop TMDLs. In this report, we focus on the incremental effort to develop the TMDL.

For perspective, if the potential outliers exceed the maximum cost of $154,000 per TMDL by an average of about $100,000 per outlier TMDL, as shown in Exhibit III-6, then the national total cost estimated in this report would be understated by perhaps 10% to 20%.[29]

Exhibit III-6
Hypothetical Distribution of Additional Cost for Outliers Over and Above $154,000 Per TMDL

Hypothetical Distribution of Outlier TMDLs	Hypothetical Cost per Outlier TMDL				
	Possible Additional Cost Per Outlier TMDL In Excess Of $154,000				Hypothetical Maximum Total Cost Per Outlier TMDL
	Low	High	Average	Weighted Average	
45%	$0	$50,000	$25,000	$11,250	$204,000
30%	$50,000	$100,000	$75,000	$22,500	$254,000
10%	$100,000	$150,000	$125,000	$12,500	$304,000
5%	$150,000	$250,000	$200,000	$10,000	$404,000
4%	$250,000	$350,000	$300,000	$12,000	$504,000
3%	$350,000	$500,000	$425,000	$12,750	$654,000
2%	$500,000	$750,000	$625,000	$12,500	$904,000
1%	$750,000	$1,000,000	$875,000	$8,750	$1,154,000
100%	**Weighted Average Additional Cost Per Outlier**			**$102,250**	------

It is important to note that the typical TMDL development costs for individual States may be substantially higher or lower than the national average. States that wish to apply the national average estimates and methodology to estimate the cost of developing TMDLs for their State, should make the appropriate State-specific adjustments as detailed in Appendix A. In particular, the distribution for the level of difficulty may be very different across States, and it may be especially important for some States to include explicit consideration of "outliers". In addition, States that broadly define a single impaired waterbody to include all of the interconnected impaired segments in a watershed (or otherwise identified large-scale waterbodies) should consider whether it is appropriate to apply the unit TMDL development costs to the segments composing the impaired waterbody. Finally, the State's ability to achieve efficiencies in developing TMDLs can importantly affect cost, and there are a number of factors to consider when evaluating the potential to achieve such efficiencies, especially in the near term, as discussed in Appendix G.

3. National present value & annualized costs for the 1998 303(d) lists

The present value of the cost of developing TMDLs takes into consideration the timing of the expenditures over this period and the fact that individuals prefer to consume now rather than later. For

[29] 2% to 5% outliers x 36,225 TMDLs x $102,250 per outlier / $1 billion total cost = 7.4% to 18.5%

this analysis we provide a range of results using 3% and 7 % real discount rates, reflecting both EPA and OMB guidance regarding discount rates. When discounting, we assumed that all of the costs incurred in a year occur at the beginning of the year, a "conservative" assumption that tends to increase the present value cost of developing TMDLs over this period (for example, all of the costs incurred in 2000 are not discounted at all). The resulting present value cost is then annualized over the 16-year period (2000 to 2015)[30] to obtain the annualized cost.

The calculations for the present value cost and the annualized cost of developing TMDLs are shown in Appendix I. The present value cost of developing the 36,225 TMDLs for the 1998 303(d) list at a uniform pace of development is $598 million (70% clustering) to $658 million (60% clustering) using a 7% discount rate; with a 3% discount rate, the present value cost is $776 to $853 million . The corresponding annualized cost for a uniform pace of development is $59 million (70% clustering) to $65 million (60% clustering) using a 7% discount rate; with a 3% discount rate the annualized cost is $60 million (70% clustering) to $66 million (60% clustering).

As discussed earlier, rather than a uniform pace, States might gradually increase their rate of developing TMDLs over a few years and then maintain this higher rate to complete the workload by 2015. For the example "transition" pace discussed earlier, the present value and annualized costs would be about 2-4% lower (with the range reflecting the discount rates of 3%-7%) than for the uniform pace because the more of the cost would be borne in the latter years.

C. National Burden and Cost of Developing TMDLs for Newly Listed Causes

In Chapter II, we described a plausible, hypothetical scenario to provide perspective on the potential workload that might be associated with new pollutant causes that are identified in future listings. For this scenario, a total of 9,000 TMDLs would be developed at a total undiscounted cost of $216 million at a typical undiscounted yearly cost of about $5-7 million[31] over most of the period through 2050. Because the identification (and associated TMDL development) of these additional waterbodies is assumed to be spread over a longer period of time (i.e., perhaps through 2050) relative to the 1998 303(d) lists, causing the present value to be lower. Consequently, the present value cost for this hypothetical workload is about $43 at a 7% discount rate and $101 million at a 3% discount rate. This is shown in detail in Appendix I (Exhibit I-2).

If the total number of new causes, the pace of identifying them, the difficulty of developing TMDLs for them, the pace of TMDL development differs, and if the unit cost of developing TMDLs differs than assumed in this hypothetical case, then these costs will increase or decrease accordingly.

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[30] Because costs are assumed to be incurred at the beginning of each year, the costs incurred in 2000 are not discounted at all, the costs incurred in 2001 are discounted by one year, etc.. Thus, the costs incurred in 2015 are effectively discounted by 15 years even though it is a 16-year period. However, when annualizing the resulting present value figure through 2015, the present value is annualized over 16 years since 2000-2015 spans 16 years.

[31] Since the workload for different listing periods would overlap (due to a four-year listing cycle and a ten-year period to develop the TMDLs), the overall pace of development would start at 100 TMDLs per year, working up to about 200-300 TMDLs per year and stay at that rate for most of the period, and then wind down.

D. Applicability of These Results to Individual States

The methodology and assumptions used in this analysis are all geared toward developing the best estimate of national cost. As discussed earlier, it is not likely that the results of this analysis of national cost can directly be applied to estimating the resources that may be required by any one State. However, the methodology and assumptions can be tailored to better represent the specific circumstances for a specific State, and thereby provide an appropriate basis for estimating the resources needed for developing TMDLs. Some of the parameters that may be appropriate to tailor to State circumstances are discussed in Appendix A.

E. Potential Future Improvements

Potential future improvements to the methodology used in this report might include:

1) addressing topics omitted from the analysis,

2) providing better information for understanding costs and for validation,

3) providing better resolution (improve applicability to regional and State levels),

4) considering factors that affect costs through time, and

5) providing information and tools that improve the ability of States to estimate and plan their TMDL development workloads.

These improvements are outlined in Appendix A.

APPENDIX A
DATA SOURCES, APPLICABILITY TO STATES, & LIMITATIONS

APPENDIX A: DATA SOURCES, APPLICABILITY TO STATES & LIMITATIONS

This Appendix addresses three topics:

A. ***data sources*** used in the analysis;

B. ***applicability to individual States*** of the results of this analysis, and the adjustments that would be appropriate for State-specific estimates; and,

C. ***limitations of the analysis and potential improvements***.

A. DATA SOURCES

Data and estimates were needed for three types of information:

1. Data regarding the existing TMDL program,

2. Estimates of the level of effort associated with developing TMDLs, and

3. Data and estimates of the potential for clustering.

The sources for these data and estimates are summarized below.

1. Data regarding the existing TMDL program

The data describing the current TMDL program were obtained by extracting data and developing summary statistics from the Agency's 1998 303(d) TMDL Tracking System Database (Version dated 2/19/00), reviewing and describing selected characteristics of the State 1998 303(d) list submissions, and reviewing the content of a sample of 1,096 TMDLs (these include a comprehensive sampling of TMDLs recently reviewed and approved by EPA. Examples of this information include:

- The Agency's 1998 303(d) data base:
  - the number of waterbodies and number of causes of impairment by type of cause
  - the number of waterbodies and causes of impairment by State
  - the distribution of the number of causes of impairment per waterbody
  - the number of waterbodies with multiple nutrient causes and the number of such causes
  - the number of waterbodies with multiple metals causes and the number of such causes

- Review of the State 1998 303(d) list submissions:
  - does the State use a rotating basin approach?
  - how many waterbodies were listed for pollution?
  - how many waterbodies were listed for pollutants?

- Review of 1,096 recently submitted or approved TMDL[32]
  - to what extent were multiple TMDLs clustered by waterbody?
  - to what extent were TMDLs clustered by watershed for multiple waterbodies?

2. Data and estimates for the level of effort associated with the TMDL program

A variety of sources provide estimates regarding the level of effort associated with all of the federal requirements associated with developing TMDLs:

- The unit estimates of the staff burden (hours) needed to perform both the tasks required by the current program and the new tasks required by the July 11, 2000 revisions to the Water Quality Planning and Management Regulation (WQPMR) were obtained through discussions with several State representatives and experts on TMDL development at an EPA contractor (Tetra Tech, Inc.), and prior analyses of these topics.[33, 34]

- The estimated cost for developing TMDLs using the unit cost estimates in this report was compared with the actual costs for a broad range of 131 TMDLs which were developed by an EPA Region and an EPA contractor (Tetra Tech, Inc.). These 131 TMDLs were developed for 119 waterbodies in 8 States across 5 EPA regions, and represent all three levels of difficulty and all types of efficiencies.

- The Agency's Gap Analysis Effort, and its State Water Quality Management Resource Needs Model (version 3.0, March 2000) provided important input regarding typical fully-loaded labor rates for State efforts, as well as perspective in assessing the magnitude and reasonableness of the estimates for TMDL-development related tasks.[35] The Gap Model is the result of a joint effort by EPA, States and other interested stakeholders to develop a tool for estimating the States' resource needs for State water quality management programs. The Gap Model is designed to allow States to enter the specifics of their own circumstances, but includes "defaults" judged to be representative of the "average," "median," or "typical" State. The Gap Model defaults are based on the consensus of a

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[32] These are a comprehensive compilation of the TMDL submittals to EPA over the period April 1998 through September 2000. Nearly all of these TMDLs were approved by EPA, with only a small portion awaiting EPA review at the time the data base was prepared. These 1,096 TMDLs were submitted by 35 States representing 9 EPA Regions. The TMDLs addressed a wide variety of pollutants representing over 60 different types of causes.

[33] Environomics and Tetra Tech, Inc., *Estimate of the Cost to Develop TMDLs*, prepared for the U.S. EPA, Office of Wetlands, Oceans and Watersheds. Unpublished draft, May 27, 1999.

[34] Environomics, *Analysis of the Incremental Cost of Final Revisions to the Water Quality Planning and Management Regulation and the National Pollution Discharge Elimination System Program*, prepared for the U.S. EPA, Office of Wetlands, Oceans and Watersheds. July 7, 2000.

[35] The Cadmus Group, Inc., *State Water Quality Management Workload Model, ver 3.0*, prepared for the U.S. EPA's Office of Wastewater Management, March, 2000. http://www.asiwpca.org/

focus group of participants including representatives from 18 States, 3 EPA regions, and 8 associations, as well as on comments from an additional 14 States.[36]

- Additional important perspective was provided by the published workload model prepared by Washington State.[37]

3. Data and estimates of the potential for clustering

- U.S. Geologic Survey hydrologic units (at the sub-basins level, as defined by 8-digit HUCs) provided an initial basis for organizing waterbodies into groups for more detailed analysis to identify the extent to which they might be clustered for TMDL development.

- U.S. EPA Reach File 3 was used to identify the interconnected impaired waterbodies and the isolated impaired waterbodies within the sub-basins

- Additional important perspective is provided by the published workload model prepared by Washington State, as well as the extent to which clustering occurred for the sample of 1,096 recently submitted TMDLs.

B. Applicability of These Results to Individual States

The methodology and assumptions used in this analysis are all geared toward developing the best estimate of national cost. It is not likely that the results of this analysis of national cost can directly be applied to estimating the resources that may be required by any one State. However, the methodology and assumptions can be tailored to better represent the specific circumstances for a specific State, and thereby provide an appropriate basis for estimating the resources needed for developing TMDLs. Some of the parameters that may be appropriate to tailor to State circumstances include:

- the average loaded hourly salary rate,

- the tasks used to describe TMDL development,

- the range for level of effort and typical value for each of the tasks at each level of difficulty and degree of efficiency,[38]

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[36] The States were Arkansas, Colorado, Connecticut, Delaware, Georgia, Illinois, Maine, Maryland, Massachusetts, Michigan, New Jersey, New York, North Carolina, Oklahoma, Oregon, Texas, Virginia, and Wisconsin. The associations were American Clean Water Federation (ACWF), Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), Association of State Wetlands Managers, Coastal States Organization, Environmental Coalition of States (ECOS), New England Interstate Water Pollution Control Commission (NEIWPCC), Water Environment Federation (WEF), and the Wisconsin Association of Lakes.

[37] *Total Maximum Daily Loads Workload Model, Program Definition and Cost*, Washington State Department of Ecology, July 1998, Ecology Publication #98-26.

[38] The average of the low-high range for a Level of Difficulty may be a poor proxy for the typical value for a particular State – e.g., a State might have a disproportionate share of more complex (or more simple) TMDLs.

- a broader range for Level 1 and Level 3 to represent the very inexpensive or the very expensive TMDLs (or alternatively adding a Level L for the least expensive and a Level H for the most expensive TMDLs),

- the extent to which the State broadly defines an impaired waterbody to include all of the impairments in a watershed or if a State has an impaired waterbody with significant spatial extent (in these cases, the State should consider whether it has defined the impaired waterbody in the same way that this report defines a "cluster,"and whether it would be appropriate to apply the unit costs in this report to segments of the waterbody).

- the number of TMDLs to be developed,

- the percentage of Level 1, Level 2, and Level 3 TMDLs,

- the extent to which waterbodies will be clustered and efficiencies realized (see the discussion in Appendix G regarding potential limitations regarding the potential for clustering in the near term),

- the pace of development over the State's schedule,

- the level of experience of State staff / startup costs, and

- the rate of increase in workload due to newly identified impaired waterbodies, and the likely characteristics of this workload.

If a State wishes to accurately estimate the year-by-year burden of developing TMDLs, it will also likely be necessary to estimate some or all of these parameters on a year-by-year basis.

C. LIMITATIONS - POTENTIAL FUTURE IMPROVEMENTS

Potential future improvements to the methodology used in this report might include:

1) addressing topics omitted from the analysis,

2) providing better information for understanding costs and for validation,

3) providing better resolution (improve applicability to the regional and State levels),

4) considering factors that affect costs through time, and

5) improve the ability of States to estimate and plan their TMDL development workloads.

These potential improvements, a number of which are inter-related, are outlined briefly below.

1) Address Topics Omitted from the Analysis

- Include monitoring costs for TMDL development and TMDL implementation costs incurred by States.

- Place TMDL development costs into context relative to total program costs.
- Cost TMDLs for Indian lands.

2) Provide Better Information for Understanding Costs and for Validation

- Replace the outdated 1996 14-case study report with a more up-to-date analysis emphasizing current data needs and applicability of the results.
- Expand the validation analysis to reflect the additional TMDLs that EPA, States and contractors have recently developed.
- Expand the comparison of estimated costs with actual costs, particularly to improve estimation of the magnitude of efficiencies for specific tasks when clustering TMDLs, and to assess the importance of spatial extent.

3) Provide Better Resolution

- Use State-specific estimates for key factors, such as labor rates, rather than national averages.
- Link cost estimates more directly to key factors affecting complexity such as waterbody type and extent, source type and number of sources, etc..
- Incorporate more explicit consideration of outliers (for both the very low cost TMDLs - Level L - and the very high cost TMDLs - Level H).
- Evaluate whether differences in the ways that States define impaired waterbodies should be explicitly considered when estimating national cost, and if appropriate, make the necessary adjustments (see Appendix G, section D).
- Expand the cluster analysis to further reflect potential barriers to achieving maximum clustering efficiencies and ways to reduce the impact of these barriers, and the applicability of the unit costs in this report (see Appendix G, section D).

4) Account for the Change in Costs through Time

- Estimate start-up costs for States (although these are not likely to be important from the standpoint of estimating national costs for the duration of the program, these might be relatively significant for some States for specific years).
- Estimate the extent to which costs may change in the future (presumably, increasing experience and technology improvements will result in declining unit costs).
- Improve the forecasting of new causes to be identified in future lists.
- Improve the estimates for the national pace of developing TMDLs

5) Improve Estimation of State Workloads

- Develop “model” State TMDL Development work plans that are both efficient and effective, perhaps developing several specific State case studies, including consideration of the relationship between the TMDL and other water programs.

- Prepare operational guidance for estimating TMDL development costs, useful information regarding TMDL development costs (including ways to address and maximize efficiencies), and perhaps a “tool” reflecting the full range of considerations addressed in this report that will be useful for States for estimating and planning their TMDL development workloads.

APPENDIX B:
COMPARISON OF ESTIMATED VS ACTUAL COSTS FOR 131 TMDLS

APPENDIX B: COMPARISON OF ESTIMATED VS ACTUAL COSTS FOR 131 TMDLs

In the time-frame allowed for this study, we were able to compare the estimates in Exhibits I-8 with actual costs for 55 submission for 131 TMDLs in which an EPA Region and an EPA contractor developed a broad range of TMDLs. We provide an overview of the submissions as an indication of the extent to which they may be representative, describe the approach we used to compare the unit costs developed in this report with the actual costs for developing these TMDLs, and then assess the results. Overall, the unit costs estimated in this report appear to be reasonable in comparison to the actual costs for the 131 TMDLs.

A. OVERVIEW OF THE 131 TMDLS

The 55 submissions analyzed included 131 TMDLs for 119 waterbodies in 8 States across 5 EPA Regions. The causes for which TMDLs were developed include nutrients, metals, siltation, sediment and fecal coliforms. Four lakes were grouped into one submission, and 107 rivers into 46 submissions. Of the eleven waterbodies with multiple causes, six were identified as having efficiencies due to multiple metals or multiple nutrients. The levels of difficulty included 112 Level 1 TMDLs, 6 Level 2 TMDLs, and 1 Level 3 TMDL.

B. APPROACH USED TO COMPARE COSTS FOR SPECIFIC TASKS

For all of the TMDLs used in this comparison, the contractor or the Region performed modeling and analysis (Task 2) and development of the TMDL document for public review (Task 4). For all but one of the TMDLs, the allocation analysis (Task 3) was performed, and for all but two of the TMDLs, the watershed characterization (Task 1) was performed. For all but six of the TMDLs, assistance was provided for the formal public participation and response (Task 6). For 100 of the TMDLs, overall administration services (Task 7) were also provided.

For each case, we identified the specific tasks performed by the contractor, state and/or the EPA Region, and the actual cost associated with these tasks. We then developed cost estimates for the specific tasks undertaken by the contractor or EPA Region for each case using the “low” and “high” unit cost estimates found in Exhibits I-3, I-5 and I-6, taking into consideration the level of difficulty, whether waterbodies were grouped, whether there were multiple causes for waterbodies, and whether modeling efficiencies could be realized (i.e., multiple metal or multiple nutrient causes). When the contractor provided partial assistance for formal public participation (Task 6) we included half of the cost for that task in order to provide a comparable estimate. In one case where clustering occurred, the clustering was only partial, so we applied 2/3 of the savings associated with clustering to provide a comparable estimate.

The comparison of the estimated costs with the actual costs for the 55 submissions is summarized in Exhibit B-1, with additional detail provided in Exhibit B-2. Each vertical line represents the range of costs that we estimated for a submission using the appropriate unit costs from Exhibits I-3, I-5 or I-6 for each of the tasks performed, adjusted as appropriate to reflect the level of the analysis, multiple pollutants, modeling efficiency (for metals or the nutrient group), the extent to which Task 6 was performed, and the degree to which clustering occurred. The actual cost is seen on the chart as a horizontal tick. The exhibit provides additional information for each submission including the level of difficulty, the number of pollutants, whether there are multiple metals or nutrients, and the number and type of waterbodies in the submission. The first bar is different from the others in that it represents 44 submissions; each submission consisted of Level 1 TMDLs for one pollutant in a cluster of 2-3 rivers.

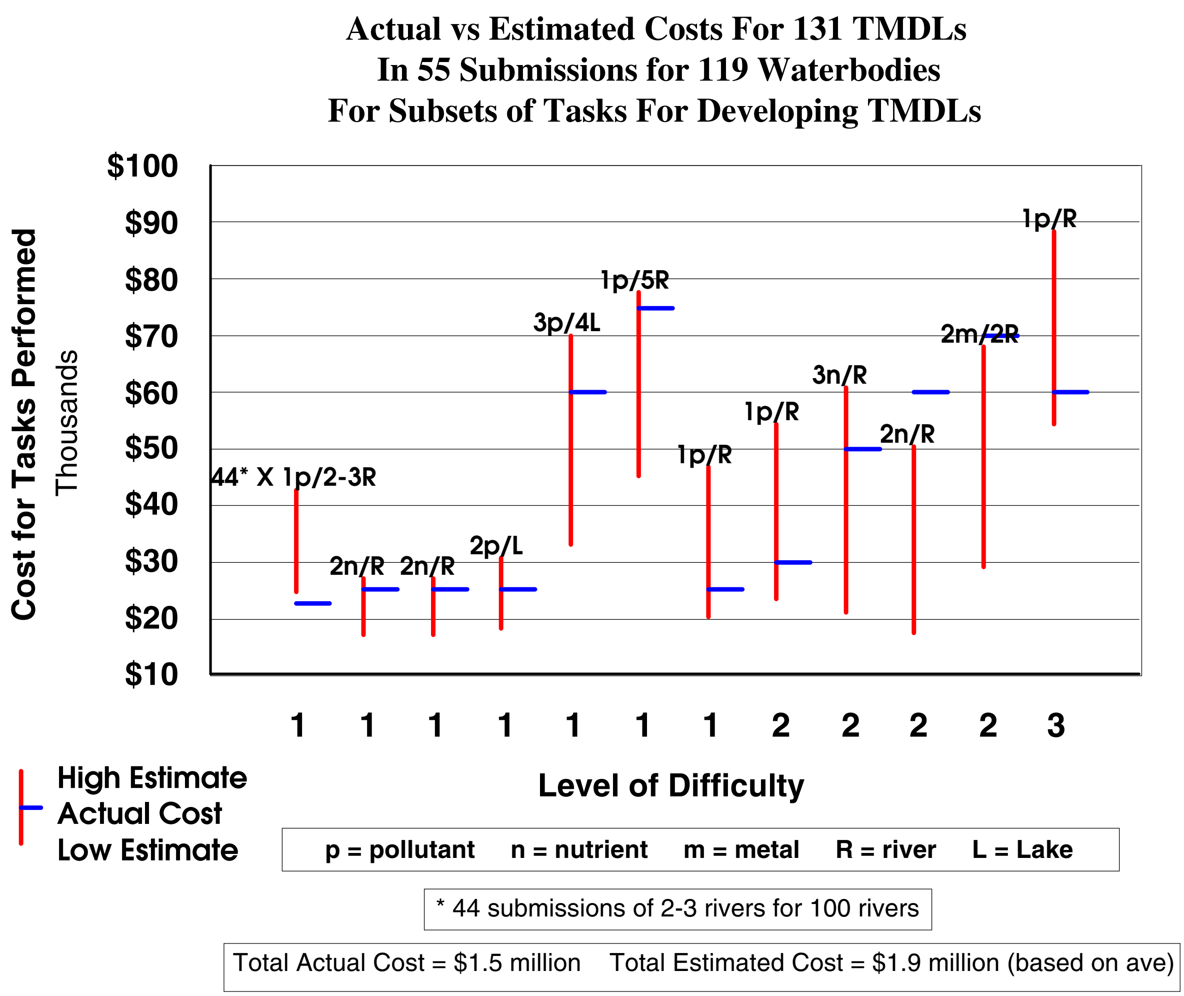
The remaining bars provide similar information: the second and third submissions are each for Level 1 TMDLs for a river with two pollutants in the nutrient group (for which there are modeling efficiencies), the fourth submission is for a Level 1 TMDL for a lake with two pollutants, the fifth submission is for Level 1 TMDLs for four lakes with 3 pollutants (the combinations of pollutants for each of these lakes is shown in Exhibit B-2), and so on.

C. RESULTS

As can be seen from Exhibit B-1, the actual costs for each of the case studies tend to be either below or well within the range of costs estimated from Exhibits I-3, I-5 and I-6. This increases our confidence in the estimates developed in this chapter for single pollutants, as well as for the savings associated with multiple pollutants, clustering and modeling efficiencies. Further, the total actual cost for all 131 TMDLs is $1.5 million, which compares favorably with an estimated average cost of $1.9 million in a range of $1.4 - $2.5 million.

When considering the results shown in Exhibit B-1, it should be kept in mind that the 55 submissions represent readily available cases that are not necessarily "representative" of TMDLs within a given level of difficulty. This explains, for example, why actual costs exceed the estimated costs for the submission in which a Level 2 TMDL was developed for two nutrients; although the modeling technique used was consistent with Level 2, the actual level of effort needed was higher than would normally be expected because of additional complexity due to the number and mix of point and non-point sources (see Nanticoke River in Exhibit B-2). As discussed at the end of this report (potential future improvements), a more detailed breakdown of unit costs that explicitly reflects source type, waterbody type, and pollutant type will provide more accurate ranges of cost for specific cases.

Exhibit B-1



Actual vs Estimated Costs For 131 TMDLs
In 55 Submissions for 119 Waterbodies
For Subsets of Tasks For Developing TMDLs
Cost for Tasks Performed
Thousands
$100
$90
$80
$70
$60
$50
$40
$30
$20
$10
44* X 1p/2-3R
2n/R
2n/R
2p/L
3p/4L
1p/5R
1p/R
1p/R
3n/R
2n/R
2m/2R
1p/R
1
1
1
1
1
1
1
2
2
2
2
3
Level of Difficulty
High Estimate
Actual Cost
Low Estimate
p = pollutant n = nutrient m = metal R = river L = Lake
* 44 submissions of 2-3 rivers for 100 rivers
Total Actual Cost = $1.5 million Total Estimated Cost = $1.9 million (based on ave)

EXHIBIT B-2
COMPARISON OF ACTUAL VERSUS ESTIMATED TMDL DEVELOPMENT COSTS FOR SUBSETS OF TASKS
131 TMDLs IN 55 SUBMISSIONS FOR 119 RIVERS & LAKES

#	Waterbody / TMDL Description				Actual Cost		Estimated Cost Per Submission				#
	Location / Type/ Clusters	Status	Causes	Level	Tasks	Cost	Tasks	Low Cost	Ave Cost	High Cost	
1	R4/GA 100 rivers clustered as 44	approved	fecal coliforms	1	1,2,3,4,6,7	$22,727	1,2,3,4,6,7	$24,476	$33,665	$42,853	1
2	R7/IW Mudd Creek	draft	ammonia, BOD	1	1,2,3,4	$25,000	1,2,3,4	$17,112	$22,167	$27,223	2
3	R5/IN Kokomo Creek	draft	ammonia, BOD	1	1,2,3,4	$25,000	1,2,3,4	$17,112	$22,167	$27,223	3
4	R7/IW Rock Creek Lake	draft	siltation, phosphorus	1	1,2,3,4	$25,000	1,2,3,4	$18,045	$24,384	$30,723	4
5	R3/WV 4 lakes clustered as 1	approved	combinations of 3 pollutants	1	1,2,3,4,6 (partial)	$60,000	1,2,3,4 + ½ 6	$33,095	$51,549	$70,002	5
6	R3/WV 5 rivers clustered* as 1	approved	fecal coliforms	1	1*,2,3,4*,6 (partial)	$75,000	1*,2,3,4* + ½ 6	$45,112	$61,446	$77,780	6
7	R9/CA Noyo River	approved	sediment	2	1,2,4	$25,000	1,2,4	$20,223	$33,445	$46,668	7
8	R3/WV Lost River	approved	fecal coliforms	2	1,2,3,4,6 (partial)	$30,000	1,2,3,4 + ½ 6	$23,334	$38,890	$54,446	8
9	R3/DE Appoquinimink River	approved	phosphorus, CBOD, NBOD	2	2,3,4	$50,000	2,3,4	$21,001	$40,835	$60,668	9
10	R3/WV Nanticoke R	approved	TN, TP	2	2,3,4	$60,000	2,3,4	$17,501	$34,029	$50,557	10
11	R3/WV 2 rivers clustered as 1	approved	iron, aluminum	2	1,2,3,4,6 (partial)	$70,000	1,2,3,4 + ½ 6	$29,168	$48,613	$68,058	11
12	R3/VA Muddy Creek	approved	fecal coliforms	3	1,2,3,4	$60,000	1,2,3,4	$54,446	$71,558	$88,669	12
					Totals (with 44 x #1)	$1,505,000		$1,373,089	$1,930,325	$2,487,560	

1. The total cost was $1,000,000 for the 100 waterbodies, amounting to an average of $10,000 per waterbody or $22,727 per submission.

5. Mountainwood Park Lake (siltation), Tomlinson Run Lake (siltation & phosphorus), Burches Run Lake (siltation & phosphorus), Hurricane Lake (siltation, phosphorus & iron)

6. South Branch Potomac River, North Fork River, Mill Creek River, Lunice Creek, Anderson Run River
*These were "partially" clustered because there were 5 separate Task 1 & 4 efforts that were not fully "clustered." Therefore, we applied 50% of Tasks 1 & 4 rather than 25%.

11. Buckhannon River and Ten Mile River

APPENDIX C
COMPARISON WITH THE GAP STATE WATER QUALITY MANAGEMENT RESOURCE NEEDS MODEL

APPENDIX C: COMPARISON WITH THE GAP STATE WATER QUALITY MANAGEMENT RESOURCE NEEDS MODEL

Both this report and the Gap Analysis Effort's State Water Quality Management Resource Needs Model (version 3.0, March 2000) appear to cover the same full range of activities needed to develop TMDLs at Level 1, 2 and 3 difficulty, although the individual tasks themselves are grouped differently for the purposes of estimating burden.[39] As shown in Exhibit C-1, the default unit burdens in the Model appear to roughly correspond in magnitude to the burden for Type A TMDLs as estimated in this report. However, it is unclear how to compare the estimates in this report with the defaults in the Model (which were intended to be representative of the "typical" State) for two reasons:

- Some of the Gap Model's tasks include effort for implementation in addition to TMDL development as defined in this report.

- The Gap Model's default estimates combine a number of important factors. For example, the Gap Model did not separately and explicitly estimate the burden that would result for Type A, B and C TMDLs or the typical distribution of TMDLs that would fall into these three categories. In addition, the documentation for the Gap Model does not indicate the extent to which such factors were considered or how they were incorporated into the default estimates.[40]

Therefore, we could not directly compare the estimated unit burdens in this report with those of the Gap State Water Quality Resource Needs Model or know how to interpret the result.

Exhibit C-1
Burden Estimates in Exhibit I-3 and from the Gap Model's TMDL Module

Source	Level 1 (hours)	Level 2 (hours)	Level 3 (hours)
Type A TMDL in this report (Exhibit I-3)	933	1,798	3,175
Gap Model's TMDL Module	806	1,798	3,249
Difference in hours: Exhibit I-3 less Gap Model	127	0	(74)
Exhibit I-3 as a percent of Gap Model estimates	116%	100%	98%

[39] The task definitions used in this report were designed to facilitate our ability to compare the unit burdens estimated in this report with the known actual cost for completed TMDLs (see Appendix B).

[40] For example, one possibility is that the degree and incidence of efficiencies were directly incorporated into each of the estimates for Level 1, Level 2 or Level 3 difficulty; however, another possibility is that TMDLs with efficiencies, were simply considered to be lower cost and could be represented by a lower level of difficulty (e.g., describe efficient Level 2 TMDLs as Level 1 TMDLs because they have the cost of Level 1 TMDLs).

APPENDIX D
COMPARISON WITH THE WASHINGTON STATE WORKLOAD MODEL

APPENDIX D: COMPARISON WITH THE WASHINGTON STATE WORKLOAD MODEL

The Washington State Department of Ecology prepared an estimate of its expected workload for implementing Section 303(d) of the federal Clean Water Act.[41] Washington State's workload model (for convenience in this appendix, referred to as "Washington's Model") was based on Washington's 1996 303(d) list, for which a consent agreement was entered into in 1997 that requires the Department of Ecology to develop TMDLs for all those waterbodies within 15 years. Washington's model estimates the required resources for developing TMDLs and includes the resources needed by the Department to implement them as well. About 1/3 of the total effort estimated by Washington State is associated with developing TMDLs, and the remaining 2/3 is associated with listing and implementing TMDLs.

This appendix compares the results of Washington State's workload model for the effort needed to develop TMDLs with the estimates that result from applying the model developed in this report (for convenience, referred to as the "EPA Model"). In this appendix, we consider the Washington Model to provide a benchmark by which we roughly assess the accuracy of the EPA Model. The estimate from the EPA Model should not be considered to be an alternative estimate to the Washington Model, because far more State-specific adjustments are needed to the EPA Model to provide reliable estimates at the State level (as discussed in Appendix A).

Overall, we found that EPA's Model, when tailored to reflect the State-specific circumstances of Washington State, over-estimates the total workload associated with TMDL development by perhaps 4% when compared to the results of the Washington Model. Therefore, the EPA model appears to be relatively accurate, and more likely to over-estimate cost rather than underestimate cost.

This Appendix is organized as follows:

A. Overview of Washington State's Workload Model
B. Application of the EPA Model
C. Comparison

A. OVERVIEW OF WASHINGTON STATE'S WORKLOAD MODEL

1. Types of activities included in the Washington Model

The Washington State Workload Model estimates the effort needed to develop and implement TMDLs for about 1,554 TMDLs associated with its 1996 303(d) list. For achieving efficiencies in developing TMDLs, these 1,554 individual TMDLs for 666 waterbody segments were grouped into 173 "projects"[42] – in this report, we have referred to such projects as "clusters." The Washington Model divides the projects into four categories: simple, clean lakes, landscape, and complex. The Washington

[41] *Total Maximum Daily Loads Workload Model, Program Definition and Cost, Implementing Section 303(d) of the federal Clean Water Act in Washington State*, Department of Ecology, Ecology Publication #98-26, July 1998

[42] Ibid. Table 3, page 14.

Model estimates the average workload associated with the following program components for each type of project as shown in Exhibit D-1:

Exhibit D-1
The Extent that the EPA Model Includes Tasks in the Washington Model

Tasks Included In The Washington Model	% of Task Included in EPA Model
1. TMDL Development	100%
2. Implementation of Controls	0%
3. Assessment of WQ-Based Controls (during implementation)	0%
4. Appeals – TMDL development dependent	100%
5. Data Management – TMDL development dependent	100%
6. Listing	0%
7. Priority Ranking & Targeting	0%
8. Programmatic Data Management (Development and maintenance of the TMDL data base. Day-to-day data entry and data extraction to demonstrate and track trends and compliance)	50%
9. TMDL Program / Policy Development (Coordination and policy development in partnership with EPA and stakeholder groups. Development and maintenance of policies, guidance and resources on listing, prioritization, implementation, technical assistance, TMDL effectiveness assessments, and alternative controls. Includes maintaining the TMDL workload model, operator certification, and TMDL and 2514 guidance for local planning units.)	10-50%
10. Management & Support (Supervisor and clerical function support for the TMDL program at 24.8% of other tasks)	100%

In this report, we only estimate the workload associated with developing TMDLs. In the Washington Model, this includes: 100% of TMDL development, 100% of appeals, 100% of data management, perhaps 50% of programmatic data management, perhaps 10%-50% of TMDL program and policy development, and 100% of management and support associated with these tasks With regard to incorporating consideration of management and support, the EPA and Washington Models use different approaches: the Washington Model adds additional labor effort to account for management and support (an additional 24.8% of the effort for the applicable tasks), while the EPA Model incorporates the additional cost of management and support into the fully loaded overhead rate. Therefore, we address the management and support activity separately in the last step of this comparison.

2. The Washington Model's estimates for tasks included in the EPA Model

The projects and the associated level of effort as estimated by Washington State (in terms of FTEs[43]) is summarized in Exhibit D-2a and D-2b below:

Exhibit D-2a
Washington State's Estimate of its TMDL Development Workload for its 1996 303(d) List[44]

Type of Project	Number	FTEs/Project	Total FTEs
Simple	87	1.29	112.23
Clean Lakes	48	0.42	20.16
Landscape	12	1.43	17.16
Complex	26	3.96	102.96
Totals	173	1.46	252.51

Exhibit D-2b
Washington State's Programmatic Activities included in the EPA Model

Type of Activity	# Years	FTEs/Year	Total FTEs
Programmatic Data Management (50%)	15	0.50	7.50
Program Development/Policy (10-50%)	15	.69-3.42	10.26-51.30
Totals	15	1.19-3.92	17.76-58.80

Therefore, from Exhibits D-2a and D-2b, Washington's estimate for developing the TMDLs associated with its 1996 303(d) list is 270.27 - 311.31 FTEs (prior to management and support, and not including other TMDL program activities such as listing and implementation).

B. APPLICATION OF THE EPA MODEL

Using the EPA Model, we can develop a rough workload estimate for the State of Washington that we can be compared to Washington's estimate of 311.31 FTE. This estimate is adequate for only roughly comparing the results of the EPA model with the Washington State model to assess the accuracy of the EPA model. Applying the EPA model to Washington State to obtain reliable workload estimate requires far greater detail and tailoring to the specifics of Washington State than was feasible for the purposes if this report, as discussed in Appendix A, Applicability to Individual States.

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43 Ibid. An FTE in Washington's workload model is "the amount of staff time a person would be employed working full time on a given activity. 1.0 FTE indicates a full time employee working for an entire year." We interpret this to mean that an FTE includes consideration of vacation time, etc, so that the actual working time might represent about 1,800 hours.

44 Ibid. Table 2 and Table 3, pages 13-15

1. Characteristics of Washington State's 1996 303(d) list

The Washington State Workload Model estimated the resource requirements for 1,554 causes for 666 waterbodies.

Since the purpose of this comparison is to evaluate the unit costs estimated in this report, it is necessary to adjust two State-specific factors in the EPA Model: the degree of clustering and the distribution of level of difficulty.

- Nationally, we have assumed that States will achieve up to 70% clustering. However, Washington State plans on extensive clustering, with 74% of the waterbodies receiving clustering efficiencies – (672-173)/672. Therefore, we apply Washington State's planned clustering.

- Nationally, we assumed that the distribution of level of difficulty for TMDLs is as follows: Level 1 = 45%, Level 2 = 30%, and Level 3 = 25%. However, we have the benefit of Washington's project categorization, which we interpret as follows:

  Level 1 - Simple Projects and Clean Lake Projects
  Level 2 - Landscape Projects
  Level 3 - Complex Projects

  Therefore, from Washington State's Workload Model, the actual distribution of level of difficulty for Washington State is: Level 1 = 78%, Level 2 = 7% and Level 3 = 15%. Because Washington State has a significantly smaller proportion of high-cost TMDLs than we assumed nationally, for this comparison, we adopt Washington State's distribution to more directly evaluate the accuracy of the unit cost estimates in this report.

The resulting workload is shown in Exhibit D-3 below:

Exhibit D-3
Washington States TMDL Workload for its 1996 303(d) List

Description of the Submission	Total 100%	Level 1 78%	Level 2 7%	Level 3 15%
A. TMDLs requiring full cost: the only or first cause for a waterbody	173	134	12	27
B. TMDLs with standard efficiencies: clustered waterbodies or multiple causes	248	193	17	38
C. TMDLs with additional modeling-related efficiencies: subsequent related causes	1,133	883	79	171
Total Number	1,554	1,210	108	236

2. Resulting level of effort for developing TMDLs

Applying the unit burdens for developing TMDLs from Exhibit I-7 to Washington's TMDL workload developed in Exhibit D-3 provides the resulting level of effort (in hours) for developing TMDLs (prior to consideration of management and support) in Exhibit D-4 below:

Exhibit D-4
Total Hours for Developing 1,554TMDLs for Washington State's 1996 303(d) list

Description of the Submission	Total (hours)	Level 1 (hours)	Level 2 (hours)	Level 3 (hours)
A. TMDLs requiring full cost: the only or first cause for a waterbody	232,323	125,022	21,576	85,725
B. TMDLs with standard efficiencies: subsequent causes for a waterbody or cluster	127,466	59,444	12,580	55,442
C. TMDLs with modeling-related efficiencies: subsequent related causes	366,356	199,558	34,444	132,354
Total Hours	726,145	384,024	68,600	273,251

The total effort of 726,145 hours translates into about 403.4 FTE (at 1,800 hours per FTE). However, we note that the Washington State workload model assumes that approximately 10% of the TMDLs will be developed by local planning units instead of by the Department of Ecology.[45] Therefore, the total effort should be reduced by 10%, resulting in 363.1 FTE.

C. COMPARISON

The EPA model results in an estimated 363.1 FTE as compared to the Washington State workload model's estimate of 270.27 - 311.31 FTE;. On an FTE basis, the EPA Model's estimate is about 17-34% greater than the results of the Washington Model, prior to consideration of management and support.

The two models' results converge when incorporating the cost of management and support:

- In the EPA Model, applying the national average of $38.89 for fully loaded labor rates to the estimate of 363.1 FTE results in a total cost of about $28.2 million, which includes the cost of management and support since it is part of the fully loaded labor rate.

- In the Washington Model, the comparable level of effort is 337.3 - 388.5 FTE (to include 24.8% for management and support). Applying Washington State's projected labor rate for fiscal 2000 of $83,000[46] results in a total cost of $28.0 to $32.3 million.

However, since the fully loaded hourly rate of $38.89 for the EPA Model does include management and support, and the Washington Model's fully loaded hourly rate of $46.11 per hour does not include management and support, at a minimum, the 18.6% difference between the two labor rates must represent a higher labor cost in Washington State than the national average. Therefore, it is appropriate to take this additional State-specific consideration into account when tailoring the EPA Model to reflect Washington State's circumstances. Using Washington State's labor rate of $46.11 results in a total cost for developing TMDLs of $33.5 million.

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[45] Ibid. Page 20. The additional effort required by the Department to provide support to the local planning units was not included in the per/project effort estimates, so no further adjustment beyond the 10% reduction is needed to obtain comparable estimates.

[46] Ibid. Page 9. Note that on an hourly basis, $83,000 annually amounts to $46.11per hour, which does not include management cost and is about 19% higher than the national average estimate of $38.89 per hour that does.

Therefore, on a roughly comparable dollar basis (which allows the inclusion of management and support costs, and tailoring the EPA Model to reflect State-specific factors including clustering of waterbodies, distribution of level of difficulty, and State labor rates), the EPA Model's estimates are $33.5 million as compared to the Washington Model's estimate of $28.0 - $32.3 million.

Overall, it appears as though the basic methodology and the unit burden estimates developed in the EPA Model for this report tend to provide similar results to the more detailed State-specific assessment developed by Washington State. In the absence of taking State-specific factors into account, the national average estimates in the EPA Model results in a cost that far exceeds the cost estimated by the Washington State Model.[47] When State-specific factors are reflected in the EPA Model (such as Washington State's more aggressive efforts to cluster waterbodies, the relative low percentage of higher-difficulty TMDLs, and the slightly higher labor costs), the EPA Model still slightly overestimates the cost of developing TMDLs by less than 5% of Washington State's high-end estimate. If the EPA Model is in error, it appears more likely to over-estimate cost than to under-estimate cost.

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[47] This report assumes that nationally a far greater portion of the TMDLs will be of Level 2 and Level 3 difficulty and even the high-end clustering assumption of 70% is lower than Washington State's planned clustering. These assumptions which increase cost are only partially offset by the lower national average salaries assumed for this analysis.

APPENDIX E
EVALUATION OF EPA’S 1996 REPORT: CASE STUDIES OF 14 TMDLS

APPENDIX E: EVALUATION OF EPA'S 1996 REPORT: CASE STUDIES OF 14 TMDLS

In 1996, to begin to develop an understanding of the costs associated with developing TMDLs, EPA prepared an initial analysis, *TMDL Development Cost Estimates: Case Studies of 14 TMDLs* (May, 1996), the 1996 Report. There are significant limitations associated with the estimates in 1996 Report. Once the useful information from the 1996 Report is properly extracted and evaluated, the results tend to be consistent with the conclusions of this analysis:

- the unit costs developed in Chapter I result in costs that are similar to those of the 1996 Report, and

- if the costs extracted from the 1996 Report are applied in a manner that is consistent with the national workload (as described in Chapter II), we obtain a national average cost of developing TMDLs that is similar to that estimated in this report.

These results are described in more detail below. We begin by describing the limitations of the 1996 Report. We then characterize each of the 14 case studies in terms of the framework developed in this report (e.g., three levels of difficulty, three degrees of efficiencies, etc), and isolating the cost information associated only with developing TMDLs (as opposed to other activities such as monitoring and implementation). After extracting the useful cost information from the 1996 Report, we then compare the costs from the 14 case studies with estimates from Chapter I this report. Finally, we show how to use the information from the 1996 Report to estimate national costs.

A. LIMITATIONS OF THE 1996 REPORT

While the 1996 Report provided a helpful start in understanding this topic, the results of the study cannot be directly applied to the purpose of estimating either the average cost or the national cost of developing TMDLs:

- *The costs in that study are probably not representative of current costs.* The cases represent experience in developing TMDLs as of 1995 or earlier. Much has been learned since then regarding more efficient approaches for developing TMDLs. In addition, some of the cases represent costs associated with learning how to develop TMDLs or are forecasts of costs for TMDLs that were about to be developed made by staff that had little experience in actually developing TMDLs. Therefore, the estimated costs for at least some of the cases are either not reliable or representative of current costs.

- *The 14 cases are not representative of the national TMDL workload.* The 14 case studies were selected to represent a wide range of TMDLs based on readily available information at the time of the study. The 14 cases were not selected to be representative of the national TMDL workload since that was unknown; at the time of the study, even the 1996 303(d) lists had not been submitted. Upon comparing the composition of the 14 case studies with the analyses in Chapters II and III of this report (which analyze the national TMDL workload based on the 1998 303(d) lists), it is clear that the mix of 14 cases does not represent the national TMDL workload.

- *The costs include monitoring and implementation costs, not just TMDL development.* The types of costs that were included in the 14 cases varied from one case to the next, and the costs for some of the cases included substantial expenditures for monitoring and implementation. Therefore, the costs in the study cannot be used without substantial adjustments to isolate those cost components of interest.

- *The costing methodology is inconsistent across cases.* The costs estimated in the 1996 Report were not consistently developed from one case to the next (reflecting widely different methods to estimate the cost per FTE). Therefore, the cost information in the 1996 report cannot be used. However, the level of effort information (FTE's) provided in the 1996 Report may provide a more reliable and consistent measure for the cases.

Therefore, the results of the 1996 Report cannot be used directly to estimate either the average cost of developing TMDLs or the cost of the national workload. Instead, each case in the 1996 Report requires evaluation and careful adjustment to derive information that can be helpful for these purposes. The next section of this appendix reviews the 14 case studies in this light and extracts the useful information from the study.

B. EXTRACTION OF USEFUL INFORMATION FROM THE 1996 REPORT

1. Approach for using the information in the 14 cases

We reviewed all of the information in the 1996 Report for each of the 14 cases to characterize them in terms of level of difficulty, the number of causes that were addressed by each case, and the types of efficiencies that would be realized when developing TMDLs for these causes. Because the 1996 Report tended to include cases that represented extremely low cost and high cost TMDLs, we have included two additional levels of difficulty: Level "L" for low-cost TMDLs (lower cost than Level 1) and Level "H" for high-cost TMDLs (higher cost than Level 3).[48] In addition, some of the cases represented "learning" situations in which the cost far exceed expectation for the level of difficulty of the TMDL: in these cases we classify the TMDL as Level "F" for "first" TMDL developed, representing "learning curve" costs rather than being indicative of typical future costs. Using this approach, the 14 case studies included 6 "outliers" that represented either extremely low-cost TMDLs or extremely high-cost TMDLs as summarized below in Exhibit E-1.

[48] We categorized the overall TMDL on this basis, rather than specific tasks. For example, even though the modeling task for Lake Chelan might be considered Level 2, the unusually high public outreach and public participation efforts dominated the overall costs, so Lake Chelan is classified as Level H in Exhibit E-1.

Exhibit E-1
Classification of the 14 Cases in the 1996 Report

Type	# Cases
Level 1, 2 or 3 difficulty (25^{th} to 75^{th} percentile)	8
Level L - extreme low cost	2
Level H - extreme high cost	2
Level F - learning or inadequate information	2
Total	14

We evaluated the cost information for each case to allocate the estimated effort to the 8 TMDL development tasks described in Chapter I of this report. In a number of cases, the costs in the 1996 Report included estimates for activities that are not considered TMDL development tasks in this report (such as monitoring and implementation). Sometimes the 1996 Report integrated the costs associated with monitoring and implementation with TMDL development tasks in a manner that could not be separated; in these instances, we could not extract the estimates for the affected TMDL development tasks. To provide a consistent basis for comparison across the 14 case studies and with the estimates in this report, we used only the FTE estimates from the 14 case study as well as any estimates of contractor costs (escalated to 2000 dollars as needed, using the consumer price index). To arrive at consistent dollar costs, we applied the national average fully loaded labor rate of $70,000 per FTE used in this study to the FTE estimates from he 1996 Report. In this way, we have factored out some of the inconsistencies in how the 1996 Report estimated cost per FTE across different cases, are able to combine the costs associated with FTEs with the reported expenditures for contractor services, and can compare the resulting adjusted costs for the 14 cases with estimates from Chapter 1.

Exhibit E-2 shows the results of this assessment, with the total costs shown in the last column for the tasks estimated in the previous columns. This provides a basis for comparing the costs estimated in the 1996 Report with the estimates that result when applying the methodology and assumptions developed in Chapter I of this study. Note that the estimates in Chapter 1 cannot be applied directly to those cases that are Level "L" or Level "H" difficulty, although we can still compare our estimates to those of the 1996 Report. Finally, there are a few instances where no comparison can reasonably be performed at all: these are the cases representing Level "F" or cases where the information provided for the cases in the 1996 Report either represents initial learning costs, or is otherwise too inconsistent, aggregated or unreliable to be used.

The remainder of this section, which extracts useful information from the 1996 report, discusses each of the 14 cases.

2. Evaluation of each of the 14 cases

Each of the 14 cases is described in detail in the 1996 Report. The following does not repeat the information provided in the 1996 Report, but rather summarizes only those aspects of the cases that are important regarding the extraction of useful information for the purposes of this analysis.

Exhibit E-2
Description of Cases and Level of Effort for Selected Tasks as Estimated in the 14 Case Study Report

Name	Type of Estimate	Status	# Causes By Type			Level of Difficulty	Level of Effort (FTEs) By Task										Total Cost at $70,000 per FTE
			A	B	C		1	2	3	4	5	6	7	8	Total	Other	
a. Appoquinimink River	Actual	Approved	1		2	2	0.33	0.02	0.21	Other	NA	0.06	0.08	See 6	0.70	$50K	$99,000
b. Lake Chelan	Actual	Approved	1	1		H	------	Other	1.2		2.65		0.96	See 3	4.81	$15.5K	$352,200
c. Chenoweth Run	Forecast	Unknown	1			1	------	0.574						-----	0.574	-----	$40,180
d. Cobbossee Lake	Actual	Approved	1			L	0.03	0.02	0.05	See 7	NA	NA	0.03	NA	0.13	-----	$9,100
e. Delaware River Estuary	Actual	Approved	1	4		H	NA	2.8	2.9		0.1	0.25	1.75	See 5	7.8	-----	$546,000
f. Flint Creek	Forecast	Not Submitted	1	?		F?	NA	1	7.0?		0.04	0.02	1.14	See 3	9.2?	-----	? $644,000?
g. Hillsdale Lake	Actual	Not Submitted	1		1	1	0.08	0.3	0.04	See 7	See 7	0.002	0.084	See 7	0.506	-----	$35,420
h. Little Deep Fork Creek	Forecast	Unknown	1	3	1	2	NA	0.23	0.11	See 7	~1.3	~0.58	~0.26	See 5	~2.48	-----	~$173,600
i. Lower Minnesota River	Actual	Unknown	1		1	3	NA	2.83		0.33				See 2	3.16	-----	$221,200
j. Oil Branch Creek	Actual	Approved	1		1	L	0.04	0.02	0.01	0.0	0.0	0.0	0.01	See 7	0.08	-----	$5,600
k. South Fork Salmon R.	Actual	Approved	1			1	0.1	0.08	0.06		0.02	0.08	NA	NA	0.34	-----	$23,800
l. Sycamore Creek	Actual	Unknown	1			F	NA	0.9	0.7	See 7	NA	NA	0.2	See 3	1.8	-----	$126,000
m. Truckee River	Actual	Unknown	1	1	1	3	NA	Other	0.17	See 7	0.19	0.02	0.08	See 5	0.46	$124.8K	$157,000
n. Yankee Hill Lake	Forecast	Unknown	1	?	?	1	0.1	0.02	0.03	See 7	Other	Other	0.03	Other	0.18	$27.3K	$39,900

A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster
B. TMDLs w/ standard efficiencies: subsequent causes for a waterbody or cluster
C. TMDLs with additional modeling-related efficiencies: subsequent related causes

Task 1 - watershed characterization
Task 2 - modeling & analysis
Task 3 - allocation analysis
Task 4 - develop TMDL document
Task 5 - public outreach
Task 6 - public participation & response
Task 7 - tracking, planning, etc.
Task 8 - implementation plan

Level 1 - Simple TMDLs
Level 2 - Mid-Range TMDLS
Level 3 - Complex TMDLs

Level L - Low cost TMDLs
Level H - High cost TMDLs
Level F - "First" TMDLs, with higher costs due to learning

a. Appoquinimink River, Delaware

The Appoquinimink River Level 2 submission was also included in the verification analysis of 131 TMDLs in Appendix B of this report. However, in Appendix B, the actual estimated costs of $50,000[49] were actual contractor costs for Tasks 2, 3 and 4 only. The 1996 Report, however, provides estimates for Tasks 1, 2, 3, 4, 5, 6 and 7 because the State staff costs are included along with the contractor costs. The resulting total adjusted cost for the three pollutants for these tasks as derived from the 1996 Report is $99,000.

b. Lake Chelan, Washington

The 1996 Report's cost estimates for the Lake Chelan TMDL included substantial monitoring costs. Unfortunately, the 1996 Report combined the estimates for watershed characterization and data collection with the cost of monitoring, so that we cannot estimate the effort associated with only Task 1. Overall, this was a comprehensive TMDL development effort that included scenarios for implementing pollution controls and the potential costs of those scenarios. The tasks for which we could separate out the associated costs and effort are Tasks 2,3,4,5,6,7, and 8 for a total cost of $352,200. For Task 2, the modeling costs were all for contractors amounting to $10,000 in 1989, or equivalent to about $15,500 in 2000. Unfortunately, Tasks 5, 6 and 7 (public participation, outreach, and coordination) include exceptionally costly coordination efforts (Task 7) amounting to 3.61 FTE or $252,700. The costs associated with these three tasks alone far exceed the full costs for developing typical Level 3 TMDLs. As explained below, this is an unusually high level of effort for these tasks, and also includes activities associated with implementation.

Although we classify this submission as Level 2 difficulty based on the modeling approach used, the public participation and outreach situation exceeds even Level 3 difficulty. As noted in the 1996 Report, "The Lake Chelan TMDL was politically sensitive because of controversies surrounding future development in and around the lake... In addition, other issues involving selection of appropriate land uses within the watershed and the preservation of wetlands have involved federal, state and local government agencies." Consequently, there were meetings with "local stakeholders on a routine basis for approximately three years."(1996 Report, page 41). Further, the public participation, outreach and planning/coordination tasks included elements of outreach for implementation. This also affected related costs such as the cost of preparing the TMDL document.

Therefore, this case is in the group of high-cost TMDLs that are not directly estimated in this report. We have no basis for assessing the extent to which this case might be representative of high-cost TMDLs.

c. Chenoweth Run, Kentucky

At the time the 1996 Report was prepared, the TMDL for Chenoweth had not been completed. At the time, about .26 FTE amounting to a cost of $19,625 had been accumulated, of which .08 FTE

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[49] We note that the 1996 Report estimates the contractor cost at $40,000 in 1993. The 131 TMDL comparison estimated the contractor cost at $50,000 in 2000 dollars. For this analysis, we have used the $50,000 for both the 131 TMDL comparison, as well as for the estimates from the 1996 Report.

representing $12,500 was for monitoring and data collection. The FTE's had been costed at an average rate of $39,000 per FTE. The anticipated total cost for completing the TMDL was $35,000.

Therefore, additional effort of $15,375 was expected ($35,000 - $19,625), amounting to 0.394 FTE. Previously, 0.08 of effort (plus additional expenses of about $9,500 for laboratory analysis) had been devoted to monitoring-related effort, so that the previous effort for TMDL development tasks was 0.18 FTE (0.26 - 0.08). Thus, the total expected effort for Tasks 2,3,4,5,6,and 7 was expected to be 0.574 FTE.

At this study's average fully loaded labor rate of $70,000 per FTE, the cost associated with this effort of 0.574 FTE is $40,180.

d. Cobbossee Lake, Maine

The TMDL expenses shown in the 1996 Report for Cobbossee Lake were all related to TMDL development and very low because only simple modeling was needed, the lake watershed was small, and there was over 20 years of historical monitoring available. Altogether, the total effort for Tasks 1, 2, 3, 4 and 7 amount to 0.13 FTE, equivalent to a total current cost of $9,100 based on the average fully loaded rate of $70,000 per FTE. This is an extremely low cost TMDL, and is classified as Level L.

e. Delaware River Estuary, New Jersey

The Delaware River Estuary TMDL was for 5 pollutants that were not related. The 1996 Report provides estimates for all 8 tasks (the implementation plan is included in the estimate for outreach, and much of "administration" can be considered outreach under our definition of these tasks). However, Task 1 includes substantial monitoring costs that we were not able to factor out. Therefore, we include all of the effort identified in the 1996 Report for the Delaware Estuary TMDL except for Task 1. As shown in Exhibit B-1, the total effort was 7.8 FTE at a cost of $546,000 based on the average fully loaded rate of $70,000 per FTE.

We classify the Delaware River Estuary submission as a high-cost submission (Level H). As pointed out in the 1996 Report, "The Delaware River Estuary is unique as a result of the number and complexity of pollutants, and the strong tidal action in the waterbody. Given the hydrodynamic complexity of the estuary, the numerous pint source discharges, and the various fate processes affecting toxic pollutants, DRBC selected complex mathematical instruments to model the estuary." Over 80 point sources were involved in 11 tributaries, the headwaters of the Delaware River, the C&D Canal and a seaward boundary. While the TMDLs were eventually developed for toxics, the analysis included up to 10 toxics. In addition, there was extraordinary public participation and outreach efforts involving "numerous committees and subcommittees" composed of "members of each state environmental agency bordering the estuary, USEPA, local governments and the general public."

f. Flint Creek, Alabama

We don't have an adequate understanding of the Flint Creek case based on the limited information presented in the 1996 Report.

- Based on the information in 1996 Report, the sophistication of the modeling may represent Level 2 or 3 difficulty, because several approaches seem to be referenced and perhaps all of them were applied.
- Further, the estimates themselves are unclear. There appears to be an unusual amount of analysis for Flint Creek. For comparison, the level of effort for analysis for Flint Creek is more than double that for the Delaware Estuary, which we classified as a Level H submission for 5 toxic pollutants. Overall, for the same tasks, the Flint Creek estimate exceeds the Delaware Estuary estimate.

- Perhaps the estimates include other efforts beyond TMDL development for one cause. For example, although the case seems to indicate that there was primarily focus on a TMDL for dissolved oxygen, there is mention of additional TMDLs being worked on. Further, there could be extensive implementation-related effort included in this estimate.

- The TMDL never was submitted so we don't have that information from that submission to review.

Therefore, we don't have an adequate basis for working with the resulting total effort of 9.2 FTE ($644,000).

<u>g. Hillsdale Lake, Kansas</u>

The Hillsdale Lake case represents a Level 1 submission for two related pollutants. All of the estimates in this case can be used directly for Tasks 1, 2, 3, 5 and 6. The case estimated a 20% surcharge on the other tasks for "administration," by using a labor rate that was marked up by the 20% surcharge. However, administration included the preparation of the report (our Task 4) and substantial outreach activities (our Task 5). Therefore, we estimated the FTE effort for Task 7 (which primarily constituted Tasks 4 and 5) by taking 20% of the other tasks, per the State's convention. As a result, the total effort for this case was 0.506 FTE representing a total cost of $35,420 using the average fully loaded rate of $70,000 per FTE.

<u>h. Little Deep Fork Creek, Oklahoma</u>

The Little Deep For Creek case represents a Level 2 submission for 5 pollutants, of which 2 are related. However some adjustments to the case estimates are needed to separate out the TMDL development costs:

- The information in the case combines monitoring with data collection, so that we are unable to derive a separate estimate for Task 1, watershed characterization.

- In addition, the outreach (Task 5) and public participation (Task 6) tasks in the case include substantial public education and implementation related efforts that, while important, cannot be considered part of TMDL development. For example, the activities listed for outreach include: educating land owners about BMPs, providing oversight responsibilities for and coordination of projects, writing conservation and management plans, and conducting public education programs. The activities listed for public participation include: educational and organizational meetings to increase awareness of land-stream interactions, recruiting and enrolling landowners in the BMP demonstration program, etc. Therefore, from the descriptions in the case, it appears that the bulk of the efforts is for implementation-related activities.

- Similar to Tasks 5 and 6, the Administration task (Task 7) also includes implementation-related activities, including: managing the public information activities, tracking BMP implementation activities, post implementation monitoring, and performing awareness surveys.

Therefore, we are not able to include Task 1 in Exhibit E-1. Rather than fully exclude Tasks 5, 6 and 7 from Exhibit E-1, we conservatively assume that perhaps half of the effort estimated in the case is for TMDL development, and the remainder of the effort is for implementation – based on the description in the case, this is more likely to overstate the effort associated with TMDL development than to understate it. This results in a total effort of 2.48 FTE for TMDL development amounting to a cost of $173,600 based on the average fully loaded rate per FTE.

i. Lower Minnesota River, Minnesota

The Lower Minnesota River represents a Level 3 submission addressing two related causes of impairment. This TMDL effort was undertaken over a decade ago during the period 1974 through 1987. The bulk of the effort shown in the 1996 Report was for monitoring and data collection. The effort associated with Tasks 2, 3, 4, 5, 6,7 and 8 amounted to 3.16 FTE representing a current cost of $221,200 at the average fully loaded labor rate of $70,000 per FTE.

j. Oil Branch Creek, Oklahoma

The Oil Branch Creek represents a Level L submission addressing 2 related causes of impairment. The simplicity of the watershed and its pollutant problems resulted in a very low level of effort to develop the TMDL, including no public participation. The total effort was 0.08 FTEs, representing a current cost of $5,600 at the average fully loaded labor rate of $70,000 per FTE.

k. South Fork of the Salmon River, Idaho

The South Fork of the Salmon River represents a Level 1 submission addressing 1 cause of impairment. The 0.34 FTE estimated in the 1996 Report applies to the Tasks 1 through 6. In this case, it doesn't appear that the estimates include the preparation of an implementation plan (Task 8). In addition, the administration task in this case appears to be truly administrative overhead only (unlike the other cases, where administration involved direct effort for other tasks (e.g., preparing the TMDL report), so that we do not include the administrative effort here because administrative overhead is incorporated into the $70,000 fully loaded overhead rate per FTE. Therefore, the effort for this TMDL was 0.34 FTE representing a current cost of $23,800 at the average fully loaded labor rate of $70,000 per FTE.

l. Sycamore Creek, Michigan

Sycamore Creek was the first TMDL of its type prepared by the Michigan Department of Natural Resources (MDNR). This TMDL was considered to be "an invaluable learning experience," by the MDNR, indicating that the costs incurred for this TMDL are not representative of what the costs might be today for the same TMDL. We note that while we consider the type of modeling and analysis performed for Sycamore Creek to be representative of Level 1 difficulty, the 1996 Report estimates a total of 1.6 FTE for modeling and analysis alone, which exceeds the higher end of our estimated Level 3 modeling and analysis effort by a factor of 3. Therefore, we denote the Sycamore Creek TMDL as representing a Level F submission for 1 cause of impairment.

Most of the effort shown in the 1996 Report is for monitoring. While there were outreach and public participation efforts, these were not estimated in the 1996 Report. The effort associated with Tasks 2, 3. 4 and 8 amounted to 1.8 FTE, primarily composed of the modeling and analysis work. This represents a current cost of $126,000 at the average fully loaded labor rate of $70,000 per FTE.

m. Truckee River, Nevada

The Truckee River represents a Level 3 submission for 3 causes of impairment, 2 of which were related. The data collection effort was primarily monitoring costs and so we do not include that task as part of the TMDL development effort in Exhibit B-1. The modeling was performed by contractors at a cost of $109,778 in 1995 dollars, representing $124,800 in March, 2000 dollars. The effort associated with the remaining tasks (3, 4, 5, 6, 7 and 8) amounted to 0.46 FTE representing a current cost of $32,200. Therefore, total cost for Tasks 2-8 is $157,000.

n. Yankee Hill Lake, Nebraska

Yankee Hill Lake represents a Level 1 submission for 1 cause of impairment (note that three pollutants are listed for Yankee Hill Lake in the 1996 Report, but the discussion of the TMDL only mentions one of them, so we assume all of the effort is associated with just one of the causes). At the time of the report, the Nebraska Department of Environmental Quality had incurred an effort of 0.18 FTE for Tasks 1, 2, 3 and 7 at an estimated cost in the 1996 Report of $4,598. Based on the average fully loaded rate of $70,000/FTE, the 0.18 FTE amount to $12,600 in 2000 dollars.

The Department was to receive an additional grant of $10,000 to complete the TMDL, and they did not expect to exceed this amount "due to the relatively simple nature of the tasks involved." The additional $10,000 translates into an additional effort of 0.39 FTE ($10,000/$4,598). Based on the average fully loaded rate of $70,000/FTE, the 0.39 FTE amounts to $27,300.

Altogether, the total effort for the submission for Yankee Hill Lake was expected to be $39,900.

C. Comparing the Costs of the 14 Cases with those in This Report

In summary, the previous section characterized each of the 14 case studies in terms of the framework developed in this report (e.g., three levels of difficulty, three degrees of efficiencies, etc.). Because the 1996 Report included cases that represented extremely low and high cost TMDLs, we included two new categories: Level "L" for extremely low-cost TMDLs (i.e., lower than the bottom of the range for Level 1) and Level "H" for extremely high cost TMDLs (higher than the top of the range for Level 3). In addition, some of the case studies clearly represent "learning" situations where the costs are unexplainably high given the level of difficulty and/or sophistication of the TMDL analysis, and these are classified as Level "F" (for "first" TMDLs). The results are summarized below in Exhibit E-3.

Exhibit E-3
Classification of the 14 Cases in the 1996 Report

Type	# Cases
Level 1, 2 or 3 difficulty (25th to 75th percentile)	8
Level L - extreme low cost	2
Level H - extreme high cost	2
Level F - learning or inadequate information	2
Total	14

In the previous section of this appendix, we evaluated each of the 14 cases to isolate the level of effort information associated with developing the TMDLs (as opposed to other effort associated with activities such as monitoring and implementation) for each of the 8 tasks specified earlier in this Chapter. We developed the associated cost for such by multiplying the number of FTEs by $70,000 (the average fully loaded cost of an FTE as discussed earlier in this Chapter). In this way, we estimated cost in a consistent manner across all 14 case studies (in March 2000 dollars, as are the other cost estimates in this report) and know precisely which tasks are included in these costs.

Since we knew for each case study the level of difficulty, the number of causes at different levels of efficiency, and the tasks that are included, we can apply the unit costs developed in this Chapter I to each of the case studies. We can also then compare the costs in the 1996 Report with the costs that would result from the unit cost estimates developed in Chapter I (Exhibit I-3, Exhibit I-5 and Exhibit I-6). The results for all the cases (except for the two Level F cases, which we excluded from further analysis) are summarized in Exhibit E-4.

As shown in Exhibit E-4, the unit costs from this Chapter reasonably approximate the cost of developing TMDLs for the cases in the 1996 Report, especially for the 8 cases that represented Level 1, 2 and 3 TMDLs:

- For the 8 cases at Level 1, 2 or 3 difficulty, the cost derived from the 1996 Report is $790,000 while the application of the average unit costs developed in this Chapter (based solely on tasks included, the level of difficulty, and the number of causes at different efficiencies) is $714,000 (the associated range for the eight cases was $493,000 to $936,000). Generally, using the unit costs in Chapter I significantly overestimates the cost of the two Level L cases by a factors of 3 and 6 (based on the low-end of Level 1); and underestimates the cost of the two Level H cases by about 25-30% (based on the high end of Level 3).

- For all 12 cases (including the very low and the very high cost TMDLs), the cost derived from the 1996 Report is $1.7 million. Using the unit costs from this Chapter (from Exhibits I-3, I-5 & I-6), the range of cost is estimated to span about $0.9 million to $1.7 million, with an average of $1.3 million. Thus, even when the extreme cases are included, the unit costs developed in Chapter I encompass the 1996 Report costs.

Exhibit E-4
Characterization of 12 Cases in the 1996 Report and Comparison with the Resulting Cost Using Chapter I Unit Costs

Name	# Causes By Type			Level of Difficulty	Tasks Estimated and Resulting Total Cost in the 1996 Report									Estimated Cost Using Chapter 1 Unit Costs		
	A	B	C		1	2	3	4	5	6	7	8	Cost	Low	Average	High
a. Appoquinimink River	1		2	2	✔	✔	✔	✔	-	✔	✔	-	$99,000	$55,068	$87,464	$119,859
b. Lake Chelan	1	1		H	-	✔	✔	✔	✔	✔	✔	✔	$352,200	$122,698	$166,605	$210,512
c. Chenoweth Run	1			1	-	✔	✔	✔	✔	✔	✔	-	$40,180	$18,901	$26,562	$34,223
d. Cobbossee Lake	1			L	✔	✔	✔	✔	✔	✔	✔	-	$9,100	$25,123	$33,562	$42,001
e. Delaware River Estuary	1	4		H	-	✔	✔	✔	✔	✔	✔	✔	$546,000	$239,251	$328,659	$418,068
g. Hillsdale Lake	1		1	1	✔	✔	✔	✔	✔	✔	✔	-	$35,420	$32,279	$45,074	$57,868
h. Little Deep Fork Creek	1	3	1	2	-	✔	✔	✔	✔	✔	✔	✔	$173,600	$91,314	$156,027	$220,740
i. Lower Minnesota River	1		1	3	-	✔	✔	✔	✔	✔	✔	✔	$221,200	$104,186	$139,965	$175,744
j. Oil Branch Creek	1		1	L	✔	✔	✔	✔	✔	✔	✔	✔	$5,600	$32,279	$45,074	$57,868
k. South Fork Salmon R.	1			1	✔	✔	✔	✔	✔	✔	-	-	$23,800	$21,856	$28,817	$35,779
m. Truckee River	1	1	1	3	-	✔	✔	✔	✔	✔	✔	✔	$157,000	$143,037	$193,983	$244,929
n. Yankee Hill Lake	1			1	✔	✔	✔	✔	✔	✔	✔	✔	$39,900	$25,901	$36,284	$46,668
Total causes for all 12 cases	28				Total costs for all cases (including Level L & H)								$1,703,000	$911,893	$1,288,076	$1,664,259
Total causes for Level 1,2,&3	18				Total costs for the Level 1, 2 and 3 cases only								$790,100	$492,542	$714,176	$935,810

A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster
B. TMDLs with standard efficiencies: subsequent causes for a waterbody or cluster
C. TMDLs with additional modeling-related efficiencies: subsequent related causes

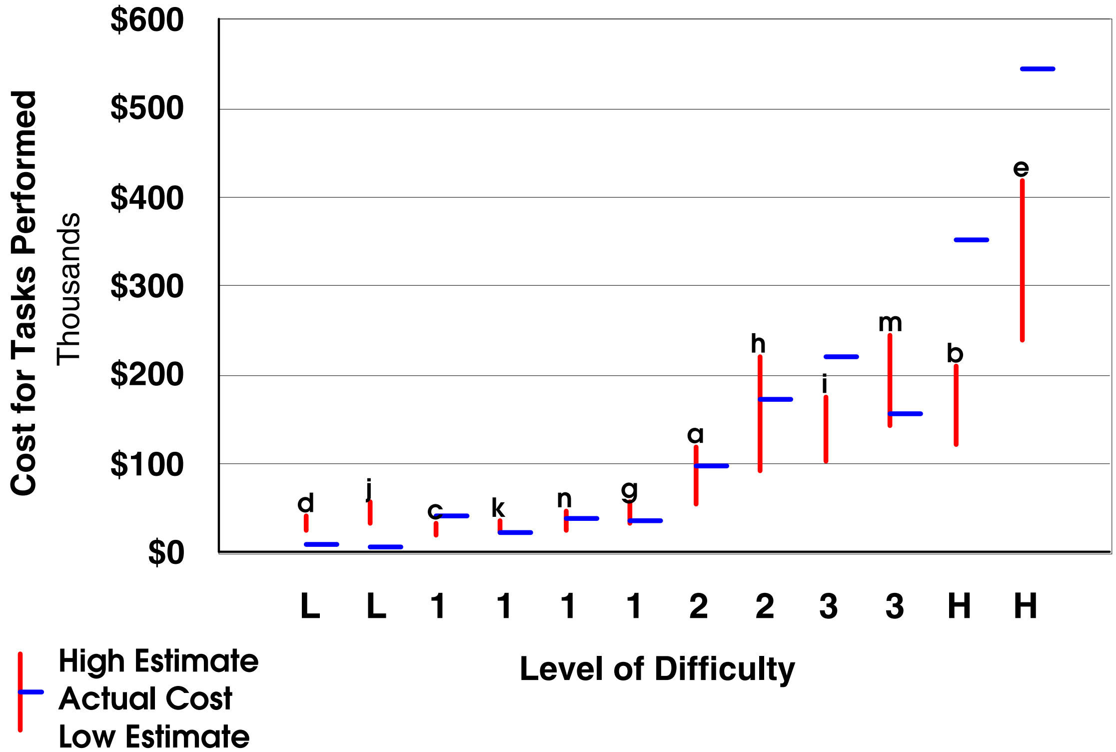
Task 1 - watershed characterization
Task 2 - modeling & analysis
Task 3 - allocation analysis
Task 4 - develop TMDL document
Task 5 - public outreach
Task 6 - public participation & response
Task 7 - tracking, planning, etc.
Task 8 - implementation plan

Level 1 - Simple TMDLs
Level 2 - Mid-Range TMDLS
Level 3 - Complex TMDLs
Level L - Low cost TMDLs
Level H - High cost TMDLs
Level F - First TMDLs, with higher costs due to learning (there were 2 cases at Level F, and these are not included in this Exhibit)

The comparison of the costs estimated in the 1996 Report and the costs based on the unit costs in this Chapter is further illustrated in Exhibit E-5 below (based on Exhibit E-4).

Exhibit E-5

Estimated Costs vs Costs in the 1996 Report
for 12 of the 14 Cases*
For Subsets of Tasks For Developing TMDLs



For the 8 lvl 1,2&3 TMDLs: 1996 Report Cost = $790,000 Total Ave Estimated Cost = $714,000

* Two cases represented learning situations or had inadequate information to be included

Because the TMDL Program was at a nascent stage when the costs in the 1996 Report were estimated, it is likely that the some of these TMDLs could be developed at a lower cost today. Thus, not only do the unit costs developed in this report correspond reasonably well to the TMDL development costs in the 1996 Report, this concordance actually suggests that the unit costs developed in this report tend to overestimate costs.

D. USING THE COSTS IN THE 1996 REPORT TO ESTIMATE NATIONAL COSTS

Some have attempted to use the costs in the 1996 Report as a basis for estimating the cost associated with the national TMDL workload. Using the costs as reported in the 1996 Report for this purpose is inappropriate and will lead to incorrect results because of the inconsistencies in the 1996 Report regarding the development of cost information, the inclusion of non-TMDL-development related activities, and the fact that the 14 case studies aren't representative of the national TMDL workload. We believe that the best available estimate for the cost of the national TMDL workload is developed in this report. However, we can provide an indication of what the national average cost per TMDL might be using the 1996 Report by appropriately adjusting the reported data. Nevertheless, it is not straightforward to work with the 1996 Report estimates to try to reflect the national distribution of the level of difficulty of TMDLs, or to properly reflect the national distribution of the extent of efficiency. The following estimate of the national average cost of developing TMDLs based on the 1996 Report is not intended to represent an alternative estimate to the one developed in this report; rather it is only intended to show that a more carefully derived estimate based on the 1996 Report does not differ much from the one we arrive at in this report.

Exhibit E-6 summarizes the distribution of the national workload by level of difficulty and extent of efficiency as estimated in Chapter II. The overall distribution of Level 1, Level 2, and Level 3 difficulty is estimated to be 45%, 30% and 25% respectively. Depending on the time frame needed by States to adopt the most efficient methods for developing TMDLs, the overall distribution of Level A, Level B, and Level C efficiency is estimated to be 16-22%, 14-15%, and 64-69%%, respectively.

Exhibit E-6
Percentage of 36,225 TMDLs for the 1998 303(d) List By Extent of Efficiency and Level of Difficulty

Description of the Submission	% Clustered		Level of Difficulty		
	60%	70%	1	2	3
A. TMDLs requiring full cost: the only or first cause for a waterbody or cluster	21.7%	16.2%			
B. TMDLs with standard efficiencies: subsequent causes for waterbodies or clusters	14.1%	15.1%	45%	30%	25%
C. TMDLs with additional modeling-related efficiencies: subsequent related pollutants	64.2%	68.7%			
Total Percentage	100.0%	100.0%	45%	30%	25%

We determined the distribution of the 28 causes addressed by the 12 cases from the 1996 Report in terms of their distribution by level of difficulty and degree of efficiency (Exhibit E-4). Exhibit E-7 indicates the level of difficulty and extent of efficiency for each of the 28 causes using the same case letters as Exhibits E-2 and E-4. It is clear from Exhibit E-7 that the 12 cases have a significantly different distribution of difficulty and efficiency than the national workload. The 12 case studies significantly overweight higher-cost TMDLs (e.g., we estimate that 25% of the national TMDL workload will be of Level 3 difficulty or greater, while the 1996 Report's cases have 42% of the causes at Level 3 difficulty or greater) as well as less efficient TMDLs (e.g., we estimate that 16-22% of the national TMDL workload will have no efficiencies while 43% of the 1996 Report's TMDLs have no efficiencies). Therefore, the average cost per TMDL for the 12 case studies clearly would not be representative of the average cost for the nation.

Exhibit E-7
Distribution of Causes Addressed by the 12 Case Study By Level of Difficulty and Efficiency

Efficiency	Level of Difficulty				
	Level L	**Level 1**	**Level 2**	**Level 3**	**Level H**
43% A	d j	c k g n	a h	i m	e b
32% B			h h h	m	b e e e e
25% C	j	g	a a h	i m	
	29% Level 1 & L		29% Level 2	42% Level 3 & H	

Based on the available information in the 1996 Report as summarized in Exhibit B-1, we can attempt to incorporate some consideration of the level of difficulty we expect for the national TMDL workload.

Exhibit E-8 presents an estimate of the national average cost of developing a TMDL based on the cost information in Exhibit E-4 for the TMDLs in the 1996 Report and the national distribution of the level of difficulty for TMDLs from Exhibit E-6. We assumed that half of the Level 1 TMDLs in Exhibit E-6 are instead of Level L difficulty and that half of the Level 3 TMDLs are instead Level H.

Exhibit E-8
National Average Cost of Developing TMDLs from the 1996 Report

From Chapter II		From 1996 Report from Exhibit E-4		
Level	National %	Level	New %	Ave Cost/Cause
1	45%	L	22%	$4,900
		1	23%	$27,860
2	30%	2	30%	$34,075
3	25%	3	13%	$75,640
		H	12%	$128,314
Weighted Average Cost Per Cause				$42,939

The resulting weighted average cost per cause is $42,939. However, we note that the cost estimates in Exhibit E-4 exclude a task or two for some of the cases. Typically, the tasks excluded account for about 10% of the cost (based on the unit cost estimates in this Chapter). Therefore, to reflect all of the TMDL development tasks, we adjusted the $42,939 from Exhibit E-8 upward by 10% to reflect these missing tasks. Based on the analysis so far, the resulting average cost per TMDL based on the 1996 Report is about $47,000.

However, while the $47,000 estimate takes into consideration the national distribution for level of difficulty, it does not reflect the national distribution for extent of efficiencies. In this report, had we used the implied distribution for the extent of efficiencies in the 1996 Report (as reflected in Exhibit E-7) instead of the estimates based on Chapter II (as reflected in Exhibit E-6), our resulting estimate would have been overstated by 31-37%. Therefore, by reducing the $47,000 by 31-37%, we can reflect the distribution of efficiencies in the national TMDL workload. The resulting estimate of the national average cost of developing TMDLs based on the 1996 Report is about $29,600 - 32,400 per TMDL.

The estimate of $29,600 - 32,400 for the national average cost of TMDLs derived from the 1996 Report is within about 10% of the estimate developed in this report of $26,700 - $29,400 per TMDL. However, since the 1996 Report is based solely on the cost of TMDLs that were developed prior to 1996, it is likely that the 1996 Report tends to overstate the costs of developing TMDLs relative to today's costs because much has been learned about developing TMDLs since then.

APPENDIX F
COMPARISON WITH COMMONLY CITED HIGH-COST TMDLS

APPENDIX F: COMPARISON WITH COMMONLY CITED HIGH-COST TMDLS

A number of cases are commonly cited either as examples of the high cost of developing TMDLs or the high total cost that States will need to shoulder to develop all of the TMDLs they have committed to doing. In this section, we review these cases only to further assess the extent to which this report's estimates for the cost of developing TMDLs might overstate or understate the true cost of TMDL development. The commonly cited examples addressed in this report include:

A. Long Island Sound

B. Dissolved oxygen TMDL for Tallahala Creek in Jones County, Mississippi

C. Phosphorous TMDL for the Bosque watershed in Texas

D. The Florida TMDL Program

E. TMDL for the Waccamaw River in South Carolina

In nearly all of these cases, the cited costs are found to include costs for activities that were not specifically part of TMDL development, such as monitoring costs, model development costs and implementation costs. While these costs are appropriate for estimating the total costs borne to achieve water quality, they do not represent the costs associated with the TMDL portion of the water quality program or, more specifically, the cost associated with TMDL development. Further, in a number of cases the cited costs are simply not relevant because they are outdated, representing early efforts to develop TMDLs without the benefit of prior experience and/or advances in the state-of-the-art. Finally, some of these cases were very complex and/or have unusually large spatial extent, and the cost of developing TMDLs for them is not representative of the effort that typically is needed to develop TMDLs, and therefore not appropriate for use in developing national estimates (just as we felt it inappropriate to include the very lowest TMDL development cost cases). This is not to say that States with such circumstances do not need to consider them when preparing State-specific budget estimates for developing TMDLs.

A. Long Island Sound

The Long Island Sound has been cited as an example of the high cost that can be associated with developing TMDLs, with estimates exceeding $20 million for expenditures from 1986 to 2000 for nitrogen based TMDLs alone. However, the Long Island Sound represents a complex case for a large geographic area where the costs incurred over the past fifteen years to achieve water quality have been substantial and not representative of even typical higher cost TMDLs (i.e., Level 3).

Moreover, the actual cost of developing the TMDLs for the Long Island Sound are a fraction of the total costs cited because they include costs for other activities such as monitoring and model development which, while legitimate and important, are not part of TMDL development per se. The $20 million estimate clearly includes substantial effort over the course of the fifteen years that provides the basis for developing a TMDL, but that is not part of the TMDL development cost. Moreover, these costs would have been incurred even in the absence of the development of the TMDL.

The Long Island Sound has been the subject of intensive study since 1985, when the Long Island Sound Study (LISS) began under the sponsorship of the U.S. EPA and the states of New York and Connecticut. In 1988, at the request of New York and Connecticut, EPA designated Long Island Sound as an *Estuary of National Significance* under the National Estuary Program, a voluntary program that brings community members together to develop a blue print (a "Comprehensive Conservation and Management Plan" or CCMP) for protecting and restoring estuaries. In 1994, the CCMP for Long Island Sound was issued. As early as 1990, EPA and the states of New York and Connecticut agreed to cap nitrogen loadings as Phase I; the 1994 CCMP contained commitments to reduce nitrogen loadings as Phase II, as well as commitments to develop nitrogen reduction targets to guide Phase III. Phase III was proposed in 1997 and was the subject of the LISS report *Proposal for Phase III Actions for Hypoxia Management* (August, 1997). In that report, the development of TMDLs were cited as the vehicles for enforcing and administering the Phase III strategy.

The Spring, 1998 *LISS Spring Update* (a quarterly publication of the LISS) introduced the concept of TMDLs for the first time and further described the development of TMDLs as the means by which the plan for the third Phase to improve oxygen levels for Long Island Sound would be administered and enforced (page 1) and noting that the approach chosen "...is to develop the TMDL now based on available information and the existing standard" (page 6). This is consistent with the assumptions in this report that the development of TMDLs do not require new information. Estimates of just the cost of TMDL development (once the data and models were available) were not provided.

Finally, the "TMDL" for Long Island Sound was a far larger and more complex affair than any single TMDL. The development of the TMDL for Long Island Sound really represented a "submission" composed of numerous TMDLs as defined in this report. In addition to comprising numerous TMDLs, the effort was far more complex than even Level 3 TMDLs because:

- The LIS has unusual hydrological circumstances with complex transport and circulation issues. This makes it difficult to establish background loadings and to assign responsibility for pollution loadings to sources.

- Multiple organizations were involved: two States, two EPA regions, and multiple other institutions and organizations.

- Over 100 point source discharges were involved, and it was difficult to assign allocations.

- There was extensive public participation including 12 public meetings and an additional 10 municipal meetings.

B. DISSOLVED OXYGEN TMDL FOR TALLAHALA CREEK IN JONES COUNTY, MISSISSIPPI

The dissolved oxygen TMDL for the Tallahala Creek in Jones County Missippi was cited as costing $450,000 for 5 FTE. A substantial portion of the cited cost was for monitoring because available data were too dated for use in developing the TMDL. In addition, according to State staff,[50] not only was

[50] 5/23/00 conversation with Greg Jackson, TMDL Chief of the Mississippi Department of Environmental Protection.

this an exceptionally complicated TMDL, it was also the State's first one. According to State staff, other TMDLs they have developed have not been as complicated or as resource intensive. Therefore, this should not be considered an example for the typical cost associated with developing TMDLs.

C. Phosphorous TMDL for the Bosque Watershed in Texas[51]

The phosphorous TMDL for the Bosque watershed in Texas has been cited as requiring $2.2 million for a TMDL that has not yet been completed. In light of its complexity, this TMDL cannot be considered to be a representative TMDL for the purposes of estimating national cost. Moreover, much of the effort is associated with tasks that are outside of TMDL development as defined in this report.

The study area includes over 1 million acres and involves multiple waterbodies, including the North Bosque River, the Upper Bosque River and the receiving reservoir Lake Waco. Thus, it requires both lake and stream modeling. The pollutant sources include both point and nonpoint sources, and the stakeholder process has been complicated due to competing upstream (agriculture) and downstream (municipal) interests. This is more complex than a Level 3 TMDL.

In addition to not being a representative TMDL for the purposes of estimating national cost, the $2.2 million estimate does not likely represent the cost of TMDL development as defined in this report. Research on this watershed dates to the early 1990s and has included funding from the State of Texas, USDA and USEPA. This effort has included model development, monitoring and analysis that has been running at about $0.5 million per year since 1996. Note also that the TMDL was not initiated formally by the TNRCC until December 1998.

D. The Florida TMDL Program

Florida's TMDL program has been cited as allocating $1.2 million and 23.5 FTEs to TMDL development, and needing an additional $0.7 million and 12 FTEs. However, the $1.2 million and 23.5 FTEs represents the entire budget of Florida's Water Quality Assessment Office, and the Office has not yet estimated how much budget and time will be needed to develop TMDLs.[52] Nevertheless, we can indicate the order of magnitude cost that the results of this study might estimate for Florida and compare it to the cited costs. Note that to apply this report's methodology to estimate Florida's TMDL development costs, all of the factors discussed in III.D should be considered carefully. However, the purpose of the following crude estimate is not to actually estimate the cost of developing TMDLs for Florida, but to see what this report's implied costs are for Florida based on the national average costs.

To develop a very crude estimate for Florida based on the national average costs estimated in this report, we simply apply this report's estimated national average cost per TMDL of $38,000 to Florida's 1,972 listed pollutant causes to arrive at a total cost of about $75 million. Florida has committed to a 13-year schedule that results in completing all TMDLs by 2011 (i.e., in 12 years). Applying the averages in this report results in an annual estimated cost of about $6.2 million. If about half of this cost is for expenses and the other half is for FTEs (using the national average of $70,000 per

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[51] Perspective on the Bosque watershed research was provided by e-mail by Clifton Wise, TMDL Program TNRCC, and Larry Hauck, Texas Institute for Applied Environmental Research.

[52] 5/25/00 conversation with Jan Mandrup-Poulson, Administrator of the Water Quality Assessment Office, Florida Department of Environmental Protection.

FTE), we would arrive at a crude budget estimate for Florida of $3.1 million and 44 FTEs annually. Based on this very crude calculation, it does not appear that the methodology and assumptions used in this study results in underestimating the cost of developing TMDLs relative to the citation of $1.9 million and 35.5 FTEs. Moreover, we note that the cited costs include items that we do not include as part of TMDL development (such as model development costs and lab analysis).

E. TMDL for the Waccamaw River in South Carolina

The TMDL for dissolved oxygen for the Waccamaw River in South Carolina has been cited as costing more than 3 FTEs and $1.9 million. According to State staff[53], the $1.9 million was largely associated with monitoring efforts. Further, as explained below, this was a very complex TMDL and would not be representative of even Level 3 TMDLs, nor appropriate for the purpose of estimating national cost.

This was a very complex TMDL because of the area's complex hydrology. The TMDL encompassed Myrtle Beach, including a small inlet, a large bay, and three rivers. Further, a canal that was dug during the depression by the Federal public works bureau connects the rivers; freshwater enters the area, with some flowing north and some south, with both eventually mixing with estuarine waters. The hydrology is further complicated by the existence of wetlands and the fact that the rivers have been modified by rice farming.

[53] 5/23/00 conversations with Larry Turner of the South Carolina Department of Health and Environmental Protection, and with Jan Davis of the Waccamaw Regional COG.

APPENDIX G
POTENTIAL FOR CLUSTERING

APPENDIX G: POTENTIAL FOR CLUSTERING

States are already beginning to aggressively manage their TMDL workloads to garner the cost savings that results when coordinating the development of multiple TMDLs. The extent to which States realize these efficiencies is likely to increase in the future as States establish plans and set TMDL development priorities with these cost savings in mind. Current trends are described below based on the characteristics of a comprehensive sample of 1,096 recent TMDL submittals to EPA We then estimate the maximum extent to which States can cluster waterbodies and TMDLs to achieve the cost savings in TMDL development that can result.

A. THE CURRENT EXTENT OF CLUSTERING – SAMPLE OF 1,096 TMDLS

A comprehensive sample of 1,096 TMDLs recently submitted to EPA provides the basis for assessing the extent to which efficiencies in TMDL development are already being realized. As explained previously, a TMDL represents an individual pollutant and waterbody combination (e.g., a waterbody with two pollutants requires two TMDLs). A submittal is one document that can contain many TMDLs, as might be the case for a waterbody with multiple pollutants and/or for a watershed with multiple waterbodies. This sample is a compilation of submittals to EPA over the period April 1998 through September 2000 (nearly all of these submittals were approved by EPA, with the remainder still under review). The 1,096 TMDLs represent 496 submittals for 668 waterbodies by 35 States in 9 EPA Regions. These TMDLs addressed a wide variety of pollutants representing over 60 different types of causes: about 38% of the TMDLs were for nutrient-related pollutants, about 22% were for fecal coliforms, about 14% were for metals, and the remaining 26% spanned a variety of other pollutants.

The 496 submissions included varying degrees and types of clustering: 270 of the submissions had no clustering whatsoever (Type a); 159 submissions were for individual waterbodies that involved multiple TMDLs (Type b); 38 submissions were for clustered waterbodies that had single TMDLs (Type c); and 29 of the submissions involved clustered waterbodies that also had multiple TMDLs (Type d). The numbers of TMDLs and waterbodies involved in the submissions for each of these four different degrees of clustering are summarized in Exhibit G-1.

The sample of 1,096 TMDLs shows substantial evidence of the use of efficient methods for developing TMDLs:

- About 45% of the 496 submissions realized some form of efficiency: 159 Type b submissions, 38 Type c submissions and 29 Type d submissions.

- About 55% of the 1,096 TMDLs realized some form of efficiency: applying the methodology developed in Chapter I, efficiencies were realized for 300 of the 459 TMDLs in the Type b submissions (459-159); 74 of the 112 TMDLs in the Type c submissions (112-38); and 226 of the 255 TMDLs in the Type d submissions (255-29).

- About 54% of the 668 waterbodies realized some form of efficiency: all 159 waterbodies in the Type b submissions realized efficiencies due to multiple TMDLs, 112 single-TMDL waterbodies were clustered together in 38 Type c submissions, for which 74 of the waterbodies realized efficiencies (112-38); and all 127 waterbodies in the Type d submissions realized efficiencies.

Exhibit G-1
Extent and Type of Clustering Represented in the 496 Submissions for the 1,096 TMDLs

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2">CLUSTERING WATERBODIES</th><th rowspan="2">TOTALS</th></tr>
<tr><th>Single-Waterbody Submissions</th><th>Multiple-Waterbody Submissions</th></tr>
<tr><td rowspan="2">CLUSTERING TMDLs FOR A WATERBODY</td><td>Single-TMDL Waterbodies Only</td><td><u>Type a</u>
270 TMDLs
270 Waterbodies
270 Submissions</td><td><u>Type c</u>
112 TMDLs
112 Waterbodies
38 Submissions</td><td>382 TMDLs
382 Waterbodies
308 Submissions</td></tr>
<tr><td>Multiple-TMDL Waterbodies</td><td><u>Type b</u>
459 TMDLs
159 Waterbodies
159 Submissions</td><td><u>Type d</u>
255 TMDLs
127 Waterbodies*
29 Submissions</td><td>714 TMDLs
286 Waterbodies
188 Submissions</td></tr>
<tr><td colspan="2">TOTALS</td><td>729 TMDLs
429 Waterbodies
429 Submissions</td><td>367 TMDLs
239 Waterbodies
67 Submissions</td><td>1,096 TMDLs
668 Waterbodies
496 Submissions</td></tr>
</table>

** 47 of these waterbodies had single causes, but were clustered with at least 1 multiple cause waterbody in the 29 submissions.*

As discussed next, there is substantial potential for States to increase their use of clustering to achieve the cost savings that this approach can afford.

B. The Maximum Likely Extent of Clustering

We estimated the maximum potential for realizing efficiencies from clustering through a detailed analysis for all of the 1998 303(d) impaired waterbodies for which data were available. Adequate data were available for 15,012 waterbodies including 25,494 pollutant causes, representing 77% of the waterbodies and 70% of the pollutant causes for the 1998 303(d) lists.[54]

The following describes the approach we used, the resulting estimate for the maximum likely extent of clustering, and the factors that might limit achieving maximum clustering, especially in the near term.

1. Approach

<u>a. Data Used</u>

We grouped impaired waterbodies by watershed as defined by the U.S. Geologic Survey's hydrologic units. The USGS divides the nation into successively smaller hydrologic units: 21 major regions, which are then subdivided into 222 subregions which include areas drained by a river system, a

[54] As explained later in this Appendix, adequate data for the cluster analysis were available for all of the impaired waterbodies except for those in EPA Region X.

reach of river and its tributaries in that reach, a closed basin(s) or a group of streams forming a coastal drainage area. A third level of classification subdivides the subregions into 352 units that nest within the subregions. The fourth, smallest unit in the hierarchy, is the cataloging unit which represents part or all of a surface drainage basin, a combination of drainage basins or a distinct hydrologic feature. The hydrologic units are identified with a unique code ranging from 2 to 16 digits – the more digits, the smaller the size of the unit. The 6 digit HUCs are generally referred to as basins and the 8 digit HUCs are generally referred to as sub-basins. There are 2,262 8-digit HUCs in the Nation. Although many States have defined smaller watersheds, the 8-digit level is the smallest watershed delineation uniformly available throughout the United States and is an appropriate size for planning and for larger scale assessment. We grouped the impaired waterbodies at the 8-digit HUC level.

The EPA's Reach Files are a series of national hydrologic databases that uniquely identify and interconnect the Nation's stream segments or "reaches" -- Reach File 3-Alpha, a preliminary version of Reach File 3, was the most detailed hydrography data available within the deadline for completing this report. To locate the impaired waterbodies, EPA used the reach-indexing data from the 1998 303(d) lists. EPA and the States had "geo-referenced" the waterbodies on the 1998 303(d) lists to Reach File 3-Alpha through an extensive process of initial mapping and review. EPA had initially mapped the 303(d) waterbodies to the appropriate Reach File 3-Alpha reaches (based on location description on the lists) and then sent the resulting maps to the States for review. Unique identification numbers (IDs) were assigned by EPA and/or the States to each listed waterbody. The resulting mapping and IDs allow EPA to "crosswalk" the information from the 1998 303(d) lists with the information in Reach File 3-Alpha.[55] Information within Reach File 3-Alpha allows one to determine upstream/downstream relationships and made the clustering analysis possible.[56]

b. Steps in the analysis

There were three key steps in the analysis:

- we started by grouping the impaired waterbodies by 8-digit HUC,
- within each HUC, we identified the groups (i.e., "clusters") of waterbodies that were interconnected based on the RF3 data, and
- for each cluster, we identified the extent to which waterbodies shared the same pollutant causes or class of causes that would allow there to be modeling-related efficiencies.

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[55] This "crosswalk" between the listed waterbodies and Reach File 3 could be performed for all of the States except those in EPA Region X. These States have their own, completely separate geographic information system coverages of their waterbodies. The coverages are at different scales than for Reach File 3 and there is no crosswalk between the IDs. So although these States have mapped their 303(d) waterbodies, it wasn't possible to convert those mappings to Reach File 3 to allow for the same analysis as was done for the other States. Nevertheless, the analysis is extensive, including 77% of the Nation's impaired waterbodies and 70% of the pollutant causes.

[56] For more detailed information, see documents available at www.epa.gov/OWOW/monitoring/rf, and www.epa.gov/OWOW/tmdl/point303d.html. Note that the USGS National Hydrography Dataset, which incorporates EPA's RF3 and the USGS Digital Line Graph hydrology files, and which is superior to RF3-Alpha, was not available at the time this analysis was performed.

Thus, we identified the number of clusters of waterbodies benefitting from standard efficiencies , as well as the number of TMDLs which can also benefit from modeling-related efficiencies. The number of clusters in a watershed may range from one (because there is only one impaired waterbody in the watershed or because all of the impaired waterbodies in the watershed are interconnected) to many (representing varying combinations of circumstances ranging from many impaired waterbodies that are not interconnected to many groups of interconnected impaired waterbodies within the watershed). For example:

- A watershed has 5 impaired waterbodies each of which has 1 TMDL, but none are interconnected. This would result in 5 clusters and there would be no efficiencies for any of the clusters.

- A watershed has 3 interconnected impaired waterbodies each with one cause: one has a metals cause, one has a nutrient cause, and one has an organic cause. These three waterbodies would be considered to be a single cluster, and would be eligible for standard efficiencies but not also for modeling-related efficiencies.

  If there were an additional impaired waterbody with a nutrient cause, but which was not interconnected with the other 3 waterbodies, this would represent a second cluster in the watershed, but with no efficiencies.

- A watershed has 3 interconnect impaired waterbodies each with one nutrient-related cause. These three waterbodies would be considered to be a single cluster, and would be eligible for all efficiencies.

  If there were an additional impaired waterbody with a nutrient cause, but which was not interconnected with the other 3 waterbodies, this would represent a second cluster in the watershed, but with no efficiencies.

- A watershed has 3 interconnected impaired waterbodies, with each impaired by the same pesticide. This would represent a cluster which would be eligible for all efficiencies.

- A watershed has two impaired waterbodies which are not interconnected, in which one waterbody has two nutrient-related causes while the other has two metals-related causes. In this case there would be two clusters, each requiring two TMDLs. Each cluster would have one TMDL that would receive full efficiencies.

2. Resulting maximum likely extent of clustering

The 15,012 waterbodies could be grouped into 2,995 clusters. Thus, 12,017 of the waterbodies could realize standard clustering efficiencies. According to the convention used in this report, 2,995 of the TMDLs are Type A TMDLs, since they would be the first TMDL done for a cluster and therefore would require the full cost of development. Therefore, the remaining 22,499 TMDLs would receive some sort of clustering efficiencies (either the standard efficiencies of Type B, or the full efficiencies of Type C which also include modeling-related efficiencies). Evaluating the types of pollutants within each cluster reveals that 22,499 of the pollutant causes would receive maximum (Type C) efficiencies, so that the remaining 4,054 TMDLs would receive only standard efficiencies.

Thus, the maximum extent to which efficiencies might be achieved for this sample of 25,494 pollutant causes is as follows: 12% might have no efficiencies, 16% might benefit from standard efficiencies (i.e., no modeling-related efficiencies), and 72% might benefit from maximum efficiencies. Note that this sample represents 77% of the Nation's impaired waterbodies, but only 70% of the TMDLs (pollutant causes). Therefore, it might be expected that there might be even greater clustering efficiencies for the remaining waterbodies since they have more TMDLs per waterbody.

3. Factors that may limit clustering

For States that are less familiar with developing TMDLs, the extent to which they will be able to achieve clustering efficiencies in the near term because they may wish to begin with smaller "pilot" efforts. As they become more experienced in developing TMDLs, we assume that clustering will continue to increase to some upper practicable limit. Factors that may limit the extent of clustering, especially in the near term, might include:

- ***Technical/analytical reasons.*** A method may not yet be developed or tested for one or more pollutant types identified in the listed water. The State may defer development of one or more pollutants until they have an appropriate technique. This is increasingly difficult for the more unusual pollutant types.

- ***Insufficient data.*** There may be insufficient data for one or more pollutants. The State may perform additional monitoring to confirm listing, delist or prepare for TMDL analysis. This would result in delaying the TMDL or removing the listing.

- ***Insufficient source identification.*** For some listings the source characterization may require additional data collection and reconnaissance. The State may choose to defer a specific pollutant until a source inventory can be performed. Typically this occurs for listing related toxics such as PCB and Chlordane, where the source may include old facilities or superfund sites.

- ***High level of public concern.*** High profile watersheds with significant public interest may result in more complex and longer TMDL development schedules. The State may select watersheds which have more intense analysis. These watersheds could be at a smaller scale than the cataloguing unit. For instance, a recreational lake located in the vicinity of a metropolitan area might have a smaller watershed but be treated as a separate unit.

- ***Hydrologic features.*** Natural or anthropogenic hydrologic features such as lakes and reservoirs may identify watershed units which are smaller. Each impoundment requires a separate analysis.

- ***State planning units.*** Each State defines their own analytical units. The State plans may use units that are smaller or have different groupings than the cataloguing unit.

- ***Scheduling issues.*** The State may have a predetermined schedule, responding to lawsuits, public comments or need (waterbodies at high risk of further deterioration). This schedule may include waters that are not clustered, or clustered as a smaller unit.

- ***Pilot studies.*** The state may develop TMDLs for individual waterbodies or small clusters in order to test and demonstrate new methods.

Over time, many of these factors will decline in importance in effecting the extent to which TMDLs are clustered. It should be noted that TMDLs need not be done contemporaneously to still receive the benefit of some clustering efficiencies for such tasks as watershed characterization, development of the TMDL document, etc.

C. Clustering Assumptions Used in This Analysis

Some States are already planning to cluster TMDL development to a significant degree. For example, as described in Appendix C, Washington State's TMDL Workload Model already plans on achieving 74% clustering. In recent submissions, as described earlier in this appendix, States have realized 26% clustering. We think it likely that States will strive to achieve as much cost efficiencies as possible when developing TMDLs. Therefore, for this analysis, we assume that States will make steady progress in taking advantage of the cost savings that can be realized from clustering waterbodies for TMDL submissions:

- If States steadily increase their use of clustering over 10 years to achieve the maximum likely clustering efficiency of 80%, their average use of clustering to complete the 1998 303(d) lists would be 60%.

- If States are able to adopt the use of clustering more rapidly, say over 5 years instead of 10 years, their average use of clustering to complete the 1998 303(d) lists would be 70%.

For this analysis, we estimate a range for the cost of developing TMDLs for the 1998 303(d) lists based on the national average clustering of 60%-70%. In addition, for those TMDLs which benefit from efficiencies, the will do so in the same proportion as for this cluster analysis: 18% would be Type B TMDLs and 82% would be Type C TMDLs. For causes identified in future lists, we assume that by the time these TMDLs are scheduled for development, the States will be achieving 80% clustering.

D. Potential Refinements for the Cluster Analysis

Three potential refinements might improve the accuracy of the cluster analysis.

- ***Limiting Factors.*** While the analysis reflects the potential effect of the limiting factors listed in this appendix by assuming a 5-10 year transition period, it may be feasible to refine the analysis to identify some of the cases in which full clustering efficiencies are less likely to be achieved.

- ***State Boundaries.*** The cluster analysis implicitly assumed that States would cooperate to develop TMDLs for clusters that crossed State boundaries. For a more conservative estimate for the potential for clustering, it may be appropriate to apply State boundaries as an additional constraint when identifying clusters. Of the 2,995 clusters identified, 198 of the clusters contained impaired waterbodies in different States. Assuming that, in each of these cases only two States were involved, this would imply that applying State boundaries would result in an additional 198 clusters over and above the 2,995 clusters that were identified in the current analysis.

Note that the implication for national cost is not significant. The cost implication of an additional 198 clusters is that there would be an additional 198 Type A TMDLs instead of 198 Type B or C TMDLs. The 60% to 70% national average clustering assumption already includes a range for the number of Type A TMDLs of about 2,000 (as shown in Exhibit II-4, the number of Type A TMDLs at 60% clustering is 7,844 and the number of Type A TMDLs at 70% clustering is 5,883). Thus, the magnitude of the impact of including State boundaries is only about 10% of the range that is already reflected in the range used for the national average clustering assumption.

- ***Decomposition Analysis.*** As discussed in Chapter III and in Appendix A, some States may have defined some impaired waterbodies on a watershed basis or some impaired waterbodies may have significant spatial extent. In either of these two cases, the unit costs developed in this report may not apply directly to the impaired waterbody as defined in the 303(d) lists. To the extent this occurs, the national cost estimate would understate the total cost by virtue of indirectly having understated the number of Type C TMDLs (and possibly also Type B TMDLs) from the perspective of the applicability of the unit costs developed in this report.

  To address this issue, it may be appropriate and feasible to perform the "opposite" of a cluster analysis, to determine whether and the extent to which some individual impaired waterbodies as defined in the 303(d) lists should be "decomposed" into segments for the purposes of applying the unit costs developed in this report.

APPENDIX H
DESCRIPTION OF CAUSES AND SOURCES OF IMPAIRMENT

APPENDIX H: DESCRIPTION OF CAUSES AND SOURCES OF IMPAIRMENT

This appendix describes the causes and sources of impairment as well as the frequency distribution for the number of causes per waterbody.

A. CAUSES AND SOURCES OF IMPAIRMENT

The 1998 303(d) lists identify 21,851 waterbodies that are not attaining water quality standards as a result of 41,881 causes of impairment of various types.[57] It is important to remember that these causes include both "pollution" and "pollutant" causes, and that only pollutant causes are required to have TMDLs developed for them. Of the 41,881 reported causes, 5,656 of these causes are for pollution so that TMDLs are required for 36,225 causes. The breakdown for the 5,656 pollution causes is shown below in Exhibit H-1 below.

Exhibit H-1
Causes Of Impairment Categorized As "Pollution"

Cause of Impairment	Count
Other Habitat Alterations	2,112
Impaired Biologic Community*	1,439
Flow Alterations	1,099
Noxious Aquatic Plants*	831
Taste and Odor*	68
Debris*	64
Exotic Species	27
Aesthetics	16
Total	5,656

*A portion of these causes may be eventually be identified as resulting from pollutants, and this is taken into consideration in section I.B. TMDL Development Workload.

[57] Note that 337 of the 21,851 waterbodies did not have any causes specified for them, and we did not feel it appropriate to attribute "zero" causes to these 337 waterbodies. Therefore, we assumed that these 337 waterbodies had either one, two, or three causes in the same proportion as the rest of the waterbodies (we felt this to be generally representative since about 85% of the 21,851 waterbodies have either 1, 2 or 3 causes associated with them). Applying this procedure results in an estimate of 550 causes for the 337 waterbodies, and this amount is included in the total of 41,881causes. Further, we assumed that all 550 causes were "pollutant" causes requiring the development of TMDLs, even though about 15% of all reported causes are for "pollution" and would not require TMDLs.

The breakdown for the 36,225 pollutant causes is shown in Exhibit H-2 below.

Exhibit H-2
Causes Of the 36,255 Impairments Categorized As "Pollutants"

Cause of Impairment	Count		Cause of Impairment	Count
Sediments	6,133		Fish Consumption Advisory**	411
Pathogens	5,293		Other	366
Nutrients	4,773		PCBs	342
Metals	3,984		Sulfates	213
Dissolved Oxygen	3,772		Organic Enrichment	195
Temperature	1,884		Suspended Solids	142
pH	1,798		Toxics	137
Pesticides	1,432		Dioxin	98
Unknown*	1,233		Total Dissolved Solids	76
Mercury	1,089		Total Dissolved Gas	51
Organics	1,069		Contaminated Sediments**	29
Ammonia	752		Radiation	23
Salinity / TDS / chlorides	459		Conductivity	20
Inorganics	451		---	---
Total = 36,225				

* *Includes 550 unknown causes artificially assigned to 337 waters that had no reported causes of impairment.*
** *Pollutant not specified.*

The sources for all of the impairments (both for pollution and pollutants) are summarized in Exhibit H-3 below based upon the information provided in the 303(d) listings. Sources have not been identified in 303(d) lists for over half the waterbodies.

Exhibit H-3
Categorization of the 1998 303(d) Listed Waterbodies According to Source Type

Type of Source	# Listed Waters
no sources reported	11,729
nonpoint sources only	4,921
mixed other*	2,415
other	1,009
unknown	691
mixed point sources and nonpoint sources**	613
point sources only	473
Total	21,851

* *Combinations of sources not included elsewhere in the table*
***At least 1 point source and 1 nonpoint source, and no other source types*

B. DISTRIBUTION OF THE NUMBER OF CAUSES IN THE 1998 303(D) LISTS BY WATERBODY

Of the 21,851 listed waterbodies, 2,240 are listed solely due to pollution causes for which TMDLs are not required. The remaining 19,611 waterbodies each have at least one pollutant cause and, therefore, at least one TMDL required for them. The distribution of the number of causes per waterbody is shown in Exhibit H-4.

Exhibit H-4
Frequency distribution for the number of "pollutant"causes listed per water
(only waterbodies with at least one non-pollution listing)

# Pollutant Causes per Waterbody	Frequency (# waterbodies)	Total Pollutant Causes
1	11,356	11,356
2	4,053	8,106
3	2,022	6,066
4	1,236	4,944
5	568	2,840
6	188	1,128
7	78	546
8	42	336
9	15	135
10	10	100
11	6	66
12	10	120
13	5	65
14	2	28
15	5	75
16	5	80
18	1	18
19	1	19
21	1	21
22	2	44
24	2	48
26	2	52
32	1	32
Total	19,611	36,225

While most of the waterbodies have only one pollutant cause, 42% of the waterbodies have more than one cause, some with many. This is important because, as discussed in Chapter I, the development costs for successive TMDLs for a waterbody will be less due to both the availability of readily applicable information from the first TMDL that was developed and the opportunity to jointly perform some TMDL development tasks for several TMDLs at the same time.

APPENDIX I
PRESENT VALUE AND ANNUALIZED COSTS

APPENDIX I: PRESENT VALUE AND ANNUALIZED COSTS

This appendix provides the supporting calculations for the present value and annualized cost for:

- the uniform and increasing paces for developing TMDLs for the 1998 303(d) lists for discount rates of 3% - 7% and at 60% clustering efficiency (Exhibit I-1A) and at 70% clustering efficiency (Exhibit I-1B); and
- for future causes (Exhibit I-2).

Exhibit I-1A
Present Value and Annualized Cost of Developing All TMDLs for the 1998 303(d) List
For a National Uniform Pace of Development and a "Transition" Pace Through 2015
Based on 60% Clustering Efficiency
(Thousands of March 2000 Dollars)

Periods			TMDLs By Year		Annual Cost of Developing TMDLs					
Calendar Year	Years	Years Discounted	Uniform Pace	Transition Pace	Undiiscounted Yearly		PV for Uniform Pace		PV for Transition Pace	
					Uniform	Transition	@ 3%	@ 7%	@ 3%	@ 7%
2000	1	0	1,000	1,000	$29,390	$29,390	$29,390	$29,390	$29,390	$29,390
2001	2	1	2,350	1,310	$69,065	$38,500	$67,054	$65,547	$37,379	$35,982
2002	3	2	2,350	1,620	$69,065	$47,611	$65,101	$60,324	$44,878	$41,585
2003	4	3	2,350	1,930	$69,065	$56,722	$63,205	$56,378	$51,908	$46,302
2004	5	4	2,350	2,230	$69,065	$65,539	$61,364	$52,690	$58,230	$49,999
2005	6	5	2,350	2,550	$69,065	$74,943	$59,576	$49,243	$64,647	$53,434
2006	7	6	2,350	2,550	$69,065	$74,943	$57,841	$46,021	$62,764	$49,938
2007	8	7	2,350	2,550	$69,065	$74,943	$56,157	$43,010	$60,936	$46,671
2008	9	8	2,350	2,550	$69,065	$74,943	$54,521	$40,197	$59,161	$43,618
2009	10	9	2,350	2,550	$69,065	$74,943	$52,933	$37,567	$57,438	$40,764
2010	11	10	2,350	2,550	$69,065	$74,943	$51,391	$35,109	$55,765	$38,097
2011	12	11	2,350	2,550	$69,065	$74,943	$49,894	$32,812	$54,141	$35,605
2012	13	12	2,350	3,550	$69,065	$74,943	$48,441	$30,666	$52,564	$33,276
2013	14	13	2,350	3,550	$69,065	$74,943	$47,030	$28,660	$51,033	$31,099
2014	15	14	2,350	3,550	$69,065	$74,943	$45,660	$26,785	$49,546	$29,064
2015	16	15	2,325	3,635	$68,331	$77,441	$43,859	$24,766	$49,707	$28,068
Total			**36,225**	**36,225**	**$1,064,636**	**$1,064,636**	**$853,416**	**$658,165**	**$839,485**	**$632,891**
				Annualized Cost over 16 years:			**$65,962**	**$65,114**	**$64,886**	**$62,613**

Exhibit I-1B
Present Value and Annualized Cost of Developing All TMDLs for the 1998 303(d) List
For a National Uniform Pace of Development and a "Transition" Pace Through 2015
Based on 70% Clustering Efficiency
(Thousands of March 2000 Dollars)

Periods			TMDLs By Year		Annual Cost of Developing TMDLs					
Calendar Year	Years	Years Discounted	Uniform Pace	Transition Pace	Undiiscounted Yearly		PV for Uniform Pace		PV for Transition Pace	
					Uniform	Transition	@ 3%	@ 7%	@ 3%	@ 7%
2000	1	0	1,000	1,000	$26,708	$26,708	$26,708	$26,708	$26,708	$26,708
2001	2	1	2,350	1,310	$62,764	$34,988	$60,936	$58,658	$33,969	$32,699
2002	3	2	2,350	1,620	$62,764	$43,267	$59,161	$54,821	$40,784	$37,791
2003	4	3	2,350	1,930	$62,764	$51,547	$57,438	$51,234	$47,173	$42,078
2004	5	4	2,350	2,230	$62,764	$59,559	$55,765	$47,883	$52,918	$45,438
2005	6	5	2,350	2,550	$62,764	$68,106	$54,141	$44,750	$58,749	$48,559
2006	7	6	2,350	2,550	$62,764	$68,106	$52,564	$41,822	$57,038	$45,382
2007	8	7	2,350	2,550	$62,764	$68,106	$51,033	$39,086	$55,376	$42,413
2008	9	8	2,350	2,550	$62,764	$68,106	$49,547	$36,529	$53,763	$39,638
2009	10	9	2,350	2,550	$62,764	$68,106	$48,104	$34,140	$52,198	$37,045
2010	11	10	2,350	2,550	$62,764	$68,106	$46,703	$31,906	$50,677	$34,622
2011	12	11	2,350	2,550	$62,764	$68,106	$45,342	$29,819	$49,201	$32,357
2012	13	12	2,350	3,550	$62,764	$68,106	$44,022	$27,868	$47,768	$30,240
2013	14	13	2,350	3,550	$62,764	$68,106	$42,739	$26,045	$46,377	$28,262
2014	15	14	2,350	3,550	$62,764	$68,106	$41,495	$24,341	$45,026	$26,413
2015	16	15	2,325	3,635	$62,097	$70,376	$39,857	$22,507	$45,172	$25,508
Total			**36,225**	**36,225**	**$967,505**	**$967,505**	**$775,556**	**$598,118**	**$762,896**	**$575,150**
					Annualized Cost over 16 years:		**$59,944**	**$59,173**	**$58,966**	**$56,901**

Exhibit I-2
Plausible, Hypothetical Scenario for Newly Identified Causes in Future Listings
Present Value & Annualized Cost of Developing TMDLs
For 1,000 New Causes Per Listing Cycle Over 9 Cycles and 80% Cluster Efficiency
(Thousands of March 2000 Dollars)

Year	Workload by Year by Listing Cycle											Total	Cost of Developing TMDLs			
													Allocated	Years	Present Value	
	2002	2006	2010	2014	2018	2022	2026	2030	2034	2038	2042	TMDLs	Real Cost	Discounted	@ 3% disc rate	@ 7% disc rate
2000												0	$0	0	$0	$0
2001												0	$0	1	$0	$0
2002												0	$0	2	$0	$0
2003	0											0	$0	3	$0	$0
2004	0											0	$0	4	$0	$0
2005	0											0	$0	5	$0	$0
2006	0											0	$0	6	$0	$0
2007	0	100										100	$2,403	7	$1,954	$1,496
2008	0	100										100	$2,403	8	$1,897	$1,399
2009	0	100										100	$2,403	9	$1,842	$1,307
2010	0	100										100	$2,403	10	$1,788	$1,222
2011	0	100	100									200	$4,806	11	$3,472	$2,283
2012	0	100	100									200	$4,806	12	$3,371	$2,134
2013		100	100									200	$4,806	13	$3,273	$1,994
2014		100	100									200	$4,806	14	$3,177	$1,864
2015		100	100	100								300	$7,209	15	$4,627	$2,613
2016		100	100	100								300	$7,209	16	$4,492	$2,442
2017			100	100								200	$4,806	17	$2,908	$1,521
2018			100	100								200	$4,806	18	$2,823	$1,422
2019			100	100	100							300	$7,209	19	$4,111	$1,993
2020			100	100	100							300	$7,209	20	$3,991	$1,863
2021				100	100							200	$4,806	21	$2,583	$1,161
2022				100	100							200	$4,806	22	$2,508	$1,085
2023				100	100	100						300	$7,209	23	$3,653	$1,521
2024				100	100	100						300	$7,209	24	$3,546	$1,421
2025					100	100						200	$4,806	25	$2,295	$886
2026					100	100						200	$4,806	26	$2,229	$828
2027					100	100	100					300	$7,209	27	$3,245	$1,160
2028					100	100	100					300	$7,209	28	$3,151	$1,084
2029						100	100					200	$4,806	29	$2,039	$676
2030						100	100					200	$4,806	30	$1,980	$631
2031						100	100	100				300	$7,209	31	$2,884	$885
2032						100	100	100				300	$7,209	32	$2,800	$827
2033							100	100				200	$4,806	33	$1,812	$515
2034							100	100				200	$4,806	34	$1,759	$482
2035							100	100	100			300	$7,209	35	$2,562	$675
2036							100	100	100			300	$7,209	36	$2,487	$631
2037								100	100			200	$4,806	37	$1,610	$393
2038								100	100			200	$4,806	38	$1,563	$367
2039								100	100	100		300	$7,209	39	$2,276	$515
2040								100	100	100		300	$7,209	40	$2,210	$481
2041									100	100		200	$4,806	41	$1,430	$300
2042									100	100		200	$4,806	42	$1,389	$280
2043									100	100	0	200	$4,806	43	$1,348	$262
2044									100	100	0	200	$4,806	44	$1,309	$245
2045										100	0	100	$2,403	45	$635	$114
2046										100	0	100	$2,403	46	$617	$107
2047										100	0	100	$2,403	47	$599	$100
2048										100	0	100	$2,403	48	$582	$93
2049											0	0	$0	49	$0	$0
2050											0	0	$0	50	$0	$0
2051											0	0	$0	51		$0
2052											0	0	$0	52		$0
Total	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0	9,000	$216,270	—	$100,829	$43,280
														Annualized Cost:	$3,874	$2,946