6.0 QUANTITATIVE ASSESSMENT OF BENEFITS

This chapter reports estimates of the potential value of quantifiable benefits of the Phase II rule. It begins with an overview of the economic concepts and analytical issues associated with defining benefit categories and developing quantified and monetized benefits estimates. This framework for the benefits analysis is in Section 6.1.

EPA estimated benefits using two separate approaches.[1] The first approach utilized the National Water Pollution Control Assessment Model (NWPCAM) to model reductions in pollution loadings due to the municipal minimum measures and soil erosion control provisions of the Phase II rule. The changes in loadings are translated into changes in water quality in a model that estimates water quality for more than 600,000 river reaches in the United States. Section 6.2 briefly describes the modeling approach and benefit valuation method. This method transferred willingness-to-pay estimates (WTP) from a national study of the value of water quality improvements (Mitchell and Carson, 1986) to derive benefits.

EPA's second approach, which is described in Section 6.3, has separate estimates of the benefits for the municipal minimum measures and the soil erosion control provisions and also provides estimates for some marine benefits. The benefit analysis for the municipal minimum measures provision used national water quality assessment data reported under Section 305(b) of the Clean Water Act to estimate both the impact of urban storm water runoff on national water quality and the subsequent benefits of efforts under the Phase II rule to mitigate this source of water quality impairment. The valuation step of the analysis incorporated estimates from Carson and Mitchell (1993) of household WTP to improve national water quality. EPA also used a benefits transfer analysis to estimate potential human health and recreation benefits associated with marine water impacts. For the soil erosion control provision, EPA estimated the share of national construction activity affected by the rule to apportion a household WTP value reported in Paterson et al. (1995) for soil erosion control policies.

Section 6.4 describes the key limitations and uncertainties in the benefits estimated using either approach and provides sensitivity analyses for selected sources of uncertainty. Section 6.5 presents a comparison of benefits estimated using the two approaches.

[1] In the economic analysis for the proposed rule, EPA used a "top down" approach to estimate economic benefits. That is, EPA estimated the potential total economic benefits of all wet weather programs and then allocated the benefits to individual programs using best professional judgement. The use of best professional judgement introduced uncertainty into the benefits estimates. In addition, the top down approach differed from the "bottom up" approach used to estimate the cost of the proposed storm water rule, which developed unit costs per municipality and construction start that were multiplied by the estimate of affected municipalities and starts. Therefore, for this analysis, EPA developed two bottom up approaches for estimating benefits from the rule.

6.1 Framework for Estimating Benefits

Economic benefits refer to the dollar value associated with all outcomes of the rule that lead to higher social welfare and reflect estimated changes in consumer and producer surplus. These surplus values reflect the degree of well-being enjoyed by people given different levels of goods or services and prices, and are widely accepted concepts of applied welfare economics (see, for example, Freeman, 1993). An important component and potential limitation of this conceptual foundation is that benefit values are related to how environmental changes are perceived and valued by humans. Some analysts, however, argue that ecological benefits accrue and are separate from the values placed by humans on the protection and enhancement of habitat and living species. But because there would be no way to assign a value to such benefits for consideration in a benefit-cost analysis, ecological values are considered to be included within the traditional use and nonuse (passive use) benefits discussed below.

6.1.1 Definition of Benefit Categories

To move from the qualitative assessment of benefits presented in Chapter 5 to quantitative estimates of value, EPA first categorized the potential outcomes as they relate to different uses of the affected water resources, using, as a starting point, a list of categories developed for the analysis of the California Toxics Rule (US EPA, 1998). Categorizing benefits in this manner helps ensure that all benefits are identified and double counting is avoided. The potential benefit categories associated with water quality improvements are shown in Exhibit 6–1.

Use Benefits

Use benefits include all of the current direct and indirect ways that people expect to make physical use of the resource (Mitchell and Carson, 1989). Direct use benefits are those that result from enhanced recreational water activities such as swimming or boating, or from reduced exposure to contaminants (e.g., the avoided illness cases reported in Appendix C). Diversionary benefits are also direct use benefits and include avoided water storage replacement costs and water treatment costs. Indirect use benefits are those that result from water quality improvements that enhance other, nearby activities. For example, improvements in water quality may sustain waterfowl habitat, enhancing bird watching. A wide range of direct and indirect use benefits are expected to result from the Phase II rule.

Exhibit 6–1. Potential Benefits of Water Quality Improvements

In-Stream Use	• Commercial fisheries, shell fisheries, and aquaculture; navigation • Recreation (e.g., fishing, hunting, boating, swimming) • Subsistence fishing • Human health risk reductions
Near-Stream Use	• Water-enhanced noncontact recreation (e.g., picnicking, photography, jogging, biking, camping) • Nonconsumptive use (e.g., wildlife viewing, hiking near water) • Flood control (reduced property loss and risk to health and safety)
Diversionary Use	• Industry/commercial (process and cooling waters) • Agriculture/irrigation • Municipal drinking water (treatment cost savings, water storage dredging and construction savings, and human health risk reductions)
Aesthetic Use	• Residing, working, traveling, and owning property near water, etc.
Passive Use	• Existence (satisfaction gained from knowing the resources exist and knowing others enjoy the resources; ecologic value, including reduced mortality and morbidity, improved reproductive success, increased diversity of aquatic and piscivorous wildlife, improved habitat for threatened and endangered species, and improved integrity of aquatic and aquatic-dependent ecosystems) • Bequest (intergenerational equity)

Note: Previous analyses have included option value as a potential benefit of environmental improvement. For this analysis, EPA adopted Freeman's (1993) conclusion that option value does not exist as a separate benefit category.

Nonuse (Passive Use) Benefits

Nonuse or passive use benefits include the values humans place on the resource apart from their desire to use the resource. Storm water runoff can negatively impact aquatic and wildlife species, as well as the ecosystems in which they live and reproduce. Control of harmful quantities of runoff and loadings can result in ecological benefits, including reduced mortality and morbidity of aquatic and other wildlife; improved reproductive success of aquatic and other wildlife; increased diversity of aquatic and other wildlife; improved conditions for successful recovery of threatened and endangered species; and otherwise improved health of aquatic and aquatic-dependent ecosystems. Passive use values may stem from a sense of stewardship for an aquatic resource or from knowledge that others do and can use a resource (vicarious consumption). These values also may arise from the desire to preserve the resource for future generations (bequest value) or from a philanthropic sense of environmental responsibility.

6.1.2 How Benefits Arise from Water Quality Improvements

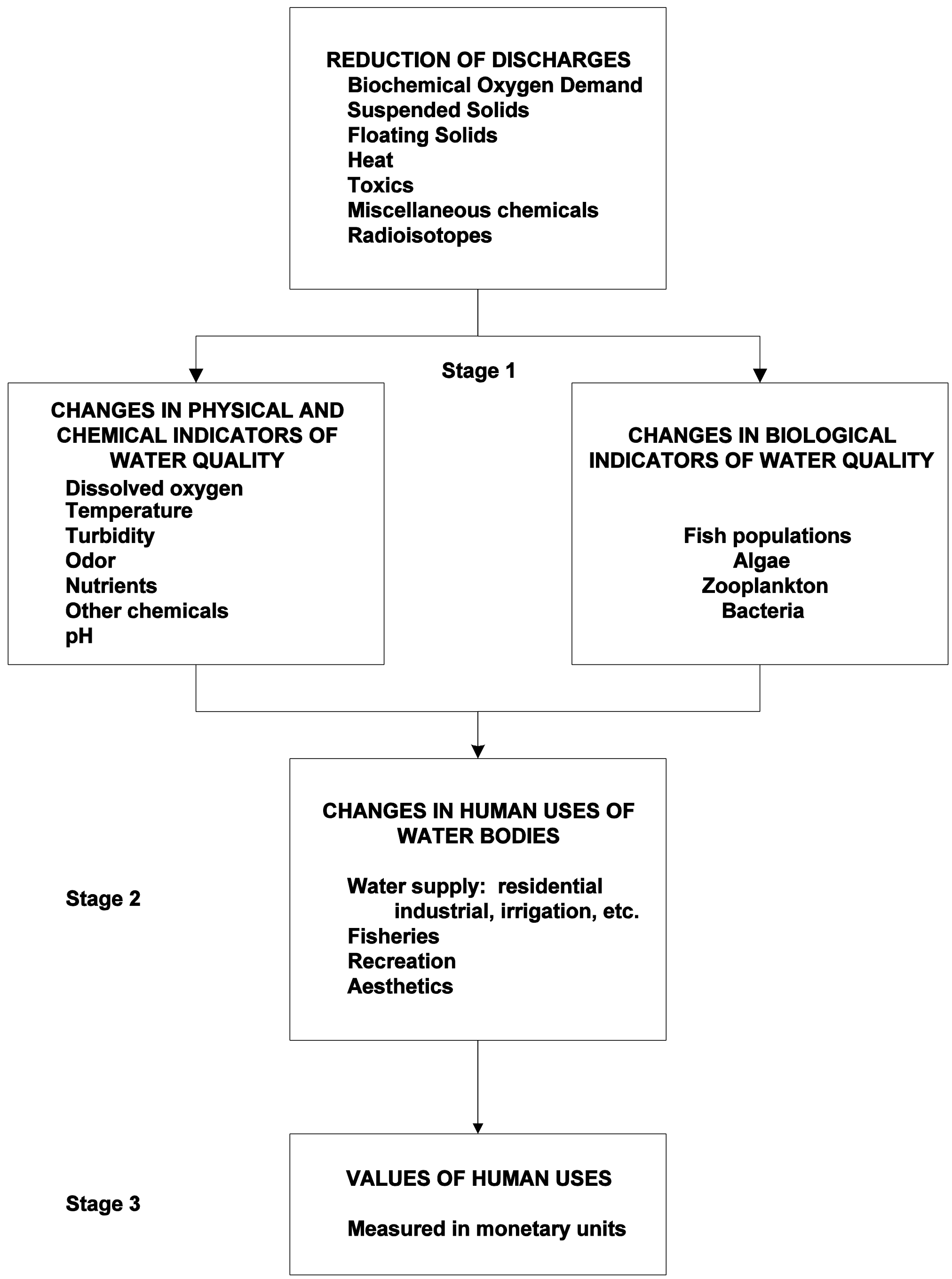
Freeman (1993) describes three functional relationships that link a particular regulatory action to beneficial outcomes: the relationship between resource quality and pollution control; the relationship between resource quality and human use of the resource; and the relationship between economic value and human use of the resource (Exhibit 6–2). Thus, estimating the potential benefits of implementing storm water controls involves the use of applied economic theory, but also requires involving a range of other types of information on the biological and ecological links between aquatic and other wildlife and their environments. Exhibit 6–2 depicts the stages involved in determining the benefits associated with environmental improvements. Although developing information to shed light on all stages of this process can be challenging, Freeman notes that it is particularly difficult to determine the link between resource quality and human use of the resource (Stage 2 in Exhibit 6–2). This difficulty arises because only in rare cases is the level of resource use a simple function of a single water-quality indicator such as dissolved oxygen (Freeman, 1993). Instead, some uses (e.g., commercial fisheries, recreation) depend, in complex ways, on the whole range of physical, chemical, and biological water-quality indicators (Freeman, 1993).

For example, Freeman notes that species distributions of fish, algae, zooplankton, and bacteria may be affected by changes in physical and chemical parameters of water quality, and not necessarily in the same manner, such that even providing a descriptive characterization at this stage is a formidable task. In addition, defining which water quality parameters are most important in influencing uses of a water body (such as fishing or swimming) requires extensive research (Freeman, 1993). Freeman notes that the development of predictive models for these parameters is a major research priority.

Despite the many difficulties associated with determining Stage 2 in Exhibit 6–2, there is a well-developed theory of economic value for use at Stage 3 of a benefits analysis where monetary value is placed on things such as improved recreational opportunities, increases in fish production, or the availability of a particular fish species (Freeman, 1993). However, even at this stage, difficulties arise. For example, the travel cost method is often used to value site specific recreation and is sometimes a preferred approach because it relies on observed behavior to determine value. The method uses travel costs to a recreation site as surrogate prices. With information on travel costs and the frequency of an individual's use of a site, demand functions can be developed and consumer surplus estimated. However, the travel cost method has shortcomings when attempting to value changes in the quality characteristics of a resource. For example, as Bockstael et al. (1989) discuss, the method only includes sites that are visited, excluding sites that indeed may have desirable quality characteristics that are not necessarily more expensive. The wide array of services and quality characteristics among sites in conjunction with population centers also makes it difficult to discern which aspects of environmental quality are being valued. As a result, determining use value can be difficult despite the availability of data based on observed behavior.

Another example of potential difficulties at Stage 3 is related to estimating nonuse or passive use values. Total resource value is thought to consist of personal use value, including existence and bequest values (Stevens et al., 1991). Indeed, Stevens et al. (1991) note that preliminary evidence suggests that existence value may be the most important component of value. Contingent valuation (CV) is the only technique capable of measuring existence values and this technique has been ruled as an appropriate and acceptable means of estimating nonuse values in a damage claim (US Court of Appeals, 1989). A National Oceanic Atmosphere Administration

Exhibit 6–2. The Production of Benefits from Improved Ambient Water Quality



Source: Freeman (1993). Reproduced with permission.

(NOAA) "Blue Ribbon" Panel (1993) also evaluated CV for determining nonuse values in litigation and concluded that well-designed studies provide an "adequately reliable benchmark."

However, there is concern that many CV respondents may not be able to provide meaningful answers to valuation questions (see, for example, Stevens et al., 1991). For example, 25% of the respondents who stated that they were not willing to pay for the existence of species that were the subject of a CV survey protested for ethical reasons, claiming that wildlife values should not be measured in dollar terms (Stevens et al., 1991). Stevens et al.'s (1991) results lead them to argue that benefit-cost analysis should generally not be used to make decisions about the existence of wildlife. As supporting evidence, they provide the case of the snail darter, which had no economic value prior to its discovery (Randall and Stoll, 1983); thus, small changes in information or knowledge may produce large shifts in existence value (Stevens et al., 1991).

6.2 National Water Quality Model Approach

For this analysis, EPA simulated baseline water quality impairment and improved water quality for the Phase II municipal minimum measures and construction site controls using the National Water Pollution Control Assessment Model (NWPCAM). Documentation for this analysis is provided in Appendix E.

NWPCAM estimates water quality parameter values and the associated level of use support for the 632,000 miles of rivers and streams in the EPA's Reach File Version 1 (RF1), which covers a fraction of the 3,600,000 river and stream miles in the continental United States.[2] The water quality parameters in the NWPCAM are biological oxygen demand (BOD5), total suspended solids (TSS), dissolved oxygen (DO), and fecal coliforms (FC). NWPCAM incorporates geographical and hydrological information as it produces estimates of the water quality parameters, which are converted to use support designations based on the standards for FC, BOD, DO, and TSS shown in Exhibit 6–3. The model computes the designation for each river and stream segment of one mile or less by:

- Determining the values for each water quality parameter based on loadings and river reach data
- Comparing these values to the reference conditions for meeting each of the use categories
- Assigning the use to the entire segment.

The model classifies a stream or river segment based on an exceedance of any of the four criteria presented in Exhibit 6–3. For example, if the segment meets the FC, BOD5, and TSS criteria for swimming, but it meets the DO only for game fishing, then the segment is classified as supporting game fishing. If any of the boating criteria are exceeded, then the segment is classified to indicate no recreational use support.

[2]This model was used for the Executive Order on "Infrastructure" that was reviewed by Office of Management and Budget (OMB). EPA also used an older version of this model as documented in the appendix of the Economic Analysis for the Proposed Phase II rule submitted for OMB review.

Exhibit 6–3. NWPCAM Water Quality Ladder

Beneficial Use	Fecal Coliforms (MPN/100 mL)	Dissolved Oxygen (mg/L) / (% sat.)	5-day BOD (mg/L)	Total Suspended Solids (mg/L)
Drinking	**0**	**7.0 / 90**	**0**	**5**
Swimming	**200**	**6.5 / 83**	**1.5**	**10**
Game Fishing	**1000**	**5.0 / 64**	**3.0**	**50**
Boating	**2000**	**3.5 / 45**	**4.0**	**100**

Source: Bondelid et al., 1999.

To estimate the impact of the soil erosion control provision on water quality, the construction start modeling component of the model estimates loadings reductions by simulating the effects of various BMPs (e.g., seed and mulch of the model, and sediment traps) using the Revised Universal Soil Loss Equation (RUSLE). The analysis is based on a U.S. Army Corps of Engineers (1998) report on BMPs for small construction sites and is described in more detail in Appendix E. Note, however, that the NWPCAM does not address potential impacts of post-construction controls.

The construction part of the NWPCAM contains a “small streams” submodel that adds 34,500 miles of small streams to the original NWPCAM/RF1 framework. This “small streams” submodel is included in the model to address the fact that many construction starts are not located next to the larger streams contained in the overall NWPCAM/RF1 river framework, but they are located near smaller streams. With the addition of the small streams, the submodel routes the loadings from construction sites to the overall RF1 framework. The model treats the community with construction sites as a point source. For each community with construction sites, the submodel assumes one small stream to transport loadings to the nearest RF1 stream. The submodel decays the loadings using the same assumptions that the rest of NWPCAM uses. Data for flow in the small streams is based on a hydrologic analysis that relates distance from RF1 to drainage area and then uses an RF1 flow analysis to estimate mean summer flow as a function of the drainage area. For this initial work on small streams, the model includes a straight-line distance from the construction sites to RF1 (i.e., stream sinuosity is not taken into account).

6.2.1 Potential Fresh Water Quality Improvements

Using the NWPCAM, EPA simulated baseline water quality and improved water quality caused by the anticipated loading reductions from municipal point sources and construction sites affected by the Phase II rule. These water quality changes are estimated for a river reach that is located immediately below a discharge source.

Baseline Simulation Conditions

EPA used NWPCAM to estimate baseline water quality conditions nationwide using the following assumptions to estimate baseline loadings from various point and nonpoint sources including urban and rural sources:

- All combined sewer overflows (CSOs) are controlled by detention basins and the assumed runoff capture rate is 85%, which is based on NEEDS Survey assumptions

- Detention basin controls are at each of the 1,723 individual NWPCAM Phase I urban sites and the assumed runoff capture rate is 85%

- Construction start BMPs are in place in areas with existing State programs

- Construction start BMPs are in place at sites greater than five acres.

A statistical groundtruthing of the model to storage and retrieval ambient water quality data indicates that the NWPCAM produces a reliable baseline estimate that can be considered a reasonable predictor of the actual use support for the 1990s.

Phase II Scenario Conditions

The Phase II conditions include the baseline conditions and are assumed to further impose the following:

- Detention basin controls at each of the 5,038 individual NWPCAM Phase II urban sites with an assumed runoff capture rate of 85%

- Construction start BMPs are in place at sites between 1 and 5 acres.[3,4]

NWPCAM requires an engineering surrogate for treatment of specific pollutants contained in discharges, whereas the Phase II program includes both structural and nonstructural controls. Therefore, the model uses detention basins as a proxy to represent the impact of the municipal program. Based on surveys of existing literature on removal of pollutants from detention basins, EPA assumed controls on the urban runoff loadings would remove 33% of BOD5, 60% of TSS, and 70% of FC. These removal rates can be considered conservative median values; as noted below in Section 6.3, EPA believes that the actual implementation of the Phase II minimum measures will result in an overall program effectiveness of approximately 80%. Pollutant

[3]The Phase II municipalities identified in the model are 5,038, instead of 5,040 used for the cost analysis and the second benefit analysis approach, because matching for two of the municipalities could not be made in the population data bases used for the model.

[4]The Phase II construction starts used by NWPCAM to estimate benefits (120,447) differ from the starts used to estimate costs in Chapter 4 and benefits using the water quality assessment approach (110,223). EPA updated the construction start estimates for the latter analyses with building start information from additional communities after entering the construction start data into the model. Moreover, the structure of the data made it very difficult to use it for the modeling purpose. However, the sensitivity analysis described later in this section shows that this difference in the construction starts does not effect the benefit estimates significantly.

loadings sources in the model include 37,005 municipal and industrial point sources, 742 CSO loadings on 505 reaches, urban and nonpoint source loading estimates at 42,479 individual places, rural loadings (primarily from agriculture), and construction starts. The summary of the regulated universe and the assumptions are presented in Exhibit 6–4.

Exhibit 6–4. NWPCAM Summary of Key Model Assumptions For the Storm Water Phase II Benefits Analysis

Variable	Baseline Analysis	With Phase II Implementation
Number of Construction Starts	Current State Programs: 100,316 Phase I: 184,520	Phase 11: 120,047 Phase II "R" Waivers: 13,057 0–1 Acres (unregulated): 91,332
Number of Acres of Construction Starts (Estimated from Input Dataset of Numbers of Starts)	Current Programs: 207,869 Phase I: 1,845,204	Phase I: 289,819 Phase II Waivers: 33,517 0–1 Acres (unregulated): 45,491
Construction Site Parameters	7% Slope, Medium Soils	7% Slope, Medium Soils
Construction Site BMPs	1. Between 0 and 4 Acres: Silt Fence, Seed & Mulch, and Stone Check Dams 2. Greater than 4 Acres: Seed and Mulch, Stone Check Dams, and Sediment Traps	1. Between 0 and 4 Acres: Silt Fence, Seed & Mulch, and Stone Check Dams 2. Greater Than 4 Acres: Seed and Mulch, Stone Check Dams, and Sediment Traps
Combined Sewer Overflows (CSOs)	742 CSOs on 505 Reaches	
CSO Runoff Control	Detention basin-level of control for CSOs, capturing 85% of the runoff, with 33% removal of BOD5, 60% removal of TSS, and 70% removal of FC.	
Urban Runoff Sources *Note:* Population adjustments made to reflect 1998 values and populations served by CSOs.	Phase I: 1,723 Places, 72.4 million people Not Phase I or II: 35,718 Places with 81.7 million people	Phase II: 5,038 Places, 78.5 million people
Urban Runoff Controls	Capture 85% of the runoff, with 33% removal of BOD5, 60% removal of TSS, and 70% removal of FC.	Capture 85% of the runoff, with 33% removal of BOD5, 60% removal of TSS, and 70% removal of FC.

The number of miles projected by NWPCAM to meet the designated uses as defined in the Resources for the Future water quality ladder under the baseline and the Phase II conditions are summarized in Exhibit 6–5. Miles are reported for swimming, game fishing, boating, and no support. The exhibit also shows the net change miles for each use category. For example, the net change of an additional 4,548 miles that meet fishing and boating water quality standards accounts for improvements in miles that were previously classified as boatable or no support minus the miles that were previously classified as fishing and boating that improved to swimmable.

Because the model uses water quality parameters rather than designated uses to determine impairment levels, the implied number of impaired miles is approximately twice as large as the impaired miles reported in the 305(b) data (US EPA, 1998a). According to impairment data summarized in Exhibit 3–4, approximately 36% of the 693,905 surveyed river and stream miles in the nation are classified as impaired based on their respective designated uses. Thus, 249,800 miles are impaired. In contrast, in NWPCAM any river stretch that does not meet swimmable water quality standards will be considered impaired. Consequently, the model estimates that approximately 447,600 miles are impaired. This will tend to generate a larger benefit estimate than the approach in Section 6.3, which is based on 305(b) data.

Exhibit 6–5. Summary of Miles Meeting Designated Uses Under Baseline and Scenario Phase II Conditions

Use Support	Baseline Miles (mid–1990s)	Phase II Miles	Change in Miles (Phase II—Baseline)
Swimming, Fishing, and Boating	219,547	223,674	4,127
Fishing and Boating	418,190	422,738	4,548
Boating	480,515	483,451	2,936
No Support	186,589	183,653	–2,936
Total Miles	667,104	667,104	n/a

6.2.2 Potential Value of Improved Fresh Waters

EPA monetized the changes in designated uses of stream reaches using Carson and Mitchell's (1993) estimates of household WTP for incremental water quality improvements. EPA determined the number of households in the proximity of an affected stream reached by overlaying the modeled water quality results with population data from the 1990 Census of Populated Places and Minor Civil Divisions, updated to 1998 population levels. EPA then developed economic benefits based on these household estimates and estimates of household WTP.

Carson and Mitchell (1993) estimated the magnitude of WTP for incremental improvements in fresh water quality on the basis of their 1983 national survey. In the survey, respondents were asked to value three minimum levels of fresh water quality:

- Boatable: the value to keep the nation's waters from falling below boatable water quality

- Fishable: the value to raise the minimum standard from boatable to fishable

- Swimmable: the value to raise the minimum standard from fishable to swimmable.

Carson and Mitchell (1993) reminded respondents of several reasons for valuing fresh water quality:

- Using fresh water for boating, fishing, and swimming

- Using areas near fresh water for picnicking, bird watching, and staying in a vacation cottage

- Getting satisfaction from knowing that other people use fresh water resources

- Knowing that the nation's water is cleaner.

In addition, respondents were provided with the following information regarding baseline water quality:

- The (then current) minimum level of water quality is boatable

- Most of the nation's's fresh water bodies are fishable

- About 70% to 80% of fresh water bodies are swimmable.

Respondents used a payment card displaying a wide range of payment amounts to indicate their household WTP. Carson and Mitchell corrected their WTP estimates for biases inherent in the response rate and adjusted them for inflation using the Consumer Price Index (CPI). The authors also discussed appropriate adjustments to their estimates based on changes in the regression variables that determined a household's WTP for water quality improvements: real income and attitudes toward pollution control. Carson and Mitchell noted that the University of Chicago's National Opinion Research Center's General Social Survey suggests an approximate 30% increase in the number of respondents who think that there should be more spending on pollution control; other survey organizations report similar or larger changes in attitudes. To update WTP estimates to 1998 levels, EPA made similar adjustments to the WTP amounts to account for inflation growth in real per capita income, inflation, and a 30% increase in attitudes toward pollution control.[5] The adjusted bids are shown in Exhibit 6–6.

[5] The adjustment for inflation is based on the change in the CPI from 1983 to 1998 (a 64% increase) as reported by the Bureau of Labor Statistics (U.S. Department of Labor, 1998). Note, however, that there is currently a debate regarding the accuracy of the CPI. Recent analysis indicates it may overstate inflation by about 1%. To adjust for changes in income and attitude, EPA adjusted the mean explanatory variables for income and attitude in the WTP function (Carson and Mitchell, 1993) by 28%, which is the change in personal disposable income (U.S. Department of Commerce, 1998b), and 30% respectively to recalculate WTP for the category of boatable to fishable. These changes to the explanatory variables resulted in a 38% increase in the calculated WTP. Consequently, EPA applied an adjustment factor of 1.38 to all WTP values.

Exhibit 6–6. Mean Annual Household WTP Amounts for Different Levels of National Water Quality

Water Quality Level	WTP[1] (1983 dollars)	Adjusted Corrected Bid[2] (1998 dollars)
Nonboatable to boatable	$93	$210
Boatable to fishable	$70	$158
Fishable to swimmable	$78	$177

Note: N=564

[1] Source: Carson and Mitchell (1993), annual household values adjusted for unit and item bias.

[2] Adjusted bid: bid as adjusted by Carson and Mitchell × adjustment for inflation × adjustment for changes in income and attitude = ($93) × (1.64) × (1.38).

These WTP estimates are applied to value improvements in local and nonlocal waters separately because the survey results indicated that changes in statewide water quality are more important than changes in water quality elsewhere. In their survey, Mitchell and Carson asked respondents to apportion each of their stated WTP values between achieving the water quality goals in their own state and achieving those goals in the nation as a whole. On average, respondents allocated 67% of their values to achieving in-state water quality goals and the remainder to the nation as a whole. Mitchell and Carson (1986) argue that for valuing local (substate) water quality changes 67% of the WTP value is a reasonable upper bound for the local multiplier; the remaining 33% of the value is applicable to nonlocal water quality changes.

To apply the Mitchell-Carson values to changes in local water quality where only a subset of the waters is affected, Mitchell and Carson (1986) describe three "multipliers." The first is a percent-local multiplier, which defines the percentage of the stated WTP amount that is applied specifically to water quality improvements in the local area in question. The second is an impairment multiplier, which describes how WTP changes in relation to the fraction of local water quality impairment that is addressed by the rule. The third is a population multiplier, which is simply the size of the population benefitting from the local improvement in water quality.

For this analysis, EPA defined the locality as urban sites and associated populations linked into the NWPCAM framework. In this analysis, "local" waters are defined as reaches that are located near each of the population locations. The definition of "local" depends on whether an area is classified as a Census populated place or minor civil division. For populated places, EPA drew a circle with an equivalent area to the place, centered on the place latitude/longitude coordinates given by the U.S. Census Bureau and considered any reaches that fell in whole or in part within that circle "local" to that place. For minor civil divisions, the closest reach is considered to be the "local" water. EPA estimated "local" benefits based on use support changes in reaches that are "local" to each population location. The benefits depend on the portion of the local and the national impaired waters improved as a result of the Phase II soil and erosion controls for construction sites and the municipal pollution prevention measures.

Using this methodology, the EPA estimated benefits of the Phase II rule to be $1.63 billion per year. This estimate does not include potential benefits of post-construction controls. A summary of the local and nonlocal benefits are presented in Exhibit 6–7.

Exhibit 6–7. Local and Nonlocal Benefits of Phase II Controls Estimated Using the NWPCAM[1]

Use Support	Local Benefits ($million/yr)	Nonlocal Benefits[2] ($million/yr)	Total Benefits ($million/yr)
Swimming, Fishing, and Boating	306.2	60.6	366.8
Fishing and Boating	395.1	51.9	447.0
Boating	700.1	114.6	814.7
Total	1,401.4	227.1	1,628.5

[1] Does not include potential benefits of post-construction controls.

[2] To estimate nonlocal WTP per household, the 33% of willingness is multiplied by the fraction of previously impaired national waters (in each use category) that attain the beneficial use as a result of the Phase II rule. To estimate the aggregate nonlocal benefits, nonlocal WTP is multiplied with the total number of households in the United States.

While the numbers of miles that the model estimates will change their use support seem small, the benefits estimates are quite significant. This is because urban runoff and, to a large extent, construction activity occurs where people actually reside and, consequently, the water quality changes mostly occur close to those population centers. NWPCAM indicates that the changes in pollution loads have the most effect immediately downstream of the pollution changes. This is because rivers "treat" the wastes (using similar processes that occur in a wastewater treatment plant) as they move downstream. As a result, the aggregate benefit is large because there are large numbers of households in these population centers that benefit from improved water quality. If water quality improves in reaches that are away from the population centers, their economic value is comparatively less. The model captures this economic phenomenon. Moreover, the model fully incorporates the construction starts modeling (including the "small streams") and an improved population database for the estimation of benefits.

6.2.3 NWPCAM Sensitivity Analysis

EPA investigated the impact of alternative assumptions for the NWPCAM approach. Specifically, EPA investigated the impact of different levels of control, such as 60% or 80% pollutant removals from municipal sources. EPA estimates that controls in the 60% to 80% range will increase economic benefits by $200 million to $300 million per year, respectively, compared to the original $1.63 billion estimate.

As another sensitivity analysis, EPA assumed that the construction starts sediment loadings were 25% higher or lower than originally assumed. The resulting local economic benefits estimates show a change of only plus or minus 5%.

6.3 National Water Quality Assessment Approach

EPA also estimated benefits using national water quality impairment data in the 305(b) report (US EPA, 1998a). EPA used the Carson and Mitchell WTP estimates discussed in Section 6.2 to value the removal of designated use impairment in streams, rivers, and lakes attributed to the Phase II urban sources, which was discussed in Chapter 3. For estimating benefits of the sedimentation and erosion control (SEC) requirements of the rule, EPA used estimates of the value of the SEC program in North Carolina. The derivation of benefits is discussed in the following subsections.

6.3.1 Potential Benefits of Municipal Measures

As described in previous chapters, Phase II municipalities contribute loadings of nutrients, metals, oil and grease, and litter that result in impairment of the nation's rivers and streams, lakes, reservoirs, Great Lakes, estuaries, and oceans. The benefits of implementation of the Phase II municipal minimum measures to remove impairment depend on a number of factors, including the number, intensity, and duration of wet weather events; the success of the municipal programs; the site-specific water quality and physical conditions; the current and potential uses of the receiving waters; and the existence of nearby "substitute" sites of unimpaired waters. Because all these factors will vary substantially from municipality to municipality, data and information are not available with which to develop estimates of benefits measure by measure and water body by water body.

Previously, EPA developed a method for estimating the potential benefits of the storm water program using national-level data that can be adapted to shed light on the benefits of the Phase II rule. As part of an effort to quantify the value of United States' waters impaired by storm water discharges, EPA applied Carson and Mitchell's (1993) estimates of the WTP for incremental water quality improvements to estimates of waters impaired by storm water discharges as reported by states in their 305(b) reports.

To develop estimates of the potential value of waters impaired by Phase II municipal sources, EPA used the proportion of impairment estimated for just these communities as developed in Chapter 3. That is, the potential Phase II benefits are assumed to equal the WTP for the different water quality levels multiplied by the water quality impairment associated with Phase II municipalities (see Exhibit 3–9, Urban Runoff/Storm Sewers column) and multiplied by the relevant number of households (WTP × % impaired × # households). Although households in Phase II communities will most directly benefit from improved local water quality, the WTP values from Carson and Mitchell (1993) are applied to all households in the United States because these WTP values represent the benefits—including nonuse benefits—that will accrue to all households as a result of the water quality improvements of the Phase II rule. The 1998 population (270 million) was divided by the number of persons per household in 1997 (2.62) to arrive at an estimate of 103 million households.

To apply the WTP values, EPA assumed that aquatic life support and fish consumption categories in the 305(b) data are similar to the fishable level that respondents were asked to value in Carson and Mitchell's study. Likewise, EPA assumed that primary contact (swimming) is similar to the swimmable level and that secondary contact (boating) is similar to the boatable level. However, these matches are not exact, as measurement and reporting standards for 305(b) reports differ from state to state.

Using the equation described above, the WTP to bring water quality in lakes to the swimmable level is: ($177 adjusted WTP) × (0.56% impairment) × (103 million households) = $102.2 million.[6] The Carson and Mitchell estimates apply to all fresh water lakes and rivers. As shown in Exhibit 3–8, lakes are the most impaired by urban runoff/storm sewers, followed closely by Great Lakes, and then rivers. It is not clear, however, how the Carson and Mitchell values would be apportioned among rivers, lakes, and Great Lakes because the physical units reported in the 305(b) (river miles, lake acres, and Great Lakes shoreline miles) cannot be aggregated. In light of this problem, EPA developed a benefits range by applying the WTP values to the categories separately and assuming that the higher resulting value for lakes represents the high end of the range (i.e., assuming that lake impairment is more indicative of national fresh water impairment) and that the lower resulting value for impaired rivers represents the low end of a value range for all fresh waters (i.e., assuming that river impairment is more indicative of national fresh water impairment).

The designated uses given in the 305(b) data list two categories that can be interpreted as "fishable water quality:" aquatic life support and fish consumption. Calculating the WTP for each category and aggregating every category is likely to lead to double counting. Therefore, EPA used the sum across every category to determine an upper bound on both the low and high WTP estimates. To determine a lower bound on the low and high WTP estimates, EPA included only the aquatic life support category, the larger impairment impact, eliminating the fish consumption category. The resulting benefit estimates are presented in Exhibit 6–8. These results differ from the NWPCAM results, in part, because they exclude the soil erosion control impacts, which are valued separately. Furthermore, the changes in impairment levels based on the 305(b) data are substantially lower than the baseline impairment levels simulated using the NWPCAM. As noted earlier, the 305(b) data only identify impairments to designated uses, whereas the NWPCAM classifies as impaired any river reach that does not meet swimmable standards.

Exhibit 6–8. Potential Annual WTP Estimates for Fresh Water Impaired by Phase II Municipal Sources (1998 dollars)

Designated Use	Adjusted Household WTP	Impairment from Urban Runoff/ Storm Sewers	Aggregate WTP[1] (millions)
Low Estimate (Based on Impairment Data for Rivers)			
Aquatic Life Support	$158	0.36%	$58.7
Fish Consumption	$158	0.19%	$31.2
Primary Contact—Swimming	$177	0.24%	$42.7
Secondary Contact—Boating, etc.	$210	0.22%	$48.7
Subtotal (upper bound)[2]			$181.5
Subtotal (lower bound)[3]			$150.3

[6]Equation result is not exact due to rounding of factors.

Exhibit 6–8. Potential Annual WTP Estimates for Fresh Water Impaired by Phase II Municipal Sources (1998 dollars)

Designated Use	Adjusted Household WTP	Impairment from Urban Runoff/ Storm Sewers	Aggregate WTP[1] (millions)
High Estimate (Based on Impairment Data for Lakes)			
Aquatic Life Support	$158	0.70%	$113.7
Fish Consumption	$158	0.79%	$128.3
Primary Contact—Swimming	$177	0.56%	$102.2
Secondary Contact—Boating, etc.	$210	0.56%	$121.8
Subtotal (upper bound)[2]			$466.0
Subtotal (lower bound)[3]			$337.6

Source: US EPA, 1998a.
[1]Based on 103 million households (US Bureau of the Census, 1998a). Results subject to rounding.
[2]Totals may not add due to rounding. Includes all designated uses.
[3]Totals may not add due to rounding. Excludes fish consumption values.

Although the results provided in Exhibit 6–8 indicate the potential value of impaired waters, the extent to which impairment will be eliminated by the municipal minimum measures is not clear. The estimates are presented in Exhibit 6–9 for a range of potential effectiveness of municipal programs excluding post-construction control measures.

Exhibit 6–9. Potential Annual Benefits of Improving Fresh Water Impaired by Phase II Municipal Sources to Support Their Designated Uses (Millions of 1998 dollars)

Municipal Program Effectiveness[1]		
60%	**80%[2]**	**100%**
Low Estimate (based on impairment data for rivers)[3]		
$90.2–$108.9	$120.2–$145.2	$150.3–$181.5
High Estimate (based on impairment data for lakes)[3]		
$202.6–$279.6	$270.1–$372.8	$337.6–$466.0

[1] Figures subject to rounding.
[2] EPA expects that municipal programs will strive to achieve at least an 80% effectiveness.
[3] Adjusted for program effectiveness (e.g., for rivers: $150.3 × 80% = $120.2; $181.5 × 80% = $145.2).

6.3.2 Potential Benefits of Avoided Water Quality Impairments

The fresh water benefit analysis in Section 6.3.1 does not include prospective benefits that are expected to accrue from municipal measures to address post-construction runoff control. This is because the benefit analysis is based on current water quality impairment levels in the 305(b) report. Post-construction runoff control measures will mitigate future impairment to water bodies by controlling contaminated storm water runoff from sites that are developed or redeveloped in the future. Without this provision, national water quality impairment would increase relative to the impairment levels currently reported in the 305(b). This section describes the approach developed by EPA to estimate potential benefits of avoiding future water quality impairment.

New development and redevelopment activities can increase the types and amounts of pollutants that enter waterways in storm water runoff by increasing the amount of impervious surface and the presence of contaminants. Storm water quality sampling results from EPA's Nationwide Urban Runoff Program show that development activities increase contaminant concentrations in runoff. Exhibit 6–10 compares mean concentrations of pollutants in runoff from residential and commercial areas with runoff from nonurbanized areas. Runoff concentrations of a wide variety of contaminants from land converted to residential and commercial use are fairly comparable, but both are substantially greater than runoff concentrations from nonurbanized land. Subsequent studies have shown that annual pollutant loadings from residential, commercial, and industrial areas can be one to three orders of magnitude greater than loadings from areas with low levels of impervious surface such as parks, and the concentrations of some pollutants in urban runoff are comparable to untreated domestic wastewater (US EPA, 1998a).

Exhibit 6–10. Mean Contaminant Concentrations in Storm Water Runoff from Developed and Nonurbanized Areas

Pollutant (units)	Residential Use	Commercial Use	Nonurban Use
BOD (mg/l)	10	9.3	—
COD (mg/l)	73	57	40
TSS (mg/l)	101	69	70
Total lead (µg/l)	144	104	30
Total Copper (µg/l)	33	29	—
Total Zinc (µg/l)	135	226	195
Total Kjeldahl Nitrogen (µg/l)	1900	1179	965
Nitrate + Nitrite (µg/l)	736	572	543
Total Phosphorus (µg/l)	383	201	121
Soluble Phosphorus (µg/l)	143	80	26

Source: US EPA (1983) as cited in US EPA (1998a).

Under the post-construction runoff control provision, developments in the urbanized areas of Phase II communities that disturb between one and ten acres may implement structural and nonstructural BMPs to minimize the impact of development on storm water runoff. These BMPs are designed to remove pollutants from storm water through settling or filtration. Studies of the types of BMPs included in the cost analysis in Chapter 4 demonstrate their effectiveness in reducing the pollutant loadings in runoff. Exhibit 6–11 summarizes some of the potential loadings reductions.

Exhibit 6–11. Effectiveness of BMPs in Removing Contaminants from Storm Water Runoff

BMP	Median Removal (Percent of Loading without BMP)									
	TSS	TDS	BOD/ COD/ TOC	Total N	Total P	FC	Cd	Cu	Pb	Zn
Detention Pond	7	ND	–1	5	10	ND	54	26	43	26
Infiltration trench/basin	99	ND	90	60–70	65–75	98	95–99	95–99	95–99	95–99
Sand Filter	87	16	66	44	44	51	ND	34	71	80
Swale	81	ND	67	ND	ND	–58	42	51	67	71

Source: US EPA (1998b)

Note: ND = insufficient data

EPA assumes that future new development and redevelopment activities in urbanized areas of Phase II communities will lead to further impairment of fresh water resources. To characterize the potential degree of the additional impairment attributed to urban runoff impairment sources that the rule addresses, EPA assumed that baseline impairment would increase at roughly the same rate as development. EPA calculated area disturbed to approximate the rate of development by dividing the annual development acreage implied in the cost analysis by an estimate of the total urbanized area in Phase II communities. The development acreage was calculated as the product of the number of construction starts in each size category by the midpoint acreage of that category. This generated a total disturbed area estimate of roughly 40,000 acres for the multi-family residential, commercial, and institutional construction starts. An additional 7,000 acres were added to this total to account for single family residential construction starts. These starts are excluded from the cost analysis because EPA determined that the flexibility of the rule would enable developers to satisfy the goals of this provision without incurring significant additional costs. However, due to the use of nonstructural practices such as improved site design that minimize impervious areas, they are part of the baseline development against which benefits are estimated.

Thus, the total disturbed area potentially affected by the rule is 47,000 acres, which accounts for about 0.17% of the 27.3 million acres of urbanized area in Phase II communities. Although a larger percentage of land in Phase II urbanized areas is disturbed on an annual basis, some of the disturbance should not further impair water quality because it falls under an equivalent runoff control program (e.g., industrial developments, developments that disturb more than 10 acres, and development in coastal counties that are covered by an equivalent CZARA program), and some of the disturbance that may further impair water quality is not affected by the rule (e.g., construction starts that disturb less than one acre). EPA also assumed that all of the construction starts in the cost analysis would cause future water quality impairments, regardless of whether they are new development or redevelopment starts.

Assuming that the incremental impairment of new development and redevelopment activities is roughly proportional to the amount of land disturbed, EPA multiplied the 0.17% by the urban runoff/storm sewer impairment attributed to Phase II communities, shown in Exhibit 3–10. Exhibit 6–12 summarizes the resulting incremental impairment estimates, which EPA then multiplied by the adjusted household WTP values used in the fresh water analysis in Section 6.2.1 to obtain benefit estimates. These estimates range from a low of almost $308,000 to a high of over $950,000 per year for a single year of construction starts. Because the rule affects new construction starts each year, EPA assumes that it mitigates the potential water quality impairments from an additional 47,000 disturbed acres each year.

Exhibit 6–12. Potential Annual WTP Estimates for Fresh Water Impaired by One Year of New Development and Redevelopment Activities (1998 dollars)

Designated Use	Adjusted Household WTP	Impairment from Urban Runoff/ Storm Sewers	Incremental Impairment from New Development and Redevelopment Activities	Aggregate WTP[1] (millions)
Low Estimate (Based on Impairment Data for Rivers)				
Aquatic Life Support	$158	0.36%	0.0007%	$0.12
Fish Consumption	$158	0.19%	0.0004%	$0.06
Primary Contact—Swimming	$177	0.24%	0.0005%	$0.09
Secondary Contact—Boating, etc.	$210	0.22%	0.0005%	$0.10
Subtotal (upper bound)[2] Capitalized stream[4]				$0.37 $2.62
Subtotal (lower bound)[3] Capitalized stream[4]				$0.31 $2.17
High Estimate (Based on Impairment Data for Lakes)				
Aquatic Life Support	$158	0.70%	0.0014%	$0.23
Fish Consumption	$158	0.79%	0.0016%	$0.26
Primary Contact—Swimming	$177	0.56%	0.0012%	$0.21
Secondary Contact—Boating, etc.	$210	0.56%	0.0012%	$0.25
Subtotal (upper bound)[2] Capitalized stream[4]				$0.96 $6.74
Subtotal (lower bound)[3] Capitalized stream[4]				$0.69 $4.88

[1] Based on 103 million households (US Bureau of the Census, 1998a). Results subject to rounding.
[2] Totals may not add due to rounding. Includes all designated uses.
[3] Totals may not add due to rounding. Excludes fish consumption values.
[4] Annual benefits were capitalized over a 10-year period assuming a 7% discount rate.

Because these are annual WTP estimates to avoid incremental impairments to water quality, they accrue each subsequent year that O&M expenditures are incurred to maintain the effectiveness of BMPs. To adequately represent the annual social costs imposed by installing and maintaining BMPs on approximately 15,000 new construction starts per year, total annual BMP costs in Chapter 4 included construction costs and a capitalized O&M value representing the 10-year stream of the O&M costs that would be incurred annually to maintain those BMPs over time. To make the benefit analysis comparable with the cost analysis, EPA similarly capitalized the benefit stream that corresponds with this O&M stream, assuming the same 10-year period and 7% discount rate. The resulting ranges of annual benefits, which are ongoing benefits that have been capitalized to the year the BMP is installed, are shown in Exhibit 6–12 ($2.2 million to $2.6 million for the low estimate and $4.9 million to $6.7 million for the high estimate).

There are a number of potential biases in this approach. The 305(b) data may include new development or redevelopment impacts on water quality in other impairment source categories such as construction or habitat modification. Consequently, restricting the analysis to the urban runoff category may underestimate the potential impairment. Also, the assumption that future impairment will increase in a roughly proportional manner with the share of urban area that is disturbed may overestimate or underestimate water quality impacts. There is some evidence that the hydrologic impacts (e.g., streambed erosion) of storm water impacts are difficult to mitigate once impervious surface area surpasses 20%. The 305(b) results suggest, however, that such hydrologic changes are considered to be relatively minor sources of impairment compared to the types of contaminants found in urban runoff (e.g., siltation, nutrients, and pathogens). Nevertheless, if water quality throughout the urbanized areas is already substantially degraded such that incremental development activities have a small marginal impact on quality, then the analysis overestimates the potential impairment and subsequent benefits. If, however, water quality near undeveloped areas is relatively high, then the marginal impact of development activities may be greater than the proportional analysis suggests.

EPA applied the same municipal program effectiveness percentages used in Section 6.3.1 to the potential benefits of the post-construction runoff control provision. Assuming municipal program effectiveness ranges from 60% to 100%, Exhibit 6–13 summarizes the range of annual future benefits.

Exhibit 6–13. Potential Annual Benefits of Avoiding Future Fresh Water Impairments from New Development and Redevelopment Activities in Phase II Urbanized Areas (Millions of 1998 dollars)

Municipal Program Effectiveness [1]		
60%	**80%[2]**	**100%**
Low Estimate (based on impairment data for rivers)[3]		
$1.3–$1.6	$1.7–$2.1	$2.2–$2.6
High Estimate (based on impairment data for lakes)[3]		
$2.9–$4.0	$3.9–$5.4	$4.9–$6.7

[1] Figures subject to rounding.

[2] EPA expects that municipal programs will strive to achieve at least an 80% effectiveness.

[3] Adjusted for program effectiveness (e.g., for rivers: $2.2 × 80% = $1.7; $2.6 × 80% = $2.1).

6.3.3 Potential Value of Improved Marine Waters

The Phase II rule will affect marine waters as well as fresh waters. Consequently, EPA anticipates additional benefits as a result of improvements to marine waters. These benefits are not reflected in the analyses above because the WTP estimates from the Carson and Mitchell study only capture fresh water benefits.

Benefits to Commercial Fisheries

Commercial marine fisheries are a significant part of the nation's economy. In 1997, the value of the commercial finfish catch was $581 million and the value of the commercial shellfish catch was $1.04 billion (National Marine Fisheries Service, 1997). However, as noted in Chapter 2, the pollutants found in storm water such as pathogens and silt can adversely affect the productivity and viability of fisheries populations. Although several studies document the adverse effects of pollution on fish and shellfish, there are limitations to estimating marine commercial fishing benefits. To develop a defensible, "bottom-up" economic valuation approach EPA would need to quantify three links: how changes in urban runoff affect marine water quality, how changes in marine water quality affect fishery productivity, and how changes in fishery productivity affect the commercial catch and resulting producer and consumer surplus measures. Although there is limited information for the first and third links (e.g., the 305(b) water quality impairment data and total commercial catch values and estimates of surplus measures), there is little quantitative information regarding the second link. EPA is aware of proposed research efforts to develop such links between water quality variables and fishery characteristics, but research in not complete at this time. Thus, national level estimates are not feasible.

Despite these noted difficulties and the lack of national level data, EPA did attempt to characterize the impacts of storm water runoff on commercial fisheries for areas of the country where fisheries are a significant part of the economy: Puget Sound, Gavelston Bay, and the Gulf of Mexico. While fisheries experts and state officials were able to confirm that pathogens have indeed adversely affected or caused the closing of various fisheries, they were unable to identify the source of contamination. Furthermore, those contacted were unaware of any completed comprehensive studies on the economic impacts of pollution on commercial fishing, including pollution associated with storm water runoff.

The baseline value of commercial fishing can be characterized using the available national level catch data described above. Because the national value of finfish and shellfish catches are high, even a small contribution to enhancing these values (e.g., through the reopening of shellfish beds) is potentially large. For instance, if controlling runoff from Phase II communities led to a relatively small 1% increase in the value of the shellfish catch, the corresponding market value would be about $10 million.

Benefits from Enhanced Marine Recreational Fishing

The 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation reveals that 9.4 million anglers participated in saltwater fishing in 1996 (US Department of the Interior, 1998). In addition, a review of the literature by Freeman (1993) suggests that one year's access to a multi-species fishery per person could be as high as $120 to $1,200 (1998 dollars). If 9.4 million anglers participate in saltwater fishing, the potential value of marine recreational fishing is $1.1 billion to $11.3 billion per year. However, poor water quality may affect fishery populations and may negatively affect participation and the enjoyment associated with fishing trips. Thus, implementation of the Phase II rule may increase the value of fishing experiences and lead to increased participation.

There are, however, limitations associated with estimating the benefits to marine recreational fishing that are similar to those associated with commercial marine fishing. For instance, although travel cost models may provide information about how changes in catch rate affect recreational angling values, EPA lacks quantitative data regarding how loadings reductions are likely to affect fish populations and catch rates. In addition, as noted by Freeman (1993), benefit estimates are difficult to transfer because estimates vary widely based on the characteristics of individuals, species of fish studied, number of species included in the study, and estimation techniques. For these reasons, EPA did not estimate national benefits of recreational fishery improvements. Because marine recreational fishing is a highly valued activity, even a slight improvement could yield large benefits. For example, if controlling runoff from Phase II communities led to a relatively small 1% increase in recreational fishing, the corresponding potential value would be between $11 million to $113 million per year.

Benefits from Enhanced Marine Recreational Swimming

There is little question that marine recreational swimming is an activity enjoyed by many people. EPA estimates that Americans participated in approximately 1.3 billion nonpool swimming days in 1998, using current population estimates (US EPA, 1995c). Furthermore, EPA (US EPA, 1995c) estimates that approximately 44.6% of swimming trips were to the ocean. Multiplying these figures yields almost 580 million swimming trips to oceans per year. To approximate the number of people swimming at ocean beaches potentially impacted by the Phase II rule, EPA assumed that the total number of swimming trips is distributed among Phase I and Phase II beaches in the same way that the coastal population is distributed between Phase I and Phase II communities. Approximately 32.0 million people reside in Phase II communities that are located in coastal counties and approximately 111.7 million US residents live in coastal counties. Thus, about 28.7% of the coastal population lives in Phase II communities, and the number of swimming trips allocated to Phase II communities is about 166 million trips, which is equivalent to approximately five trips per person per year for the coastal residents.

This approach may tend to overestimate the number of swimming trips to beaches in Phase II communities because it does not allocate trips to beaches that are located outside Phase I and Phase II communities, e.g., at national parks. On the other hand, however, this approach may tend to underestimate the number of swimming trips to beaches in Phase II communities because it assumes that a large share of trips occur in Phase I coastal communities (e.g., Baltimore and the Bronx) although many people in those communities may travel to beaches in smaller coastal communities to swim. In the absence of better national visitation data for Phase II beaches, EPA assumes that these potential sources of bias offset one another.

Unfortunately, fecal coliform concentration and other pollutants such as oil, grease, and litter, may degrade beach quality and thus inhibit people's enjoyment and participation in outdoor swimming. Degradation of beach waters can also result in beach closures that prohibit swimming, resulting in welfare losses. EPA anticipates that the Phase II rule will reduce these losses.

To evaluate the potential benefits of reducing beach closures in Phase II communities, EPA used information on beach use and closures from beaches in 159 Phase II communities in the EPA Beach Watch program. This program only includes data for beaches that monitor and report water quality and beach closures. There are 428 beaches in the dataset that are in Phase II communities; the number of beaches in Phase II communities that do not monitor or report is unknown. The data include daily visitation estimates and the reported number of closings for each beach in 1997, both categorized by weekday, weekend, holiday, peak and nonpeak season. EPA multiplied these visitation rates by the number of daily beach closings per beach and then summed over all the Phase II beaches in the dataset to produce a total of 86,100 lost beach days caused by beach closures. This estimate is subject to some limitations. It is important to note that several beaches in the dataset did not report visitation statistics and EPA estimated that zero visits were lost at these beaches, thereby understating lost beach days. Another limitation is that these beaches reported storm water as a significant source of pollution, but elevated bacteria levels were ultimately the reason for the closures. Some of the elevated bacteria levels may have sources other than storm water, so the estimate may overstate lost beach days.

To value these lost beach days, EPA reviewed two meta-analyses, Walsh et al. (1990) and Freeman (1993) to obtain a mean benefit measure of $30.00 per person per visit for a beach day.[7] The literature included in the meta-analyses mostly used the travel cost method to estimate the consumer surplus per person per day. The majority of these studies accounted for the effects of substitution between different beach sites with the use of dummy variables. However, some of the work included in the Walsh et al.(1990) meta-analysis that used the contingent valuation

[7] EPA used the mean of the aggregate value for swimming from the Walsh et al. (1990) and the value from the Leeworthy and Wiley (1991) study included in the Freeman (1993) analysis.The Leeworthy and Wiley estimates of $19.41 are in 1988 dollars and the Walsh et al. estimates of $22.97 are in 1987 dollars. To derive a mean benefit measure, both estimates were adjusted to 1998 dollars using the CPI.

method did not explicitly account for substitute sites, thus potentially biasing the estimate upward.

Using the $30.00 per person per day estimate of consumer surplus for a beach visit and the 86,100 lost beach days yields approximately $2.6 million in lost swimming benefits. This estimate is expected to be a subset of marine recreational swimming benefits because it does not account for the increased participation of those who are not currently swimming, but would do so after an improvement in water quality. That is, this value only represents the benefits existing users have at current water quality levels and does not account for the increased potential enjoyment of new and existing swimmers for a water quality improvement. Thus $2.6 million can be taken as a lower bound to lost marine swimming benefits.

The extent to which the Phase II rule will reduce the incidence of beach closures is uncertain. Exhibit 6–14 reports an effectiveness range for municipal programs that is similar to ranges reported earlier.

Exhibit 6–14. Potential Annual Benefits of Reducing the Number of Beach Closures in Phase II Communities (Millions of 1998 dollars)

Municipal Program Effectiveness [1]		
60%	**80%[2]**	**100%**
$1.6	$2.1	$2.6

[1] Adjusted for program effectiveness (e.g., $2.6× 80% = $2.1). Figures subject to rounding.

[2] EPA expects that municipal programs will strive to achieve at least an 80% effectiveness.

Benefits of Reduced Health Risks from Swimming

One of the anticipated benefits of the Phase II rule is a reduction in human health risks caused by swimming in contaminated waters. Although the Carson and Mitchell survey asked respondents to state a value for swimmable water quality, EPA does not believe that waters identified as swimmable according to federal standards are completely free of potential health risks. Indeed, EPA estimated that 19 out of 1,000 persons swimming in ocean and bays just meeting the acceptable standard of 35 enterococcus bacteria per 100 milliliter of water will become ill (EPA, 1986). In addition, the health risks associated with swimming in contaminated marine waters are not included in the estimates because the Carson and Mitchell study includes only fresh waters.

To estimate the benefits of reduced health risks associated with swimming in marine waters, EPA extrapolated health impacts from an epidemiological study of swimmers at Santa Monica Bay, conducted by Haile et al. (1996) to a national level. This section briefly summarizes the benefit analysis, which is discussed in further detail in Appendix C.

The Santa Monica Bay study of 13,278 swimmers found swimmers within 100 yards of storm drains experienced increased incidences of gastrointestinal and respiratory diseases, and that illness rates were often highest among those who swam in the immediate vicinity of the storm drain (Haile et al., 1996). The increased incidence of illness was associated with swimming in areas where monitoring results showed high densities of bacterial indicators. The study identified illicit connections to storm sewer drains as possible sources of contamination.

EPA developed a method for extrapolating the results of the Santa Monica Bay study that did not require water quality monitoring data, which is often not available for beaches in Phase II communities. The Santa Monica Bay study reported “attributable numbers,” which characterized the additional number of illnesses occurring among the people who swam near the storm sewer drains compared to baseline illness incidences among swimmers who were more than 400 feet away from a storm drain. These attributable numbers provide a means for estimating the number of incremental illnesses at total coliform (TC) concentrations above or below a 1000 cfu/100 ml cutpoint. EPA verified that concentrations above and below the cutpoint were possible at storm sewer drains (see Appendix C). Then, using exposure information from the Santa Monica Bay study, EPA estimated that of the 166 million swimming trips to beaches in Phase II communities, 11.6 million trips may bring swimmers within the vicinity of a storm sewer outfall (see Appendix C).

EPA multiplied the attributable numbers by the exposure range to obtain estimated incremental illnesses. For highly credible gastroenteritis two (HCGI 2), defined as a person having vomiting and fever, the additional cases range from 35,795 for low contamination to 118,501 for high contamination. For significant respiratory disease (SRD), defined as a person having fever and nasal congestion or fever, sore throat and cough with sputum, the increased cases range from 0 for low contamination to 119,199 for high contamination. Other health effects included fever, chills, nasuea, vomitting, diarrhea, cough, cough with phlem, runny nose, sore throat, and highly credible gastroenteritis one (HCGI 1), defined as a person having vomiting, diarrhea and fever or stomach pain and fever. These various conditions are expected to increase by 249,340 cases, for high contamination exposures. However, EPA only applied economic values to two of the health effects, significant respiratory disease (SRD) and highly credible gastroenteritis 2 (HCGI 2), because of the unknown overlap between other health effect categories and a lack of valuation information for many of the health effects.

If the Santa Monica Bay study results are indicative of national swimming activity, avoided health impacts among children may make up a disproportionate share of the potential health benefits. Among the study sample, children appeared more likely than adults to swim near storm sewer drains in the study; children made up 48% of the study sample, but they accounted for 62% of the subsample that swam within one yard of a drain.

Since SRD and HCGI 2 are the only health effects accounted for, the consquent health benefits are underestimated. For the SRD cases, EPA used WTP values reported in EPA (1997d) to avoid upper respiratory symptoms, which was $19 per case in 1990 dollars. The symptoms associated with this illness are head/sinus congestion, cough, and eye irritation (US EPA, 1997d), which are similar to the symptoms for the SRD category. This value potentially underestimates losses associated with SRD cases because it does not include the value of any foregone work or leisure activities. The Santa Monica Bay study did not collect such information. EPA assumed that the combination of symptoms was severe enough to constitute one mild restricted activity day per case, which is valued at $38 per day (US EPA, 1997d). EPA escalated both of these values to 1998 dollars using the CPI. The adjustment factor is 1.24, which equals 163.0 (annual average CPI for 1998) divided by 130.7 (annual average CPI for

1990). The resulting values are $24 per case for upper respiratory symptoms and $47 per day for a mild restricted activity day.

For the HCGI 2 cases, EPA used cost of illness (COI) values estimated by Mauskopf and French (1991) for related gastrointestinal illnesses. Exhibit 6–15 summarizes the illnesses and symptoms valued by Mauskopf and French, average illness durations, and COI estimates based on medical and work loss estimates. EPA did not attempt to adjust the COI values to WTP values, which are generally higher because they account for nonpecuniary costs such as pain and suffering. The COI in Mauskopf and French were estimated on a per case basis. The symptoms for moderate salmonellosis better match the HCGI 2 symptoms (vomiting and fever). The potential duration for HCGI 2 cases, however, is more comparable to the three-day duration of mild salmonellosis: one to 10 days for viral infections and four to six days for *e. coli* infections (Center for Disease Control and Prevention, 1998 and 1994). Consequently, EPA used the $197 per-case cost ($1990) for a mild case of salmonellosis to value the benefits of avoided HCGI two cases; escalated for inflation, the COI value per case is $244 ($1998).

Exhibit 6–15. Cost of Illness Estimates for Gastrointestinal Illnesses

Illness	Symptoms	Length	Treatment	Total COI[1]	
				($1990)	($1998)
Mauskopf and French (1991)					
Botulism–mild	malaise, weakness, fatigue	5 days	antitoxin	$470	$583
Salmonellosis–mild	nausea/vomiting, diarrhea, abdominal pain, anorexia, weakness	3 days	oral fluids, antispasmodics	$197	$244
Salmonellosis–moderate	same as mild plus fever, headache, dehydration/ prostration	7 days	oral fluids, antispasmodics	$622	$771

Source: Mauskopf and French (1991).

[1]Original 1990 values escalated to 1998 values using the CPI for all items. The adjustment factor of 1.24 equals 163.0 (annual average CPI for 1998) divided by 130.7 (annual average CPI for 1990).

Exhibit 6–16 summarizes estimated health benefits associated with the Phase II rule. For each symptom category, EPA multiplied the number of cases estimated for the two exposure assumptions and the two TC concentration levels by the appropriate per case value. The annual benefit estimate for the low contamination assumption is $8.7 million. EPA believes this underestimates the potential low range of health benefits because the attributable number for SRD below the 1000 cfu/100 ml cutpoint is zero. A method based on a dose-response function would most likely generate a positive value for the low range of SRD cases. The benefit estimate for the high contamination assumption is over $37 million per year. This estimate most likely overstates annual benefits for these particular health effects because it assumes that concentrations at all storm sewer drains exceeds 1000 cfu/100 ml at all times swimmers are nearby, which is not likely. Exhibit 6–17 summarizes benefits after adjusting these values for the range of municipal program effectiveness assumptions.

Exhibit 6–16. Summary of Potential Marine Health Benefits by Symptom, Exposure Assumption, and Total Coliform Concentration at Outfall

Symptom	WTP or COI Value[1]	Low Contamination (TC <1000 cfu/100 ml)	High Contamination (TC >1000 cfu/100 ml)
HCGI 2	$244 per case	$8,733,980	$28,914,244
SRD	$24 per case $47 per day	$0	$8,463,129
Total		$8,733,980	$37,377,373

[1] COI value for HCGI is the per day value for a mild case of salmonellosis from Mauskopf and French (1991), adjusted from 1990 to 1998 dollars. The WTP value for a case of SRD is the sum of the upper respiratory symptom value and the mild restricted activity day value from EPA (1997b), adjusted from 1990–1998 dollars. In both instances, the adjustment factor is 1.24, which equals 163.0 (annual average CPI for 1998) divided by 130.7 (annual average CPI for 1990).

Exhibit 6–17. Potential Annual Benefits of Avoided Health Impacts from Swimming in Contaminated Marine Waters in Phase II Communities (Millions of 1998 dollars)

Municipal Program Effectiveness[1]		
60%	80%[2]	100%
$5.2–$22.4	$7.0–$29.9	$8.7–$37.4

[1] Adjusted for program effectiveness (e.g., $8.7 × 80% = $7.0). Figures subject to rounding.
[2] EPA expects that municipal programs will strive to achieve at least an 80% effectiveness.

6.3.4 Potential Benefits of Construction Site Controls

The national benefits of construction site storm water runoff controls will also depend on a number of factors, including the number, intensity, and duration of wet weather events; the effectiveness of the selected construction site BMPs; the site-specific water quality and physical conditions of receiving waters; the current and potential uses of receiving waters; and the existence of nearby "substitute" sites of unimpaired waters. Again, because these factors will vary substantially from site to site, data are not available with which to develop estimates of benefits for each site.

Nonetheless, a survey of North Carolina residents (Paterson et al., 1993) indicates that households are willing to pay for erosion and sediment controls similar to those contained in the Phase II program. This study provides one way to develop national level benefits estimates of the rule and, therefore, EPA chose to use benefit transfer methodology to apply the study results. Paterson et al's. (1993) study is applicable to the construction component of the Phase II rule not only because North Carolina's program requires similar controls, but also because the median income of North Carolina residents is just below the median income for the United States. The similarity of the median incomes indicates that the WTP estimates developed by Paterson et al. (1993) may reflect the WTP of residents elsewhere in the United States.

Furthermore, two other surveys conducted at approximately the same time—one in Maryland and one in Wisconsin—obtained comparable WTP estimates to improve water quality.

Value of North Carolina Storm Water Program

In North Carolina, any activity disturbing one or more acres is regulated by an erosion and sediment control program. In 1990, Paterson et al. (1993) conducted a CV survey of North Carolina residents in urban areas to determine their WTP for the program. For the survey sample, the authors randomly selected urban residents from one of three geographic regions in the state: Asheville (Mountain region), Durham (Piedmont region), and Wilmington (Coastal Plain region). These regions also represented a range of soil erosion conditions.

First, the survey explained the problems associated with sedimentation and the procedures commonly used to control soil erosion and prevent sedimentation. The "harmful or costly effects" from sedimentation described to respondents were (Malcom et al., 1990):

- Killing fish and other water life, reducing catches for fishermen
- Reducing the depth of streams, rivers, and lakes, increasing the possibility of flooding, and requiring expenditures for either flood control or the removal of sediment from the bottom by "dredging"
- Filling reservoirs with dirt, reducing the amount of water in the reservoir and requiring additional expenditures either to remove the sediment from the bottom of the reservoir or to build more reservoirs
- Causing rivers, streams, and lakes to appear muddy and less attractive to hikers and swimmers
- Filling channels used for recreational boating and commercial fishing, requiring removal of sediment by dredging.

Procedures available to developers for controlling sedimentation that were outlined and illustrated for respondents were (Malcom et al., 1990):

- Rapid completion of construction so that land is disturbed for short periods of time
- Construction of sediment trapping devices, including ponds and ditches, so that sediment is kept on the property, and does not wash into a nearby river, stream, or lake
- Construction of silt fences or check dams to catch or slow down sediment runoff before it reaches a nearby water body
- Use of stone-lined or paved channels to direct water runoff away from vegetation, especially on steep slopes
- Sodding and tree protection to preserve the natural ground cover.

Respondents were asked to assume that no funding sources for administration of the program existed, and that the public would pay for all administration, monitoring, and enforcement costs. Respondents were then asked about their recreational activities and to state their willingness to contribute to a special fund to administer, monitor, and enforce sediment control measures. Finally, respondents were asked about household characteristics and their opinions on environmental quality.

It is important to note that Paterson et al. conducted their survey in 1990, based on the state of contingent valuation (CV) science in the late 1980's; CV survey methods and analytical techniques have developed considerably since then. In particular, the survey predated publication of proposed recommendations developed by the NOAA Panel on Contingent Valuation (58 FR 4601). Nevertheless, the survey was reviewed and pretested prior to implementation (Lindsey, Paterson, and Luger, 1995) and the research team followed the recommendations in Mitchell and Carson (1989) to the extent possible (R. Paterson, personal communication, January, 1999). The authors also obtained technical advice from Dale Whittington, who is well recognized in the fields of water resource economics and nonmarket valuation.

Although the response rate to the mail survey was only 41%, this response rate is similar to response rates for other mail surveys that obtain WTP values for policy development. For example, a 1987 CV study for Mono Lake, California had a 44% response rate (J. Loomis, personal communication, January, 1999), and the recreation demand study for the Columbia River System Operation Review Environmental Impact Statement (Cameron et al., 1999) had a raw response rate of 36%.

Discussion of Survey Results

Paterson et al.'s (1993) analysis of the survey results indicated a mean of $20 per year (in 1990 dollars). This estimate is a simple statistic calculated from the open-ended valuation question that followed the dichotomous choice question. EPA adjusted the mean WTP value to $25 to account for inflation from 1990 to 1998.[8]

The good that the authors asked respondents to value was a program that would administer, monitor, and enforce requirements that developers control erosion from construction sites. It is likely that the average household WTP responses reflect values for avoiding the sedimentation damages caused by construction site erosion because the survey discussed these types of damages (especially impacts on water-based recreational activities) and included photos showing examples of eroded construction sites with descriptions of adverse watershed impacts. Furthermore, 56% of the respondents reported participating in water-based recreational activities and would be more likely be familiar with water quality impacts on these activities than people who do not engage in such recreation activities (Lindsey, Paterson, and Luger, 1995).

The respondents provided only their WTP for a state program that would help protect water quality (respondents were told that developers would pay for their own erosion control measures). Therefore, they may have provided lower bound estimates of their WTP to prevent construction site sedimentation damages in urban runoff either because they internalized development price increases or because they engaged in free riding behavior.

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[8]Based on the change in the CPI from 1990 to 1998 (1.25%) as reported in the Economic Report of the President (Office of the President, 1998). Note again that currently there is a debate regarding the accuracy of the CPI.

The survey did not provide specific quantitative information about how water quality would be affected by the program[9]. This potentially raises the question of whether the respondents are valuing a well-defined environmental good or whether their WTP really reflects a willingness to support environmental quality in general. It is useful to note, however, that a coincident water quality study obtained higher WTP estimates for a specific good: reduced nutrient loadings in urban runoff for the Chesapeake Bay. Lindsey (1992) obtained WTP estimates for a new government program to reduce nutrient loadings to the Chesapeake Bay from urban storm water runoff. Annual WTP for a 4% reduction in loadings was $42 and the WTP for a 1% reduction was $24 (Lindsey, Paterson, and Luger, 1995). This study demonstrates scope effects (i.e., WTP varies with the level of provision and, thus, provides evidence it represents values for an environmental good rather than a "warm glow") and elicits WTP for a similar type of water quality impact (i.e., a small change in the effect of urban runoff on water quality). Consequently, it provides support for the contention that the WTP values in the North Carolina study represent benefits of improved water quality[10]. It further suggests that the WTP values obtained in the North Carolina study are not particular to North Carolina residents.

Benefit Transfer of Survey Results

Although North Carolina's erosion and sediment control program is similar to the construction site controls of the Phase II rule, the program covers all activities disturbing one or more acres whereas the Phase II rule covers construction sites between one and five acres in size. Other states also have soil and erosion programs in place that are similar to Phase II (including CZARA states with primary enforcement). Therefore, to transfer Paterson et al.'s results to estimate the potential benefits of the Phase II rule, EPA calculated the percentage of Phase II construction starts that are not covered by a state program or CZARA.

Nonurban households were not surveyed by Paterson et al. (1993) and EPA has no information on the WTP of these households. However, it is likely that these households also value soil and erosion control programs. One variable that may indicate potential differences in WTP is income. However, the per capita incomes of the urban residents surveyed by Paterson et al. reflect the range of incomes throughout the State. Thus, EPA does not believe that the value to urban residents would be significantly different from that of nonurban residents. Therefore, EPA estimated the aggregate WTP for all households.

If construction site erosion rates are higher for North Carolina than for other areas of the country, the WTP values to prevent erosion from migrating off-site may be greater in North Carolina as well. However, it is likely that erosion rates differ within North Carolina, so there is no one figure to use for comparison. Likewise, storm water erosion rates elsewhere differ across a variety of geological and climatological dimensions. The CV study developers were sensitive to this issue and developed a stratified sampling plan to include respondents from three major geological regions of the state: the coast (sandy soils), the Piedmont (clay soils), and the

[9]EPA is similarly unable to quantify water quality impacts of the Phase II rule because damage functions are not available to estimate how the soil erosion controls might avoid future impacts on water quality. Consequently, the good in the survey more closely approximates the provisions of the rule than any household benefits measure that could derived from the Carson and Mitchell (1993) water quality study.

[10]Lindsey, Paterson, and Luger (1995) note that North Carolina State officials used the results of the Paterson et al. (1993) benefit-cost analysis in educational workshops in New England to assist states considering similar construction erosion control programs.

mountains (Paterson et al., 1993 and R. Paterson, personal communication, January, 1999). Consequently, the aggregate values represent WTP across respondents who are familiar with a variety of soil types. Therefore, EPA did not adjust WTP for households to account for differences in watersheds.

As shown in Exhibit 6–18, EPA multiplied the percentage of Phase II construction starts by the number of households and by the $25 WTP value. For example, in Virginia, 21.6% of construction starts in 1994 were on sites of between one and five acres and were not regulated to control storm water runoff under a state program or CZARA. Also, in 1997, there were approximately 2,522,096 urban households in Virginia.[11] To estimate the number of households using the WTP estimate of $25, the calculation is:

($25 adjusted WTP) × (2,522,096 households) × (21.6% Phase II starts) = $13.59 million.

EPA considers the resulting benefit estimate a high estimate because using the percentage of construction starts potentially overstates the contribution of the Phase II starts to overall soil erosion caused by construction activities. As a lower bound, EPA used shares based on site perimeter, which was chosen as a proxy for the share of eroded soils that would migrate offsite from different sizes of sites during construction. To estimate the share for each state, EPA estimated aggregate site perimeter length assuming square sites and taking the acreage midpoints for site size for all of the Phase II starts and for all starts. Exhibit 6–19 reports the site-specific assumptions used to calculate the perimeter shares. Exhibit 6–18 reports the resulting percentages, which are lower than the percentages calculated on a start basis.

Exhibit 6–18. Potential Annual WTP for the Phase II Soil and Erosion Control Program (1998 dollars)

State	Phase II Share of Starts	Phase II Share of Perimeter	1998 Households	Benefits ($ millions)	
				Low Estimate	High Estimate
Alabama	40.5%	32.7%	1,617,661	13.21	16.38
Alaska	11.7%	9.5%	228,206	0.54	0.67
Arizona	34.3%	25.9%	1,705,980	11.06	14.63
Arkansas	41.1%	32.9%	944,876	7.76	9.72
California	36.3%	27.8%	12,085,506	83.99	109.67
Colorado	39.7%	32.1%	1,457,919	11.68	14.49
Connecticut	0.0%	0.0%	1,224,666	0.00	0.00
DC	0.0%	0.0%	274,000	0.00	0.00
Delaware	0.0%	0.0%	198,114	0.00	0.00
Florida	0.0%	0.0%	5,488,369	0.00	0.00
Georgia	18.0%	11.4%	2,803,836	8.02	12.59
Hawaii	36.0%	27.3%	444,420	3.03	4.00
Idaho	41.0%	32.9%	453,270	3.73	4.65
Illinois	40.1%	32.0%	4,455,374	35.68	44.64
Indiana	41.7%	34.0%	2,196,295	18.66	22.90

[11] Estimates of households per state are based on the most recent estimate of population by state from 1997.

Exhibit 6–18. Potential Annual WTP for the Phase II Soil and Erosion Control Program (1998 dollars)

State	Phase II Share of Starts	Phase II Share of Perimeter	1998 Households	Benefits ($ millions)	
				Low Estimate	High Estimate
Iowa	42.2%	34.4%	1,068,323	9.19	11.27
Kansas	41.8%	34.1%	971,850	8.28	10.16
Kentucky	40.6%	32.7%	1,463,717	11.98	14.86
Louisiana	40.8%	33.0%	1,629,876	13.44	16.64
Maine	43.3%	35.9%	465,188	4.17	5.04
Maryland	0.0%	0.0%	1,907,973	0.00	0.00
Massachusetts	7.7%	6.1%	2,291,206	3.48	4.41
Michigan	0.0%	0.0%	3,660,634	0.00	0.00
Minnesota	43.7%	36.5%	1,754,887	16.03	19.18
Mississippi	42.1%	34.5%	1,022,660	8.81	10.78
Missouri	40.3%	32.3%	2,023,243	16.32	20.39
Montana	42.7%	34.8%	329,142	2.86	3.51
Nebraska	39.8%	31.5%	620,551	4.89	6.17
Nevada	33.7%	25.3%	628,018	3.97	5.29
New Hampshire	19.1%	12.3%	439,217	1.35	2.10
New Jersey	0.0%	0.0%	3,016,048	0.00	0.00
New Mexico	40.2%	32.6%	647,847	5.28	6.51
New York	40.0%	31.6%	6,792,969	53.65	67.93
North Carolina	0.0%	0.0%	2,780,967	0.00	0.00
North Dakota	43.1%	35.6%	240,031	2.14	2.59
Ohio	40.2%	32.1%	4,189,637	33.65	42.11
Oklahoma	41.1%	33.4%	1,242,356	10.36	12.78
Oregon	40.7%	32.6%	1,214,789	9.91	12.36
Pennsylvania	0.0%	0.0%	4,501,746	0.00	0.00
Rhode Island	0.0%	0.0%	369,824	0.00	0.00
South Carolina	0.0%	0.0%	1,408,307	0.00	0.00
South Dakota	44.1%	36.7%	276,394	2.54	3.05
Tennessee	40.1%	32.3%	2,010,561	16.24	20.16
Texas	38.2%	29.9%	7,280,651	54.49	69.51
Utah	39.8%	32.0%	771,216	6.16	7.68
Vermont	43.5%	36.1%	220,591	1.99	2.40
Virginia	21.6%	17.3%	2,522,096	10.91	13.64
Washington	38.3%	30.0%	2,101,259	15.76	20.14
West Virginia	30.8%	22.3%	680,070	3.80	5.24
Wisconsin	28.7%	20.4%	1,936,209	9.86	13.89
Wyoming	42.8%	35.3%	179,679	1.59	1.92
Total	24.8%	19.5%	100,238,225	540.45	686.02

Exhibit 6–19. Assumptions Used to Derive Perimeter Shares

Site Size Category	Average Site Size	Site Perimeter
0 to 0.5 acres	0.25 acre	417
0.5 to 1 acre	0.75 acre	723
1 to 2 acre	1.5 acre	1,022
2 to 3 acre	2.5 acre	1,320
3 to 4 acre	3.5 acre	1,562
4 to 5 acre	4.5 acre	1,771
5 to 10 acre	7.5 acres	2,286
More than 10 acres	14 acre[1]	3,124

[1] The midpoint for the open-ended size category was estimated using the housing density implied by the sample data shown in Appendix B–2.

EPA then summed the lower and upper bound results across all states. The results indicate that WTP for the erosion and sediment controls of the Phase II rule may range from $540.5 million to $686.0 million per year (Exhibit 6–18).

Small Stream Benefits

The WTP estimates derived above reflect the potential benefits of erosion and sediment control programs that protect all lakes, rivers, and streams. Because construction can be especially harmful to small stream habitat, EPA is interested in the benefits that may be attributable to improvements in small stream ecology. Information on the different proportions of waters in the United States may provide a rough approximation of, and may not fully capture, how these benefits may be attributable to small streams versus larger water bodies. However, such an exercise is complicated because lakes are measured in acres or square miles and rivers and streams are measured in miles. Therefore, EPA converted stream miles to square miles using the average width and depth of each stream order. Based on inventory data reported in state 305(b) reports and the distribution of streams by stream order (Keup, 1985), approximately 20% of all water bodies in the United States are rivers or streams and 10% of rivers and streams are classified as first order streams. First order streams are non branching and form the headwaters of riverine systems. Approximately 2% of all water bodies are first order streams, suggesting that $10.8 to $13.7 million of the total annual benefits from erosion and sediment controls may reflect a desire to protect small streams (2% × $540.5 million and 2% × $686.0 million, respectively).

6.3.5 Summary of Benefits

A summary of the potential benefits from implementing the Phase II municipal measures and erosion and sediment controls for construction sites is presented in Exhibit 6–20. Total benefits from municipal measures and construction site controls are expected to be $671.5 million to $1.1 billion per year (assuming 80% effectiveness of municipal programs), including benefits of approximately $10.8 to $13.7 million per year associated with small stream improvements. The largest portion of benefits are associated with erosion and sediment controls for construction sites.

As shown in the exhibit, some categories of benefits are not included in the WTP estimates from the research used. In particular, values for improving marine water quality (those related to commercial fishing and shell fishing and recreation, e.g. fishing) are not included in the potential benefits of the municipal minimum measures (excluding soil erosion construction sites controls).

Exhibit 6–20. Potential Annual Benefits of the Phase II Storm Water Rule (Millions of 1998 dollars)

Benefit Category	Annual WTP
Municipal Minimum Measures[1]	
Fresh Water Use and Passive Use[2]	\$121.9 – \$378.2
Marine Recreational Swimming	\$2.1
Human Health (Marine Waters)	\$7.0 – \$29.9
Other Marine Use and Passive Use	+
Erosion and Sediment Controls for Construction Sites	
Fresh Water and Marine Use and Passive Use[3]	\$540.5 – \$686.0
Total Phase II Program	
Total Use and Passive Use (Fresh Water and Marine)	>\$671.5 – >\$1,096.2

+ = positive benefits expected but not monetized
[1]Based on 80% effectiveness of municipal programs.
[2]Potential annual benefits of improving fresh water impairment (Exhibit 6–9) plus potential annual benefits of avoiding future fresh water impairment (Exhibit 6–13).
[3]Based on research by Paterson et al. (1993). Although the survey's description of the benefits of reducing soil erosion from construction sites included reduced dredging, avoided flooding, and water storage capacity benefits, these benefit categories may not be fully incorporated in the WTP values. Small streams may account for over 2% of total benefits.

6.3.6 Sensitivity Analysis

As with the cost analysis, the analysis of benefits is subject to uncertainty. EPA conducted a sensitivity analysis to evaluate the impact of key assumptions on the final benefit estimates.

EPA, in its efforts to establish a baseline for water quality impairment attributable to Phase II sources, may have overestimated the extent to which the 305(b) impairment data characterizes unassessed waters. Since 305(b) data is gathered and reported by individual states, the method for deciding which waters to assess will vary from state to state. If some states choose to monitor only those waters that are likely to be impaired instead of a random sample of waters, then the reported percentage of impaired waters will not be characteristic of the unassessed waters. To determine the sensitivity of benefit estimates to the assumption that waters represented by the 305(b) data characterizes all waters, EPA estimated benefits assuming that only 50% of the unassessed waters are similarly impaired. As Exhibit 6–21 shows, this assumption reduces overall benefits by 8% to 12%.

Exhibit 6–21. Results of Sensitivity Analysis

Assumption[1]	Estimated Total National Benefits (1998 dollars)
Original estimates	\$671.5–\$1,096.2
Impairment for 305(b) assessed waters applied to 50% of unassessed waters	\$619.2–\$964.5
Percentage change from original estimates	–8% to –12%

[1] EPA expects that the municipal program will achieve at least an 80% effectiveness.

6.4 Limitations and Uncertainties Associated with the Benefits Analyses

EPA's benefit analysis used two different approaches to estimate potential benefits of the Phase II rule. The first approach used the NWPCAM to simulate the effect of the Phase II municipal minimum measures and soil erosion control provisions on water quality at the local level. Benefits, including benefits accruing to local and nonlocal populations, were estimated to be \$1.6 billion per year based on a benefits transfer of WTP values from Carson and Mitchell (1993). The second approach estimated benefits for the municipal minimum measures and the soil erosion control provisions separately. The municipal minimum measures benefit analysis was primarily based on national water quality assessment data in the 305(b) report and Carson and Mitchell's (1993) WTP values for changes in national fresh water quality, although some marine benefits were also estimated. The soil erosion control benefit analysis was based on construction start activity and a WTP value for a similar program in North Carolina. Total benefits for the second approach are estimated to range from \$671.5 million to \$1,096.2 million per year.

Key limitations and uncertainties associated with the above estimates are summarized by analytical approach in Exhibit 6–22. Among the most important of these limitations is the inability to monetize some categories of benefits, which may underestimate potential benefits. There is also uncertainty associated with the applicability of the WTP values used to estimate benefits of the rule, and with many details of the modeling approach. Some assumptions made to address uncertainty may tend over estimate benefits and others may tend to under estimate benefits. The net effect is unknown.

Exhibit 6–22. Key Limitations and Uncertainties in the Benefits Analysis

Factor	Impact on Benefits Estimates	Comments
National Water Pollution Control Assessment Model Benefits Analysis		
The estimates of potential benefits do not include benefits from improvements to marine waters.	–	Uses of marine waters (e.g., commercial fishing and shellfishing, recreational fishing, and swimming) are highly valued. The model does not include marine water, nor do the WTP values reflect household benefits associated with improved marine water quality.
The WTP estimates were assigned to "local" waters on the basis of changes to local water quality rather than statewide water quality.	+	Survey respondents assigned two thirds of their total valuation for water quality improvements to improvements in in-state waters. By assigning this share to improvements in local waters, the analysis may have overstated WTP for these improvements.
The small stream analysis may have overstated improvements to small streams.	+	Because small streams were modeled only as conduits from construction sites to RF1 waters, both the baseline level of pollution and the extent of improvement due to Phase II controls may have been overstated.
The estimated number of Phase II construction sites used in the model is 8% higher than the number used in the rest of the economic analysis.	+	This may slightly overstate the benefit estimate relative to the cost estimate.
National Water Quality Assessment Benefits Analysis		
The estimates of potential benefits from the municipal minimum measures do not include some categories of potential benefits from improvements to marine waters.	–	Uses of marine waters (e.g., commercial fishing and shellfishing, and recreational fishing) are highly valued. Individuals also likely hold passive use values for marine waters. However, the extent to which marine waters will be improved by the Phase II rule is unknown.
The estimates of potential benefits from erosion and sediment controls for construction sites may not fully capture the value of the flood control, water storage, and reduced dredging benefits.	–	Paterson et al. (1993) suggest that existence value motivated survey respondents' WTP. Thus, their results may not fully capture the total program value.
The WTP values for the soil erosion control provision may overstate household WTP.	+	Paterson et al. (1993) had a 44% response rate to their mail survey; those not responding may have been less concerned about construction site run-off than those who did respond.
Carson and Mitchell's survey mentioned limited examples of passive use benefits for fresh waters, therefore it is not clear whether their results fully reflect these values.	+/–	EPA did, however, adjust for changes in attitudes towards spending for pollution control.
Estimates of the potential benefits from the	+/–	Municipal programs may be more or less

Paterson et al.'s survey was conducted prior to recommendations developed by the NOAA Panel on Contingent Valuation.	+/–	Paterson et al. (1993) followed methods, recommendations, and technical advice as published and provided by experts in the fields of water resource economics and nonmarket valuation.
Survey respondents in Paterson et al.'s study were not informed of the full costs of the state program.	+/–	Additional information regarding total program costs may have influenced WTP.
Nationally, WTP for erosion and sediment controls may differ from that of North Carolina households. WTP of nonurban households may also differ from that of urban households.	+/–	EPA examined income data (a factor likely influencing WTP) and found that the median incomes for the urban areas surveyed by Paterson et al. are representative of the range of incomes across NC counties. EPA also found that the median income of NC ranks 31 among all states and, therefore, concluded that no adjustment for income differences was necessary.
Overall Impact on Benefits Estimates for either analysis	+/–	There is not sufficient information to assess the direction of potential bias in the analysis of benefits.

– = understates benefits

+/– = unclear impact on benefits

6.5 Conclusion

The two approaches to estimating the potential benefits of the rule generate a wide range of benefits, although both approaches show that the benefits are likely to exceed costs. The NWPCAM approach obtains a higher overall benefit estimate. In part, this is because the river reach modeling approach generates a higher estimate of water quality improvements because impairment is based on water quality parameters rather than designated use. The water quality improvements that could be obtained using the national assessment data from the 305(b) report are constrained by designated use (e.g., improving water quality to a swimmable level will not generate incremental benefits if the designated used is fishing). The WTP values are based on improving national water quality regardless of designated use, however, and the NWPCAM approach is not affected by this constraint. The NWPCAM valuation approach, however, tends to increase the estimate of benefits associated with any particular change in water quality. Consequently, part of the difference between the estimates may be caused by the benefits transfer method used.