
CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This report assesses compensable values of recreational fishing service flow losses to the public (referred to herein as recreational fishing damages) as a result of releases of polychlorinated biphenyls (PCBs) into the waters of Green Bay. This report was prepared as part of the Lower Fox River/Green Bay Natural Resource Damage Assessment (NRDA) in accordance with the regulations at 43 CFR §11.81-11.84, the “Assessment Plan: Lower Fox River/Green Bay NRDA” noticed at 61 FR 43,558 (August 12, 1996), and the “Lower Fox River/Green Bay NRDA: Initial Restoration and Compensation Determination Plan” (IRCDP) noticed at 63 FR 50,254 (September 21, 1998). As explained in Chapter 5 of the IRCDP, this report uses existing literature and data, as well as data from a new survey of recreational anglers, to identify and quantify impacts of the PCB contamination on recreational fishing through time.

This report computes total recreational fishing damages, including damages both for losses that have already been incurred and for losses that are projected to continue until the FCAs are lifted. The calculation of damages for losses that have already occurred will be incorporated by the U.S. Fish and Wildlife Service (Service) into its determination of the compensable values portion of the NRDA. The estimate of damages for projected future losses is based on remedial scenarios proposed in the draft remedial investigation/feasibility study (WDNR, 1999), and will be revised and incorporated into the Service’s compensable values determination after the U.S. Environmental Protection Agency (U.S. EPA) has issued a record of decision and the Trustees have selected a preferred restoration alternative.

Background

PCBs are hazardous substances that were released into the Lower Fox River of Wisconsin by local paper company facilities as part of the manufacturing, deinking, and repulping of carbonless copy paper that contained PCBs (Sullivan et al., 1983; WDNR, 1998a; Stratus Consulting, 1999b), primarily between the late 1950s and mid-1970s.¹ Through time, PCBs have been and continue to be redistributed into the sediments and natural resources of the Lower Fox River and the Bay of Green Bay. Through the food chain process, PCBs bioaccumulate in fish and wildlife. As a result of elevated PCB concentrations in fish, in 1976 the Wisconsin Department of Health

1. PCBs are a hazardous substance under 40 CFR § 301.4 pursuant to Section 102(a) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Section 311 of the Federal Water Pollution Control Act.

and Human Services first issued fish consumption advisories (FCAs) for sport-caught fish in the Wisconsin waters of Green Bay, and in 1977 Michigan first issued FCAs for the Michigan waters of Green Bay (Stratus Consulting, 1999a).

These FCAs for the waters of Green Bay continue today, although the specifics of the FCAs have varied through time and vary by location, fish species, and for some species by fish size (see Chapter 2 for an additional discussion). In 1999, sport-caught fish throughout the waters of Green Bay were subject to FCAs. Even with significant removal of PCB contaminated sediment in the Lower Fox River, FCAs are expected to continue for decades; and with no additional sediment removal, the FCAs may continue for 100 years or more (Velleux and Endicott, 1994; WDNR, 1997b). PCBs may also cause injury to fish populations, thereby reducing recreational fish catch (61 FR 43558; ThermoRetec Consulting, 1999b), but these injuries have not been quantified.

There is abundant literature demonstrating that the existence of FCAs cause recreational fishing service flow losses to anglers in that anglers change where and how often they fish, change what they fish for and what they keep, change how they prepare and cook the fish they catch, and experience reduced enjoyment of the fishing experience (see Chapter 2). The literature also demonstrates that the value of these service flow losses (damages) to anglers can be substantial. The potential significance of these losses in the waters of Green Bay is amplified because there are hundreds of thousands of recreational fishing days each year at the site (Chapter 2).

While there is ample literature to confirm that FCAs and any reduction in fish populations diminish the level of recreational fishing services provided by the resource, the literature does not provide site-specific and case-specific information that is sufficient for this assessment. Therefore, we conducted a new recreational fishing study specific to the site and the case.

Report Organization

The remainder of this introduction provides an overview of the recreational fishing study and summarizes key results from the report. Chapter 2 provides background data on the assessment area and FCAs at the assessment area, and illustrates literature that confirms that anglers respond to, and value, the impacts of FCAs and value changes in catch rates. Chapter 3 summarizes the data collection methods, including sampling methods and the survey instruments; and Chapter 4 provides a profile of the surveyed anglers. Chapter 5 provides the choice questions used to value changes in FCAs, Chapter 6 presents the economic model and estimation to value changes in FCAs, and Chapter 7 summarizes the model parameter estimates. Chapter 8 provides lower-bound 1998 damage estimates, and Chapter 9 includes sensitivity analyses to alternative model specifications. Chapter 10 provides total damage estimates and conclusions. The appendices provide detailed models and results, a copy of the survey materials, and supporting data tables.

1.2 SCOPE OF THE RECREATIONAL FISHING ASSESSMENT

Assessment Area

The assessment area for this determination of recreational fishing damages is the waters of Green Bay, which are located in northeastern Wisconsin and in the Upper Peninsula of Michigan (Figure 1-1). The waters of Green Bay include the Bay of Green Bay, all bays within Green Bay (e.g., Little and Big Bay de Noc, Sturgeon Bay), and all rivers feeding into Green Bay up to the first dam or obstruction, including the Lower Fox River from the Dam at De Pere to the Bay of Green Bay. The entire waters of Green Bay are included because PCBs, and fish and wildlife that uptake PCBs, are mobile within the waters of Green Bay and because there are PCB fish consumption advisories for the entirety of Green Bay, including its tributaries. Thus, the PCBs released into the Lower Fox River result in service losses, and therefore damages, throughout the waters of Green Bay. While PCBs from the Lower Fox River are transported to the waters, sediments, and natural resources of Lake Michigan, this assessment does not address any recreational fishing service flow losses from the release of PCBs into Lake Michigan outside of the waters of Green Bay.

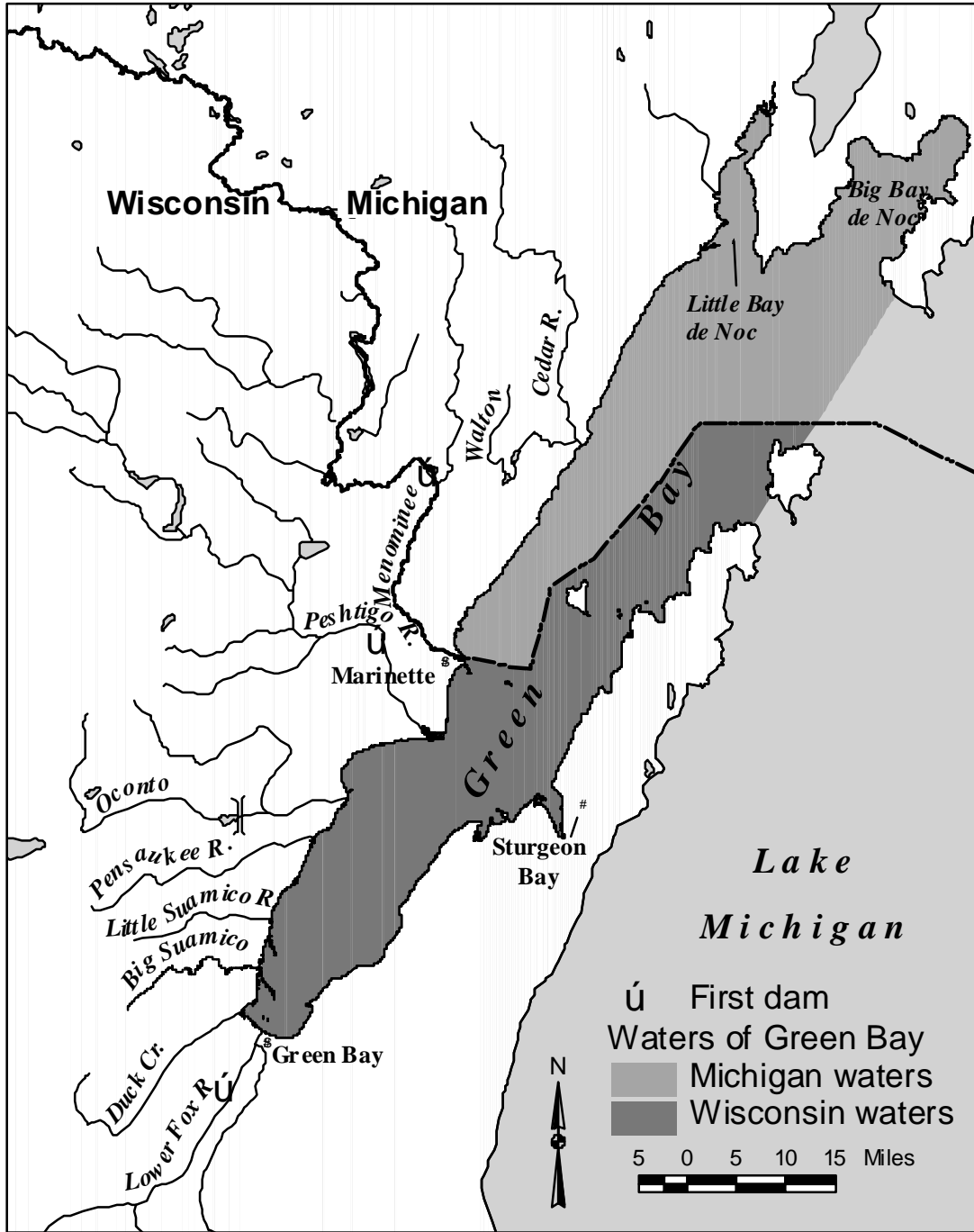
The waters of Green Bay are split into the Wisconsin waters of Green Bay and the Michigan waters of Green Bay (Figure 1-1). The dividing line on the western shore is the state line at the Menominee River, and on the eastern shore it is just above Rock Island.

Throughout this report several terms are used interchangeably to refer to activities in and natural resources and waters of Green Bay (e.g., waters of Green Bay, Green Bay fishery, Green Bay fishing). In the general discussions in Chapters 1, 2, and 10, these terms refer to all of the waters of Green Bay, unless specifically identified otherwise (e.g., Lower Fox River, the Bay of Green Bay, Michigan waters of Green Bay). Chapters 3 through 7, 9, and the appendices focus on assessing damages in the Wisconsin waters of Green Bay and, for presentation ease, refer to these waters without always identifying Wisconsin.

Types and Measures of Service Flow Losses

This report estimates the value of recreational service flow losses (e.g., damages) resulting from the imposition of FCAs in response to PCB contamination in the assessment area. While fish populations may be injured by PCBs, resulting in recreational fishing flow losses through reduced catch rates, these injuries have not been quantified and are not included in the valuation of recreational service losses. However, the damage assessment methods and results are designed to support the valuation of recreational fishing service flow losses from reduced catch rates if such injuries are quantified at a later date, and to compute the value of service flow benefits from increased catch rates if increasing catch rates is part of a restoration package.

Figure 1-1
Wisconsin and Michigan Waters of Green Bay



Recreational fishing service flow losses from FCAs can be classified into the following four categories:

1. ***Reduced enjoyment from current Green Bay fishing days.*** Anglers active at the assessment site may experience reduced enjoyment from their days at the site because of concerns about health safety and displeasure with catching contaminated fish. These concerns can result in changes in fishing locations within the waters of Green Bay, changes in target species type and size, and changes in behavior regarding keeping, preparing, and consuming fish.
2. ***Losses by Green Bay anglers from fishing at substitute sites.*** Because of FCAs, anglers who fish the waters of Green Bay may substitute some of their fishing days from the waters of Green Bay to other fishing sites that, in the absence of FCAs in the waters of Green Bay, would be less preferred sites.
3. ***Losses by Green Bay anglers who take fewer total fishing days.*** Because of FCAs, anglers who fish the waters of Green Bay may take fewer total fishing days than they would otherwise prefer. For example, an angler may still take the same number of days to other sites, but take fewer days to the waters of Green Bay to avoid the FCAs.
4. ***Losses by other anglers and nonanglers.*** Because of FCAs, some anglers may completely forego fishing the waters of Green Bay, in one year or many years. Other individuals who would fish the waters of Green Bay if it did not have FCAs may completely forego fishing.

The approach employed in this report measures the value of service losses within categories 1 and 2, but not for categories 3 and 4. As a result, the calculations understate recreational fishing damages. The magnitude of this omission is unknown, although results presented in Chapter 3 indicate that losses in category 4 are not inconsequential, as the total potential number of anglers who would be active in Green Bay fishing in the absence of FCAs may be as much as 30% larger than occurs with the current FCAs.

Consistent with the Department of Interior regulations for conducting NRDA's, this report measures the value of service flow losses through measuring recreational anglers' willingness to pay (WTP) for changes in FCA levels [43 CFR §11.83 (c)].

Time Period

Consistent with the CERCLA regulations, compensable damages are computed for interim services lost to the public resulting from PCB contamination from 1981, beginning with the 1981 fishing season after the enactment of the Superfund Amendment of Reauthorization Act (SARA) in late 1980, until the service flows are restored to baseline [43 CFR § 11.80 (b)]. For purposes of this determination, which concerns the value of losses to recreational anglers, the service flows

are considered to be returned to baseline when there are no longer FCAs. We compute interim damages to include (1) damages for past service flow losses starting at January 1, 1981 through 1999, and (2) damages for future service flow losses beginning in 2000 until FCAs are removed. Future damages are computed under alternative remediation and restoration scenarios. Past damages are computed both from 1981 and 1976, when FCAs were first issued in response to PCB contamination.

1.3 THE DAMAGE ASSESSMENT APPROACH

This assessment is designed to measure damages accurately and cost-effectively using the approach summarized below.

A Mix of Primary Data Collection and Benefits Transfer

The assessment focuses on primary data collection and analysis to estimate open-water recreational fishing damages for a target population of anglers who purchase Wisconsin fishing licenses in eight Wisconsin counties near Green Bay and who are active in Green Bay fishing. Data collection focuses on the Wisconsin waters of Green Bay because PCB loadings and the resultant FCAs are more severe for the Wisconsin waters of Green Bay than for the Michigan waters of Green Bay, and because the recreational fishing activity in the Wisconsin waters of Green Bay is much larger than in the Michigan waters of Green Bay (Chapter 2). Therefore, recreational fishing losses are expected to be greater in the Wisconsin waters of Green Bay than in the Michigan waters of Green Bay. We focus on a target population of anglers who purchase licenses in eight counties near the Bay of Green Bay because these anglers account for the vast majority of anglers and fishing days in the Wisconsin waters of Green Bay (see below and Chapter 2). Data collection focuses on open-water fishing (e.g., non-ice fishing) because it accounts for almost 90% of all fishing on the waters of Green Bay.

Based on the damages per open-water fishing day in the Wisconsin waters of Green Bay, we employ benefits transfer methods [43 CFR § 11.83 (c)(2)(vi)] to compute damages for fishing days in the Michigan waters of Green Bay, and for ice-fishing days in the Wisconsin waters of Green Bay. This provides a high-quality benefits transfer because it applies to the same water body, and to the same or similar fish species and fishing activities.

Focus on Green Bay Fishing by Green Bay Anglers

The primary data collection is from a sample of the target population of anglers who currently fish the Wisconsin waters of Green Bay and focuses on the valuation of changes in fishing conditions in the Wisconsin waters of Green Bay. Through this approach, we estimate the extent and value of service flow losses with a large sample of anglers who are specifically knowledgeable of the resources and injuries of interest, and the survey is designed so that the valuation questions are

relevant to respondents. Respondent familiarity and relevant questions specific to the site and conditions of interest, combined with the real world nature of the questions, enhances response accuracy and the applicability of the results to the valuation of service flow losses and the determination of compensable values.

Focus on FCAs, Catch Rates, and Costs

The survey focuses on FCAs and catch rates for four species that account for about 90% of the Green Bay fishing activity, and on fishing costs. Interviews with anglers indicate they are most concerned with changes in these site characteristics, and much less concerned with changes in most other site characteristics such as improving recreational facilities. By focusing on the key target species and key site characteristics, site conditions can be efficiently presented, resulting in a cost-effective assessment that has limited cognitive burden on survey respondents.

Combining Revealed Preference and Stated Preference Data

The assessment is designed to collect and combine data on actual fishing activities under current conditions (e.g., days fishing in the Wisconsin waters of Green Bay and elsewhere), referred to as revealed preference data, with stated preference data on how anglers would be willing to trade-off changes in fishing characteristics, including catch rates, FCAs, and costs, and on how many days anglers would fish Green Bay under alternative conditions for the waters of Green Bay. This combination of data allows the benefits of both types of data to be realized.

Stated preference data are collected using choice questions, which are related to conjoint analysis. The revealed preference and stated preference data, along with site-specific and individual-specific data, are combined in random utility models of recreation demand to estimate damages. These economic methods are recognized in the NRDA regulations at 43 CFR § 11.83 and at 15 CFR Part 990 Preamble Appendix G, and are well established in the literature (see Chapter 6).

1.4 PRIMARY DATA COLLECTION

A primary assessment of damages is performed through new survey research to measure the value of recreational fishing service flow losses for the Wisconsin waters of Green Bay. A three-step procedure was used to collect data from a random sample of individuals in the target population of anglers who purchased licenses in eight counties near Green Bay and who are active in fishing the Wisconsin waters of Green Bay. First, a random sample of anglers was drawn from lists of 1997 license holders in the county courthouses in the eight counties near the Bay of Green Bay: Brown, Door, Kewaunee, Manitowoc, Marinette, Oconto, Outagamie, and Winnebago. This population includes residents of these counties, as well as residents of other Wisconsin counties, and nonresidents who purchased their Wisconsin fishing licenses in these eight counties.

Second, a telephone survey was completed in late 1998 and early 1999. From the courthouse sample, the telephone numbers were obtained and a telephone contact was attempted with 4,596 anglers; 3,190 anglers completed the telephone survey for a 69% response rate. The telephone survey collects data from all anglers on the number of total days fished in 1998, how many days were in the waters of Green Bay, and on attitudes about actions to improve fishing. Anglers who had participated in open-water fishing in the Wisconsin waters of Green Bay in 1998 were recruited for a followup mail survey: 92% of the recruited open-water Green Bay anglers agreed to participate. Data from the telephone survey allow comparisons of anglers who were and were not active in fishing the Wisconsin waters of Green Bay, as well as a comparison of those anglers who completed the mail survey versus anglers who did not complete the mail survey.

Third, a mail survey was used to collect data for estimating damages associated with PCB contamination and the resultant FCAs. The core of this mail survey is a series of eight choice questions used to assess damages for reductions in enjoyment for current open-water fishing days in the Wisconsin waters of Green Bay (Figure 1-2). In each question, respondents are provided two alternatives (A and B), each with different levels of fishing characteristics for the waters of Green Bay, and asked to choose whether Alternative A or Alternative B is preferred. Fishing characteristics include catch rates and FCA levels for yellow perch, trout and salmon, walleye, and smallmouth bass; and an angler's share of a daily fee. By varying the levels of the characteristics (e.g., catch rates, FCA levels, and the amount of fees) across alternatives and questions, the survey provides input data for computing the amount of money the anglers would be willing to pay (or the increases in fish catch rates the anglers would be willing to give up) to reduce or eliminate FCAs, as well as the amount of money the anglers would be willing to pay for increased catch rates (see Chapter 6 for a detailed discussion).

As part of each choice question, a followup question asks how often the respondent would fish the Wisconsin waters of Green Bay under the alternative they select. This followup question allows for the estimation of damages associated with substituting days from the waters of Green Bay to other fishing sites because of FCAs.

The mail survey also updates the angler's fishing activity profile for 1998 by asking how many days fishing occurred since the telephone survey; collects attitude, opinion, and socioeconomic data; and collects other data to evaluate the choice question responses. Of the 820 anglers mailed the survey, 647 (79%) completed and returned the survey.

Based on an evaluation of the sampling plan and available data, adjustments to the sample estimate of average days fished per angler are made to obtain a target population estimate accounting for potential recall, sampling, and nonresponse (Section 3.5.4) biases. Further, the sample can be expected to account for on the order of 90% of recreational fishing days on the Wisconsin waters of Green Bay and to be reasonably representative of the mix of resident and nonresident anglers (Section 3.5.5).

Figure 1-2

Example Choice Question

If you were going to fish the waters of Green Bay, would you prefer to fish the waters of Green Bay under Alternative A or Alternative B? Check one box in the last row

	Alternative A ▼	Alternative B ▼
Yellow Perch		
Average catch rate for a typical angler.....	40 minutes per perch	30 minutes per perch
Fish consumption advisory.....	No more than one meal per week	No more than one meal per week
Trout and Salmon		
Average catch rate for a typical angler.....	2 hours per trout/salmon	2 hours per trout/salmon
Fish consumption advisory.....	Do not eat	No more than one meal per month
Walleye		
Average catch rate for a typical angler.....	8 hours per walleye	4 hours per walleye
Fish consumption advisory.....	Do not eat	No more than one meal per month
Smallmouth bass		
Average catch rate for a typical angler.....	2 hours per bass	2 hours per bass
Fish consumption advisory.....	No more than one meal per month	Unlimited consumption
Your share of the daily launch fee.....	Free	\$3
Check the box for the alternative you prefer.....	<input type="checkbox"/>	<input type="checkbox"/>

1.5 SUMMARY OF ANALYSIS AND RESULTS

Awareness and Impacts

Eighty-five percent of the anglers active in the Wisconsin waters of Green Bay had heard or have read about the FCAs. Generally, the anglers' perceptions of the specific advisory levels (i.e., how often one could eat fish of each species) are generally consistent with the published FCAs, although perceptions tend to understate the actual FCA severity for smallmouth bass.

The majority of the anglers rate the advisories as somewhat to very bothersome to their Green Bay fishing. Seventy-seven percent of the anglers identify behavioral responses to the FCAs in the Wisconsin waters of Green Bay, with 30% of active anglers reporting they spend fewer days fishing the Wisconsin waters of Green Bay because of the FCAs. Over half the anglers have changed the species or size of fish they keep to eat, and over half have changed the way the fish they keep are cleaned, prepared, or cooked.

Per Day and Per Angler Damages

Applying random utility models to the primary survey data, an estimate of damages per fishing day per angler is developed for the population of anglers who purchased a fishing license in the eight targeted counties and who are active in open-water fishing in the Wisconsin waters of Green Bay. Two measures are computed and reported in Table 1-1 for the elimination of existing FCAs.

1. The value of eliminating the current Green Bay FCAs per fishing day spent in the Wisconsin waters of Green Bay in 1998, which measures the value of reduced enjoyment of existing fishing days in these waters. Our primary estimate for this measure is \$9.75 per Green Bay open-water fishing day.
2. The value of eliminating the current Green Bay FCAs per fishing day spent at all fishing sites in 1998. This measure includes the value of reduced enjoyment of existing fishing days in the waters of Green Bay (as above) plus the value of services lost when anglers are compelled to substitute to fishing days from Green Bay to other sites (sites that in the absence of FCAs in Green Bay would be less preferred) because of the FCAs at Green Bay. Our primary estimate for this measure is \$4.17 per open-water fishing day, and is applied to all open-water fishing days, not just those to Green Bay.

In Table 1-1, the estimated per fishing day values are multiplied by the estimated average number of fishing days per angler in the target population to compare the two value measures on a per angler basis. As shown in Table 1-1, the values for the more comprehensive second damage measure are about 7% larger than for the first measure. In short, the largest values from the elimination of Green Bay FCAs arise from reduced enjoyment of current trips, with modest increases arising from substituting visits to other sites.

<p style="text-align: center;">Table 1-1 1998 per Day and per Angler Damages for Open-Water Fishing in the Wisconsin Waters of Green Bay (for anglers active in open-water fishing on the Wisconsin waters of Green Bay)</p>			
Measure	Damages per Fishing Day	Applicable Days (average/angler)	Average Annual Damages per Angler
1. <i>WTP^G</i>	\$9.75 per Green Bay fishing day	5.25 days in the Wisconsin waters of Green Bay	\$51.18
2. <i>WTP^F</i>	\$4.17 per fishing day	13.19 total fishing days	\$55.00

The per day estimates are computed with our primary economic model. Sensitivity analyses for model assumptions have found the per fishing day value estimate to be very robust (see Chapter 9 and Appendix D). Further, the values per day in the Wisconsin waters of Green Bay do not differ greatly by location of origin of the angler. Thus, modest variations in the composition of the anglers will have little impact on per fishing day value estimates. This stability validates the benefits transfer portion of the assessment.

Damages per day are also computed per fishing day for changes from less stringent FCAs to no FCAs. These values (reported in Chapter 8) are used to evaluate damages through time and to conduct the benefits transfer to ice fishing in Wisconsin waters of Green Bay and to all fishing in Michigan waters of Green Bay.

Total Recreational Fishing Damages

Annual recreational fishing damages in 1998 and the present value of all interim recreational fishing losses from the beginning of 1981 until restoration is complete are summarized in Table 1-2. The values reported in Table 1-2 for Wisconsin open-water fishing are based on damage measure 2 in Table 1-1, and the values reported for Wisconsin ice fishing and Michigan fishing are based on the less comprehensive damage measure 1 in Table 1-1 because we do not have estimates of total fishing days at all sites (as opposed to just at Green Bay sites) for anglers active in these fishing activities.

To compute damages in each past and future year, estimated fishing days for the year are multiplied by an estimate of damages per fishing day for the FCAs that existed in past years or for future years. For example, in 1998, the estimated 641,060 open-water fishing days (to all fishing sites) is multiplied by \$4.17 per open-water fishing day for a total open-water fishing damage

Table 1-2
Total Values for Recreational Fishing Service Losses for the Waters of Green Bay
Resulting from Fish Consumption Advisories for PCBs
 (\$ millions, \$1998, present value to 2000)^{a,b}

Damage Category	(A) Wisconsin Waters of Green Bay		(B) Michigan Waters of Green Bay	(C) All Waters of Green Bay (A + B)
	Open-Water Fishing	Open-Water plus Ice	All Fishing	All Fishing
	Primary Study	Primary + Transfer	Benefits Transfer	Primary + Transfer
1998 Value of 1998 Losses	\$2.673	\$3.127	\$0.438	\$3.566
1. Present Value of Past Losses:				
a. 1981-1999	\$37.8	\$44.3	\$20.2	\$64.5
b. 1976-1980	\$5.4	\$6.3	\$5.8	\$12.1
2. Present Value of Future Losses ^c				
a. Intensive Remediation ^d	\$30.7	\$36.2	\$5.3	\$41.5
b. Intermediate Remediation ^e	\$43.2	\$51.0	\$7.5	\$58.5
c. No Additional Remediation ^f	\$62.3	\$72.9	\$10.2	\$83.2
3. Present Value of Total Damages from 1981 to Baseline (1a+2)				
a. Intensive Remediation	\$68.5	\$80.5	\$25.5	\$106.0
b. Intermediate Remediation	\$81.0	\$95.3	\$27.7	\$123.0
c. No Additional Remediation	\$100.2	\$117.3	\$30.4	\$147.7

a. Rounded to the nearest \$1,000 for 1998 annual values and to the nearest \$100,000 for present value estimates. Totals may not equal sum of elements due to rounding.

b. Values for Wisconsin open-water fishing include reduced quality of current days plus substitution of days to other sites. Values for Wisconsin ice fishing and Michigan fishing include only reduced quality of current days. See text for additional discussion.

c. Present values computed adjusting for changes in FCAs through time, assuming an average fishing activity at 1998 levels, and a 3% discount rate.

d. 20 years of damages = 10 years sediment removal plus 10 years of declining FCAs.

e. 40 years of damages = 10 years sediment removal plus 30 years of declining FCAs.

f. FCAs decline to zero over 100 years due to natural recovery.

estimate of \$2.673 million (rounded to the closest \$1,000). For Wisconsin ice fishing in 1998, we employ the benefits transfer and select the 1998 open-water fishing value of \$9.75 (measure 1 in Table 1-1) times an estimated 46,541 ice-fishing days in the Wisconsin waters of Green Bay for a total of \$454,000. For ice fishing we use the same \$9.75 per day damage as for open-water fishing days in Green Bay because the ice fishing is in the same waters, for the same species, and the ice anglers predominately are also open-water anglers. The combination of open-water fishing and ice fishing is the total estimate of damages from 1998 recreational fishing service losses in the Wisconsin waters of Green Bay of \$3,127,000.

We also apply the benefits transfer values for fishing in the Michigan waters of Green Bay. A value of \$2.92 per fishing day in the Michigan waters of Green Bay is selected, reflecting the lower FCA levels in these waters for 1998 as compared to the Wisconsin waters of Green Bay. The per day damage is multiplied by 150,500 fishing days for a Michigan total of \$439,000. The 1998 total for all waters of Green Bay is \$3,566,000.

The present value of all interim damages from 1981 until restoration is complete is also provided in Table 1-2 (rounded to the closest \$100,000). Damages for past service flow losses are computed from 1981 and are continued through 1999. Fishing activity through time is based on WDNR and MDNR estimates for the waters of Green Bay. Damages per Green Bay fishing day are scaled through time to reflect changes in FCAs through time. Generally, the damages per day from FCAs in Wisconsin are the same or less in the past because the FCA levels were the same or less (as a result, anglers may have experienced the same or less loss of enjoyment but experienced increased health risks in the past, which is not included in the damage estimates). In Michigan, however, the FCAs were more restrictive in some past years. Also note that fishing days in the past were often larger than in 1998. Total damages for past service flow losses are estimated to be about \$64.5 million, with about 69% of these damages in the Wisconsin waters of Green Bay.

FCAs were first issued in response to PCB contamination in the waters of Green Bay in 1976. Including damages for the period from 1976 to 1980 adds about \$6.3 million for all Wisconsin fishing, \$5.8 million for all Michigan fishing, and \$12.1 million in total, which increases the total past damages by about 19%.

Damages for future recreational fishing service flow losses are computed starting in 2000. The duration and levels of the FCAs depend on the level of remediation efforts to address PCB contaminated sediments, which have not been selected. Therefore, pending final selection of remediation efforts, we have identified three potential remediation scenarios to illustrate how the magnitude of damage estimates for projected future recreational service losses may vary with the selected remediation. The estimation of damages for future service losses will be revised and incorporated into the Service's compensable values determination after the U.S. EPA has issued a Record of Decision and the Trustees have selected a preferred restoration alternative.

The three remediation scenarios reflect the range of options considered in the draft Remedial Investigation/Feasibility Study (RI/FS) (ThermoRetec Consulting, 1999a,b), as well as the October 27, 1997 Fox River Global Meeting Goal Statement (FRGS-97) by the Fox River Global Meeting Participants (1997).

1. ***Intensive remediation.*** All FCAs are removed in 20 years. This is modeled as a 10-year PCB removal period, during which time the FCA-caused service losses and accompanying damages per fishing day are assumed to decline linearly at a natural recovery rate (see Scenario 3), followed by a 10-year accelerated recovery period during which time the FCA-caused service losses and accompanying damages per fishing day are assumed to decline linearly to zero. This scenario closely reflects the FRGS-97 goal, and is similar to the RI/FS scenario of PCB removal to a 250 µg/kg minimum concentration level throughout the Lower Fox River (however, the draft RI/FS suggests the potential for removal of FCAs in less than 10 years after the above removal is complete, which would reduce damages).
2. ***Intermediate remediation.*** All FCAs are removed in 40 years. This is modeled as a 10-year PCB removal period, during which time the FCA-caused service losses and accompanying damages per fishing day are assumed to decline linearly at a natural recovery rate (see Scenario 3), followed by a 30-year accelerated recovery period, during which time the FCA-caused service losses and accompanying damages per fishing days are assumed to decline linearly to zero. This scenario is similar to the RI/FS scenario of PCB removal to a 250 µg/kg average concentration level throughout the Lower Fox River.
3. ***No additional remediation (no action remedy).*** No significant additional PCB removal occurs and the elimination of FCAs occurs due to natural recovery. We model the natural recovery rate to be a linear decline in FCA-caused service losses and damages per fishing day to zero at the end of 100 years. This is a conservative assumption as the draft RI/FS suggests that with no additional remediation, the Wisconsin FCAs may continue with little change for 100 years or more. Using an assumption of no change for 100 years would increase past damages by over 40% and total damages by over 20%.

For all future years we assume that fishing effort remains constant at 1998 levels for all fishing considered, and those levels are based on estimates in this study, as described in Section 8.4. The assumption of current fishing activity levels into the future may or may not be a conservative assumption as fishing effort in the waters of Green Bay was at a decade lowest level in 1997 and 1998. Fishing effort may or may not remain depressed, most likely depending on the future catch rates, changes in FCAs and other water quality measures, and changes in the population of northeast Wisconsin. This assumption can be revisited and revised after the U.S. EPA selection of a Record of Decision and the Trustees have selected a preferred restoration alternative.

The damages per fishing day due to FCAs decline as identified in each scenario. These assumptions are the same for each category of damages considered (open-water and ice fishing in Wisconsin, and all fishing in Michigan). Again, after the U.S. EPA's selection of a Record of Decision and the Trustees' selection of a preferred restoration alternative, the time path of FCAs can be revisited and damages computed based on the projected time path of FCAs and the values for different FCA levels in Table 8-1.

Damages for future recreational fishing service losses range from \$41.5 million (under Scenario 1 with intensive remediation) to \$83.2 million (under Scenario 3 with no additional remediation). The Wisconsin share of the damages for future service losses is about 87%, reflecting the more significant fishing activity and more restrictive advisories in the Wisconsin waters of Green Bay.

Total damages for past and future service losses range from \$106 million under Scenario 1 (with intensive remediation) to \$148 million under Scenario 3 (with no additional remediation). The Wisconsin share is about 76% to 79%, depending on the remediation scenario, reflecting the greater number of fishing days and more severe FCAs in these waters.

A 3% discount rate is used to escalate past damages and to discount future damages to the year 2000. A 3% discount rate is consistent with the average real 3-month Treasury bill rates over the last 15 years (Bureau of Economic Analysis, 1998; Federal Reserve, 1998) and is consistent with U.S. DOI recommendations (U.S. DOI, 1995) for NRDA's under CFR §11.84(e).

The present value of past and future service flow losses varies with the discount rate. For example, increasing the discount rate to 6% increases the value of past service flow losses but decreases the value of future service flow losses. The value of the total of past and future service flow losses would increase by about 15% under Scenario 1, increase by about 7% under Scenario 2, and decrease by about 6% under Scenario 3. Decreasing the discount rate to 2% would decrease the value of past and future service flow losses in Scenario 1 by about 3%, increase the value in Scenario 2 by less than 1%, and increase the value in Scenario 3 by about 9%.

These damage estimates are conservative. The computations exclude damages to anglers and nonanglers who do not fish Green Bay at all because of the FCAs, damages from reducing total fishing days by Green Bay anglers, damages due to injuries to Oneida tribal waters, and damages that could result from potential fish population injuries. The computations are based on a conservative selection of per fishing day damage values and conservative estimates of ice-fishing activity. Chapter 10 provides a detailed presentation of the computation of damages through time and of key factors leading to conservative damage estimates.
