NRDA CASE STUDY: THE ARTHUR KILL OIL SPILL[1]

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ABSTRACT: *The natural resource damage assessment (NRDA) methods used to estimate the damages from the Arthur Kill oil spill employed a transfer methodology. The base-case estimate for use damages was $46,000 and for non-use damages was $525,000.*

On January 1, 1990, a rupture in an Exxon USA pipeline released 567,000 gallons of No. 2 fuel oil into the Arthur Kill, a waterway located between Staten Island, New York, and New Jersey. Although the Arthur Kill is an intensively industrialized corridor in the New York metropolitan area, it serves as an access waterway for local recreational boaters and fishermen and contains a variety of wetlands habitats.

The Clean Water Act (CWA) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) allow government agencies to claim damages for injuries to natural resources. The CWA authorizes certain government agencies to recover damages to natural resources resulting from oil spills. Similarly, CERCLA extends the liability of the parties responsible for releases of hazardous substances to "damages for injury to, destruction of, or loss of natural resources, including the reasonable costs of assessing such injury, destruction, or loss resulting from such release" (Section 107 [a][4][C]).[10]

Our damage assessment covers two main categories of potential damages: use—water-based recreation and near-water recreation—and non-use—people's value for the existence of wetlands and bird habitats apart from their intention to use or view them directly.

The estimates for the Arthur Kill study are based on a "transfer" methodology that values natural resource damages by using the monetary value for similar resource services from other studies. The first step of a transfer study is to obtain a technical assessment of the change in water quality due to the oil spill. The second step involves collecting basic socio-economic, recreation, and water quality information for the Arthur Kill area. The third step uses the information from the first two steps to develop a qualitative assessment of the damages, at which point any sites with negligible damages can be excluded from additional phases of the analysis.

The fourth step is where the actual transfer occurs. The goal of this step is to estimate per-household willingness to pay (WTP) to avoid losing access to resource services. Analysts can use the WTP estimate from a previous study of a similar site to predict the WTP for a return to baseline conditions at the Arthur Kill site. The specifics of how the transfer is accomplished depend on the available data. The final step in a transfer study provides the aggregate value of damages. Analysts estimate participation rates and the geographic extent of the relevant market and multiply the number of households who use the damaged resources by the per-household WTP estimate.

As may be apparent, this transfer methodology does have some important limitations, including the low availability of high-quality, relevant studies and the fact that original studies are not designed for transfer. As a result of this latter problem, analysts must make assumptions during the study, thereby introducing added subjectivity to the analysis. Transfer studies do have the advantage, however, of saving time and resources, which can be especially important in cases where relatively small damages do not justify a large and expensive study.

Background of the Arthur Kill oil spill

The Arthur Kill, a waterway approximately 15 miles long and 328 yards wide, opens into the Raritan Bay at the south end and the Kill van Kull and Newark Bay at the north end (Figure 1). It provides access to New York Harbor, Raritan Bay, Lower Bay, Jamaica Bay, Newark Bay, the Hudson and East Rivers, and the Atlantic Ocean from the New Jersey coast of Newark, Linden, and Elizabeth.

The Arthur Kill and Kill van Kull are both lined with a variety of industries, predominantly chemical manufacturing and oil refining. The New York City landfill, Fresh Kills, is directly adjacent to the Kill and is the largest landfill in the United States, towering about 500 feet above the Arthur Kill. As a result of the intense industrialization and the proximity of the New York City and the Linden, New Jersey, landfills, the area is vulnerable to industrial and municipal pollution. City reports indicate that the water quality in the Arthur Kill is the poorest in the New York Harbor area.[9]

The entire Kill is surrounded by salt marshes and salt and fresh water estuaries that serve as nurseries for more than 145 different species of fish and birds. These areas cover approximately 1,035 acres, including approximately 463.5 acres of freshwater wetlands and 571.4 acres of tidal wetlands in the Arthur Kill area.[2] The areas where potential effects from the oil spill may be found are along the Kill between Bridge Creek (north of Goethals Bridge) and the Isle of Meadows and cover approximately 127 acres.[2]

One of the key features of this wetlands network is the abundance of harbor herons. The harbor herons consist of wading birds—glossy ibises, great egrets, snowy egrets and cattle egrets, and herons. Ducks, geese, and a vast population of gulls also live in the area. The wetlands network supports the high marshes and mud flats, which serve as feeding sites for many of these birds. The abundance of grey birch trees makes ideal nesting sites for the wading birds while the gulls generally nest on beach areas and in marshes. The intensive industrial activity and location make this habitat inaccessible to humans, so it appeals to many bird species desiring isolation.[8] The harbor herons, though not an endangered or threatened species on the federal or state level, are a source of pride in the area. Their numbers have been on the rise in the past 10 years as they extend their colonies northward, and many people view the return of these birds as a positive indicator of the environmental health of the area.[1] People in the metropolitan area derive pleasure from these birds through bird watching from Staten Island and the New Jersey coast and studying their role in the ecosystem. Local

1. This paper reports on research funded by Exxon Company, USA. The results reflect the opinions of the authors and not necessarily those of Exxon.

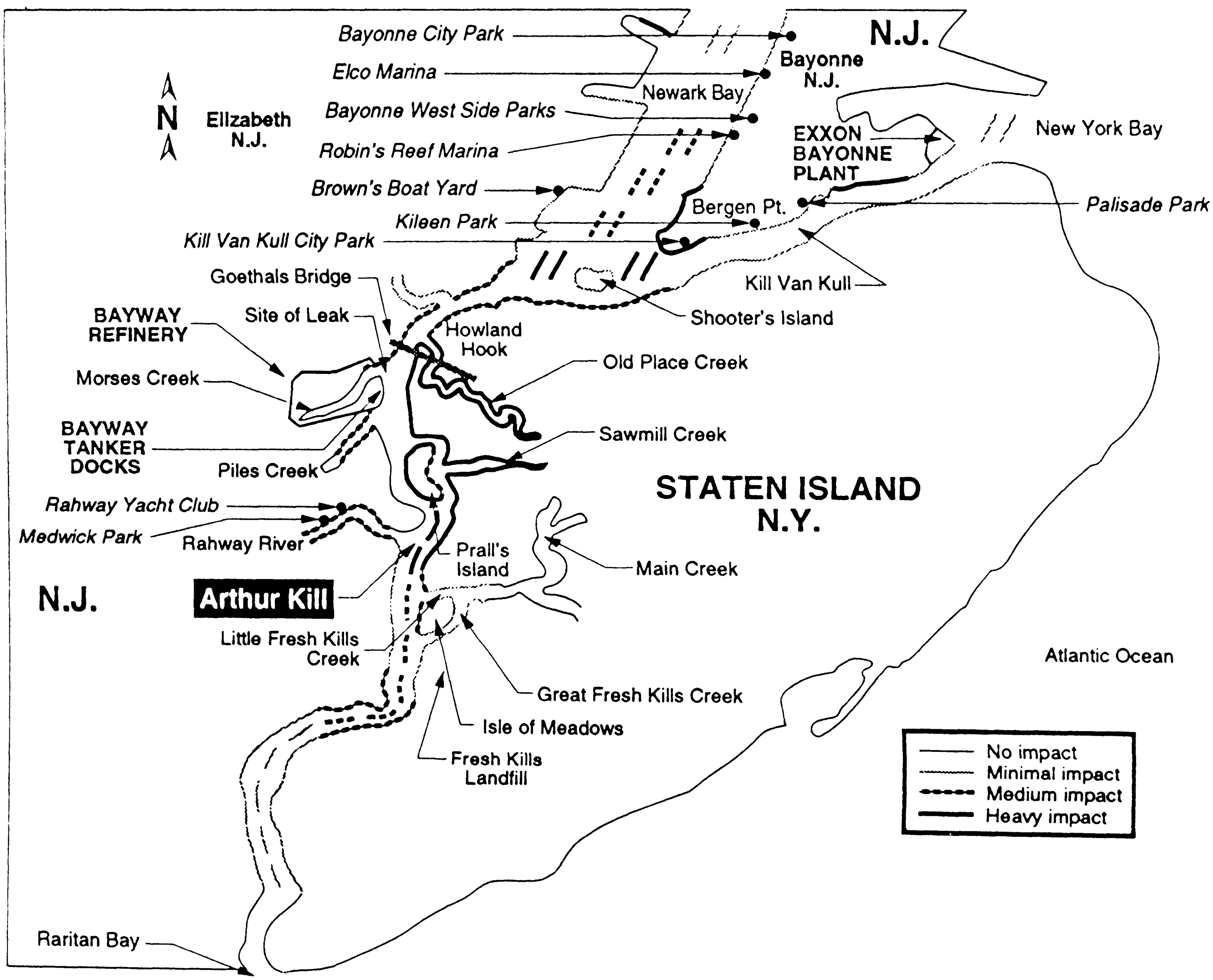

Figure 1. Affected regions of the Kill

chapters of the National Audubon Society, attesting to this interest, have set up rookery sites for the birds.

The oil spill occurred from a gash (5 feet by 0.5 inches) in the 12-inch pipeline that connects the Bayway Refinery at Linden, New Jersey, to the Bayonne Plant in Bayonne, New Jersey. The leak site is just south of the Goethals Bridge (see Figure 1). The spill occurred near the New Jersey coast, but tides and winds moved the oil to the three islands in the Kill and the Staten Island coastline.

One of the immediate concerns of the cleanup efforts that began on Tuesday, January 2, 1990 was the harbor birds in the area, particularly those on Prall's Island, which was closest to the spill site.[4] The Exxon cleanup crews used approximately 60,000 feet of boom and recovered approximately 141,000 gallons of oil. About 50 percent of the oil evaporated. Exxon crews completed the cleanup on March 15. The bird rescue phase of the cleanup resulted in the treatment of 150 birds, of which 110 survived. Approximately 747 birds were collected.[4]

Potential use damages

Measuring use damages. Basic economic principles assume that individuals' decisions are the appropriate basis for determining the value of a good or service. When a natural resource is injured, analysts use the individual's WTP, or value, for a natural resource to estimate what the resource is worth, both with the injury and without the injury.

An individual demand curve, D, is shown in Figure 2. This demand function describes for any good or service, X, the amount of X an individual would buy at various prices. (For example, X could be fishing days in a recreation area.) Equivalently, a demand curve shows what an individual is willing to pay per unit for specific amounts of X. The demand curve slopes downward, indicating that individuals demand more as the price decreases. Analysts assume that other factors such as income and the price of similar goods do not change because these factors also may influence the demand curve.

If the market yields a price P_0, the individual will buy Q_0 of X (fishing days). The total expenditure equals P_0aQ_0O. The area under an individual's demand curve up to Q_0 (that is, $ObaQ_0$) reflects this total WTP. Consumer surplus is defined as the difference between an individual's total WTP and his total expenditure on the good or service (that is, P_0ba). Thus, consumer surplus is a monetary measure of the satisfaction that individuals derive from consuming a good or service in excess of what they pay for it.

Now, suppose an oil spill occurs at the recreation site. Demand shifts down (D′), indicating individuals are no longer demanding as many fishing days as a result of the spill. Given that price remains fixed at P_0, the number of fishing days demanded decreases from Q_0 to Q'. Expenditures now equal OP_0cQ' and consumer surplus now equals P_0dc. The loss in consumer surplus, equivalent to dbac, as measured by WTP, is the basis for estimating the economic damages discussed in this report.

As required in the NRDA regulations, losses of consumer surplus are the appropriate basis for measuring natural resource damages. Consumer surplus reflects the value of natural resources to people because it is a monetary measure of the satisfaction they receive from the

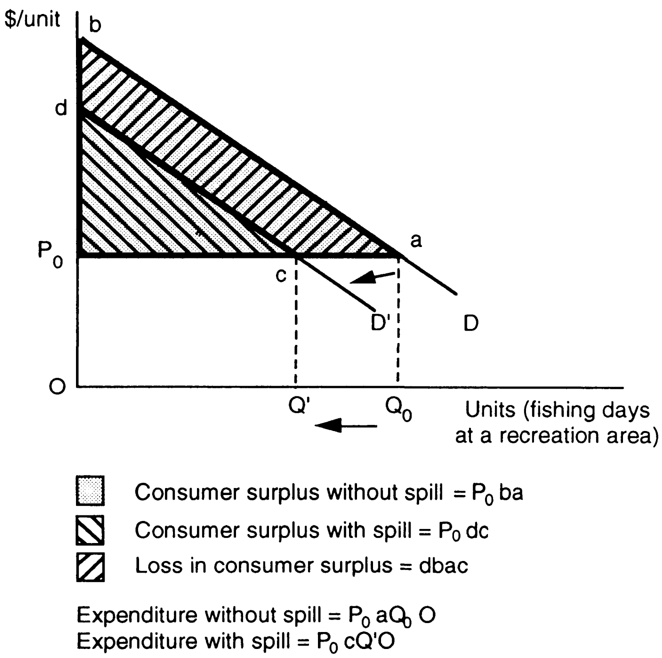

Figure 2. Demand for fishing days without and with an oil spill

natural resources. Therefore, losses in consumer surplus reflect the monetary losses in satisfaction attributable to natural resource injuries.

Water-based recreation losses. Because the Arthur Kill and the Kill van Kull are intensely industrialized and used by commercial shipping tankers, the recreation activities that take place in the Kill itself are limited or nonexistent. However, it is an important access waterway to reach the adjacent areas where recreation opportunities are more abundant. A great deal of water-based and land-based recreation takes place in and around Raritan Bay, particularly near the New Jersey portion of the Gateway National Recreation Area. Likewise, the Atlantic Ocean side of Staten Island offers recreational activities at the Great Kills Park and the other portion of the Gateway National Recreation Area. The Jamaica Bay Wildlife Refuge and several popular beaches are across the Lower Bay and adjacent to Brooklyn and Long Island. Because these recreation areas are so close to New Jersey, the Arthur Kill and Kill van Kull offer inexpensive, convenient access to popular recreation sites in the greater New York area.

To determine the extent of damages to recreation activities, we identified the harbors and marinas along the Kill using maritime maps and travel guides. These guides list four marinas, marked on Figure 1, either on the Kill or within a mile of the Arthur Kill or Kill van Kull. One of the marinas offers a public boat ramp while the others predominantly provide slip storage for moored boats. Because these marinas provide services for moored or trailered boats, we assumed the operators would probably know where their customers boated and fished, and to what extent they used the Arthur Kill for these activities. We asked the marina operators to identify the major recreation activities in the area, when and where these activities take place, the peak and off-peak seasons for the area, and their vacancy rates for both time periods.

From these interviews, we learned that boating, skiing, fishing, and shellfish harvesting take place in a number of areas *adjacent* to the Arthur Kill, but no activities take place directly in the Arthur Kill and Kill van Kull. We also learned that the total number of slips available for recreation users to house their boats in the immediate Arthur Kill area is 265. Because the spill occurred in January, we asked the marina operators about the occupancy of their marinas during the winter months. They said that approximately 20 to 50 percent (53 to 133) of their slips are occupied during the off-peak time period, generally November to March. During peak times, the boat ramp is used by approximately 20 to 30 users per day during weekends and about 10 to 15 per day during weekdays. For off-peak times, this launching ramp is not usually used. Table 1 provides data from these interviews.

According to the respondents, 95 percent of the users of these facilities are residents of New York and New Jersey. The majority of these people use these four marinas because they are close to their homes in New York and New Jersey and because these marinas are less expensive to use than marinas located directly on the popular recreation areas. All of the individuals we spoke to believed that the Arthur Kill and Kill van Kull are too heavily industrialized and polluted to be used as recreation areas.

Table 1. Sensitivity analysis for water-based recreation damage estimates

Key informant interview data			
	Number of slips	Occupancy rate[1] (%)	Number of boats in slips
Name of marina			
Elco Marina	140	50	70
Rahway Yacht	25	30	8
Robin's Reef	50	50	25
Brown's	50	20	10
Totals	265		113
Values for each factor			
	Base value	Low value	High value
Boats in slips as a percentage of total boats	75%	100%	50%
Percentage of boats participating per day	10%	5%	20%
Number of days (10 weeks fixed)	70	70	70
Valuation per boating day	$30[2]	$10	$70
Damage estimates[3]			
Best case damage estimate (using most favorable values)		$3,955	
Base case damage estimate		$31,640	
Worst case damage estimate (using least favorable values)		$221,480	

1. Off-peak season
2. Walsh, Johnson, and McKean[11]
3. The damage estimates are derived by dividing the number of boats in slips by the boats in slips as a percentage of total boats, and multiplying by the following: the percentage of boats participating per day, the number of days, and the valuation of a boating day.

We estimated the potential damages by assessing the change in the value of these services due to the spill. Damage estimates are calculated for the time period between the date of the oil spill and the date these services return to baseline levels, which we assumed occurred with the completion of the cleanup. This assumption will probably overestimate damages because only the first stages of cleanup are likely to have affected access for recreation use.

After assessing the characteristics of the area and the information obtained in interviews with the marina operators, we developed preliminary scenarios that evaluated key variables such as the number of affected user days and unit-day values to obtain a high, or worst case, damage estimate, a low, or best case damage estimate, and a base case estimate. By developing a best case and a worst case damage estimate of impacts, we provided a range of damage estimates. The difference between the best and worst case depends on the impact of certain variables we identified and the potential exclusion of other relevant variables. The development of best and worst scenarios counters, to some extent, the degree of uncertainty involved in calculating damages based on historical data, which are subject to extrapolation and interpretation.[11] In addition to the interview data, Table 1 summarizes the scenarios. The damage estimates range from $3,955 (best case scenario) to $221,480 (worst case scenario).

Near-water recreation losses. We learned from our interviews that a few small municipal parks (identified in Figure 1) located along the Arthur Kill and the Kill van Kull provide near-water recreation. Softball, basketball, and tennis are the most popular activities, and some park users watch birds and picnic close to the water.

We identified only two types of recreation that are sensitive to changes in water quality: bird watching and picnicking. We asked park officials to provide estimates for participants per week during the peak season and off-peak season for these two activities. The total of users per week for April through November for bird watching is approximately 525 to 825; for December through March, the number of users drops to approximately 95. For April through November, the number of users per week ranges from 475 to 950 for picnicking, whereas there are no estimated users for December through March.

The park staff indicated that the majority of the users of these areas are New York and New Jersey residents. Because these areas are not particularly scenic with unique recreational features, most of the users seem to use these parks because they are close to their homes.

Given the small number of parks and the small number of visitors at the time the spill occurred and even into the months of cleanup, we found that the near-water uses were not significantly affected. Most of these parks and green spaces are located off the shoreline and were not oiled. Because the spill occurred during the winter months, picnicking, a seasonal activity, probably was not affected at all. The bird watching activities may have been affected by the spill, but because the birds winter further south, few people were observing them from these areas.

We did not have estimates for picnicking during the off-peak season, so we based our analysis on bird watching alone. Table 2 contains the information on which the base case, the best case, and the worst case scenarios were based, as well as the damage estimates. The damage range is $1,425 for the best case to $32,063 for the worst case, with the base case damage estimate being $14,250.

Potential non-use damages

Non-use services are the services that natural resources provide to people or to other natural resources that do not require any human use. Because we cannot observe the behavior for nonuse services—we cannot count non-use services as we do boaters at marina slips or the users at parks—these services are among the most controversial elements in an NRDA. However, some aspects of non-use services do lend themselves to some degree of measurement, especially the services that a wetlands area provides to other types of resources.

Potential effects. In general, wetlands provide a wide array of non-use services. Undeveloped or natural wetlands support hydrologic systems by acting as a water storage and/or groundwater recharge area to regulate surface water flows. They also support ecosystems through waste cycling (water purification) and nutrient export to support the food chain. Possible services associated with undeveloped wetlands include the following: water supply, flood hazard reduction, commercial harvest of fish and game, visual/cultural/educational, recreational harvest of fish and game, nonconsumptive recreational use of fish and game, reduction of erosion damage, aquaculture, maintenance of natural stability, and diversity.[7]

Another type of non-use service occurs when wetlands provide services to other natural resources. In general, wetlands provide habitat, which includes nesting sites, vegetative cover from predators, and food supply, to many forms of fish and wildlife. In the Arthur Kill area, the wetlands areas support bird habitats within the waterway and along the creeks adjacent to the Kill. The three islands in the Kill are the primary sites for the nesting and protection services while the creeks, tidal lands, and marshes adjacent to the Kill are the feeding areas. Because the bird populations and the wetlands are intricately con-

Table 2. Sensitivity analysis for near-water based recreation damage estimates

Key informant interview data			
	Off-peak bird watching (user-days per week)[1]		
Name of park			
Kill Van Kull City Park	0		
Bayonne City Park	50		
Bayonne West Side Parks	25		
Palisade Park	20		
Medwick Park	0		
Kileen Park	0		
Total	95		
Values for each factor			
	Base value	Low value	High value
Percentage of user-days affected	50%	10%	75%
Number of weeks (fixed)	10	10	10
Valuation per user-day	$30	$15	$45
Damage estimates[2]			
Best case damage estimate (using most favorable values)	$1,425		
Base case damage estimate	$14,250		
Worst case damage estimate (using least favorable values)	$32,063		

1. Off-peak season
2. The damage estimates are derived by multiplying user-days per week, percentage of user-days affected, number of weeks, and valuation per user-day.

Table 3. Sensitivity analysis for non-use damage estimates based on the service approach

Values for each factor	Base value	Low value	High value
Acreage affected	25	10	25
Value per acre per year	$3,000	$198	$3,000
Years to total recovery	7	2	10
Damage estimates[1]			
Best case damage estimate (using most favorable values)		$3,960	
Base case damage estimate		$525,000	
Worst case damage estimate (using least favorable values)		$750,000	

1. The damage estimates are derived by multiplying acreage affected, value per acre per year, and years to total recovery.

nected, the impacts to wetlands areas directly affect the bird populations. Therefore, we estimated both damages using wetlands acreage.

Biologists assess wetlands in terms of their functions using a qualitative method of evaluation called Wetlands Evaluation Techniques (WET). WET analyzes the wetlands area in terms of social significance, effectiveness, and opportunity. Social significance assesses the value of the wetlands area based on its potential economic value, special designations, and location. The effectiveness factor analyzes the wetlands area with respect to its capability to perform a function based on its own physical, chemical, and biological characteristics. The opportunity factor assesses the ability of an area to perform a function up to its potential. WET does not predict the impact to an area but rather assesses the resulting consequences in terms of changes in value. WET assesses the wetlands area and its ability to function with respect to eleven factors: groundwater recharge, groundwater discharge, flood flow alteration, sediment stabilization, sediment/toxicant retention, nutrient removal transformation, production export, wildlife diversity/abundance, aquatic diversity/abundance, recreation, and uniqueness or heritage.

A WET analysis has been completed on the Arthur Kill region. Its results are cumulative for the many oil spills that occurred in the region in a short time period, implying that the effects are likely to be greater than just those from the Exxon spill. The results also indicate that the Arthur Kill wetlands have a limited ability to perform their functions. First, because of the disturbances in the area resulting from commercial and recreational traffic in the waterways, they have a limited potential to remove the plant nutrients from incoming waters that nourish plant and animal life in the area as well as provide eutrophic effects downstream. Second, these wetlands have a limited potential to flush out sediment, pathogens, and toxic substances from the water (waste assimilation) before they reach other areas nearby where fishing and other recreation activities are more extensive.[8] The Arthur Kill lacks a strong directional current as a result of its location; therefore, it does not benefit from tidal flushing and is highly vulnerable to pollution at its tributaries. However, the Arthur Kill wetlands do provide moderate erosion control, particularly along the shorelines of the wetlands where peat sediment is stabilized by the intertidal marshes, contributing to a stable shoreline and deterring erosion of the mainland.[12]

The Exxon oil spill had the potential to affect wading bird habitats. Because the spill was in January, nesting sites were not affected. The spill was more likely to affect the feeding grounds, primarily the mud flats during low tide and the low marsh areas, and our calculations show that 14 acres of feeding area were affected. These habitat functions were also factored into our analysis.

Assessment of potential non-use damages. According to our calculations, the oil affected approximately 25 acres of wetlands in the region. This estimate originates from the Exxon schematic oil impact drawings, which show the extent of oiling in the region. We then matched these impact areas to a topographical map to determine the acreage of wetlands. To calculate non-use damage estimates for the wetlands, we used the number of acres affected, a value per acre per year, and the time period needed for recovery of the wetlands. In all of the cases, we assumed relatively high estimates to establish an upper bound on possible non-use losses.

We reviewed five valuations of U.S. wetlands areas for per-acre value estimates. We relied on the Constanza, Farber, and Maxwell study[3] because we thought it had the best information. The value used in the base and worst case scenarios is based on the energy analysis approach. This method looks at the total amount of energy captured by an ecosystem, which is then converted to dollars using a conversion factor. However, the energy analysis approach is not an accepted approach in the NRDA regulations because it does not value the economic services but rather the ecological productivity of the area. We used this estimate because of the lack of acceptable valuation estimates for wetlands.

Table 3 provides the base case, worst case, and best case estimates for our sensitivity analysis. We begin with the base case for estimating the damages. The baseline acreage affected is 25 acres. The value per acre per year calculates total life support services for a Louisiana wetlands using the energy analysis methodology. The value is $848 per acre per year (in 1983 dollars).[3] After converting this number to 1990 dollars, the resulting value is $1,068 per year. We roughly tripled this number to derive the $3,000 per acre per year value. This value takes into account not only the wetlands but also the importance of the life support system for the harbor herons. Because data on the importance of the harbor herons in this region are lacking, by tripling the value we took into account the interaction at its fullest potential. For the base case damage estimate, we assumed the estimated recovery time to be 7 years. The base case damage estimate is $525,000. Even for this case, we think the parameters are at the high end of the range, which leads to a potential overstatement of damages.

In a high value case, we assumed that 25 acres of wetlands would be affected as a result of the spill. The time period needed for recovery is 10 years, and the value per acre per year is again $3,000. This yields a damage estimate of $750,000. Next, we computed a low value scenario for damages using the lowest variables. The affected acreage is 10 acres. The value per acre per year is $157 per acre per year (in 1983 dollars) and represents recreation and storm damage values of the Louisiana wetlands.[3] This estimate is then converted to 1990 dollars using the GNP deflator with the result of $198 per acre per year. We assumed a two year recovery. The resulting damage estimate is $3,960. Thus, our potential damage estimates range from $3,960 to $750,000.

Summary

Table 4 presents the aggregate range of potential estimates for the Exxon Arthur Kill oil spill. Three points are apparent from examining the table. First, the range of potential damages from losses in non-use values is wide, ranging from less than $4,000 for the best case to $750,000 in the worst case. Second, the potential damages from losses in use value are small compared to the nonuse services. Most importantly, the base case shows potential damages for water based and near water recreation of approximately $46,000.[2]

The base case damage estimates for potential losses in use services

2. In 1991, Exxon agreed to pay $58 million in total settlement costs. Cleanup costs accounted for $18 million of the total, and $25 million was allocated to operational integrity assurances. The value of the restoration and remediation component of natural resource damages was $15 million, which excludes damage assessment costs.[5] No additional details on the cost of the damage assessment are available.

Table 4. Ranges of potential damage estimates: Exxon Arthur Kill oil spill

Category of service	Base case damage estimate	Best case damage estimate	Worst case damage estimate
Potential use damages[1]			
Water-based recreation	$32,000	$4,000	$221,000
Near-water recreation	$14,000	$1,000	$32,000
Potential non-use damages[1]			
Wetlands areas (services approach)	$525,000	<$4,000	$750,000
Total	$571,000	<$9,000	$1,003,000

1. Rounded to the nearest thousand

for the Arthur Kill spill are highly plausible and very sound. We used generous estimates for the value of boating days, using values from studies of much more appealing areas; for the quantity of boating activity, using values that were larger than the key informant interviews implied; and for the time period, assuming that the Kill saw little activity until the cleanup was entirely completed. However, the relatively low damage estimate is intuitively appealing given that the characteristics of the area do not support a high level of baseline usage, the spill was during the off-peak season, and many substitute sites are available.

Unfortunately, we are less certain of the plausibility of the baseline non-use damage estimates for losses in non-use services. The uncertainty in the economic information about the value of wetlands, combined with the unavailability of definite data on the actual effects of the spill on several key species, makes judging the plausibility of our base cases more difficult. We do believe that our estimates of the affected acres are reasonable and generous, especially because we did not control for other spills in the area. We also believe that a seven year period of recovery is adequate for the types of effects on the wetlands. However, important information on exact bird populations and the relative importance of the Arthur Kill wetlands to the total stock of wetlands in the region is missing. Moreover, the available valuation estimates for wetlands are very poor—they do not match the services that were affected in the Arthur Kill. Our judgment is that the valuation estimate we used for non-use damages is probably generous, but that judgment is not based on any hard empirical data.

Overall, the judgments underlying our base case damage estimates seem to be sound. However, the lack of good data on the size of the target population and the value of wetland services limits the strength of our arguments.

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