Potential Benefits and Costs to Delaware from Proposed Delaware River Channel Deepening Project: Review and Critique of USACE Economic ReAnalyses

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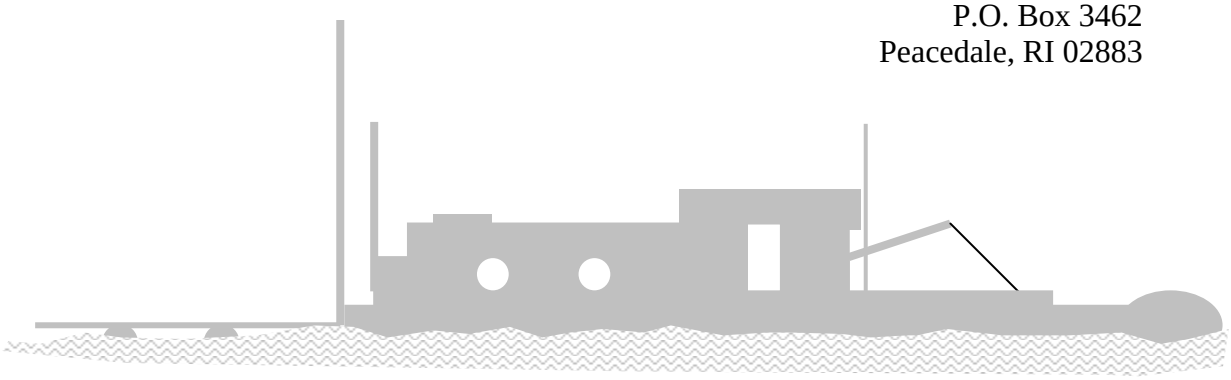

October 1, 2003

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Abstract

A Reanalysis of the proposed deepening of the Delaware Bay and River main federal channel by the US Army Corps of Engineers' ("USACE") (2002) concluded that the estimated benefits justified the costs of the proposed project. The USACE report spurred numerous comments from interested parties. The USACE Reanalysis and virtually all comments focus on the benefits and costs to the nation as a whole. This review and critique ("Review") examines the *potential benefit and costs which might be realized by the State of Delaware*, should the channel deepening project proceed. For this Review, we were not able to do original research, but instead relied upon the available record. We considered prospective quantified (1) transportation costs savings, (2) cost savings from beneficial use of dredged sediments at Broadkill Beach, (3) payments Delaware residents would incur as federal taxpayers, and (4) the share of profits Delaware residents might receive, should benefiting companies not pass forward to consumers all estimated cost savings. As part of our Review, a series of reasoned judgments were made about the share of transportation savings which could reasonably accrue to Delaware. We also noted unquantified potential benefits, such as those from restoration and protection of salt marsh at Kelly Island and Egg Island, and unquantified costs, such as from air emissions during dredging. Other economic issues raised in the USACE Reanalysis and in comments also are reviewed.

Questions remain concerning some quantified net benefits. For example, questions have been raised regarding the costs savings from lightering to MOTIVA and other refineries, (and hence benefits to users or refineries operators), and the size of cost savings at Broadkill Beach. Other outstanding questions remain concerning some unquantified costs, such as the effect of air emissions during dredging on air quality and on exposure of people, materials, and resources to lower air quality during the dredging period. Time and resource constraints did not allow us to do any original research for this Review, as noted, and we were unable to resolve all of these issues.

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Recognizing the many uncertainties concerning benefits to Delaware, several alternative cases were used as a form of sensitivity analysis. These cases include the possibility that (1) one or more Delaware refineries would not benefit from transportation cost savings, and (2) transportation cost savings would not be fully passed forward to users.

Stated briefly, we find that estimated quantifiable benefits exceed costs to Delaware in all of the cases we considered. However, we also note that there are apparently serious flaws in the USACE analysis of savings from lightering, as pointed out by MARITRANS. We understand the USACE is redoing its analysis of lightering, but we have not seen any new results. Additionally, remaining uncertainties affect not only NED benefits but also the benefits to Delaware. After subtracting Delaware's payment of $7.5 million as a non-federal co-sponsor, the *present value* of quantifiable net benefits from the project to Delaware ranges from $6.7 million to $8.03 million, depending upon the case we considered. Looked at another way, the present value of benefits before deducting Delaware's share of costs as a non-federal co-sponsor imply a range for the benefit-cost ratio to Delaware from 1.893 (= $14.2M/$7.5M) to 2.07 (=$15.5M/$7.5M). Cost savings at Broadkill Beach are the single largest benefit to Delaware. Using estimates *adapted from the USACE Reanalysis*, transportation cost savings are smaller but by no means trivial.

Should either the ongoing USACE reanalysis of transportation cost savings from lightering dramatically change the results or -- more importantly for Delaware benefits -- should cost savings at Broadkill Beach be substantially revised downward as suggested by some, then the national benefits and costs and our results certainly would change. The conclusions we reached for Delaware may or may not change.

I. Background and Introduction

In 1998, the US Army Corps of Engineers (USACE) published a Limited Revaluation of the economic benefits and costs of the proposed deepening of the federal main channel in the Delaware Bay and River. The proposed project involves deepening 102.5 miles of the main federal channel from 40 to 45 feet mean low water and, in addition, straightening 12 bends in the river. The USACE economic study focused on National Economic Development (hereinafter, "NED") benefits, which are the benefits and costs to the nation as a whole. Using a discount rate of 7 3/8 % and a 50-year planning period, the USACE estimated a benefit-cost ratio greater than 1, indicating that for every dollar of cost expended more than 1 dollar of benefits would be received.

The USACE analyses of economic and environmental issues sparked a wealth of comments on the proposed project. These included economic critiques by Stearns (2002), Taxpayers for Common Sense (2002), and many other comments on economic, environmental, and other issues by stakeholders, interest groups, and residents. A major, detailed critique by the Government Accounting Office (GAO) called into question many of the assumptions and estimates used in the USACE economic analysis (GAO, 2002).

Several recalculations of benefits and costs by the GAO, using corrected and more recent data, suggested that the proposed deepening project might yield a benefit-cost ratio of less than one – that is, costs could exceed benefits. The GAO report went on to state that:

> "…. we believe that the Corps' current project analysis does not provide a reliable basis for deciding whether to proceed with the project. …. [and the] actual economic merits of the Delaware River deepening project will not be reliably known unless and until it is comprehensively reanalyzed."

The GAO report, like the original USCOE assessment, addressed NED benefits. Environmental issues also were noted by GAO.

The estimation of NED benefits is appropriate for projects, such as the one proposed for the Delaware Bay and River, where benefits are widely dispersed and the costs are largely financed by federal taxpayers throughout the nation through budget allocations. However, studies using only a NED perspective provide little information about the potential distribution of benefits and costs to affected states. Answers to the questions Who gains? Who pays? and How much? can be important information for individual states, particularly those states asked to contribute to the funding of a proposed project as non-federal co-sponsors.

Working through *Economic Analysis Inc.*, (hereinafter, "EAI"), the authors of this document were asked to provide an objective review and critique (hereinafter, "Review") of the original USACE economic study (EAI, 2002). EAI's Review was done prior to, and independently of, the GAO critique. It was funded by the State of Delaware, Department of Natural Resources and Environmental Control, in order to determine whether the benefits which might accrue to Delaware would justify the share of costs state residents would be asked to pay ($7.5 million) as a non-federal co-sponsor, should the deepening project move forward.

As noted, the USACE and the GAO studied national benefits and costs; neither group analyzed the distribution of economic benefits and costs for potentially affected states. (The USACE did address many state-specific issues in Environmental Impact Statements and documents presented at public hearings and in response to public comments but made no systematic effort to analyze state benefits and costs.) Hence, our perspective on benefits and costs *to residents of the State of Delaware*, rather than to the nation as a whole, differed considerably from that of the USACE and the GAO.

The purpose of the review, as given in our original "Terms of Reference", was:

> …. to arrive at an overall assessment as to whether the USACE studies adhere to "best practices" with respect to environmental and natural resource economics of the relevant issues…. We will focus on incremental benefits and costs of the proposed dredging project to the State of Delaware and *not* the overall benefits and costs of shipping, nor benefits or costs to parties outside of Delaware…. Our review will cover work

> done by the US Army Corps of Engineers as well as other studies that may be submitted by other parties as part of the hearing and post-hearing process, as feasible within the available budget.

Our initial review recognized the many difficulties faced in assessing the Delaware Bay and River deepening project, including the (1) the large number of complex issues raised, (2) the multitude of [public] comments, many of them quite detailed, (3) changes in the nature of the issues over time, (4) disagreements ….over the validity of the findings of some studies, and (5) the fact that some studies were still in progress. Many of these same issues are as applicable now (September 2003) as they were at the time of our original review in April, 2002.

In our 2002 review, we also took note of efforts by the USACE to address a number of concerns expressed early on by citizens, environmental groups and agencies:

> In many respects, the USCOE did a good job carrying out the environmental and natural resource aspects of their national study, particularly in responding to concerns raised initially by many parties about perceived threats to Delaware River natural resources. Early on in the project, members of the public and government agencies expressed serious concerns about a variety of issues. Among these were concerns about possible or perceived adverse effects of (1) toxic sediments stirred up by dredging possibly affecting water quality and (2) increases in salinity levels in the Delaware River…(3) perceived threats to groundwater due to upland disposal of sediments, (4) risks to several endangered and listed species, (5) possible harmful effects on horseshoe crab (and by that, on migrating shorebirds dependent for food upon seasonal availability of horseshoe crab eggs), (6) vulnerability of oyster beds, (7) crab resources, and (8) loss of subtidal habitat. To the extent any of the services provided by these resources would be impaired by project activities, external costs would be imposed on the public, including in many cases residents of Delaware.
>
> Generally speaking, the USACE responded to these concerns in a variety of positive ways. It supported studies to assess better the expressed concerns. In some cases, such as proposed creation of subtidal stockpiles (storage banks) for dredged sand to be drawn upon over time for Delaware beach renourishment, the USACE reversed course and instead proposed beneficial uses of the sand by placement on beaches, creation of Kelly Island wetlands, and other uses. In other instances, the USACE agreed to (1) environmental windows to avoid sensitive periods for particular species, or (2) place observers on dredges to watch for injury to species at risk, for example turtles. The USACE agreed to monitoring programs for groundwater and for Kelly Island and agreed to maintain or take other actions in the event that monitoring detected problems, for example, at Kelly Island and Broadkill Beach.

> As a result of all of the above actions …., several public trustee agencies formally expressed the view that the USACE had addressed their major concerns and the planned Delaware River channel deepening program no longer posed an unacceptable risk. In the absence of other careful studies, many of the issues mentioned above, which were originally raised as major concerns, do not seem to be important at this point, assuming all of the agreed-upon plans are implemented.
>
> At the same time, ….[m]any remain concerned with the consequences of proposed actions and who will bear the cost of maintenance or will repair and/or be responsible for damages, maintenance or repair, should activities not work as planned. Recent assurances by the USACE (2002) that it will bear, in part or whole, many of these costs may allay these concerns about the risk of Delaware residents being asked to bear possible later costs. Furthermore, the USACE has asked for relief from some environmental windows for at least one year, although the USACE (2002) has agreed to consult with the state on these issues. Also, NOAA has expressed concerns about lost habitat from restoration/construction of a 60 acre wetland at Kelly Island (but recall, the lost habitat will be replaced by intertidal habitat, which may be more valuable).

In light of these challenges, this Review necessarily reflects our understanding of the conclusions reached on many issues. We recognize, however, that disagreements and outstanding issues remain.

Important comments on the USACE Limited Reevaluation report included:

- NED benefits from the project likely are much overstated because an overly optimistic growth rate was assumed from crude oil deliveries, which account for some 81 percent of benefits.
- Cost savings are overstated, since many vessels (even those recently purchased) do not require deeper drafts
- Benefits to steel and scrap metal shipments likely are overstated
- Costs of dredging and (perhaps) of disposal appear to be understated
- The USACE does not appear to include the cost of monitoring (and possible mitigation) in estimate of NED benefits

Our earlier report also noted that the USACE's use of an NED approach did not make clear the benefits and costs to Delaware:

> …….to assess potential benefits and costs to the State of Delaware, a more extensive effort would include quantification of the following:

- An updated and more realistic assessment of potential transportation benefits, in general
- An estimate of the fraction of cargoes (especially petroleum products) that is ultimately delivered to Delaware customers
- The extent to which cost savings of this fraction of cargo are likely to be passed down to Delaware customers
- Quantification of the benefits to Delaware associated with beach renourishment and wetlands restoration projects
  - Projects to be carried out irrespective of the deepening project should use cost savings to Delaware, which are net of federal share of costs
  - Projects which are conditioned on the deepening project should benefits of new, versus existing habitats, which are challenging, but not impossible, to estimate
  - Estimates of the share of payments to inputs that can reasonably be regarded as a gain to the resource provider (see Grigalunas, Luo and Chang (2002) for further discussion of this point in the port context)

> In summary, we believe that the net benefits of the Delaware River deepening project are overstated, and the costs are understated. Additional quantification beyond the scope of this effort is needed to determine whether the benefits of the project justify the costs from a national perspective. *Many of the benefits are national in scope, and Delaware's share of benefits appears modest …. but not well quantified by existing studies. Thus, we also find no compelling evidence that the project as planned is a good investment from the perspective of the State of Delaware* [emphasis added].

Following the GAO critique, the USACE conducted a reanalysis of project benefits and costs, also using a NED perspective (USACE, 2002). The USACE reanalysis estimated a new (base case) benefit-cost ratio of 1.14 (or 1.18 recognizing that Preconstruction Design and Engineering costs incurred early on are sunk costs not relevant to forward-looking (ex-ante) decisions.) As part of their reanalysis, the USACE also presented additional quantitative and qualitative information, described below, on benefits and costs to the State of Delaware that are regarded as national benefits.

I.B. Purpose and Scope of This Review and Critique

This document provides a new review and critique (hereinafter, "Review") of the USACE Re-analysis of the proposed Delaware deepening project. As with the initial 2002 Review, our concern is with the benefits and costs to Delaware – not to the nation as a whole. *Benefits and costs estimated by the USACE using its NED perspective are examined only insofar as they contribute to our assessment of the benefits and costs of the proposed deepening project on Delaware.*

We continue to follow the original terms of reference, as stated in our earlier Review:

> Our review relies upon material in the record and other, pertinent studies and data[2]. We address what we see as key issues, based on the record for this case. In all cases we make every effort and to cite the document(s) used. Following the "Terms of Reference", our review of the material in the record examines the:
>
> - concepts used
> - methods employed
> - data relied upon
> - reasonableness of assumptions used, and
> - soundness of the conclusions drawn from the analysis
>
> We also were asked to give our opinion about whether additional economic studies might be needed to assess the full impacts of dredging, if we find that such studies would clarify the nature and scale of potential costs or benefits.
>
> Our review draws upon standard concepts and methods from applied benefit-cost analysis, and especially from the fields of environmental and natural resource economics and applied welfare economics. Standard technical references include Just, Hueth, and Schmitz (1982), Freeman (2003), Smith and Kopp (1993), and Braden and Kolstad (1991). Examples of uses of environmental and natural resource economics in coastal decisions that might be applicable to the Delaware River project can be found in Grigalunas and Congar (1995), Opaluch, et al. (1999), Johnston, et al. (2001), Parsons (e.g., 2000; 2001), Grigalunas, Opaluch and Luo (2001a,b).
>
> We recognize that the economic analyses done for and by the USACE to estimate national economic development (NED) benefits follow a prescribed set of principles for carrying out benefit-cost analyses of specific types of proposed projects (USACE, ER 1105-2-100, 2000). However, within these broad principles, latitude exists regarding the benefits and costs that can be included, the scope and depth of the analyses done, and the concepts and methods used. Further, our economic review is not necessarily restricted to the principles followed by the USACE.
>
> In summary, based on the record for this case, and on the vast open literature available, we use our professional judgment regarding the

[2] The record used for the present EAI review consists of documents presented at public hearings, in the DEIS and SEIS, responses provided by the USACE to public questions and comments, the GAO report, the 2002 Comprehensive Re-analysis by the USCOE, and public comments received by EAI through the State of Delaware, Department of Natural Resources. We also draw upon other results when useful to clarifying the arguments and issues. In all cases, we identify the source used.

coverage of issues in the record and the quality of the studies relative to "best practices" in the profession.

As was the case with the original TOR, time and resource constraints did not allow us to undertake any original research as part of this Review. Instead, we rely on information and data readily available in the record. Most of the USACE materials consulted are contained on a CD ROM made available by the USACE. Comments by the public and other parties were sent to EAI by the Delaware Department of Natural Resources. Included in this material were comments prepared by MARITRANS (Doherty, 2003), Stearns (2003), Maritime Exchange (2003), Fleming (2003), labor unions, and many others, including letter from interested and concerned Delaware residents.

The remainder of this Review is organized as follows. First, we summarize the USACE Reanalysis. Then, we describe the basic concepts we use, and outline the benefits and costs to be considered for Delaware. Next, adapt the USACE information to assess the share of these benefits and costs which might reasonably be expected to accrue to Delaware. To do this, we use readily available information and make a series of reasoned judgments about the share of benefits and costs which Delaware residents might receive. Recognizing the many remaining uncertainties, several alternative outcomes are given as a form of sensitivity analysis. Finally we present our conclusion on quantifiable benefits and costs to Delaware and point out unquantified benefits and costs and remaining uncertainties and concerns.

Given the available information, and time and resource constraints, many of the judgments we make necessarily are subjective. Nevertheless, we believe that our overall assessment reasonably reflects the scope and rough magnitude of benefits and costs to Delaware and, therefore, expands upon the information available for understanding the economic consequences of the proposed channel deepening project for Delaware.

Finally, we are aware of the significance of the issues raised by all sides of the debate on the proposed deepening of the Delaware Bay and River and have sought to provide an objective, careful, and fair review. We attempt to make clear the concepts, assumptions, and judgments we use so that readers can assess for themselves the reasonableness of our approach and, hence, the appropriateness of the conclusions reached.

II. OVERVIEW OF THE 2002 USACE REANALYSIS

The USACE Reanalysis of benefit and costs from the proposed Delaware deepening project used the standard NED accounting standpoint and a 50 year planning period, in this case covering the period, 2009 - 2058. In the Reanalysis, annual benefits and costs were discounted using the official rate of 5 7/8% for such projects, as compared with the 7 3/8% discount rate used in the 1998 USACE Limited Reevaluation report.

Overall, the updated analyses carried out by USACE were more appropriate to the current situation than the earlier study, more thorough, and much better documented. The

rationale for quantified transportation cost savings and other benefits is given, and the cost and consequences of dredging are much more thoroughly documented in separate appendices for benefits and for costs. To its credit, a series of sensitivity analyses also were used by the USACE to reflect uncertainty for several key variables for the benefit analysis (USCAE, 2002, Final Appendix C) and also for the assessment of costs (USACE, 2002 Final Appendix A).

The USACE Reanalysis resulted in estimated total quantified annualized benefits of $24,658,630 and annualized quantified costs of $21,448,666 (in May 2003 dollars). The particular commodities included and their relative importance in the USACE Reanalysis differ considerably from those in the 1998 USACE Limited Reevaluation economic assessment. For one thing, only transportation cost savings were quantified in the 1998 USACE economic study. Further, the estimated savings from delivering imported crude oil to Delaware River refineries was 81% of total quantified benefits in the original study. In the Reanalysis, transportation costs savings continue to make up virtually all of the quantified benefits, but cost savings to petroleum refineries ($15,153,722) are a smaller share of total benefits -- 61.4 % -- than the 81% in the original study. Annual savings of $355,008 for imports of refined petroleum product through the Delaware Terminal also are included (USACE, C-32).

Other important transportation annualized cost savings estimated in the 2002 USACE Reanalysis are for imports of

- Containerized Cargo: $3,490,717,
- Steel Slabs: $3,597,997, and
- Blast Furnace Slag: $1,811,496.

An additional NED benefit included in the Reanalysis is the estimated annualized cost savings ($604,698) from the beneficial use of sediments from maintenance dredging for renourishment on Broadkill Beach, DE.

III. Review and Critique of the Reanalysis

The USACE Reanalysis raises several issues. Our concern in this document is the benefits and costs Delaware might anticipate, should the deepening project proceed. To address this concern, a number of issues requiring detailed discussion must be addressed.

A potential major issue stems from detailed comments by MARITRANS (Doherty, 2003), the company which operates lightering vessels for the Delaware Bay and River. In his comments, Doherty point out apparent substantial errors in the analysis of lightering costs done for the USACE, and included in the USACE Reanalysis. The effect of these apparent errors is to overstate greatly, in the Reanalysis, the estimated potential savings from channel deepening (Doherty, 2003). We acknowledge the importance of Doherty's comments, and return to this issue later. We also understand that, at the current time (September 2003), the USACE is restudying this core issue. Lacking these new results, we must proceed without the benefit of the new USACE analysis.

Another issue involves the proper estimation of cost savings to Delaware from use of dredged sand to renourish Broadkill Beach.

The choice of the interest rate is always an important issue. As a matter of arithmetic, the use of 5 7/8% in the Reanalysis (versus 7 3/8% in the USACE's 1998 economic analysis) substantially increases discounted and annualized net benefits in the Reanalysis. The proposed project simply "looks better" – has a higher benefit-cost ratio -- when a lower rate is used. To be sure, choosing a single "correct" social discount rate for a 50-year project raises nettlesome issues (see, for example, Wietzman, 2001). However, in adopting the 5 7/8 % rate for the proposed Delaware project, the USACE is following established guidelines for such projects, and the same rate is used nationally for similar projects. Hence, the use of the current, lower rate of 5 7/8% seems an appropriate decision[3].

Two "accounting" issues have been raised. One concerns how to handle prior Preconstruction, Engineering and Design (hereinafter, "PDE") costs incurred years ago. Sunk costs are history and thus not incremental cost at this point. Hence, these past PDE costs have no bearing on whether or not to proceed from this point (2003) forward. As a consequence, the PDE costs should be omitted from a current benefit-cost assessment. This increases the USACE's estimate of the benefit-cost ratio (from 1.14 to 1.18), measured today (USACE, 2002).

The second has to do with the fact that certain project benefits apparently would accrue a year earlier (2008) than the initial year used in the overall USACE benefit-cost cost, 2009. If benefits indeed accrue a year earlier, then it is correct to take this fact into account.

IV. Issues Considered in This Review

IV.A. Introduction

Should deepening of the Delaware Bay and River federal channel proceed, Delaware residents would potentially receive several benefits and bear a number of costs. Both benefits and costs have market and non-market elements.

IV.B. Potential Benefits and Costs to Delaware -- General

On the benefit side, Delaware residents will share in transportation cost savings because of use of deeper draft vessels and other vessel economies. Estimates of these savings should be net of both the incremental associated initial cost of improvements and the subsequent periodic maintenance dredging required in order for private facilities to accommodate deeper-draft vessels. (These costs incurred by private beneficiaries are

[3] One can criticize the choice of the rate used by the USACE, but such criticisms really might better focus on the broader issue of how discount rates are selected in general for USACE projects and indeed for major public projects of all types (see, for example, Weitzman (2001)).

referred to in the USACE documents as "Non-Associated Costs") This is because refineries would have to realize sufficient transportation cost savings from dredging the channel in order to pay back their initial investment and annual operating costs to accommodate larger tankers. For some Delaware River facilities, these initial associated costs are several million dollars (USACE, 2002, Appendix C).

The net benefits will accrue to Delaware residents who

- are users of transported goods, if cost savings are passed forward to consumers, or
- own shares directly or indirectly (e.g., in retirement accounts; mutual funds) in the domestic companies involved, if transport cost saving are kept by domestic companies and not passed on to consumers.

Benefits to Delaware also will arise from:

- the cost savings from the beneficial use of dredged sand on Broadkill Beach and
- directly and indirectly through improvements in the quantity and quality of environmental and natural resource services to wildlife -- various bird, fish and shellfish species (including benefits to horseshoe crab and migratory bird species which rely on seasonal consumption of horseshoe crab eggs) -- arising from successfully restoring and protecting saltmarsh at Kelly and Egg Islands.

On the other hand, costs will be borne by Delaware residents:

- who will bear any external costs not avoided or otherwise offset, and
- as federal taxpayers who will pay a share (albeit a very small share), of incremental national costs associated with federal funding for the project, just like citizens of any state, and
- as non-federal co-sponsors of the proposed project who would pay $7.5 million.

IV.C. Potential Benefits and Costs to Delaware - Concepts

IV.C.1. Market Goods

Here we describe general economic concepts and present arguments pertinent to estimating the distribution of transportation benefits and costs later in this section. Our arguments focus on transportation cost savings on crude oil because this is, by far, the major category of quantified annual benefits in the USACE Reanalysis calculations. However, with some modification, similar arguments apply to other commodities (containerized goods, steel slab and slag).

Markets tend to equilibrium, and transportation relating to the Delaware River is no exception. The *quantity* demanded of crude oil or refined petroleum products, such as

gasoline and heating oil, is not highly responsive to price changes, particularly in the short-run (that is, demand is price inelastic). An inelastic demand for a good means that its *market price* is highly responsive to shifts in supply. Even casual observation of crude oil and petroleum prices demonstrably show that prices move with market conditions. For refined products, gasoline prices increase in the peak summer driving season; heating oil prices go up in the winter; product prices increase sharply following pipeline and refinery interruptions; and concerns with international disruptions raise prices. The inelastic demand, and the structure of the petroleum market, provide some guidance as to what can be expected to happen following dredging of the Delaware River to a deeper depth.

In light of underlying competition, decreases in the cost of importing crude oil because of a deeper channel would put downward pressure on the cost of delivering oil by tanker to Delaware River refineries. Virtually all crude oil entering the Delaware River is imported, so that for imports of crude oil to Delaware River refineries, foreign tankers are the marginal supplier. The international tanker market is highly competitive. Following dredging to a deeper depth, tanker owners who do not reduce rates for delivery to Delaware River refineries with a deeper water capability will, over time, find themselves undercut by other tanker operators who will. We note that the USACE assumes that vessel cost savings from a deeper channel are substantially, if not entirely, passed forward to refineries. This estimated transportation cost savings, in fact, provide the basis for the "Associated Cost Reasonableness Test" for refineries. This is the test which the USACE uses to judge whether individual facilities would have a financial incentive to incur the extra costs necessary to accommodate deeper draft vessels at their Delaware River facilities (see USACE, 2002, Appendix C).

One or more Delaware River refineries could attempt to maintain prices in order to keep transportation cost savings, after covering the extra costs incurred for facility improvement and dredging of berths to handle deeper draft vessels. However, refineries attempting to maintain prices would very likely find themselves undercut by other refineries which will reduce their prices. Again, the USACE calculations under their "cost reasonableness tests" suggest that the transportation costs savings from channel deepening are much higher than costs for refineries to accommodate deeper draft vessels. Hence, refineries could invest in and maintain new facilities for deeper draft vessels, capture some of the transportation cost savings, and pass some or all of the remaining savings along to wholesalers and retailers, if the USACE estimates of transportation costs savings to refineries are correct.

Further, wholesale and retail petroleum product markets are competitive, again as evidenced by market responses to seasonal demand changes for gasoline and heating oil, to supply disruptions, and to international events. Hence, any decline in product prices at the refinery level likely would be distributed in whole or in part over wholesale and retail markets served by Delaware River refineries and, in turn will tend to be passed along to individual, business, and institutional users.

Generally, any price declines would put some pressure on petroleum product prices in nearby markets. This is because, in equilibrium, market prices for the same good tend to

be equal, except for differences in transportation costs and state taxes (the "law of one price"). Differences in prices – except for state fuel taxes and transportation costs -- cannot persist over time because consumers have a built-in incentive to buy from low cost suppliers, and suppliers have an incentive to move goods from low-price markets to high- price markets[4].

Savings in cost, such as the beneficial use of dredged sediment at Broadkill Beach, are another benefit, as noted. These savings will depend upon whether (1) the quality of the dredged sand used on the Beach is the same as that which otherwise would be used from a borrow area by the State of Delaware, and (2) the savings accrue over identical time periods whether done by the USACE or the State of Delaware.

IV.C.2. Non-Market Goods

In the case of non-market goods, the proposed deepening project would restore and maintain salt marsh at Kelly (60 acres restored, 80 acres protected over 50 years) and Egg Islands (135 acres restored, 110 acres protected for 25 years (USACE, Appendix C, P. C-74)). Salt marsh generally is credited with providing many valuable natural resource functions, such as serving as habitat and nursery grounds, as a buffer for storm energy and flooding, and as a natural "filters" for pollution from runoff (Opaluch, et al., 1999). Hence, successfully restored salt marsh can provide a range of direct (non-consumptive wildlife viewers and amenity) and indirect (recreational, water quality; habitat) benefits (US Department of the Interior, Fish and Wildlife Service, 2003).

Birds – especially migratory waterfowl -- and fish are mobile and hence benefits from additional salt marsh will be shared with other states and, indeed, internationally. For example, many non-residents visit Delaware to enjoy viewing or photographing wildlife (US Department of Interior, Fish and Wildlife Service, 2003). Other "indirect" benefits may arise from passive use (or "non-use") value associated with additional saltmarsh[5], although estimation of these values may be more problematic than direct use values.

Nonmarket costs arise if external costs of the project are not avoided or otherwise mitigated through monitoring, corrective action, or offsets. Numerous potential issues have been raised in various public and agency comments throughout the planning process for the deepening project. Many of these have been resolved or addressed by studies, redesign, commitments to monitor -- and take corrective actions if problems arise -- and to follow environmental windows for sensitive species in many (but not all cases, such as exceptions requested in a few cases). However, disagreements and issues remain.

Air quality issues during dredging raised in recent comments is one such issue. Dredging has been found in the Port of New York and New Jersey, for example, to generate

[4] We acknowledge that some impediments hamper market competition, such as tie-ins due to credit cards and limited availability of options in some areas. Nevertheless, there is a general tendency for prices to be passed forward.

[5] These are benefits to people over and above any use value benefits they may have for particular wetlands. In the context of coastal wetlands, see Mazzotta (1996) and Opaluch, et al. (1999).

considerable emissions of air emissions which are precursors for ozone. The section of Delaware near Philadelphia has been designated a non-attainment area for ambient air quality standards (http://www.epa.gov/reg3artd/airquality/2002_naareas.pdf). Since Delaware residents would be exposed to additional air emissions from dredging equipment during the dredging period, this is a legitimate cost to acknowledge, although difficult to quantify in monetary terms.

IV.D. Quantifying Benefit and Costs to Delaware

IV.D.1. Categories Considered by the USACE

The USACE Reanalysis quantifies two categories of benefits, Transportation Costs Savings and Beneficial Use Cost Savings at Broadkill Beach (USACE, 2002, Table C-32). Below we take up, in sequence, each of these and discuss qualitative benefits at Kelly and Egg Islands.

IV.D.2. Annual Transportation Cost Savings

As a group, annual Transportation Cost Savings in the USACE Reanalysis are 97% of all benefits ($24,658,630). Most of these benefits (63%) are estimated savings on imports of crude oil ($14.8 million per year), as noted. Annual savings on imports of refined petroleum products at the Delaware Terminal amount to $355,008.

Seven Delaware River petroleum refineries are identified in the USACE-estimated Transportation Cost Savings analysis. One of these refineries, MOTIVA, is located in Delaware. The USACE analysis implicitly assumes that refineries capture much (perhaps all) of the benefits from reduced transportation costs. This is apparent from their "Associated Cost Reasonableness Test" in which they compare the costs and benefits to Delaware River facilities from accommodating larger tankers.

Given their importance in relation to estimated total benefits, the discussion which follows focuses on Transportation Costs Savings for imported crude oil and refined petroleum products.

IV.D.2.a. Assumptions

The Delaware Bay and River, according to the USACE, serves as a node for a variety of hinterland markets (see Table 1). These range from a "Core" Area, which is essentially the Philadelphia metropolitan area, to a 17-state hinterland.

Table 1. Population in Delaware and Delaware River Hinterland Areas, 2000 (in thousands)

	Delaware	Core Hinterland [a]	4-State Hinterland [b]	17-State Hinterland [c]	United States
Population *	703	14,835	27,348	108,925	279,583
Delaware Percent	100%	4.74%	2.57%	0.645%	0.251%

* Source: USACE (2002) Appendix C, Table C-1

[a] Core Hinterland – Philadelphia Metropolitan Area

[b] 4-State Hinterland – DE, NJ, PA, MD and DC

[c] DE, NJ, PA, MD and NY, CT, MA, NH, ME VT, plus OH, Michigan, Illinois, and Indiana, Virginia and West Virginia and the District of Columbia

Development of a formal model or original research is beyond the scope of this effort. Lacking such a model, our assessment of the distribution of benefits rests on a series of judgments about how the estimated transportation cost savings which are passed on to users would be distributed to Delaware. Below we summarize the assumptions we use for each commodity concerning the share of benefits accruing to Delaware. Later, we consider a range of possible cases as a form of sensitivity analysis.

Crude Oil: Petroleum Products from Delaware Refineries. The Delaware River is a major East Coast petroleum refining center. Refineries located along the river process crude oil into a gasoline, distillate oil, residual oil and other refined petroleum products which are then distributed over a broad area by trucks, vessels and pipeline to Washington, DC and New York. Vessel shipments move product up and down the river and also involve deliveries in inter-coastal trade. Hence, transportation cost savings passed along by Delaware River refineries will be distributed to users over an extensive area, and Delaware's share of savings will be relatively small inasmuch as the state is a relatively small market.

To estimate transportation cost savings to Delaware, we assume that the market served by Delaware River refineries is the area referred to as 17 State Hinterland by the USACE (Table 1). Some 109 million people live in this area. If the per person benefit is the same in this area, Delaware's population of around 703,000 would mean that the state gets 0.645% of the transportation cost savings passed through to users by refineries.

If refineries do not pass on savings, then refinery profits would increase. This, in turn, would raise dividends and/or the value of company shares. Many Delaware residents directly (as shareholders) or indirectly (through retirement funds or mutual funds) would share in these gains. We assume that Delaware residents' receive profits by refinery companies (or refinery company owners) equal to their share of the United States population: 0.251% (Table 1).

Petroleum Products through the Delaware Terminal. In contrast with refineries, the Delaware Terminal in Wilmington imports already refined petroleum products for distribution. We assume that the market served for Delaware Terminals is much smaller

than for area refineries and that Delaware's residents capture most (we use two-thirds) of the transportation cost benefits estimated by the USACE for this facility.

Containerized Goods (Fruits and Vegetables). Fruits and vegetable to be imported in refrigerated containers are highly mobile, and the Delaware River would be a distribution point for what likely is a broad market for these refrigerated goods. The area served is taken to be the same area as for petroleum refinery products. Hence, Delaware is assumed to capture 0.645% of any savings passed forward.

Slag and Steel Slabs. Slag would be delivered to Camden New Jersey, according to the USACE, to be used in cement. A fairly wide market is served, including coastal shipments and upbound traffic (USCOE, Waterborne Transportation, 2001). We assume the 4-state hinterland as identified by the USACE comprises this market. Hence, Delaware receives 2.57%.

Steel slabs, according to the USACE Reanalysis, will be delivered to the Midwest. From there, markets throughout the US could be served and Delaware is no more likely to benefit than other state. Delaware's share of benefits to this good are taken to be its share of the national population, 0.251%.

IV. D.2.b. Delaware's Share of Federal Tax Payments.

As federal taxpayers, Delaware residents pay for part of federal costs, just like residents of any other state will pay a share of such costs. Federal costs are those incurred for planning, dredging, navigational aids, land acquisition and related costs; for operation and maintenance; and for monitoring. We assume Delaware pays the same share of federal costs as its share of the national population, 0.251%.

IV.D.3. Non-Market Benefits and Costs

Broadkill Beach

Delaware receives all of the savings ($9.7 million) from the beneficial use of dredged materials at Broadkill Beach. According to the USACE, the annualized equivalent of this benefit is $604,698.

The benefit at Broadkill Beach is the estimated cost savings from using sand from maintenance dredging done as part of the proposed project. In the *without-project* case, the source of sand for Broadkill Beach would be a borrow site, and its use for renourishment of Broadkill Beach would cost Delaware of $9.7 million (USACE 2002). *With the project*, the USACE would renourish Broadkill Beach using clean sand from maintenance dredging from Reach E of the federal channel in Delaware Bay. By doing so, savings of $19.9 million would result to the proposed project, according to the USACE (2002). The $19.9 million is the difference between the cost of using an upland confined disposal site ($46.9 million), less the lower costs ($27 million) incurred using sand from maintenance dredging for beneficial use on Broadkill Beach.

Use of the estimated cost savings at Broadkill Beach as a measure of benefits to Delaware assumes that (1) the cost estimates are valid, (2) the *quality* of the sands from the borrow site the state would use and the sand from Reach E of the dredged channel the USACE would use are the same, (3) that the *timing* of the two alternatives are the same, and (4) that no changes in federal-state cost sharing occur. If any of these factors does not apply, then the estimated cost-savings to Delaware would have to be revisited.

Fleming (2003) argues that USACE significantly overstates the without-dredging costs of beach renourishment. He provides information that suggests that the USACE's estimate of the cubic yard cost to place Delaware material on Broadkill Beach of $20.69 per cubic year is excessive, and that a more appropriate value would be $11.50, using information he obtained from an earlier response from the USACE. If this lower cost is accurate, then the cost savings benefit at Broadkill Beach might be some 45 % less than in the USACE Reanalysis, which would imply that the USACE benefits of the dredging project are much overstated.

This issue could be very important because the USACE estimates of cost savings at Broadkill Beach are central to the assessment of the net benefits of deepening for Delaware, as we show below. However, we cannot take this issue further, given technical nature of the issues, the information at our disposal, and time and resource constraints.

We note, also, that residents near Broadkill Beach will benefit from beach renourishment. However, beach renourishment will occur in both the with-project and the without-project cases. Hence, no *incremental benefits* to residents near Broadkill Beach can be claimed for the channel deepening project.

In sum, use of dredged sand to renourish Broadkill Beach over a 50 year period Delaware realizes an estimated $604,698 per year savings, according to the USACE. Disposal of dredged sands on Broadkill Beach also lowers project NED costs by $19.9 million.

Kelly and Egg Islands

As noted, successful restoration and protection of salt marsh at Kelly Island and at Egg Island will support many natural functions. These functions yield direct and indirect benefits to users both in Delaware and beyond – perhaps internationally for migratory bird species which seasonally stop over.

Recent studies by the US Fish and Wildlife Service ("USFWS") show that outdoor non-consumptive birding (USFWS, 2003) and wildlife recreation in general (USFWS, 2002) are important recreational activity throughout the US, including Delaware. For example, some 172 thousand individuals engaged in birding in Delaware in 2001, and 63% of these were residents (USFWS, 2003, Table 6).

Some appreciation of the value of this activity is given from non-market study of out door recreation done for the USFWS. These studies show a value of $9 per day over the

costs of participation in the activity and a value per season of $92 (USFWS, 1998). This includes use value or onsite use, but omits the economic value of incidental use, or indirect use, such as viewing of species offsite[6].

Clearly, participation in and the total annual economic value of outdoor non-consumptive recreation in Delaware is substantial, as suggested by the above numbers. However, we are unaware of any studies of the uses of affected Delaware salt marsh areas and, more importantly, of how such recreational uses might change with an increase in the quantity and quality of salt marsh and the environmental and natural resource services as a result of the proposed ecosystem restoration and protection at Kelly Island and Egg Island. Therefore, we are unable to provide a quantitative estimate of prospective incremental non-market benefits from restoration and protection of Delaware salt marsh because of the proposed project.

IV.E. Benefits and Costs to Delaware: Alternative Cases

Here we draw upon and adapt the USACE results, and use a series of judgments, to illustrate potential benefits and costs to Delaware from deepening of the federal channel. This is done for several cases to examine not only to gain an appreciation of the total quantifiable benefits and costs but also to show how the outcome of the proposed project could vary, depending upon the case considered.

For benefits, we focus on *annual net savings* in transportation costs for the Delaware River facilities and cost savings from beneficial use of dredged materials at Broadkill Beach. By annual *net savings* we mean the estimated yearly savings in transportation cost for each facility, *less* the annual associated initial and maintenance costs. (In the parlance of the USACE, "Associated" means the parties which are the beneficiaries of projects).

We also include the incremental costs of the project to Delaware resident as federal taxpayers, just like the residents of any other state. In all of the cases considered, Delaware residents share of federal dredging costs as taxpayers is assumed to be equal to the state's share of the US population (0.25%), as mentioned above. Of the total of $229.5 million (rounded) in total costs, the federal share is $152.7 million (rounded) (Table 7-2). The average annual *federal* project costs (including first costs, maintenance, and navigation) are reported as $20,720,000 (USACE, 2002, Table 5-1). *Note that the numbers referred to here do not include the contributions which the states of Delaware, New Jersey and Pennsylvania have been asked to contribute as non-federal co-sponsors of the proposed project.*

Below, six cases are considered:

1. The USACE Reanalysis results
2. Case 1 except excluding the MOTIVA refinery

[6] Offsite use of migratory birds using Delaware as a critical stopover or habitat, such as viewing migratory birds in other states, provides public good benefits which are legitimate NED benefits.

3. Case 1 excluding Coastal Eagle refinery
4. Case 1 excluding Phillips refinery
5. Case 1 excluding MOTIVA, Coastal Eagle and Phillips refineries
6. Case 1 except refineries keep 50% of net savings

Hence, Cases 1-6 all draw upon the adapted USACE results but consider several possibilities. Cases 1-5 are based on the assumption that all annual net transportation cost savings are passed forward to petroleum product users, and Delaware gets its commodity-specific share, based on population for the relevant market area. The exception is for Delaware Terminal, which is treated as a special case, with Delaware getting 0.667 of all annual transportation cost savings from this facility.

Case 2 excludes the USACE's estimate of cost savings benefits to MOTIVA. This is because MOTIVA has argued strongly that it will not benefit from the dredging and indeed may experience a cost increase due to additional shoaling at berths because of the dredging[7]. (Also, MOTIVA is partly owned by foreign interests, so that at least some profits should not be included as benefits to US interests.)

Case 3 excludes the Coastal Eagle refinery because it is skeptical that it will benefit from channel deepening, and the Phillips refinery is excluded in case 4 because of its reservations about the benefits it would garner from channel deepening (USACE, pp. C-97-99). Case 5 is a "worst case" in the sense that *all three* of the refineries mentioned are assumed not to benefit from the dredging.

It is possible, of course, that ownership of the above three refineries – or, in fact, of any of the refineries on the Delaware River -- could change hands and interest in dredging by new owners could differ from the current owners. (This could cut both ways, creating more or less interest in dredging.) Still, the USACE argues that the results of its Associated Cost Reasonableness Test clearly suggest the investments required make financial sense for all facilities, based on the USACE's comparison of facility-specific financial benefits and costs.

Again, Cases 1 – 5 assume that all *annual net savings* are passed along to consumers, and Delaware users share in these savings, as described above. In contrast, Case 6 assumes that only 50 % of net savings estimated by the USACE are passed forward to users, with the remaining 50% used to add to company profits. Company profits benefit company shareholders, including Delaware residents.[8]

[7] The USACE strongly disputes MOTIVA's claim and disagreements between the two parties have not been resolved to our knowledge.

[8] We recognize that MOTIVA is partly owned by foreign (Saudi) interests but do not know the share of foreign interest in MOTIVA (or other refineries) or the particulars of the MOTIVA ownership. It is possible, of course that ownership for any refinery may change over the 50-year planning period.

IV.F Results

Table 2 shows the quantifiable benefits and costs for the 6 cases considered and notes that not all benefits or costs can be quantified with available data. Net annual quantifiable benefits range from a high of $977,850 (= $1,019,192 – $41,342) for Case 1 estimates using our adaptation of the basic USACE results to a low of $893,928 (= $935,270- $41,342) for case 6 where Delaware River refineries are assumed to keep 50 % of the annual transportation cost savings as profits, with the other 50% passed on to users.

Table 2. Estimated Annual Benefit and Costs to Delaware from the Proposed Channel Deepening of Delaware Bay and River under Alternative Assumptions

	Case 1[a]	Case 2[a]	Case 3[a]	Case 4[a]	Case 5[a]	Case 6
	USACE's Base Case	Case 1 excl. Motiva	Case 1 excl. Coastal Eagle	Case 1 excl. Phillips	Case 1 excl. Motiva, C.Eagle and Phillips	Case 1 Refineries keep 50% of Profits[d]
Benefits:						
Transportation	$ 414,494[e]	$410,031[e]	$403,017[e]	$370,184[e]	$353,919[e]	$331,572[e]
Broadkill Beach	604,698	604,698	604,698	604,698	604,698	604,698
Total Quantified	$1,019,192	1,014,729	1,007,715	$974,882	958,617	935,270
Kelly–Egg Islands	Unquantified	Unquant.	Unquant.	Unquant.	Unquant.	Unquant.
Cost: Delaware's Share of Annual Federal Cost as Federal Taxpayers ($16.09 Million[b] x .0025 [c])	$ 41,342	$ 41,342	$ 41,342	$ 41,342	$ 41,342	$ 41,342
Unquantified [f]	?	?	?	?	?	?

[a] All USACE estimated *annual net savings in transportation costs* are assumed passed on to product users

[b] Estimated annual federal cost, calculated as NED financial and interest first costs ($219.4 million plus $38.5 million) as share of total economic first cost of $282.1 million ((=0.915) times average annual first economic cost ($17.6 million) plus annual operating and maintenance – project ($3.0 million). (USACE, 2002,Table 5.l)

[c] Delaware's share of US population.

[d] 50% of savings passed forward to consumers; refineries keep 50% of savings as profits

[e] Estimates derived using USACE annual transportation costs savings results and EAI judgments on Delaware's share of these savings. See text for details.

[f] Includes adverse effects to air quality effects because of dredging and other external effects not avoided, mitigated or otherwise offset.

In the former case, then, *all* refinery transportation cost savings benefits are passed forward to users, and Delaware gets its share, as described earlier in the text. In the latter case, only *half* of the refinery transportation cost savings make their way to petroleum product users (including Delaware users); the remainder is retained as profit by refineries. In this case, note that Delaware residents would capture a share (albeit a very small share) of profits – 0.251% -- as direct or indirect shareholders, under the assumption that stock shares are spread equally across the nation, based on population.

To compare net benefits in Table 2 with the share of the proposed Delaware is asked to pay as a non-federal co-sponsor, the annual quantifiable flows in Table 2 must converted to a total present value. We do this next.

Case 1 results in a net present value to Delaware $15,528,393 for quantified benefits and costs. For Case 6, the net present value is $14,195,700. All other cases considered fall between these two. These results are the estimated value to Delaware, today, of all future annual flows of quantifiable benefits and costs over 50 years, under the assumptions used in our analysis, using a discount rate of 5 7/8%[9].

How do these benefits compare with the share of project costs Delaware would pay as a *non-federal co-sponsor*? Delaware has been asked to pay $7.5 million as a non-federal co-sponsor. By our calculations, after Delaware paid the $7.5 million its net benefits would range from $8.03 million (= $15.5 million - $7.5 million) to $6.70 million (= $14.2 million - $7.5 million), depending upon which of the 6 cases in Table 2 is considered most appropriate. The range of net benefits to Delaware of $8.03 to $6.70 million are *present value* calculations and are equivalent to Delaware receiving a lump sum of income of the indicated amounts today, using a discount rate of 5 7/8%.

Stated another way, the quantified benefits and costs for Delaware imply a benefit-cost ratio ranging from 1.89 (=$14.7M/$7.5M) to 2.07 (=$15.5M/$7.5M) to. That is, for every dollar Delaware spends as a non-federal co-sponsor, estimated quantifiable net benefits to the state range from $1.89 to $2.07.

Interestingly, the *annual* quantifiable benefits and costs do not vary substantially from case to case. This is because (1) cost savings to Delaware at Broadkill Beach loom so large and are the same in all cases considered, and (2) Delaware's share of federal project costs as federal taxpayers is the same in every case. Also, (3) Delaware's share of transportation costs savings is relatively small, and Delaware resident's share in any profits companies do not pass forward is very small. Hence, even large percent changes in total (NED) transportation cost savings or their distribution tend to lead to small net changes in benefits to Delaware.

Clearly, the major part of the quantifiable benefits is the cost savings for beneficial uses of dredged material on Broadkill Beach, although estimated transportation costs savings to Delaware are by no means trivial. The fact that Broadkill Beach loom large in the

[9] Because of uncertainty regarding the time on benefits and costs within a given year, each year's benefits and costs are discounted as though they occurred at mid-year (.5,1.5, 2.5, etc.).

above calculations underscores the importance of successfully carrying out these projects. We again note Fleming's (2003) argument that the cost savings benefit at Broadkill Beach might be some 45% less than in the USACE Reanalysis, although we were unable to assess the validity of his argument[10].

It is important to stress that, if correct (and the arguments in Doherty (2003) to us seem compelling) the criticisms by MARITRANS of the USACE Reanalysis -- specifically, that the USACE assessment of costs savings from lightering are vastly overstated – mean that the transportation cost savings for crude oil tankers would largely if not entirely disappear.[11] This would leave only transportation cost savings for non-petroleum commodities (containerized cargo, steel slabs, and blast furnace slag), plus cost savings at Broadkill and unquantified benefits for restoring and protecting Beach and Egg and Kelly Islands. As noted the USACE is in the process of carrying out a reanalysis of this issue, and hence we have not had the benefit of seeing their results.

We also repeat that our analysis omits potential external costs from incremental air emissions from dredging. Part of the State of Delaware (near the Philadelphia metropolitan area) is a air quality non-attainment area (http://www.epa.gov/reg3artd/airquality/2002_naareas.pdf), and emissions of air pollutants would exacerbate Delaware's air quality problems during the dredging period, unless avoided or offset. Omitting this issue understates environmental costs for Delaware.

On the other hand, the USACE points out that not all transportation cost savings benefits have been included. They give, as examples of potential savings, use of Gloucester Marine Terminals, Pier 122, and the Port of Wilmington by deeper draft vessels. However, these possible benefits are unquantified (USACE, 2002, Main Final Report, p. 12).

V. Conclusions

Summarizing and reaching a conclusion for the analysis provided above is somewhat daunting because of the many complex issues involved and the many uncertainties remaining. Given the challenges faced, readers should to take our conclusions in their entirety. We remind the reader that our analysis concerns benefits and costs to Delaware, *not* benefits and costs to the nation – i.e., *not* NED benefits.

Having said this, the available information and the estimates we have made using readily available data and a series of reasoned judgments lead us to conclude that the total

[10] If Fleming (2003) were correct that Broadkill Beach cost savings should be reduced by 45%, the range of net benefits in Table 2 drops to $747.1 thousand for Case 1 to $664.2 thousand for Case 6. The net present value of these cases would fall from $12.4 million to $11.0 million, respectively. Both of these exceed the $7.5 million Delaware is asked to pay as a non-federal co-sponsor. Hence, the benefits would still exceed costs to Delaware in this case.

[11] It is our understanding that the USACE is redoing its analysis of lightering cost savings to take into account MARITRANS criticisms. However, at the present time – September 15 – the outcome of this reanalysis is unavailable and hence is not included in this report.

quantified benefits exceed the quantified costs to Delaware, although we recognize – and re-emphasize -- that several uncertainties remain, including the fact that the USACE apparently is redoing its analysis of vessel lightering issues and costs. The results of this (or other reanalyses or new findings) would, of course, affect our results -- and may or may not affect our conclusions. In addition, there are important non-quantified benefits and costs that also need to be considered. For example, the project would restore and protect habitat on Kelly and Egg islands, which results in benefits that are not quantified by the USACE Reanalysis. On the cost side, dredging operations could result in considerable air pollution in a non-attainment area during the dredging period. These costs are also not quantified.

Delaware presumably will consider the available quantifiable information and compare our estimates of the (present value of) net benefits from deepening with the share the state would be asked to pay as a non-federal co-sponsor. It then will need to decide if the uncertainties and unquantifiable elements (for example, benefits in the case of Kelly and Egg Islands; costs with air emissions and perhaps other unresolved issues) tilt the decision either way. As noted, new or improved information from the USACE on lightering costs or on the cost savings at Broadkill Beach -- if substantially different from the results in the USACE 2002 Reanlaysis and in the analysis used in this report -- would add a new element and may require a reassessment of the conclusions reported on in this document.

VI. References

Delaware Riverkeepers and National Wildlife Federation, 2003. Strike Three … The Corps fails Again to Justify the Delaware River Deepening. (July 14).

Fleming, Richard A., 2003. Delaware Permit Application, U.S. Army Corps of Engineers Delaware River Main Channel Deepening Project. Memo to T. Bureau (July 1), 6 5 pp.

Freeman, A. Myrick III, 2003. *The Measurement of Environmental and Resource Values: Theory and Methods*. Washington, DC: Resources for the Future.

Grigalunas, Thomas A. and Richard Congar, 199.. *Environmental Economics in Integrated Coastal Management: Valuation Methods and Policy Instruments*. Report No. 164. Nairobi: The United Nations Development Programme.

Grigalunas, Thomas A. and James J. Opaluch, 2002. *Proposed Delaware River Channel Deepening Project: Review and Critique of Economic Analysis*. Peacedale, RI: Economic Analysis, Inc.

Just, Richard, Darrell Hueth, and Andrew Schmitz, 1982. *Applied Welfare Analysis*. New York: Prentice Hall.

Kolstad, Charles, 1999. *Environmental Economics*. New York: Oxford University Press.

Kopp, Raymond and V. Kerry Smith, 1993. *Valuing Natural Assets: The Economics of Natural Resource Damage Assessments.* Washington, D.C.: Resources for the Future.

Just, Richard, Darrell Hueth, and Andrew Schmitz, 1982. *Applied Welfare Analysis*. New York: Prentice Hall.

Kolstad, Charles, 1999. *Environmental Economics*. New York: Oxford University Press.

Kopp, Raymond and V. Kerry Smith, 1993. *Valuing Natural Assets: The Economics of Natural Resource Damage Assessments.* Washington, D.C.: Resources for the Future.

MARITRANS, 2003. Letter from Philip J. Doherty, President of MARITRANS to Lieutenant Colonel Thomas Chapman (March 7).

Opaluch, James J., Thomas Grigalunas, Jerry Diamantides, Marissa Mazzotta, and Robert Johnston, 1999. *Recreational and Resource Economic Value*s *for the Peconic Estuary System*. Suffolk County: Dept. of Health, Peconic Estuary Program.

Parson, George R. and D. Matthew Massey, and Ted Tomasi, 2000. "Familiar and Favorite Sites in a Random Utility Model of Beach Recreation", *Marine Resource Economics*, vol. 14: 299-315.

United States Army Corps of Engineers, 2000. ER 1105-2-100.

----------, 1998. *Delaware River Main Channel Deepening Project Limited Reevaluation Report*. US Army Corps of Engineers, Philadelphia District, North Atlantic Division (Feb.).

----------, 2002. *Delaware River Main Channel Deepening Project: Pennsylvania, New Jersey and Delaware: Comprehensive Reanalysis Report.* USACE Philadelphia District, North Atlantic Division (Dec.).

United States Department of the Interior, US Fish and Wildlife Service, 1998. *1996 Net Economic Values for Bass, Trout and Walleye Fishing, Deer Elk and Moose Hunting, and Wildlife Viewing*. Report 96-7. Washington, D.C.: US Fish and Wildlife Service (August).

----------. 2003. *Birding in the United States: A Demographic and Economic Analysis. Addedendum to the 2001 National Surevy of Fishing, Hunting and Wildlife-Associated Recreation*. Report 2001-1. Washington, D.C.: US Fish and Wildlfie Service (August).

United States General Accounting Office, 2002. *Delaware River Deepening Project: Comprehensive Reanalysis Needed* (June).

Weitzman, Martin L., 2001. "Gamma Discounting", *American Economic Review*. 91(1): 260-272.