Appendix M
SocioEconomic Impact Assessment Methods

ECONOMIC IMPACT ASSESSMENT METHODOLOGY

Introduction

This Appendix describes in detail the methodology used to estimate economic impacts of the proposed alternatives. As described in Section 4.1.9, terminating river-based dredging of sand and gravel could result in losses to both the regional and state economy through decreases in industry output, employment, and income. Tax revenues received by the public sector from business activity would also be reduced due to losses in employment and economic activity. Additional impacts to the regional and state economy would arise from price increases for construction sand and gravel, which are non-substitutable materials for a variety of infrastructure projects, including road and bridge construction.[1]

Because the supply of the construction sand and gravel within the Region of Influence (ROI) is limited by geological and social factors (e.g., regulations limiting quarry development and expansion), a large proportion of the replacement material would have to be imported from land-based quarries outside the ROI. The additional transportation costs alone would significantly increase the price of these aggregate materials to end users and would consequently raise the price of construction projects within the region. Although the change in the supply/demand equilibrium would likely further increase the price of sand and gravel (especially in the short-term, if material shortages occur) beyond production and transportation cost increases, both within the region from which the material is imported and in the ROI study area, only potential price increases due to added production and transportation costs are evaluated for this economic impact assessment.

Quantifying the potential economic impacts from the Alternative 3 (No Action) was accomplished using statistical and economic models.[2] Statistical techniques were employed to estimate probable levels of alternative sand and gravel production, the average distance from replacement quarries to the ROI, and the unit costs for transport (price per ton per mile). These variables were then entered into a cost equation and Monte Carlo simulations were performed to estimate probable price levels for sand and gravel products. The price impacts were then entered into an economic input-output model to forecast regional and state-wide economic impacts. The following sections detail how these production and cost estimates were derived and how the economic impact model was used to estimate the overall impacts of the proposed alternative.

ESTIMATES OF POTENTIAL SAND AND GRAVEL PRODUCTION FROM ALTERNATIVE LAND-BASED QUARRIES

Information Sources

Future price levels for the Type A sand, Level E aggregate, and other coarse aggregates would be largely determined by the ability of alternative land-based quarries to expand their production capacity to compensate for the loss of river-based production. Price levels would also be affected by the distance needed to transport the materials from the replacement quarries to Pittsburgh.

---

[1]For example, Level E aggregate is required by PennDOT for use in road surfaces where traffic volumes exceed 20,000 vehicles per day.

[2]Only impacts from the No Action Alternative were modeled, since none of the other proposed alternatives would affect economic activity in the ROI. Accordingly, regional economic output would not change from the baseline level for these other alternatives.

Estimates of potential alternative sand and gravel production were derived separately for Type A sand, Level E aggregate, and coarse aggregates since the three commodities have different geographical distributions and fill different market niches. For example, many of the land-based quarries that produce coarse aggregates can not produce Level E aggregates that meet Pennsylvania Department of Transportation (PennDOT) specifications. In fact, only a small proportion of quarries within the four-state area of Pennsylvania, West Virginia, Ohio, and New York are certified by PennDOT as producers of Level E aggregate for road construction. Those producers have had their products laboratory tested and certified by PennDOT as meeting all specifications for use in highways with average daily traffic of greater than 20,000 vehicles.

The universe of potential replacement sources for each of the three aggregate commodities was identified using information from PennDOT, the Pennsylvania Department of Environmental Protection (PADEP), land-based quarry producers, as well as information from the U.S. Geological Survey. In particular, *Bulletin 14*, published annually by PennDOT, lists all aggregate producers that have demonstrated the capability to produce material meeting the Department's specification for Type A sand, Level E aggregate, and other aggregate products used in state highway construction. This document is particularly useful for identifying the universe of suppliers of Level E aggregate, since this product is used almost entirely in public sector transportation projects.

Information on current output and the potential for expanded output of Type A sand, Level E, and coarse aggregates was obtained from a selected group of land-based producers located within a 150-mile radius of downtown Pittsburgh. Specifically, producers of sand and gravel certified by PennDOT were queried on current annual production for each sand and aggregate product type, their expansion capacity, and their ability to sustain increased production for prolonged periods. Information on pricing and areal extent of market was also obtained when available. This information was combined with other data obtained from publicly available documents such as PennDOT's *Bulletin 14* and Pennsylvania's *Annual Report on Mining Activities* to characterize the market for alternative suppliers of Type A sand, Level E, and coarse aggregates.

Because data collected from quarry producers could not be fully validated and represented only a small percentage of the universe of land-based facilities, statistical modeling techniques were applied to develop probability distributions around the mean value of each data set (i.e., production, expansion, and cost data). This effort was accomplished using the commercial software package *Crystal Ball*, which allows users to run Monte Carlo simulations to forecast a full range of results for a given situation. By performing these simulations on each of the input parameters, the analysis was able to take into account the high-level of uncertainty associated with each input variable.

The methodology employed in this analysis can be seen in the derivation of the estimates for current production and potential expansion of coarse aggregates. The following sections provide a step-by-step discussion on how estimates for current production, expanded production capacity, transportation distances and costs, and total costs were derived for replacement of coarse aggregates. The same analytical techniques were performed on data for Level E aggregates and Type A sand.

Estimates of Current Production and Expanded Output Capacity

The first step of the analysis involved calculating basic statistics (i.e., mean and standard deviation) for current output data representing 40 land-based producers of coarse aggregates.

Log transformations were performed on the coarse aggregate production data and confidence intervals were constructed around the geometric mean of 228,000 tons (annual production).

A similar procedure was applied to data collected on quarry expansion capacities. Data provided by land-based quarries indicated that on average these alternative sources could increase output by about a third. An analyses of the expansion data using the software package *Crystal Ball* indicated that the normal distribution curve was the best fit for these data and from which a mean, standard deviation, and confidence intervals were derived.

Using the results from these two steps, a forecast for total tonnage output was generated using Monte Carlos simulations. A total of over 5,000 trials were run on the input data (current output multiplied by expansion capability) to estimate the potential expansion output for each of the candidate alternative sources of coarse aggregate. These same procedures were used on data for Type A sand and Level E aggregate.

As presented in Table M-1, the Monte Carlo simulation results indicate that land-based quarries would on average be able to increase production of coarse aggregates by about 75,700 tons. Annual increases in the output of Level E aggregate and Type A sand would average about 45,750 and 40,400 tons, respectively. These output levels represent the mostly likely increases given the population distribution of land-based quarries evaluated for this analysis. Because the Monte Carlo simulation provides a distribution of outcomes, increased quarry output levels of the 10th and 90th percentiles are shown in parenthesis. These estimates reflect production increases that are greater than one standard deviation from the "true population" and hence, they represent less probable scenarios for average production increases than output levels reflected by the 50th percentile.

Table M-1
Facility Expansion Capacity for Coarse Aggregates,
Level E Aggregates, and Type A Sand - 50th percentile*

Product	Forecasted Expansion Output
Coarse Aggregates	**75,700 tons** (46,300, 118,200)
Level E Aggregates	**45,750 tons** (21,750, 73,400)
Type A Sand	**40,400 tons** (16,700, 94,400)

*Numbers in parenthesis reflect output at 10th and 90th percentile, respectively.

Estimating Transport Distances

The next step was to determine the average distance from the replacement sources to the city of Pittsburgh. Using the information from Pennsylvania Geological Survey, including specific geographical location information, all of the land-based producers of coarse aggregate were entered into a database and sorted by increasing mileage distance from the center of Pittsburgh[3]. The average estimated expansion capacity for land-based producers of coarse aggregate (75,700

[3] Because the final destinations of the transported material are not known and would change over time, depending on ongoing construction projects, the center of Pittsburgh was selected as the final destination point for land-based sand and gravel. As noted later, a correction factor was used to account for transport distances to points within the ROI that would be shorter or longer than delivering to central Pittsburgh.

tons) was then used to determine the most likely number of quarries needed to make up for the short-fall.

The "available tonnage" was sequentially added up, beginning with the closest company to Pittsburgh, until the total equaled the lost tonnage. This step was performed for each of the three-output levels shown in Table M-1. The analysis determined that there potentially exists sufficient output capacity to replace the loss of river-based production, although the transport distances vary significantly among the three products. The estimated mileage distances from quarries to Pittsburgh for each of the commodities is seen in Table M-2.

Table M-2
Average Distance to Meet Production Losses - 50th Percentile*

Product	Average Transport Distance
Coarse Aggregate	**31.4** miles (36.3, 26.7)
Level E Aggregate	**92** miles (142, 61)
Type A Sand	**78.6** miles (140, 67)

*Numbers in parenthesis reflect output at 10th and 90th percentile, respectively.

To account for the fact that potential users of the replacement sand and gravel, including concrete processing plants and construction sites, are mostly situated at locations other than the center of Pittsburgh, a mileage correction factor was incorporated into the analysis. For example, a concrete plant located on the outskirts of Pittsburgh would be closer to the quarries then a hypothetical site located in the center of Pittsburgh. The correction factor used in the analysis is based primarily on the location of existing processing plants and the size of the ROI. A mileage correction factor ranging from 5 to 25 miles was considered reasonable for purposes of this analysis. This mileage correction factor was applied to cost equations for all three of the material types.

Estimating Baseline and Future Prices for Sand and Gravel Products

The analysis assumes that future price levels would be a function of current Free on Board (FOB) price, incremental transport costs, and increased production costs due to expansion costs. FOB is the price paid for a product at the point of sale and serves as the baseline price for this analysis. Quoted FOB prices for sand and gravel differed among the different producers and it was necessary to calculate an average price. Using 1998 data on FOB price per ton, basic statistics were calculated. A normal distribution was fitted to the data with a mean price of $8.02/ton, and a standard deviation of $0.13. Using the same methodology, the 1998 FOB estimated mean prices for Type A sand and Level E aggregate were $6.33/ton and $8.02/ton, respectively.

Because shipping costs are quoted in price per ton per mile, transportation costs to haul aggregate material over a fixed distance would be the same for all three commodities. Using data obtained from producers of land-based aggregate material and from the dredging corporations, a mean price of $0.125/ton/mile to ship by truck was derived. Confidence intervals were built around the mean and, assuming a normal distribution of price, a standard deviation of $0.02 was calculated. This average price and distribution was applied to transportation costs for all three material types.

An expansion cost factor was estimated for all three materials. Increasing production would require additional capital and labor costs. In addition, for producers of Level E and Type A sand who also produce coarse aggregates, there may be insufficient demand for the coarse aggregate material and they may be forced to stock pile unused supply. The reason for this potential oversupply is that a quarry producing Level E aggregate typically produces significant quantities of coarse aggregate as a by-product. However, because most Level E producers are located further away from the Pittsburgh area than land quarries producing only coarse aggregates, they would be at a cost disadvantage and may not be able to market all of their product. They would then have to stockpile their surplus coarse material at increased cost. This problem also applies to producers of Type A sand.

Expansion cost factors were developed based on information supplied by producers. Expansion costs for coarse aggregates would increase total costs by a factor of 1.2 (twenty percent increase); the expansion cost factor for the other two commodities was estimated at 1.5 (fifty percent increase). To account for the significant uncertainty associated with these estimates, triangular distributions were applied. For example, for coarse aggregate a triangular distribution was fitted to this 1.2 estimate with the most likely value being 1.2 and least likely values being set at 1.0 (no increase in unit cost) and 1.4 (forty percent increase).

The final step to estimate change in total cost for the three aggregate commodities involved inputting the distance factors and cost variables into a simple equation and performing Monte Carlo simulations (approximately 5,000 trials) to take into account the large degree of uncertainty associated with each of the input variables. The equation shown below simply combines the variables described above. That is, the future price of sand and gravel is a function of the baseline price plus transportation costs and expansion costs. As noted above a correction factor is used to account for the fact that transport of the material could be to destinations other than downtown Pittsburgh. The Monte Carlo simulation provides estimates of the most likely new price (50th percentile) as well as lower and higher, but less probable, price levels.

Equation M-1

$FP_{ca}=(((A-B)*C)+(D*E))$

Where:

$FP_{ca}=$ Future price level for coarse aggregate
A= Average number of miles to downtown Pittsburgh from the land based quarries at the 50th percentile
B= Mileage correction factor
C= Cost per ton per mile to transport the material by truck
D= 1998 FOB cost per ton for coarse aggregate
E= Expansion factor

The resulting costs per ton for coarse aggregate are provided in Table M-3.

Table M-3
Estimated Future Prices for Coarse Aggregate

Percentile	Future Price
10th	$10.58
50th	$11.87
90th	$13.18

These costs were then applied to the total tonnage of replacement material to estimate the projected increase in costs to end users of coarse aggregate material. Using the same methodology described above, incremental costs were also derived for Type A sand and Level E aggregate. The price changes for all three commodities are shown in Table M-4. Price increases were then entered into the economic input-output model to project the impacts of the price increases on the regional and state economy.

Table M-4
Projected Price Changes for Aggregates

Material	FOB Price (1998)	Projected Price	Price Increase	Percentage Increase
Coarse Aggregates	$ 8.02			
10 Percentile		$ 10.58	$ 2.56	32%
50 percentile		$ 11.87	$ 3.85	48%
90 Percentile		$ 13.18	$ 5.16	64%
Type A Sand	$ 6.33			
10 Percentile		$ 15.10	$ 8.77	139%
50 percentile		$ 17.63	$ 11.30	179%
90 Percentile		$ 20.30	$ 13.97	221%
Level E	$ 8.02			
10 Percentile		$ 17.17	$ 9.15	114%
50 percentile		$ 21.72	$ 13.70	171%
90 Percentile		$ 26.35	$ 18.33	229%

OVERVIEW OF ECONOMIC INPUT-OUTPUT ANALYSIS

Economic impacts of the proposed dredging alternatives were quantified using an Input-Output (I-O) model. I-O modeling is an analytical technique that can be used to measure the economic changes resulting from proposed public or private sector actions including public policies (e.g., tax changes, natural resource management), construction and operation of new facilities, and industry relocation. Most economic impact analyses performed for Environmental Impact Statements employ I-O models, because the technique can be used to capture the range of direct and indirect impacts resulting from a change in economic activity or public policy.

I-O models explicitly consider the interrelationships between industrial sectors and how those relationships affect economic changes in the region. Transactions tables, which summarize the trade among industry sectors, form the framework for I-O Models. The national I-O tables produced by the Bureau of Economic Analysis (BEA), are based on extensive survey data and are updated approximately every 5 years. Regional transaction tables are also generated through both survey and non-survey techniques.

Transaction information is displayed in a matrix with purchasing industries detailed across the top of the table and producing industries listed down the side. The I-O system is a double entry accounting system in which the output of one industry is the input for another. In short, the transactions table describes the supply and demand relationships of an economy in equilibrium. The transactions table also includes final demand sectors, including households. The household column represents total purchases of finished goods and services by sector, while the household row reflects wages and salaries paid to workers.

While the transactions table provides useful information, its analytical utility arises from its use in deriving the direct coefficients matrix, which in turn is used to estimate the direct and indirect requirements table. It is the direct requirements table that provides the total value of the change in each sector's output per dollar change in final demand. For example, a total requirements table will provide estimates of increases in output in every sector resulting from a one dollar increase in demand for construction. Depending on the availability of data, I-O models can be used to trace how impacts originating in one sector are transmitted throughout the economy.

IMPLAN (IMpact Analysis for PLANning)

There are a number of commercial and government developed I-O models that are available for performing economic impact analysis, including RIMS II (regional input-output modeling system developed by the Bureau of Economic Analysis), EIFS (Economic Impact Forecasting System developed by the Army Corps of Engineers), REMI (Regional Economic Models Inc.) and IMPLAN (originally developed by the USDA). IMPLAN was selected from this group based on project level of effort, model cost, and data availability.

The IMPLAN model, which was originally developed by the United States Department of Agriculture Forest Service in cooperation with the Federal Emergency Management Agency and the United States Department of Interior Bureau of Land Management to assist the Forest Service in land and resource management planning. The model was initially run on a government mainframe computer, but has been significantly revised and updated by the Minnesota IMPLAN Group (MIG). The current version is a fully interactive and PC-based system capable of producing input-output accounts and input-output models for any region in the United States as small as a county. The system consists of regional data bases and software that allow users to develop these models for the purposes of describing the structure of regional economies and/or predictive analyses, particularly those associated with estimating the economic impacts of a quantifiable change in regional production. The IMPLAN system is currently used by numerous Federal and State governments, academic researchers, and private firms to perform a wide range of economic impact analyses.

The IMPLAN model is a regional input-output model that is derived by using local data combined with national input-output accounts. The model assumes that the sets of inputs an industry uses in its production process does not differ substantially across different regions. Hence, the industrial technology implied by the national accounts is applicable to sub-national regions. The regional model is differentiated from the national model through adjustment of trade flows between the region and the rest of the world. Estimating the volume of trade for a sub-national area is accomplished using a variety of techniques, including location quotients, partial surveys, and supply-demand pooling. The Regional Purchase Coefficient (RPC) procedure employed in the IMPLAN system is based on the characteristics of the region and describes the actual trade flows for a region mathematically. An RPC represents the proportion of local demand purchased from local producers. An RPC of 0.25 for a given commodity means that for each $1 of local need for that commodity, 25 percent will be supplied by local producers. Each commodity produced in a region has an associated RPC which is determined by a set of econometric equations and used to estimate trade flows (imports and exports). Trade flow affects the amount of local commodity production available to industries and thus affects the elements of the transactions matrix, which in turn affects the direct requirements matrix.

The IMPLAN model employs the above methodology to trace economic changes in a regional economy arising from changes in the level of activity in one or more identified sectors. The model uses county-level data to adjust the national income accounts to fit the trade flow characteristics of the subnational "region of influence" (ROI) for the study. The analyst develops an ROI based on various factors, including residential distribution of the directly affected workforce, and trading and commuting patterns. ROIs are typically an aggregation of one or more counties, since the county is the smallest jurisdiction for which most economic data are collected. IMPLAN estimates economic changes for the defined ROI and quantifies changes to the following economic indicators:

Sector output. The value of an industry's total production. Output can be measured either by the total value of purchases by intermediate and final consumers, or by intermediate outlays plus value added. Output can also be thought of as the value of sales plus or minus inventory. Data used in the IMPLAN model was derived from Census data and Bureau of Labor Statistics employment projections.

Employment. The single number of jobs expected. Data used in the IMPLAN model were derived from employment security data, BEA county business patterns, and Regional Economic Information System (REIS) data.

Personal Income. All forms of employment income. In Input-Output analysis, personal income is the sum of employee compensation and proprietor income.

Total Value Added. Encompasses payments made by industry to workers, such as interest, profits, and indirect business taxes. It is a sum of the four other indicators: employee compensation, proprietary income, other property type income, and indirect business taxes.

Employee Compensation. Describes the total payroll costs (including benefits) of each industry in the region.

Proprietors Income. Consists of payments received by self-employed individuals as income.

Other Property Income. Other property type income consists of payments from rents, royalties, and dividends paid by corporations.

Indirect Business Taxes. Indirect business taxes consist primarily of excise and sales taxes paid by individuals to businesses.

Economic impacts to the regional economy as measured by changes to these indicators can be estimated for every sector in the regional economy or aggregated to the level desired. Although the input-output analysis performed for this environmental impact statement is based on 298 industries within the economic ROI, the analytical results have been aggregated to 10 industrial and service sectors including the government sector. Aggregation provides a clearer picture of the breadth and magnitude of the impacts, since many of the 298 individual sectors would be of little or no perceptible impact.

The economic impact analysis presented in Section 4 evaluated the No Action Scenario, which assumes that all dredging operations on the Allegheny and Ohio Rivers would be terminated. Using production and financial information provided by the dredgers, employment reductions for the sand and gravel sector were entered into the IMPLAN model that was constructed for the three-county region comprising the socioeconomic ROI. The employment reduction was modified to take into account that some new jobs would be created by land-based coarse aggregate producers located within the ROI. As noted in Section 4, most of the substitute material would originate from outside the ROI. Table M-5 provides an example of the IMPLAN output. This particular table is an aggregated version of the types of information generated by the model. As noted above, the model estimated employment changes for all 298 industries located within the ROI (obviously, there would be no change in employment for the majority of sectors)

Economic impacts were also estimated due to prices increases. Because most of the dredger's product is ultimately used by public sector agencies (e.g., by PennDOT) for road construction and rehabilitation, the IMPLAN model was used to estimate household income losses resulting from higher transportation costs. The analysis assumed that PennDOT would continue its transportation projects as planned, but would pass on any increased costs to the state taxpayers in the form of increased taxes. Because state highways are funded at the state level and funded by all taxpayers, the region of influence for this specific economic impact would be at the state level.

Although cost changes would also effect local road construction, data are not sufficiently available to model these impacts. Similarly, the proposed alternatives could affect barge traffic on the Ohio and Allegheny Rivers resulting in job and income changes to the Pittsburgh Port Authority and the Pennsylvania Boat and River Commission. Because the magnitude of these potential impacts are uncertain, the analysis addressed these issues qualitatively.

Table M-5
No Action Alternative Employment Impact - Aggregated Report

Sector	Direct	Indirect	Induced	Total
Agriculture	0	-0.56	-0.42	-0.98
Mining	-214	-1.69	-0.13	-215.82
Construction	0	-7.75	-2.06	-9.81
Manufacturing	0	-6.45	-2.34	-8.79
Transportation, Communication, Public Utilities	0	-14.98	-3.28	-18.26
Trade	0	-23.23	-40.57	-63.8
Finance, Insurance, Real Estate	0	-9.46	-8.97	-18.43
Services	0	-28.63	-45.68	-74.31
Government	0	-1.00	-1.26	-2.26
Other	0	0	-1.28	-1.28
Total	-214	-93.75	-105.99	-413.74