ASSESSMENT OF TECHNOLOGIES FOR REDUCING AIR EMISSIONS FROM SHIP AND PORT OPERATIONS IN THE BALTIMORE AIR QUALITY NONATTAINMENT AREA

FINAL REPORT

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I. INTRODUCTION AND BACKGROUND

This report is a summary of the work performed as the second phase of a project for the Maryland Environmental Service (MES) and the Maryland Port Administration (MPA) to: 1) Characterize the emissions from the operation of commercial ships calling on the Port of Baltimore and MPA landside operations at the public marine terminals in the Port of Baltimore, and 2) To identify potential emission reduction opportunities.

The objectives of the Phase I analysis were to:

1. Compare the emissions produced by transporting cargo on a commercial ship traveling 100 miles to the emissions that would be produced by transporting the same goods by truck and/or rail.

2. Estimate the emissions from ships in the Baltimore non-attainment area.

3. Estimate the emissions from landside operations under direct control of the MPA at the public terminals of the port.

4. Document actions that have been, are being, and may potentially be taken in the future, and their benefits, to help reduce emissions from ship and MPA operations in the Baltimore non-attainment area.

5. Provide descriptions of the latest documented information on the health effects of pollutants that can potentially be associated with diesel emissions.

The objective of the Phase II assessment described in this report was to identify one or more viable technology candidates that can be implemented in the near term to reduce engine emissions from MPA ship and port operations in the Baltimore Air Quality Nonattainment Area. Since Baltimore is an ozone nonattainment area, oxides of nitrogen (NOx) reduction is a primary concern and reductions of volatile organic compounds (VOCs) are a secondary concern. While Baltimore is currently in attainment for particulate matter (PM), PM reductions that result from NOx and VOC reduction technologies are also desirable. In addition, the Maryland Department of the Environment (MDE) will be establishing new baseline emission inventories for 2002 to prepare for the need to address future new U.S. EPA air quality regulations related to fine PM, the 8-hour ozone standard, air toxics control, regional haze, sulfur dioxide (SO2), and ammonia. Thus, as the emissions from light-duty vehicles and light-duty trucks decrease and the focus on meeting National Ambient Air Quality Standards and other related air quality concerns increases, emissions from nonroad engines and equipment (of the type operating at the Port of Baltimore) are becoming increasingly more important, as is the potential emission reduction opportunities from nonroad sources in the Baltimore area.

II. CANDIDATE TECHNOLOGIES

Initial candidate technologies identified in the Phase I work and further considered in the Phase II assessment were grouped into two categories: 1) Fuels and, 2) Retrofit Technologies, as follows:

FUELS

- Compressed natural gas (CNG)
- Electricity (for ship-to-shore gantry cranes)
- Biodiesel – B20
- Fuel additives and modifiers
- E85 (for spark ignition engine vehicles)

RETROFIT AFTERTREATMENT TECHNOLOGIES (in conjunction with ultra-low sulfur diesel fuel)

- Diesel particulate matter (PM) filters
- Diesel oxidation catalysts (DOCs)
- NOx-reducing catalyst products

In addition, fuel cells fueled with natural gas were also considered as a potential candidate for providing shore power as an alternative to using ship auxiliary engine power for hoteling functions at dockside.

III. FACTORS CONSIDERED

A number of factors were considered because of their importance to the technology selection and implementation process. Current (2003) diesel fuel/equipment technology was used as the baseline for comparison. Factors considered were organized into five categories, Facility Factors; Operating and Maintenance Factors; Cost and Economic Factors; Safety and Environmental Factors (with the primary emphasis on NOx reduction and technologies that have been verified under the EPA's Diesel Engine Retrofit Program); and Implementation and Market Factors, as shown below:

FACILITY FACTORS

- Operating facility modifications needed
- Maintenance facility modifications needed
- Space needs for additional equipment

VEHICLE/EQUIPMENT OPERATING AND MAINTENANCE FACTORS

- Operating performance
- Operating range
- Ability to accept variation in duty cycle operating characteristics
- Fuel economy
- Additional maintenance requirements
- Warranty implications
- Fueling facility maintenance requirements
- Personnel training requirements

COST AND ECONOMIC FACTORS

- Minimum threshold requirements to implement a meaningful program
- Availability of incentives to assist implementation
- Incremental vehicle/equipment costs
- Incremental fuel costs
- Fueling infrastructure costs
- Costs for any required facility improvements
- Training costs
- Incremental annual vehicle/equipment maintenance costs
- Incremental annual fueling facility maintenance costs
- Incremental maintenance product inventory costs
- Economic benefits to Maryland

SAFETY AND ENVIRONMENTAL FACTORS

- Emission reduction benefits
- Ability to use emission reduction benefits re EPA requirements (e.g., SIP, conformity, TIP, etc.)
- Depth of knowledge base and understanding of health and safety aspects
- Safety and security considerations

IMPLEMENTATION AND MARKET FACTORS

- Implementation complexity
- Implementation timing issues
- Product availability
- Technology extinction considerations
- Technology supplier considerations
- Potential to influence private terminal operators
- Intermodal/roadways impact
- Impact on future growth
- Media interest and public perception of improvement
- Fuel supplier considerations

IV. ASSESSMENT APPROACH

The approach used in the assessment focused on setting priorities and importance levels to serve as screening functions for the technology selection process. In this process, the accuracy of attributes and characteristics of each technology is less important, initially. Accuracy becomes more important after the screening process has been performed to a point where a few good technology candidates have been identified. The process resulted in the best technology choice(s) that could be made for the operating constraints that needed to be respected. This approach also lends itself to ease of future updating and re-evaluation as new technology information becomes available, and/or budgetary factors or operating constraints change.

A two-level screening process was used to arrive at the technology candidates to be considered for implementation: 1) a technology and experience screen, and 2) an emission reduction and cost-effectiveness screen. The first screen provided a comparative assessment of technology features and attributes that resulted in a summary ranking of all of the technologies. Sufficient characterization of each technology for the first screen was accomplished to identify any previous experience constraints or operating constraints that would have an impact on application of a technology for further consideration for the second screen.

The second screen defined the level of NOx emission reductions that would likely result from implementing the technologies resulting from the first screen, the annualized cost that would be needed to achieve those reductions, and the cost effectiveness associated with those reductions. Accomplishing the second screen required that the emission inventory developed during the Phase I assessment be used to characterize the emissions output for the collection of equipment that is to be considered for adoption of the selected emission reduction technology(ies). Table 1 represents the emissions inventory developed from the Phase I assessment.

Table 1 – Emissions Inventory for MPA Public Port Operations

Source	**Emission Inventory, Tons Per Day**			
	VOCs	**CO**	**NOx**	**PM**
WATER-SIDE OPERATIONS:				
Ship Propulsion	**0.081**	**0.503**	**1.96**	**0.051**
Ship Auxiliary Engines	**0.015**	**0.180**	**2.26**	**0.056**
Hoteling at Dockside	**0.012**	**0.150**	**1.87**	**0.046**
Total From Ship Operations	**0.108**	**0.833**	**6.09**	**0.153**
Tug Operations	**0.036**	**0.106**	**1.08**	**0.027**
TOTAL WATER-SIDE OPERATIONS	**0.144**	**0.939**	**7.17**	**0.180**
LAND-SIDE OPERATIONS:				
Gantry Cranes	**0.030**	**0.054**	**0.371**	**0.013**
Passenger Cars and Light Trucks	**0.001**	**0.014**	**0.002**	**---**
Medium and Heavy Duty Trucks	**0.001**	**0.007**	**0.002**	**---**
Ground Service Equipment	**0.002**	**0.008**	**0.023**	**0.001**
TOTAL LAND-SIDE OPERATIONS	**0.034**	**0.083**	**0.398**	**0.014**
TOTAL SHIP AND PORT OPERATIONS	**0.18**	**1.02**	**7.57**	**0.19**

The shaded areas of Table 1 illustrate the opportunities for application of emission reduction technologies that MPA had the best opportunity to influence: tug operations and landside operations. Within land-side operations, note from Table 1 that the ship-to-shore gantry cranes and ground service equipment categories are the top two sources of emission producers, and thus are prime candidates for considering opportunities for emission reductions under the screening process described. Large, ship-to-shore gantry cranes operate at four MPA facilities: Seagirt Marine Terminal, Dundalk Marine Terminal, and the marine terminals at South Locust Point and North Locust Point. The gantries at Seagirt are electrified and thus produce no diesel engine emissions at the Port. The gantries at both the North Locust Point and South Locust Point marine terminals are expected to be phased out of service, thus leaving the diesel engine gantries at the Dundalk Marine Terminal the only ones to consider as part of this assessment.

Relative to ground service equipment, the Port operates a wide variety of diesel-engine powered equipment ranging from yard jockeys that move containers from dockside to various storage and truck/rail locations, to a collection of small equipment used for grounds maintenance and other functions. Of this ground service equipment, the yard jockeys comprise the largest group of emissions producers, and represent a good focal point for considering the application of emission-reducing technologies. The remaining ground service equipment, as a group, is too diverse and impractical to consider for application of emission-reducing technologies.

V. REQUIREMENTS FOR THE FIRST SCREEN

To complete the process required for the first screen, a matrix was developed to array the list of Initial Candidate Technologies described in Section II across the top of a table, and the list of Factors for Consideration along the left side. The blocks formed by the intersections of the Technology columns and Factors for Consideration rows create the space needed to provide a summary characterization for that block. Summary characterizations for this table were developed from most recent available and accessible data. Appendix A represents the completed matrix.

Once the technology characterization work was completed, another column was inserted into the matrix. This column provided an "importance weighting" for each of the Factors for Consideration. The weighting factors ranged from 1 to 3, with 3 indicating the "most important" weighting of importance, and 1 indicating the "least important". At this point, the characterizations contained in each of the blocks formed by the intersections of the Technology columns and Factors for Consideration rows were converted to a numerical rating comparing each characterization to that of conventional fuel and equipment. The rating scheme used "0" to signify that the characteristic is about the same as conventional fuel/equipment, and "+1" and "+2" to indicate that the characteristic is "moderately better" or "significantly better" than conventional fuel/equipment. A scale of "-1" and "–2" was used to indicate that the characteristic is "moderately worse" or "significantly worse" than conventional fuel/equipment. For cases where an extreme difference from conventional fuel/equipment was observed, a rating of "+3" or "–3" was used.

The last step in this first screening process involved performing the math required to obtain weighted ratings for each of the characteristics, then summing the weighted values of all of the characteristics for each technology to obtain final ratings and ranking of all of the technologies. Table 2 provides a summary of the results of the first screen. Appendix B contains the ratings and rankings for each of the technologies and individual factors for consideration.

Table 2 – Results of First Screen

Port Operations Category	Most Highly Ranked Technologies
Dundalk Gantry Cranes	• Electrification • Exhaust aftertreatment products • Biodiesel B20
Tug Boat Operations	• Exhaust aftertreatment products • Biodiesel B20
Ground Service Equipment	• Exhaust Aftertreatment products • Biodiesel B20

VI. REQUIREMENTS FOR THE SECOND SCREEN

The process for the second screen identified the most desirable virtues of the most highly ranked technologies for each Port operation category (tug operations, ship-to-shore gantries, and ground service equipment) evaluated in the first screen. Those virtues were:

- Affordable cost
- Cost-effectiveness within the range of typical reasonable values (generally between $5,000 to $20,000 per ton)
- Ability to qualify for U.S. EPA emission reduction credits
- High probability of success for achieving measurable emission reductions
- Near-term availability for early implementation
- Minimal product warranty concerns
- Minimal complications for implementation
- Ability to enhance relationships with industrial neighbors and facility users
- Potential to leverage outside funding sources

Tables 3, 4, and 5 present the results of the second screen, in terms of:

- Estimates of potential daily and lifetime emission reductions for each of the top-ranked technologies (for each Port operation category) identified from the first screen.
- Estimates of capital costs and operating/maintenance costs. Costs for aftertreatment technologies also include the incremental cost of using ultra-low sulfur (15ppm maximum sulfur content) diesel fuel (ULSD) through the 2010. After 2010, ULSD is planned by the U.S. EPA to be mandatory for use in non-road vehicles and equipment.
- Estimates of lifetime cost effectiveness for each of the technologies considered.
- Estimates of the economic development benefit to the State of Maryland (in terms of the amount of the net implementation cost that would be spent to support Maryland businesses).

Recall from the Introduction section of this report, that NOx emissions were emphasized as the initial focus of concern relative to the potential for emission reductions. As such, the NOx reduction technologies shown on Tables 3, 4, and 5 were given primary consideration relative to calculation of cost effectiveness. All NOx reduction technologies also provide a reduction in VOC and PM emissions, as shown on Tables 3, 4, and 5. For the NOx reduction technologies, calculations of VOC and PM reduction cost-effectiveness were also performed, even though there is no real expenditure made specifically to achieve the VOC and PM reduction benefits.

Note also from Tables 3, 4, and 5 that there are several technologies that provide PM and/or VOC reduction benefits, but no NOx reductions. This result is attributable to the relatively high ranking of those technologies from the application of the requirements for the second screen.

For the reasons described above, Tables 3, 4, and 5 also list emission reduction and cost-effectiveness calculations for the sum of VOC, NOx and PM. These calculations provide a more balanced view to valuing and comparing the cost-effectiveness of the emission reduction technologies resulting from the second screen.

Table 3 – Second Screen Results for Dundalk Gantry Cranes

Technology and Net Implementation Cost – $millions	**Daily (Tons/Day) and Lifetime (Tons) Emission Reductions, and Cost Effectiveness ($/Ton)**				**MD Econ. Devel. Benefits - $1,000's**
	VOC	**NOx**	PM	**VOC+NOx +PM**	
ELECTRIFICATION - $12.3M • **Daily Emission Reduction** • **Lifetime Emission Reduction** • **Lifetime Cost Effectiveness**	0.005 32 $383,750	**0.094** **566** **$21,696**	0.004 21 $584,762	**0.103** **619** **$19,838**	$5,720
AFTERTREATMENT (DOC) - $0.153M • **Daily Emission Reduction** • **Lifetime Emission Reduction** • **Lifetime Cost Effectiveness (W/ULSD)**	0.004 25 $6,137	**0** **0** **INF**	0.002 9 $17,048	**0.006** **34** **$4,513**	$15.3
AFTERTREATMENT (PM FILTER) - $0.538M • **Daily Emission Reduction** • **Lifetime Emission Reduction** • **Lifetime Cost Effectiveness (W/ULSD)**	0.005 29 $18,549	**0** **0** **INF**	0.003 19 $28,312	**0.008** **48** **$11,207**	$140.2
AFTERTREATMENT (NOx CAT) - $0.442M • **Daily Emission Reduction** • **Lifetime Emission Reduction** • **Lifetime Cost Effectiveness (W/ULSD)**	0.004 25 $17,677	**0.019** **113** **$3,911**	0.003 17 $25,996	**0.026** **155** **$2,851**	$44.2
BIODIESEL (B20) - $0.432M • **Daily Emission Reduction** • **Lifetime Emission Reduction** • **Lifetime Cost Effectiveness**	0 0 INF	**0** **0** **INF**	0.003 17 $25,434	**0.003** **17** **$25,434**	$43.2

Table 4 – Second Screen Results for Tug Boat Operations

Technology and Net Implementation Cost – $millions	**Daily (Tons/Day) and Lifetime (Tons) Emission Reductions, and Cost Effectiveness ($/Ton)**				**MD Econ. Devel. Benefits - $1,000's**
	VOC	**NOx**	PM	**VOC+NOx +PM**	
AFTERTREATMENT (DOC) - $0.245M • **Daily Emission Reduction** • **Lifetime Emission Reduction** • **Lifetime Cost Effectiveness (W/ULSD)**	0.029 176 $1,391	**0** **0** **INF**	0.011 64 $3,825	**0.040** **240** **$1,020**	] $24.5
AFTERTREATMENT (PM FILTER) -$ 0.309M • **Daily Emission Reduction** • **Lifetime Emission Reduction** • **Lifetime Cost Effectiveness (W/ULSD)**	0.033 198 $1,559	**0** **0** **INF**	0.024 144 $2,144	**0.057** **342** **$903**	$45.3
AFTERTREATMENT (NOx CAT) - $0.292M • **Daily Emission Reduction** • **Lifetime Emission Reduction** • **Lifetime Cost Effectiveness (W/ULSD)**	0.029 176 $1,663	**0.380** **1,292** **$227**	0.021 128 $2,287	**0.430** **1596** **$38**	$29.3
BIODIESEL (B20) - $1.24M • **Daily Emission Reduction** • **Lifetime Emission Reduction** • **Lifetime Cost Effectiveness**	0 0 INF	**0** **0** **INF**	0.021 128 $9,656	**0.021** **128** **$9,656**	$123.6

Table 5 – Second Screen Results for Yard Jockeys

Technology and Net Implementation Cost – $millions	**Daily (Tons/Day) and Lifetime (Tons) Emission Reductions, and Cost Effectiveness ($/Ton)**				**MD Econ. Devel. Benefits - $1,000's**
	VOC	**NOx**	PM	**VOC+NOx +PM**	
AFTERTREATMENT (DOC) - $0.091M					$9.1
• **Daily Emission Reduction**	0.0006	**0**	0.0002	**0.0008**	
• **Lifetime Emission Reduction**	1.8	**0**	0.6	**2.4**	
• **Lifetime Cost Effectiveness (W/ULSD)**	$49,610	**INF**	$152,137	**$37,411**	
AFTERTREATMENT (PM FILTER) - $0.171M					$45.9
• **Daily Emission Reduction**	0.0007	**0**	0.0003	**0.0010**	
• **Lifetime Emission Reduction**	2.1	**0**	1.4	**3.5**	
• **Lifetime Cost Effectiveness (W/ULSD)**	$82,745	**INF**	$126,876	**$50,083**	
AFTERTREATMENT (NOx CAT) - $0.139M					$13.9
• **Daily Emission Reduction**	0.0007	**0.0020**	0.0003	**0.0030**	
• **Lifetime Emission Reduction**	1.8	**6.0**	1.2	**9.0**	
• **Lifetime Cost Effectiveness (W/ULSD)**	$75,697	**$23,137**	$116,069	**$15,323**	
BIODIESEL (B20) - $0.221M					$22.1
• **Daily Emission Reduction**	0	**0**	0.0003	**0.0003**	
• **Lifetime Emission Reduction**	0	**0**	1.2	**1.2**	
• **Lifetime Cost Effectiveness**	INF	**INF**	$184,252	**$184,252**	

VII. RESULTS, DISCUSSION AND RECOMMENDATIONS

Results from the second screen formed the basis for the technologies that were recommended to be considered for implementation. Results of the second screen analysis can be summarized as follows:

DUNDALK GANTRY CRANES

- The best overall emission reductions are provided by electrification, but at a very high implementation cost (over $12 million) and emission reduction cost effectiveness in the range of tens-to-hundreds of thousands of dollars per lifetime ton.
- Comparable VOC and PM emission reductions can be provided by aftertreatment technologies at substantially lower implementation cost (half-million dollars or less).
- Aftertreatment NOx catalysts are the second best technology for NOx reduction, and can be implemented for a cost of less than a half-million dollars, with emission reduction cost effectiveness of less than $4,000 per lifetime ton.
- Biodiesel B20 provides only a PM reduction, and at an implementation cost and cost effectiveness that are no better than other options.
- Electrification provides the highest level of Maryland economic development benefits, mainly because of the expectation that: 1) All of the design and construction costs would be performed by Maryland businesses; and 2) the electricity needed to power the electrified gantry cranes would be provided by BGE for the estimated 20-year life of the equipment.

TUG BOAT OPERATIONS

- NOx catalyst aftertreatment products offer the best all-around opportunity for reducing VOC, NOx and PM emissions at an implementation cost of less than $300,000, and NOx emission reduction cost effectiveness of $227 per lifetime ton.
- There are no other technologies resulting from the analysis that can provide a NOx reduction.
- Biodiesel provides the highest level of Maryland economic development benefit because of the expectation that biodiesel would be purchased from a Maryland fuel distributor for the estimated 10-year life of the equipment.

YARD JOCKEYS

- Implementation of any emission reduction technology would result in minimal emission reductions at an implementation cost of about $100,000-to-$200,000, and combined emission reduction cost effectiveness in the range of tens-to-hundreds of thousands of dollars per ton.
- For the 10-year life of the equipment, PM filters provide the highest level of Maryland economic development benefit because of the expectation that: 1) the filters would be purchased from a Maryland distributor (even though they would not be manufactured in Maryland); and 2) periodic filter cleaning/maintenance would be performed by a Maryland business.

Overall, the best NOx emission reduction opportunities, at reasonable implementation costs and cost effectiveness can be obtained from outfitting the tug boats with NOx catalyst aftertreatment products.

After completion of the second screen analysis, natural gas-fueled fuel cells for shore power, the rail intermodal operations and truck intermodal operations were briefly reviewed for their potential to contribute to an emission reduction program for the Port. Results of this review can be summarized as follows:

FUEL CELL SHORE POWER

- Does not satisfy most of criteria.
- Very expensive.
- Very ship-application specific.
- Suitable for demonstration program opportunity.

RAIL INTERMODAL

- Already very efficient operation with minimal emission production.
- Potential to use CSX auxiliary power unit (APU) concept to further reduce idle emissions in rail yard operations.

TRUCK INTERMODAL

- Idle reduction technologies have excellent technical merit.
- Potential tie-in to Maryland’s weigh-in-motion (WIM) implementation strategy.
- Potential to incorporate advanced queuing/scheduling technologies to minimize truck entry/exit.

- Needs highly coordinated and nearly universal acceptance by truck operators to be successful.
- Good potential to tie-in with enhanced security measures.

For those technologies resulting from the second screen, the final step of the analysis process was to identify the major elements associated with implementing an emission reduction program, and major outside funding sources that could support program implementation. Table 6 provides a summary of these results. Note from Table 6 that it would require three-to-four years to implement electrification of the Dundalk gantry cranes, compared to less than a year to implement a program with aftertreatment products or biodiesel. In addition, there does not appear to be an immediately obvious outside funding source with an initiative to fund gantry electrification. As part of its Diesel Engine Retrofit Program, the U.S. EPA makes available grant funds for supporting diesel emission retrofit projects. The U.S. DOE has several grant program opportunities for supporting the use of alternative fuels (as biodiesel is considered).

Table 6 – Major Program Implementation Elements

DUNDALK GANTRIES				
Technology	**Participants/Roles**	**Acquisition Mechanism**	**Implementation Schedule**	**Potential Outside Funding Sources**
Electrification	A/E Firm – Design layout	RFP Devel./Contract	12 months	None obvious (MARAD?)
	Construction Co. – Construction	Spec Devel/Contract	24 months	
	Gantry Vendor - Conversion	Spec Devel/Contract	9 months	
Aftertreatment	Product supplier – Products	RFP Devel./Contract	6 months	U.S. EPA
	Product Installer - Installation	RFP Devel./Contract	2 months	
Biodiesel B20	Fuel Supplier - Fuel	Spec Devel/Contract	3 months	U.S. DOE
TUG BOAT OPERATIONS				
Technology	**Participants/Roles**	**Acquisition Mechanism**	**Implementation Schedule**	**Potential Outside Funding Sources**
Aftertreatment	Product supplier – Products	RFP Devel./Contract	6 months	U.S. EPA
	Product Installer - Installation	RFP Devel./Contract	2 months	
Biodiesel B20	Fuel Supplier - Fuel	Spec Devel/Contract	3 months	U.S. DOE
YARD JOCKEYS				
Technology	**Participants/Roles**	**Acquisition Mechanism**	**Implementation Schedule**	**Potential Outside Funding Sources**
Aftertreatment	Product supplier – Products	RFP Devel./Contract	6 months	U.S. EPA
	Product Installer - Installation	RFP Devel./Contract	2 months	
Biodiesel B20	Fuel Supplier - Fuel	Spec Devel/Contract	3 months	U.S. DOE

At the conclusion of the analysis work and presentation of preliminary results to MPA and MES staff, EK was requested to review the results of the Phase II work with representatives of the Maryland Department of Transportation (MDOT) and MDE to:

- Provide a brief review of results from Phase I work that characterized sources and quantities of emissions from MPA port operations.
- Present results from Phase II work that assessed technology options for emission reduction opportunities.
- Seek input from MDOT and MDE on value of pursuing emission reduction opportunities.
- Discuss needs for any coordinating actions.

A meeting with MDOT and MDE representatives was held on January 20, 2004 to accomplish the above and discuss:

- Value of reduction benefits
- Pollutant emphasis
- Tie-in with other programs
- Support for actions by MPA
- Current political and financial climate
- Other points for consideration

Recommendations from that meeting were as follows:

1. There is a potential good fit for using emission reductions from Port operations to support contingency needs for MDOT's general conformity requirements.
2. Conformity benefits could also result from adoption of emission reduction technologies by the U.S. Army Corps of Engineers for dredging operations.
3. Calculation of potential SO2 reductions would also be useful for addressing future SO2 standards.
4. NOx reductions can be a useful contribution to reducing airborne nitrogen loading to the Chesapeake Bay.
5. A timeline for emission reduction opportunities can be established by matching with the timing of compliance requirements for new air quality standards/concerns related to 8-hour ozone exposure, PM2.5, SO2, ammonia, CO2 (greenhouse gases) and regional haze, particularly those starting in 2005.
6. Any programs related to reducing NOx emissions from truck operations at the Port would be useful for meeting transportation conformity requirements and reducing ozone, in general.
7. Any emission reduction program that the MPA would consider should include a 1-year baseline before installation of any emission-reducing equipment. This approach will establish a sound technical basis and quantifiable measure of emission reduction benefits for consideration in Maryland's air quality compliance requirements.

Given the results of this Phase II analysis, and benefits of and support for emission reductions from Port operations, as outlined above, MPA may want to consider developing a plan for implementing an emission reduction program, the basic elements of which are described below:

1. Focus on developing an emission reduction program with the tug boat operators, based on the use of catalytic aftertreatment products and ultra-low sulfur diesel fuel, since tug operations represent a significant source of emissions and thus, a significant opportunity for reduction.
2. Work with the U.S. Army Corps of Engineers to expand the emission reduction program to operators of dredging equipment on the Chesapeake Bay.
3. Given the future emission reduction needs outlined by MDOT and MDE, establish an emission reduction program that addresses all criteria pollutants, to the extent practical.
4. Give strong consideration to converting the GSE operations to ultra-low sulfur diesel fuel, to achieve reductions in PM and SO2.
5. For the equipment selected to be included in the program, establish an emissions baseline with actual measurements of equipment emissions.
6. Identify the key program participants, develop a cost estimate for implementing the program, and identify specific outside funding sources.