Dann Marine Towing
Tug *Gulf Coast* Repower Project

Final Report

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ABSTRACT

Dann Marine Towing Company (Dann Marine), in cooperation with the U.S. Environmental Protection Agency (EPA) and the Chesapeake Bay Foundation undertook a project to repower one of its marine tug vessels, the *Gulf Coast*, with new EPA Tier 2 compliant diesel engines using funding from the American Recovery and Reinvestment Act (ARRA) of 2009.

Prior to the project, the tug boat operated with pre-regulation engines that were manufactured before EPA enacted exhaust emissions standards for marine vessels. The original engines were manufactured in 1982 (auxiliary) and 1986 (propulsion).

Based on historical operating characteristics of the vessel, Dann Marine anticipates realizing annual emission reductions of approximately 37 tons nitrogen oxide (NOx), 1.23 tons particulate matter (PM), and 640 tons carbon dioxide (CO_2).

A significant goal of the project was to maintain and/or create jobs. Using information provided by project suppliers and vendors, Dann Marine estimates that 25 jobs were retained as a direct result of this project.

ACKNOWLEDGEMENTS

Grant funding for this project was provided by the U.S. Environmental Protection Agency through the National Clean Diesel Funding Assistance Program, as authorized by the American Recovery and Reinvestment Act. Dann Marine would like to thank EPA for funding this project, and acknowledge the contributions or Mr. Paul Willey, Ms. Jennifer de Mooy, and Ms. Judy Doody at the Chesapeake Bay Foundation for their assistance in making this project a success. Also, Dann Marine would like to recognize the efforts of M. J. Bradley & Associates, LLC for their assistance as the project technical consultant.

PROJECT TEAM

[Dann Marine Towing]

Dann Marine Towing Company is a fifth generation family owned and operated tugboat company that manages a fleet of 17 ocean going tugboats and inland push boats with vessels ranging in horsepower from 1100 H.P. to 4200 H.P. Dann Marine's base of marine operation, Canal Place, is located on the Chesapeake and Delaware Canal in Chesapeake City, Maryland. The company has tugs based in Chesapeake City and Baltimore, MD, Philadelphia, PA and Norfolk, VA.

[Chesapeake Bay Foundation]

Founded in 1967, Chesapeake Bay Foundation (CBF) is a nonprofit 501(c)(3) conservation organization dedicated to saving a national treasure-the Chesapeake Bay and its tributaries. Their mission is to restore and sustain the Bay's ecosystem. The two principal goals for achieving this mission are to improve water and air quality by reducing pollution and to spur public support for effective local, state, and national public policy changes with environmental benefits. CBF is focused on achieving the improvements in water quality, as defined by the Chesapeake 2000 Agreement, to remove the Bay from the nation's list of impaired waters by 2010. Nitrogen is the number one pollutant of the Bay watershed and most of the airborne nitrogen is in the form of nitrogen oxide (NOx) emissions. In MD, CBF helped pass the "Healthy Air Act" which placed stringent limits on emissions of NOx, sulfur dioxide (SO_2) and mercury from Maryland's coal-fired power plants. In addition, CBF helped pass Clean Cars legislation in MD which sets emissions standards for automobiles at levels that are more stringent than federal guidelines. CBF is also active with the Washington Regional Network and the Coalition for Smarter Growth on transportation and urban reinvestment for the metropolitan region, including use of land in the District of Columbia and around Metro stations, affordable housing, transportation policy, and air pollution. CBF also works with the Urban Land Institute to promote regional smart growth.

EPA'S NATIONAL CLEAN DIESEL FUNDING ASSISTANCE PROGRAM

Background

For several years, the U.S. Environmental Protection Agency (EPA) has been pursuing a National Clean Diesel Campaign that advances strategies to reduce diesel emissions and move toward cleaner air. EPA's strategy to accomplish this has been to work with fleet operators, manufacturers, air quality professionals, environmental and community organizations, and state and local officials to put together targeted plans, including both regulatory and voluntary measures to reduce diesel emissions. In the early years of the diesel campaign, focus was on over-the-road trucking and construction equipment. Since then, with the advent of the new on-road truck rules in 2007 and stricter construction equipment emission standards, focus has shifted more towards marine engines and locomotives.

Diesel Emission Reduction Act

Because diesel engines can have such a long operating life (7 yr / 500,000 mile+ for on-road trucks and 10-20 years or longer for locomotive and marine engines), EPA realized that implementing cleaner regulations for new diesel engines would take a significant length of time to make an impact on local air quality. To make more immediate emission reductions, EPA sought a way to encourage fleet owners to voluntarily reduce diesel emissions. As a result, Congress authorized funding for clean diesel initiatives with the Diesel Emissions Reduction Act (DERA) as part of the 2005 Energy Policy Act.

Typically once each year, EPA announces the availability of DERA funds to be used for cost-effective emission reduction programs, with the focus primarily on reducing nitrogen oxide (NOx) and particulate matter (PM) emissions, although there is increased desire to also show fuel economy and therefore carbon dioxide (CO_2) benefits. The most recent solicitation for project funding occurred in December 2009 and included both fiscal year 2009 and 2010 EPA funding allocations. In total, EPA announced the availability of $64 million in available grant funding and is in the process of evaluating project proposals. EPA awarded $49.2 million for diesel emission reduction programs in the first year of DERA. Solicitation for projects for another round of funding was conducted in early January 2011.

American Recovery and Reinvestment Act of 2009

On March 19, 2009, EPA published a request for applications (EPA-ARRA-OAR-OTAQ-09-06) as part of the National Clean Diesel Funding Assistance Program, authorized under the Energy Policy Act of 2005 (Public Law 109-58) and the American Reinvestment and Recovery Act (Public Law 111-05), to offer funding assistance for projects designed to reduce diesel emissions and at the same time, promote the preservation and/or creation of jobs and economic recovery.

The Act allocated a total of $244 million dollars nationwide in grants and innovative financing to significantly reduce diesel emissions and improve public health. A total of $156 million was allocated towards EPA's Clean Diesel Funding Assistance Program. Funding was in the form of cooperative agreements or grants, that were used to achieve significant reductions in diesel emissions in terms of: (1) tons of pollution produced; and (2) diesel emissions exposure, particularly from fleets operating in areas designated by EPA as poor air quality areas.

The ARRA funding can be viewed as a one-time supplement to EPA's annual DERA funding that over the past few years has been funded with approximately $50 million annually.

Under the DERA and ARRA programs, EPA gives priority to projects that: (a) demonstrate a clear public health benefit in areas with high population density and poor air quality, (b) foster cost-effective strategies that maximized the useful life of a certified engine configuration, verified technology, or emerging

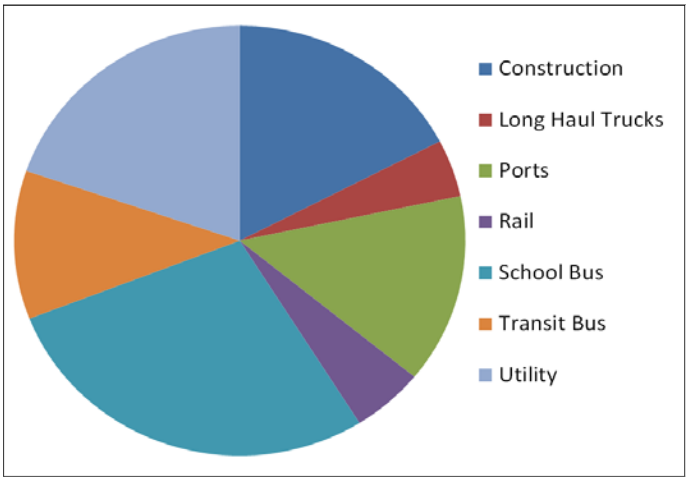
technology, (c) conserve diesel fuel, and (d) use cleaner fuels.

Projects that are eligible for funding include: (a) engine repowers, (b) engine upgrades, (c) add-on emission control retrofits, (d) idle reduction technologies, (e) cleaner fuel use, (f) vehicle and equipment replacements, and (g) creation of innovative finance programs to fund diesel emissions reduction projects.

DERA/ARRA Funding Awards by Sector

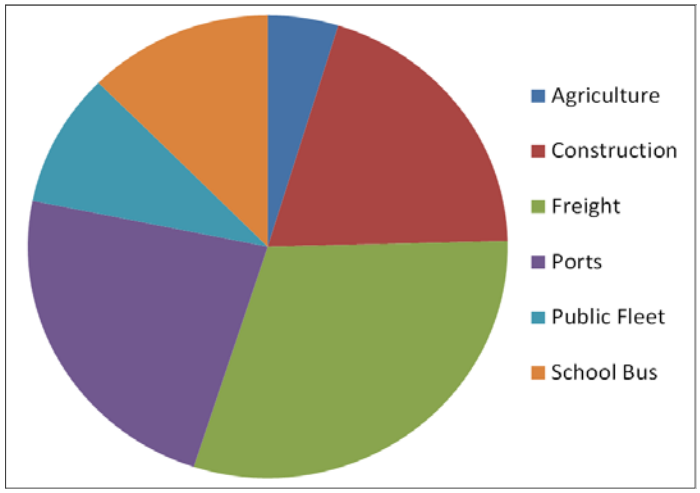
In response to the competitive ARRA procurement, nationwide, EPA received more than 600 applications requesting approximately $2 billion in project funding and offering more than $2 billion in matching funds. Compared to the national pool of funding of $156 million for diesel emission reduction projects, the demand far exceeded the available funds. The charts provided illustrate how funding has been allocated for each of the three project funding solicitations.

2008 DERA—$49.2 million

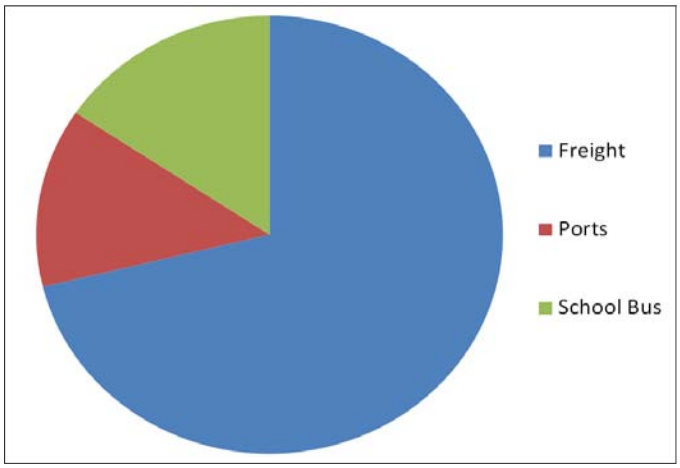


Since the inception of EPA's National Clean Diesel Campaign, funding has been available across all of the diesel fleet sectors, including school bus, construction/off-road, on-road trucks, ports (including marine vessels and port support vehicles and equipment such as drayage trucks, and rail). EPA does not have a prescriptive formula for allocating funding across the different sectors and evaluates each application in the context of best value. In determining best value, each EPA region reviews applications in comparison with the region's priorities. EPA Region 3 and the Mid-Atlantic Diesel Collaborative, a partnership between leaders from federal, state, and local government, the private sector, and environmental groups in Delaware, Maryland, Virginia, Pennsylvania, West Virginia, and the District of Columbia, have identified urban areas as priority targets for diesel emission reduction projects. By targeting urban areas, the greatest population is likely to benefit from these projects and further increase their beneficial nature. In addition to focusing on the urban nature of projects, other factors considered include: (a) providing emission benefits to areas of concern for air toxics risk, (b) reducing emissions along interstates and at marine ports, and (c) addressing climatic change and the reduction of greenhouse gas emissions.

2009 ARRA—$156 million

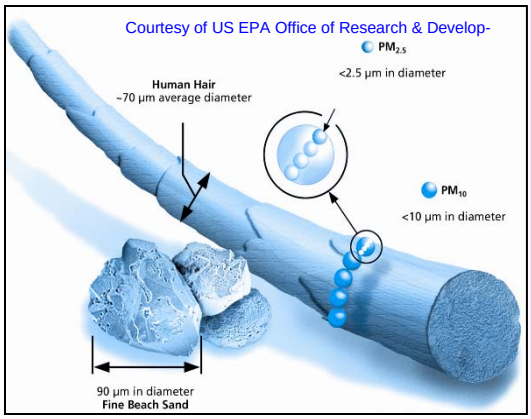


2010 DERA— $64 million



WHY REDUCE DIESEL EMISSIONS

Diesel engines are associated primarily with ozone and particulate matter (PM) pollution. Ozone is not directly emitted by the engine, but is the result of an atmospheric reaction between two classes of chemicals, volatile organic compounds (VOC) and nitrogen oxides (NO_x). Diesel engines tend to be high NO_x emitters due to the high temperature, lean conditions within the cylinder. Diesel engines also tend to be high emitters of PM due to the chemical nature of diesel fuel and the engine's mechanism of compression ignition. Diesel PM tends to be smaller than 2.5 microns in aerodynamic diameter. EPA has placed focus on this size fraction while developing the PM NAAQS due to associated adverse health effects.

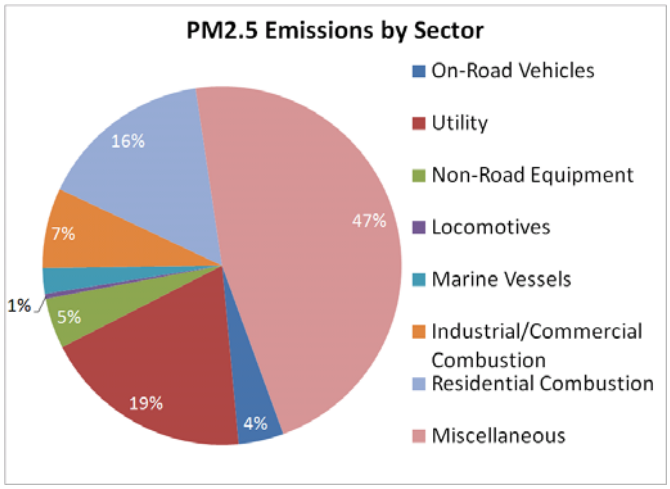


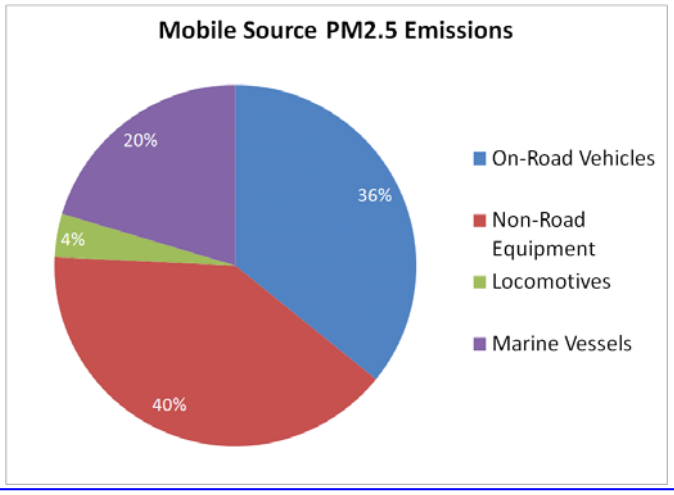
Diesel fuel combustion can be associated with emissions of SO_2, as diesel fuel can have high sulfur levels. EPA regulates the amount of sulfur allowable in fuel. As fuel sulfur content regulations become increasingly stringent, focus on SO_2 in the mobile source sector has decreased with decreasing emissions, much as with lead in gasoline during the 1970's.

PM particles formed by combustion of fossil fuels are a complex mixture of elemental carbon (EC), unburned or partly combusted fuel as organic carbon (OC), sulfate from fuel sulfur, and lubricant products (i.e., ash and additives). Particulate matter emissions are of substantial concern because they contribute to poor visibility and negatively impact human health.

The particulate matter of greatest concern is fine and "ultra-fine" particles with diameters of 2.5 microns or less. This portion of PM is referred to as PM2.5. In comparison, a human hair has a diameter of approximately 70 microns - 25 times greater than the diameter of a PM2.5 particle. At this size, the diminutive mass of the particle allows it to be suspended in the air stream, bypassing the body's mechanical respiratory defenses and they can embed in the alveoli of the lungs when inhaled. The smallest of these particles can also enter the bloodstream directly through the lungs. Human exposure to PM2.5 can be either short term (a few hours to several days); long term (from one to many years); or both.

Emissions of PM2.5 in the Maryland counties that border Chesapeake Bay are driven in large part by industrial processing (a major component of the miscellaneous emissions presented in the chart below); however, marine emissions are a notable contributor to the mobile source sector, and as presented by EPA in the National Emissions Inventory, represent 586 tons annually. Among mobile sources, marine vessels account for approximately 19% of the annual emissions.



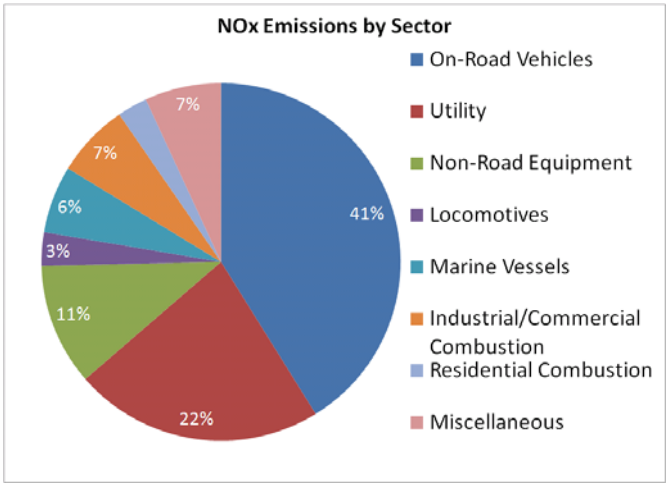


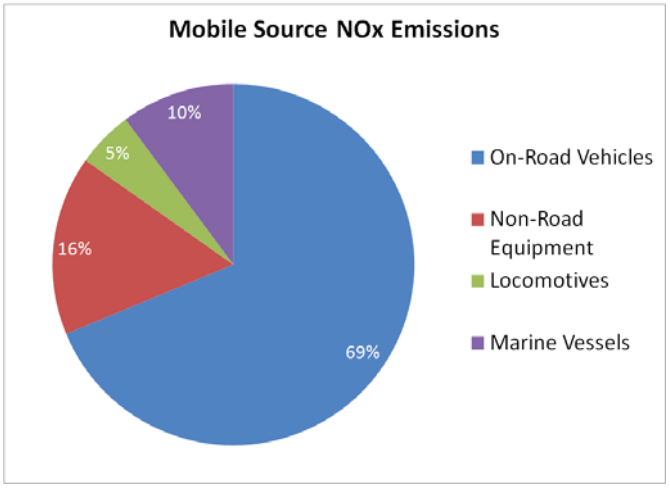
Data presented is from EPA 2005 National Emission Inventory databases—Mobile Sources and 42 Category Summary

Diesel engines are also recognized as a major contributor to the inventory of NOx in most urban regions. The charts below summarize the NOx emission profile for the same counties, as prepared for EPA's National Emissions Inventory.

NOx not only contributes to ground-level ozone formation, but also forms secondary particulate matter in the atmosphere. The bulk of the NOx is formed by the combination of nitrogen (predominately from air but fuel bound nitrogen can contribute) and oxygen (again dominated by oxygen in air but oxygenated fuels provide oxygen as well) during the high temperature combustion process in the cylinder.

Canal Place, the home of Dann Marine Towing, has been in the family since 1950. Canal Place is located on the Chesapeake and Delaware Canal, in Chesapeake City, MD.





PROCUREMENT AND INSTALLATION

Equipment Procurement

In late March 2010, Dann Marine, with the assistance of M.J. Bradley, released the first of two Request for Proposals (RFP) to repower the *Gulf Coast*. The first RFP focused on equipment purchases related to the repower, and asked proposers to provide bid pricing on different options.

RFP Bid Options

1. – Main propulsion engines
2. – Gearbox equipment for the vessel
3. – Auxiliary generator sets
4. – Propulsion controls
5. – Keel Coolers

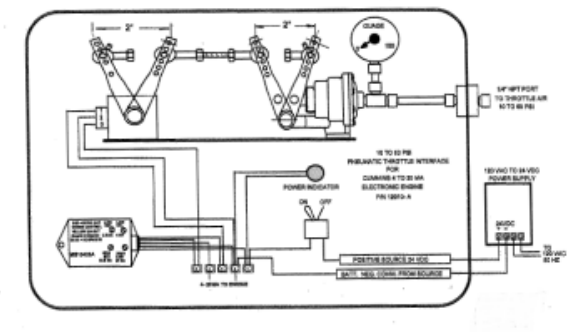
Because of the accelerated project timeline requiring ARRA projects be complete by September 30, 2010, the RFP sought a quick response from vendors and as a result, the project proceeded from RFP release to vendor award by the third week of May. Four vendors provided compliant bids which were reviewed and ranked based on several criteria, including cost, schedule, experience, machinery compatibility, warranty and minority business content. The RFP specifically requested that respondents identify whether they were designated as a or planned to utilize the services of a Small/Minority/Women/Disabled Business Enterprise (SBE/MBE/WBE/DBE). None of the bids included minority business content.

After review of the bids, three purchase orders were prepared for the equipment, propulsion controls, and keel coolers. With the timeline constraint, delivery schedule played a significant role and Flag Service & Maintenance was able to offer delivery of the engines by early July.

Major equipment provided by Flag Service & Maintenance included the two each of the main propulsion engines, gearboxes, and auxiliary generator sets, as summarized to the right.

Flag Service and Maintenance Equipment
Supply of two (2) Cummins QSK50 main propulsion engines
Supply of two (2) Reintjes WAF773 Marine Reduction Gears
Supply of two (2) John Deere 4045 Marine 65kW Generator Sets

Engine Control System Interface

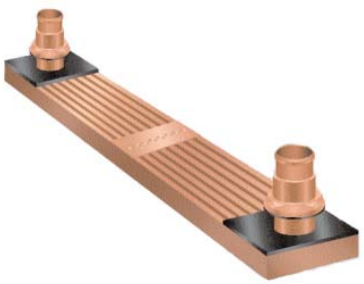


Courtesy of C&W Air Repair

Dann Marine sought to maintain the pneumatic propulsion controls and as a result required a conversion interface between the existing system and the new electronically controlled engines. Johnny White's C and W Air Repair was issued a purchase order to supply and install a complete marine engine control system to accomplish the pneumatic/electronic interface.

Because new engines were being installed, Dann Marine had a naval architect update vessel drawings showing the revised engine foundation and equipment placement. Repowering the boat with new Tier 2 engines required larger keel coolers. East Park Radiator & Battery proposed and was awarded the supply of two (2) Duraweld keel coolers (Model 2024) for the jacket water circuits for the Cummins QSK50 engines as well as supply of two (2) Duraweld keel coolers (Model 3224-2) for the gearboxes and engine aftercooler circuits.

Keel Cooler



Installation Procurement

After the equipment list was determined, an RFP was released in mid-May seeking installation services. Dann Marine released the RFP only to East Coast mid-Atlantic shipyards because sending the vessel beyond the geographic area would have added additional expense to the project (e.g., fuel for transport) and lengthened the project timeline. The RFP requested qualified shipyards to submit installation price quotations addressing a number of specific criteria.

The RFP included vessel drawings, prepared by Dann Marine's naval architect (ENTECH), information on the existing vessel and the new equipment to be integrated. In addition, the RFP required shipyards to specifically address installation/removal of particular items separately as well as addressing overall standards of performance. Some of these topics included:

- Dry-docking
- Removal/Installation of engines, gearboxes, and keel coolers
- Exhaust piping modifications
- Gas-freeing
- Engine foundation modifications
- Hull/Shaft alignment
- Access Openings
- Propellers, tail shaft and coupling removal, evaluation and installation
- Sea trials

Each bidder was asked to provide itemized bid pricing using a standardized pricing form. Beyond the prescribed form, bidders were able to provide any additional details or comments they thought should be included.

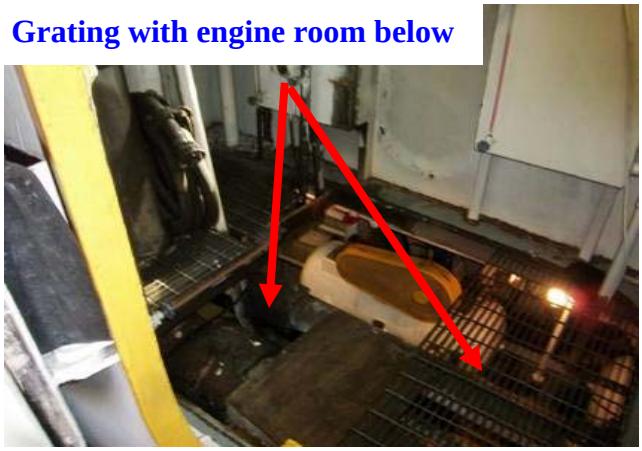
Dann Marine received three proposals from east coast shipyards—all within 300 nautical miles of their location. Similarly to the equipment RFP, DMT ranked the bidders based on price, schedule, and experience. Encouragingly, each shipyard indicated that they could complete the repowering before the ARRA required project end date of September 30, 2010 (within 50 days).

Access opening for repowering

Equipment Removal and Installation

On July 6th, the *Gulf Coast* was delivered to Lyons Shipyard in Norfolk, VA where the vessel was given a water berth during equipment removals. Once tied up at the berth, connections were made for fresh water, shore power, and ventilation. To remove the machinery, an access opening was cut on the second deck bulkhead, which was determined to be the best point of entry because behind the bulkhead floor grating provided direct access to the engine room. The bulkhead was then removed using an overhead crane and rigging service.

Grating with engine room below



Access hatch being removed

Access hatch removed

Access opening

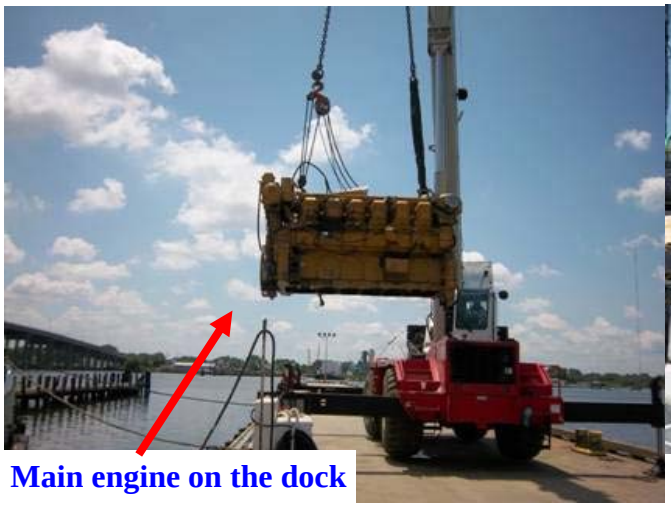
Removal of the machinery began by draining all fluids and starting with the starboard side main engine followed by port side main and then the auxiliary generator sets. To extract each of the main engines, the oil pan was removed to reduce the weight and size of the engine. After the oil pan was removed, the main engine block was rigged off the ship. The block was set on wooden beams on the dock.

Main engine oil pan removed

After the main engines were removed, the auxiliary generator sets were extracted one at a time. Each generator set was unbolted from the bedframe leaving the units attached to their frame rails.

After the machinery was removed, the vessel was moved to a dry-dock berth for hull modifications. The *Gulf Coast* required hull alterations to accommodate the new, higher capacity keel cooler units.

Main engine being removed

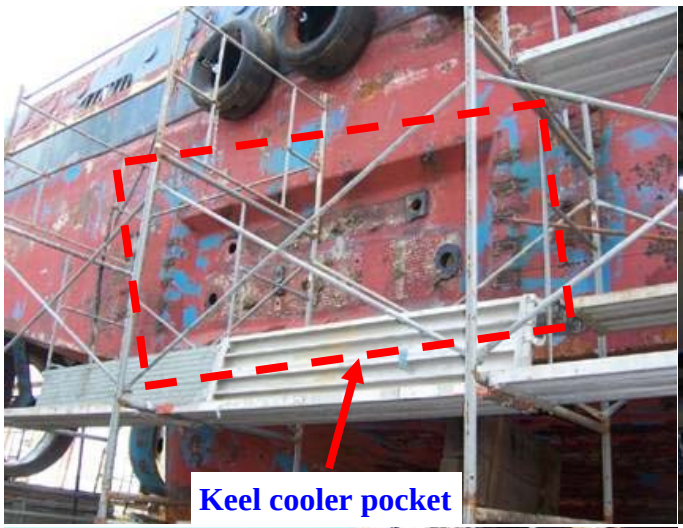


Main engine on the dock

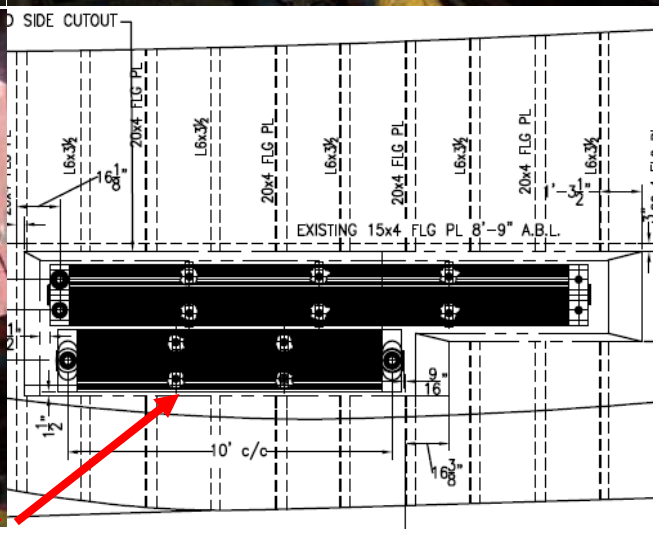
Auxiliary generator being removed

Keel Cooler Modifications

Keel coolers are mounted in pockets in the hull and designed so that the vessel can move smoothly through the water while allowing proper cooling of the main and auxiliary engines. While in dry-dock, the existing keel coolers were removed from their hull pockets and the pockets were modified to accommodate the larger keel coolers. The new pockets were fabricated, welded and painted before installing the new keel coolers.



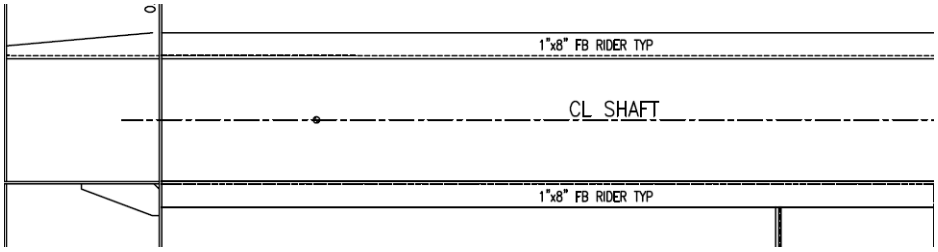
Keel cooler pocket



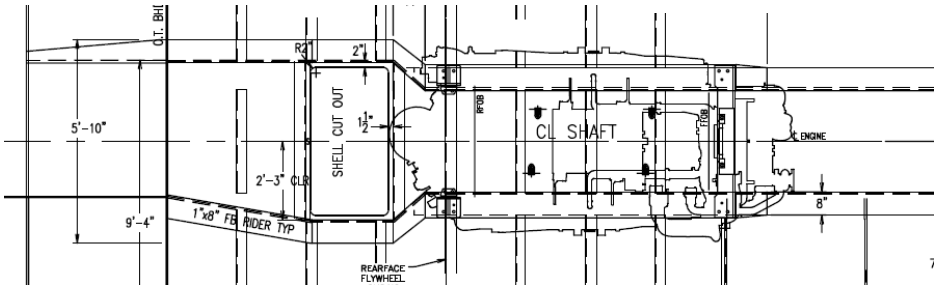
Modified keel cooler pocket

Engine Foundation Modifications

Original Foundation



Modified Foundation



Because each gearbox had a wider "footprint", the existing foundations required modification. To accomplish this, the original foundations were removed in the area where the gearboxes would sit and widened an additional 12 inches so the gearboxes would sit correctly on the rails. Additional bracing was added below the rails to reinforce the new foundations.

With the modifications to the hull and foundations complete, the main propulsion engines and gearboxes were installed. Because the new Cummins QSK50 engines were longer than the original Caterpillar 3512 engines that were removed, the access opening needed to be

cut further. The cut was extended inward toward the centerline of the vessel, removing the entire room directly aft of the starboard exhaust stack. This allowed the complete engine to be lifted and installed through the access hatch without removing components. Each main engine was rigged onto the vessel and lowered into the engine room, where they were slid into place along the foundation and new mounting holes were drilled.

Installation of the main propulsion engines was completed by connecting to necessary fluid systems including fuel, lube oil and cooling water. In addition, air starter piping was modified to mate up to the new engines and the new pneumatic to electronic control systems were installed.

Gearbox Installation

After both main engines were installed in the boat, the two new gearboxes were rigged into the engine room through the same access opening. Once inside, the gearboxes were placed on the newly modified bedplates and coupled to the new main engines.

Coupling the engines and gearboxes together required fit-up adjustment to ensure proper alignment, a procedure called "blue-fitting" which uses a blue dye on one side of the mating flanges The two flanges are then bolted together and then taken apart. The flanges are inspected to see where the blue dye transferred and where it did not. Large sections without dye indicate areas were adjustment to the alignment is required.

After the main engines and gearboxes were aligned, the tail shafts and propellers were installed and aligned to the gearboxes. The drive components were then tested to confirm proper operation.

Auxiliary Generator Set Installation

The auxiliary generator sets were the last items to be installed. These were rigged onto the vessel and lowered into the engine room. Each John Deere generator skid was bolted to the hull in the exact location from which the existing generator sets were removed. After installation, fuel lines, cooling circuits, and electrical connections were made. The generators were tested and verified to produce the manufacturer rated power output (65 kW each).

PROJECT COMPLETION

Sea Trials

Sea trials are performed to determine the "sea-worthiness" of the vessel and to ensure that all installed components and equipment are working as anticipated. Sea trials usually have two parts: (1) a full power test of the main engines, and (2) open water testing. The *Gulf Coast* concluded a successful sea trial on September 25, 2010.

Full Power Test

The full power test portion of sea trials usually consists of the vessel with its hull pointing directly at a well fortified dock and operating the engines at full throttle while pushing against the dock. During this, the engines are monitored and specific parameters are checked against manufacturer's specifications, including but not limited to engine rpm, fuel and boost pressures, coolant temperature and fuel consumption. The test is repeated at all throttle stages until the engines satisfy the engine manufacturer's representative.

Open Water Test

The second part of sea trials is testing the vessel in open water; an exercise to simulate how the vessel will operate in normal service. This test usually contains a performance analysis review that includes monitoring the engines while operating and records specific engine parameters. Similar to the data taken during the full power dock test, the parameters include fuel rates, coolant temperatures, oil pressure, etc. For both tests, recording the parameters can pinpoint potential problems in the propulsion system. Once the engines have been tested and meet the engine manufacturers specifications, the sea trials are complete and the vessel is ready for normal service.

Engine Comparison	Propulsion Engines	
	Port	Starboard
	Old / New	Old / New
Manufacturer	CAT / Cummins	CAT / Cummins
Model	3512 / QSK50	3512 / QSK50
Model Year	1986 / 2010	1986 / 2010
Serial Number	50Y00762 / 33180484	50Y00761 / 33180497
Engine Family Name	* / 9CEXN019.AAB	* / 9CEXN019.AAB
Horsepower	1,200 / 1,600 **	1,200 / 1,600 **
Annual Activity (Hr /Year)	~ 4,800 / ~ 4,800	~ 4,800 / ~ 4,800
Fuel Type	Marine Diesel	Marine Diesel
Annual Fuel Usage (Gal)	~190,000 / ~165,000	~190,000 / ~165,000
First In-Service Date	1986 / 9-25-2010	1986 / 9-25-2010

* The old engine was manufactured prior to EPA regulating ma
** Because the propellers were not changed as part of this projec existing limits of the propeller (governed by the propeller curv
*** Post-Repower fuel consumption is estimated based on manufa consumption may vary.

Engine Disposition

An important requirement of the EPA ARRA stimulus grant was that the old diesel engines be rendered permanently inoperable after being removed from the *Gulf Coast*. The reasoning behind this requirement is that EPA realizes that these engines are very durable with an active parts market that could result in them being sold and put into service somewhere else, essentially offsetting the emission reduction benefits achieved by the cleaner engines. Dann Marine demonstrated engine disposition and "destruction" by burning through a section of the engine block with a welding torch. The photo to the left shows one of the *Gulf Coast* engines after it was disabled.

Old Propulsion Engine Plates

RESULTS AND OUTCOMES

Recovery Act Priorities

This project contributed to achieving ARRA goals by investing in the U.S. freight transportation system and by preserving jobs in both the manufacturing and local cargo transportation service sectors. Specific goals of the Stimulus Act that were well served by this project are: (1) preserving and/or creating jobs and promoting economic recovery, (2) investing in the transportation system, and (3) expending grant funds quickly.

Summary of Project Benefits

Activities	Outputs	Outcomes

• Repower one marine vessel	• $1.55 million expended
	• 4 new EPA Tier 2 Compliant Engines Installed
		• 25 FTE positions were preserved
		• Significant estimated annual emission reductions
		  • 1.23 tons PM
		  • 37.1 tons NOx

Repowering the *Gulf Coast* represents a significant investment in the transportation system, more than $1.55 million, and is estimated to have preserved a total of 25 FTE. The majority of these jobs are at the first tier supplier, Lyon Shipyard, (12,149 hours were needed to complete the installation and modification of the *Gulf Coast*) and represent skilled trades workers like mechanics, fabricators, welders, service planners, and shop supervisors. Dann Marine was also able to complete the project nearly entirely within a single calendar quarter. Delivery of the major equipment (e.g., engines, gensets, and gearboxes) occurred in June 2010 with installation commencing in early July and repower completion on September 25, 2010.

Auxiliary Generator Set Engines	
Forward	Aft
Old / New	Old / New
CAT / John Deere	CAT / John Deere
3304 / 4045TFM75A	3304 / 4045TFM75A
1982 / 2010	1982 / 2010
2B16200 / PE-4045T790765	2B16217 / PE-4045T791179
* / AJDXN06.8086	* / AJDXN06.8086
74 / 87	74 / 87
~5,000 / ~5,000	~5,000 / ~5,000
Marine Diesel	Marine Diesel
~6,400 / ~6,200	~6,400 / ~6,200
1982 / 9-25-2010	1982 / 9-25-2010

rine engines and does not have an engine family name.
t, the total overall vessel cannot demand more than the
ve).
acturer-published fuel rate data. Actual fuel

Emission Reductions

Limited in-service data exists, and therefore, emission reductions presented below are projections; however they are estimated to be significant, at 1.23 and 37.1 annual tons of PM and NOx, respectively. The durable useful life of the *Gulf Coast* is well beyond 10 years, although the propulsion engines are expected to require rebuild, remanufacture or replacement at approximately 5-10 years. Using 10 years as the project duration, lifetime emission reductions are estimated at 10.8 and 371 tons of PM and NOx, respectively. The *Gulf Coast* is subject to EPA's 2008 Marine Engine Rule (40 CFR 1042), which requires unregulated Tier 0 marine engines to be upgraded to reduce PM emissions by 25% when the engines are overhauled. This rule will reduce the net lifetime PM reduction benefits of this project because some level of PM reduction from these engines is mandated within the expected 10-year remaining useful life of the vessel. The lifetime PM emission reductions presented below account for this rule; however, this requirement does not affect the estimated NOx emission reductions from the project. In addition to emission benefits, the *Gulf Coast* is projected to realize significant fuel savings due to the new, higher efficiency, electronically controlled engines. Fuel savings are estimated at approximately 50,000 gallons annually.

Project Cost Effectiveness

Pollutant	Life-time Reduction (tons)	Total Project Cost-Effectiveness ($/ton)	ARRA Funding Cost-Effectiveness ($/ton)
NOx	371	$ 4,178	$ 2,452
PM	10.8	$ 143,519	$ 84,259

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M.J. BRADLEY & ASSOCIATES

STRATEGIC ENVIRONMENTAL CONSULTING

M.J. Bradley & Associates is an environmental consulting firm with a national reputation for helping clients balance environmental goals with business objectives, as well as for demonstrating advanced low emission vehicle technologies. By providing clients with high-quality information and services, and facilitating collaboration, MJB&A assists private and public sector clients in meeting the challenges posed by changes in environmental and energy law and policy, energy markets, technology and business climate.

MJB&A has two offices, an Energy & Environmental Policy Group in Concord, MA and a Technical and Transportation Services Group in Manchester, NH. The Environmental Policy group consults in the fields of energy and environmental policy, electric generating technologies, greenhouse gas policy, and stakeholder groups.

The Transportation Services Group participates in a variety of project areas, with a concentration in advanced vehicle and optimized combustion system technologies. Projects include technology assessments, management of commercially available as well as prototype deployments, strategic analysis, feasibility studies, economic and life cycle cost analyses, emissions testing, emissions inventory development, and retrofit programs for a wide range of vehicle types, including marine vessels, locomotives, transit and school buses, and construction equipment.

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