

**Retrofits of Off-road Construction Vehicles at Xanadu**  
**N.J. Department of Environmental Protection, Diesel Risk Reduction Program**  
**February 15, 2010**

**Project Description**

The Xanadu project is located in the area immediately around the Meadowlands Sports Complex in Bergen County. This project encompasses an area of approximately 104 acres at a cost of approximately \$1.3 billion. The project includes the construction of 4.8 million square feet of entertainment, sports, retail, office, and hotel space. The project was originally scheduled to be completed in late 2008. Due to the economic downturn in late 2008-2009, the developers (Mills Corp.) filed for bankruptcy and the opening date was delayed until August 2009. Since that time, the new developers (Meadowlands Management, LLC) have been looking for additional investors to complete the project and the opening date has been delayed indefinitely. As of February, 2010, construction of the Xanadu project is approximately 95% complete, with the majority of the remaining activities related to building fit-outs (installation of electricity, plumbing, interior walls, etc.).

As part of this project, there was a required consultation process between the NJ Meadowlands Commission and the NJDEP related to the environmental impacts of the project. In addition, the NJ Sports and Exposition Authority submitted an Environmental Impact Statement for the project. In both the consultation process and the Environmental Impact Statement, there was an emphasis on reducing emissions from diesel construction equipment. Joseph Jingoli and Sons (JJS), one of the general contractors originally hired for this project, agreed to reduce particulate matter (PM) emissions from their construction equipment by 35%. In an effort to memorialize the efforts of JJS, NJDEP included the 35% PM reduction requirement in the developer's Waterfront Development Permit, which was issued in October of 2004. In addition, the NJDEP's Diesel Risk Reduction Program worked with JJS to formulate a Diesel Emissions Mitigation Plan, which specifically outlined the requirements that JJS would follow to achieve the 35% emission reduction goal (see Attachment 1). This was the first off-road PM reduction effort in the State of New Jersey. Since the remaining work will not utilize a significant amount of off-road diesel activity, NJDEP considers the project to be complete unless major construction commences during the effective dates of the Waterfront Development permit.

**Diesel Emission Reduction Strategies**

One of the innovative aspects of this project was the use of diesel particulate filters from the mining industry. When construction began at Xanadu, there were no diesel particulate filters that had been verified by the USEPA or California Air Resources Board for use in off-road applications. As a result, JJS went to the mining industry to find a technology that could be used in off-road applications. The technology selected was a diesel particulate filter called a DCL Mine-X Soot filter. The Mine-X filter was installed on several pieces of equipment. JJS also installed Closed Crankcase Ventilation Systems (CCVS) on some of their equipment in addition to providing CCVS devices to some of their subcontractors. As the project progressed, additional retrofit technologies were added and some of the subcontractors installed CCVS devices on their own equipment as part of their own retrofit program.

JJS also used Ultra Low Sulfur diesel (ULSD) fuel (15 ppm sulfur) on all of their own equipment and required the use of Low Sulfur Fuel (500 ppm) on their subcontractors' equipment. ULSD and Low Sulfur fuel give a 13% and 10% reduction in PM emissions respectively when compared to the off-road (3000ppm sulfur) fuel in use at the time. Once Low Sulfur Fuel became a requirement for off-

road vehicles in June of 2007, the 10% credit was removed. A ULSD credit of 3% is still applicable until June 2010 when ULSD will be required for all off-road equipment.

The retrofit technologies used to achieve these PM reductions are as follows:

- Mine-X Soot filter, a Diesel Particulate Filter (DPF) rated to reduce PM by approximately 90%
- Clean Emissions Purifier, a Diesel Oxidation Catalyst (DOC) rated to reduce PM by approximately 40%
- Caterpillar Catalyzed Converter/Muffler, a DOC rated to reduce PM by approximately 20%
- Universal Silencer DPF with Johnson Matthey CRT, rated to reduce PM by approximately 90%
- Engine Control Systems DPF, rated to reduce PM by approximately 90%
- Donaldson Closed Crankcase Ventilation System, rated to reduce PM by approximately 10%

### **Accomplishments**

To date, the construction phase of the project has been going on for 52 months and has achieved an overall PM reduction of approximately 35%. Retrofits have been installed on a total of 151 pieces of equipment. It should be noted that not all of the retrofitted equipment was on site at the same time. Equipment arrived and departed from the site during the various stages of construction. The total PM reduction for the life of this project was in the range of 0.8 to 1.0 ton.

### **Verification of emission benefits**

Since this was the first off-road retrofit project in New Jersey, the NJDEP wanted to obtain actual data on how these retrofit devices performed in the field to confirm the emission reductions. In order to complete this real-time sampling, NJDEP secured the services of the Northeast States for Coordinated Air Use Management (NESCAUM) and Environment Canada. Air sampling of the exhaust of two different construction vehicles was conducted, sampling both upstream and downstream of the retrofit device in order to get actual measurements of emissions reductions. One sampling event confirmed the emission reductions from the EPA/CARB verification process. The other event showed an actual increase in particulate matter emissions resulting from the retrofit device. Since this was likely an erroneous result, the retrofit device was then sent to Environment Canada's laboratory in Ottawa for confirmatory analysis. Analysis in Ottawa was in agreement with published results from the EPA's verification program. Therefore, it was determined that the erroneous result may have resulted from improper installation of the retrofit device, an error in the handling of the sample filter, or an error during field analysis. Details of this sampling effort can be found in the report issued by Environment Canada.

### **Problems Encountered/Lessons Learned**

- 1) Sulfur poisoning of a DPF was encountered because the fuel system was not completely devoid of either conventional or low sulfur diesel. This happened during one of the first installations and the DPF had to be replaced. It is recommended that any vehicle/equipment be run on ULSD for a period of time (a couple of fuel-ups) prior to filter installation. This will ensure that only ULSD is in the fuel tank, fuel lines and injectors.

This should not present a problem after June 2010 when USLD in off-road equipment is mandatory.

- 2) Difficulty in installation – In several cases, the exhaust pipe had to be reconfigured to accommodate the installation of the retrofit device. This is due to the limited space within the engine compartment and is typical of off-road construction vehicles. It often takes several days and an experienced mechanic to accomplish this installation.
- 3) Visual obstruction – Due to the confined space of an engine compartment, a retrofit device had to be installed outside the engine compartment, which created a partial visual obstruction for the operator.
- 4) Back pressure monitor false readings. Back-pressure monitors were going off prematurely, which may have been due to faulty installation, faulty equipment or inadequate exhaust temperatures. Monitors were eventually reinstalled and/or replaced.
- 5) Confirmatory sampling difficulties. As mentioned in the Project Description, the purpose of this sampling was to provide “real world” confirmation of the actual PM reductions of the retrofit technologies. However, the field tests were not successful since we actually found a PM increase in one of the pieces of equipment retrofitted with a Diesel Particulate filter. Subsequent laboratory analysis confirmed an error in retrofit installation, field handling and/or field analysis.
- 6) Removal of retrofit devices from vehicles after vehicles left Xanadu. JJS and some of their subcontractors removed the retrofit devices once their construction vehicles left the Xanadu project. This activity was not anticipated by the NJDEP, but it is believed that the lack of state-wide retrofit requirements resulted in this occurrence.

Attachment 2 is a list of equipment with its associated retrofit device and/or Closed Crankcase Ventilation (CCVS) System.

### **Conclusions**

This project has provided a valuable base of experience and information for future projects that involve the installation of retrofits on off-road vehicles. While all technical difficulties were overcome, the larger challenge to successful implementation remains the resistance to this technology on the part of contractors. There are several reasons for this resistance, such as the additional maintenance required by retrofit devices, but the lack of a state-wide requirement to retrofit vehicles led to the devices being removed upon completion of the Xanadu project.

## Attachment 1

### Diesel Emissions Mitigation Plan

- The goal for this Mitigation Plan is a minimum 35% reduction in particulate matter (PM) emissions. This reduction shall be achieved utilizing retrofit equipment and/or low sulfur fuels specified below: The methodology in achieving this goal is up to the discretion of the contractor.
- All off road diesel powered construction vehicles/equipment with engine horsepower (HP) ratings of 60 HP and above, that are on the Xanadu project or are assigned to the project for a total of 30 days shall be retrofitted with Emission Control Devices and/or use Low Sulfur Diesel (LSD), Ultra Low Sulfur Diesel (ULSD) or Clean Fuels in order to reduce diesel emissions. A day is considered to any portion of a workday and the total number of days is the combination of consecutive and non-consecutive days. In addition, all motor vehicles and/or construction equipment shall comply with all pertinent State and Federal regulations relative to exhaust emission controls and safety.
- Construction shall not proceed until the contractor submits a certified list of the diesel powered construction equipment that will be retrofitted with emission control devices or that will use LSD, ULSD or Clean Fuels. The list shall include (1) the vehicle/equipment unit number, type, make, model number, engine make, engine EPA family number, horsepower, displacement and contractor/sub-contractor name; (2) the emission control device make, model and EPA certification number or (3) the type and source of fuel to be used.
- The contractor shall submit on a quarterly basis, a spreadsheet that includes equipment type, equipment amount horsepower, activity hours, PM output, PM control devices and PM reduction. The initial spreadsheet shall be completed using estimates and projections. All subsequent spreadsheets shall incorporate empirical data to demonstrate the reduction of particulate matter towards the targeted goal of a minimum 35% reduction.
- The Emission Control Device, or retrofit equipment, shall consist of retrofit equipment control technology that is included in the USEPA or California Air Resources Board (CARB) Verified Retrofit Technology List. The use of this equipment, although not verified for off-road use, will be acceptable to the Department.
- In no case shall high sulfur off road fuel be used on the project in any equipment covered by these rules. Content of sulfur in LSD will be a maximum of less than 500ppm per federal standards. The sulfur content in the ULSD shall not exceed 30ppm. Clean Fuels shall mean a fuel verified by EPA or CARB as a Clean Fuel.

- The contractor shall submit quarterly summary reports, updating the same information stated above, and include certified, by the contractor or subcontractor, copies of the fuel delivery slips for the report time period, noting which vehicles/equipment received the fuel. The addition or deletion of diesel equipment shall be included on the quarterly report. The certified delivery slips shall state whether the fuel delivered is LSD or ULSD diesel fuel (note that highway diesel fuel (LSD) is currently legally required to be ULSD fuel after mid-2006). The certification shall include an affidavit stating the veracity of the copies attached.
- The contractor shall make retrofitted vehicles available for any emissions spot testing performed by the NJDEP or its contractor.
- Idling of delivery and /or dump trucks, or other diesel powered vehicles/equipment shall not be permitted during periods of non-active use. The contractor shall post signs advising the vehicle operators of these idling restrictions. Idling shall be limited to 20 minutes, other than initial warmup period in cold weather, as is required for efficient fuel combustion. Active use means that period of time when vehicles or equipment are actually performing their designated work function. The intervals before and after loading, unloading of deliveries, waiting in queue between loads, and waiting in queue to enter or exit the project, are subject to the idling restriction.

Attachment 2  
Retrofit Equipment List

<b>Equipment Type</b>	<b>Make</b>	<b>Model</b>	<b>Horsepower</b>	<b>Retrofit Device</b>	<b>CCVS</b>
Bulldozer	Caterpillar	D6M	145	Clean Emissions Purifier DOC	Yes
	Caterpillar	D6R	185	Catalyzed Converter/Muffler	Yes
	Komatsu	D65PX	190	Clean Emissions Purifier DOC	
	Caterpillar	D6	190	Clean Emissions Purifier DOC	
	John Deere	700H	90	Clean Emissions Purifier DOC	
	Komatsu	D41	115	Clean Emissions Purifier DOC	
Excavator	Komatsu	PC600	385		Yes
	Komatsu	PC228 (4 units)	143	Clean Emissions Purifier DOC	
	Komatsu	400HD	307	Mine-X Soot filter	Yes
	Caterpillar	420	89	Clean Emissions Purifier DOC	
	Komatsu	PC227	143	Clean Emissions Purifier DOC	
	Komatsu	PC128	86	Clean Emissions Purifier DOC	
	Komatsu	PC138	93	Clean Emissions Purifier DOC	Yes
	Komatsu	PC228	143		Yes
	Komatsu	PC300	270	Clean Emissions Purifier DOC	
	Komatsu	PC308	270	Clean Emissions Purifier DOC	
	Komatsu	PC400 (3 units)	307		Yes
	Komatsu	PC 400	307	Mine-X Soot Filter	Yes
	Komatsu	PC600 (2 units)	385		Yes
	Caterpillar	330	247	Catalyzed Converter/Muffler	Yes
Wheeled Excavator	Komatsu	PW220	124		Yes
Loader	Komatsu	WA380	190	Mine-X Soot filter	Yes
	Komatsu	WA380	190	Mine-X Soot filter	Yes
	Komatsu	WA320	187		Yes
	Komatsu	WA320	187	Clean Emissions Purifier DOC	

<b>Equipment Type</b>	<b>Make</b>	<b>Model</b>	<b>Horsepower</b>	<b>Retrofit Device</b>	<b>CCVS</b>
Loader	Komatsu	WA320	187	Clean Emissions Purifier DOC	Yes
	Komatsu	WA420 (2 units)	200		Yes
	Komatsu	WA420 (2 units)	200	Clean Emissions Purifier DOC	
	Komatsu	WA420	200	Clean Emissions Purifier DOC	Yes
	Caterpillar	966 (5 units)	200	Clean Emissions Purifier DOC	Yes
	Caterpillar	928G	160		Yes
Sweeper	GMC	TS-7500	200	Mine-X Soot filter	Yes
Backhoe	John Deere	410	95	Mine-X Soot filter	Yes
	John Deere	410G	190	Clean Emissions Purifier DOC	
	John Deere	JD410G	90	Clean Emissions Purifier DOC	Yes
	Caterpillar	416	?		Yes
Boom lift	JLG (135 foot)	1350SJP (2 units)	87	Clean Emissions Purifier DOC	
	JLG (135 foot)	1350SJP	87	Clean Emissions Purifier DOC	Yes
	JLG (125 foot)	1250AJP	87	Clean Emissions Purifier DOC	
	JLG (120 foot)	120XSJ	70	Clean Emissions Purifier DOC	Yes
	JLG (120 foot)	1200S	85	Clean Emissions Purifier DOC	
	JLG (86 foot)	860SJ	66	Clean Emissions Purifier DOC	Yes
	JLG (86 foot)	860SJ (4 units)	66	Clean Emissions Purifier DOC	
	JLG (80 foot)	800S	65	Clean Emissions Purifier DOC	
	JLG (80 foot)	800AJ (3 units)	65	Clean Emissions Purifier DOC	
	JLG (80 foot)	800AJ	65	Clean Emissions Purifier DOC	Yes
	JLG (80 foot)	800S (2 units)	65	Clean Emissions Purifier DOC	
	JLG (80 foot)	800SJ	65	Clean Emissions Purifier DOC	
	JLG (66 foot)	660SJ	65	Clean Emissions Purifier DOC	
	JLG (60 foot)	600SJ	65	Clean Emissions Purifier DOC	Yes
	JLG (60 foot)	600SJ	65	Clean Emissions Purifier DOC	

<b>Equipment Type</b>	<b>Make</b>	<b>Model</b>	<b>Horsepower</b>	<b>Retrofit Device</b>	<b>CCVS</b>
Boom Lift	JLG (60 foot)	600S (4 units)	65	Clean Emissions Purifier DOC	
	JLG	120SXJ (4 units)	68	Clean Emissions Purifier DOC	Yes
	JLG	1350JP	68	Clean Emissions Purifier DOC	Yes
	JLG	150HAX (3 units)	68	Clean Emissions Purifier DOC	Yes
	JLG	150HAX	68	Clean Emissions Purifier DOC	
	Genie	Z135 (2 units)	68	Clean Emissions Purifier DOC	Yes
	Genie	S-85 (2 units)	78	Clean Emissions Purifier DOC	
	Genie	GTH844	99	Clean Emissions Purifier DOC	
	Lull	844	110		Yes
	Lull	1054 (2 units)	110		Yes
Gradall	Lull	G6-42P	99	Clean Emissions Purifier DOC	
Off – Road Dump	Volvo	A30D	343	Clean Emissions Purifier DOC	
	Volvo	A35D (2 units)	343	Clean Emissions Purifier DOC	Yes
	Volvo	A40	404	Catalyzed Converter Muffler	Yes
	Volvo	6x6	333		Yes
	Volvo	A35	333		Yes
	Komatsu	HM350 (2 units)	390		Yes
	Komatsu	HM400	430		Yes
	Moxy	MT40B (2 units)	450		Yes
Forklift	JCB	550	100	Clean Emissions Purifier DOC	
	Lull	TL-2 (4 units)	110		Yes
	Lull	1054 (2 units)	110		Yes
	Genie	GTH-844 (2 units)	99	Clean Emissions Purifier DOC	
	Terex	TH-844C	99	Clean Emissions Purifier DOC	Yes
	Lull	844 (2 units)	110		Yes
	Lull	TH 842C	99	Clean Emissions Purifier DOC	Yes
	Lull	844C	110		Yes

<b>Equipment Type</b>	<b>Make</b>	<b>Model</b>	<b>Horsepower</b>	<b>Retrofit Device</b>	<b>CCVS</b>
Forklift	Lull	1054 (2 units)	110		Yes
Drill Rig	Bauer	BG 28 BS80	405	Universal Silencer DPF w/ Johnson Matthey CRT Filter	Yes
	Bauer	BG 40 BS80	580	ECS Purifier DPF	Yes
Crane	Manitowoc	888 (3 units)	330	Clean Emissions Purifier DOC	Yes
	Manitowoc	999	330	Clean Emissions Purifier DOC	Yes
	Manitowoc	2250 (2 units)	300	Clean Emissions Purifier DOC	Yes
	Manitowoc	4000 (2 units)	350		Yes
	Link Belt	HC238A	230	Clean Emissions Purifier DOC	Yes
	Link Belt	82 Ton	260	Clean Emissions Purifier DOC	Yes
	Link Belt	348H5	300	Catalyzed Converter Muffler	Yes
	Link Belt	348H5	300	Mine-X Soot filter	Yes
	Link Belt	108H5	220	Clean Emissions Purifier DOC	Yes
	American	TC-2200	320	Clean Emissions Purifier DOC	Yes
	Terex	100 Ton	290	Clean Emissions Purifier DOC	Yes
	Terex	RT-353	152	Clean Emissions Purifier DOC	Yes
	Grove	HC-400	224	Clean Emissions Purifier DOC	Yes
	Grove	6350	280	Clean Emissions Purifier DOC	Yes
	Liebherr	LTM1095	310	Catalyzed Converter Muffler	
Roller	Ingersoll-Rand	100D (2 units)	125	Clean Emissions Purifier DOC	
	Ingersoll-Rand	100D	125		Yes
	Ingersoll-Rand	100D	125	Clean Emissions Purifier DOC	Yes
Dirt Roller	Ingersoll-Rand	SD 122DX	190	Clean Emissions Purifier DOC	
Compactor	Ingersoll-Rand	SD 70	92	Clean Emissions Purifier DOC	Yes
Compressor	Ingersoll-Rand	WCU 1300	460		Yes
	Ingersoll-Rand	WCU 1300 (2 units)	460	Clean Emissions Purifier DOC	Yes

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Compressor	Ingersoll-Rand	WCU 1301	461	Clean Emissions Purifier DOC	Yes
Paver	Blaw-Knox	PF5510	182	Clean Emissions Purifier DOC	Yes