Analysis Of Potential Transportation Emissions Reductions Measures (TERMs) Under Consideration For The Conformity Of The 2007 CLRP & FY 2008 - FY 2013 TIP

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Contents

TERMs

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2006 CLRP & FY 2007 – FY 2012 TIP

Introduction

This report documents the analysis of potential transportation emissions reduction measures (TERMs) for the 2006 Constrained Long range Plan (CLRP) and FY 2007-FY2012 Transportation Improvement Program (TIP). The Transportation Planning Board (TPB) has been adopting TERMs since FY1995 as a method for reducing Ozone precursor emissions NOx and VOC. The Travel Management Subcommittee provides technical oversight of the TERMs analysis process and makes recommendations to the TPB Technical Committee. The Technical Committee then makes recommendations or endorsements of TERMs to the TPB for adoption.

Background

The Clean Air Act Amendments of 1990 (CAAA) and the Safe, Accountable, Efficient, Flexible, Transportation Efficiency Act (SAFETEA-LU) requires metropolitan planning organization and department of transportation to perform air quality analyses, to ensure that the transportation plan and program conform to mobile emission budget established in the State Implementation Plans (SIP). Consequently MPO's and DOT's are required to identify transportation emissions reduction measures (TERMs) that would provide emission-reduction benefits and other measures intended to modify motor vehicle use. Selection of the TERMs requires quantitative as well as qualitative assessment. The quantitative assessment includes specific information on the benefits, costs, and expected air-quality benefits. Qualitative criteria includes ranking based on the subjective criteria's such as ease of implementation, how to implement, and synergy with other measures.

Washington DC region is classified as moderate non-attainment for Ozone 8-hour standard and required to demonstrate air quality conformity for ozone precursors (VOC & NOx). In addition the region also needs to conform to the PM 2.5 standard. This may necessitate adoption of new TERMs if the region fails to meet the interim PM2.5 budget. This document contains all such potential measures identified by the Travel Management Subcommittee and includes their analysis with emissions reduction and cost effectiveness.

TERM Analysis

The TERM analysis includes estimation of NOx, VOC and PM2.5 & PM2.5 precursor NOx emissions benefits and their cost effectiveness. This Potential TERM document shows analysis and emissions reduction estimation for milestone year 2010. The PM and precursor NOx emission estimation for the potential TERMs are shown separately in the addendum. The prior Potential TERMs document included analysis and emission

estimation for year 2005. The TERMs are analyzed using Mobile 6.2 emissions factors and version 2.1D travel demand model data.

The majority of these TERMs are analyzed using sketch planning techniques. The TERMs analyzed using this approach use regional survey data, MWCOG studies, consultant studies or national research. Some measures were analyzed using various components of MWCOG's four-step modeling process (trip generation, trip distribution, mode choice, and trip assignment) or the COMSIS TDM model. The layout of each measure includes detail assumptions, analyses, and results for the potential transportation emission reduction measures.

TERM Category

Introduction of the Mobile 6.2 emissions model offered the potential for a more disaggregate emissions reduction analysis of TERMs. Instead of the 8 different vehicle classes used in the Mobile 5b model, the Mobile 6.2 model utilizes 28 vehicle classes providing an opportunity for better analysis by categorizing the TERMs. Four categories of TERMs have been developed utilizing the disaggregate nature of the vehicle classes. The four categories are:

- TERMs impacting the traffic stream (all vehicle types), such as the Signal Optimization TERM, will continue to be analyzed using a regional composite vehicle emissions factor.

- TERMs impacting commuting vehicle trips, such as the Employer Outreach, and Parking & Ride lots TERMs will be analyzed using an average light duty vehicle emissions factor composed of emissions factors for several classes of light duty vehicles and for motorcycles.

- TERMs impacting all types of heavy duty diesel vehicles, such as a Diesel Fuel Additive TERM, are categorized as engine technology TERM.

- TERMs impacting an individual heavy duty vehicle type of a specific weight class, are categorized as a specific vehicle type, such as school buses, transit buses, tractor trailers.

  Emissions rates for all the above categories and by different milestone year are included in the ‘Call for Project -2006’ document.

Emissions Estimation

The emissions emanating from the tailpipe of the any vehicle includes pollutants like NOx, VOC & PM. Typically emissions occur during the start-up, running, and hot soak portions of each trip. These emissions can be quantified using the emissions rates and using the following the formulae and procedure to estimate these emissions.

Emissions = Start up emissions + Running emissions + Soak emissions

Start-up emissions = Vehicle Trip Origin x Start up emissions rate (Cold start in Grams/Trip)

Running emissions =VMT x Running emissions rate (Grams/Mile)

Hot Soak emissions = Trip Destination x Hot Soak emission rate (Grams/Trip)

EPA's Mobile 6.2 model provides the emissions rates for NOx, VOC & PM2.5. The running and cold start/hot soak factors shown in the following tables were generated using the Mobile 6.2 emissions model with the latest VMT and vehicle registration data as input to the model.

Regional average emissions factors corresponding to average speed have been used for the emissions estimation. For the Washington DC region, 40 mph average speed is used for commute category TERM running emissions rate while 41 mph speed is considered for traffic stream TERMs. The following tables 1 & 2 show the emissions rates for VOC & NOx corresponding to 40 mph speed. Please see the 'Call for Projects -2006' document for the emissions rates at various speeds. For the special and engine technology TERMs, factors from EPA's guidance document are used.

Table-1

VOC Factors			
Year	**2010**	**2020**	**2030**
Cold start	**0.9599**	**0.5378**	**0.4717**
Running	**0.1617**	**0.0968**	**0.0905**
Hotsoak	**0.5661**	**0.2584**	**0.1995**

Table - 2

Ozone NOx factors			
	2010	**2020**	**2030**
Cold Start	**0.5811**	**0.2398**	**0.172**
Running	**0.3811**	**0.1598**	**0.1343**

PM2.5 & Precursor NOx Emissions

The EPA guidance on fine particulate matter (PM 2.5) emissions requires the region to estimate direct PM 2.5 and NOx precursor emissions. The procedure for estimating PM2.5 & precursor NOx is the same as that of ozone precursor NOx and VOC described above. However, these emissions estimations are required on an annual basis. Direct PM emissions rate is constant for all speeds and is expressed in grams/mile. Direct PM 2.5

has no start up, soak or other evaporative emissions associated with them. However, precursor NOx for PM 2.5 is similar to NOx precursor for Ozone and has start up emissions in addition to running emissions.

As shown in the 'Call for Project -2006' document the recommended methodology to estimate annual direct PM2.5 and NOx precursor emissions is to use an average of the four seasonal emission rates (Winter, Spring, Summer, and Fall) and apply these average rates to annual VT and VMT to estimate the annual direct PM2.5 and NOx precursor emissions. Direct PM emissions rates and average seasonal precursor e NOx emissions rates for the analysis years 2010 are shown in the following tables. For the commute and traffic stream TERM 250 days per year is assumed in the analysis. The PM2.5 and Precursor NOx emission estimation for the potential TERMs are shown separately. Please see the addendum.

The PM2.5 & precursor NOx emissions factors corresponding to the average speed of 40 mph used for the TERM analysis are shows in the following tables 3 & 4.

Table - 3

PM2.5 NOx Precursor Factors			
	2010	**2020**	**2030**
Cold Start	**0.6132**	**0.2505**	**0.1804**
Running	**0.3825**	**0.1557**	**0.1303**

Table - 4

PM2.5 Factors			
	2010	**2020**	**2030**
Running	**0.0117**	**0.0113**	**0.0113**

General Assumptions

The detailed assumptions for the each TERMs varies as per the nature of the TERM. However, some of the assumptions are common to the all the TERMs. Such assumptions included 2010 travel conditions, regional average emissions factors, regional average one way trip length of 15.5 miles etc.

Following tables shows regional data (VT & VMT by purpose, year) obtained from the travel demand model and some of the generic assumptions are the being used for the TERM analysis.

Table 5- Daily Regional Home Based Work Purpose Mode Analysis by Year

YEAR	HBW MOTORIZED PERSON	TOTAL HBW AUTO PSN	TOTAL HBW AUTO DRV	HBW CAROCC	HBW TRANSIT	HBW TRANSIT (%)
2002	4,316,159	3,791,490	3,383,336	1.120	524,669	12.20%
2010	4,985,050	4,378,265	3,898,063	1.120	606,785	12.20%
2020	5,713,760	5,004,517	4,445,790	1.130	709,243	12.40%
2030	6,431,361	5,661,282	5,030,783	1.130	770,079	12.00%

Table 6- Daily Regional Analysis by Year for all Trip Purposes

YEAR	TOTAL MOTORIZED PERSON	TOTAL AUTO PSN	TOTAL AUTO DRV	TOTAL CAROCC	TOTAL TRANSIT	TRANSIT (%)
2002	24,654,844	23,759,891	18,220,519	1.300	894,953	3.60%
2010	28,266,255	27,241,469	20,901,519	1.300	1,024,786	3.60%
2020	31,907,217	30,665,549	23,571,119	1.300	1,241,668	3.90%
2030	35,311,893	33,965,512	26,215,916	1.300	1,346,381	3.80%

Table 7- Daily Regional Vehicle Trips by Purpose by Year

YEAR	WORK & NON-WORK AUTO DRV	TRUCKS (MED + HVY)	MISC + THRU TRIPS	TOTAL VEH. TRIPS	TOTAL VMT
2002	18,220,519	479,095	708,631	19,407,719	149,065,567
2010	20,901,519	557,845	824,585	22,283,534	169,740,561
2020	23,571,119	650,193	952,699	25,173,882	195,371,894
2030	26,215,916	743,855	1,082,348	28,041,954	217,051,064

Source: 2005 CLRP / FY2006-2011 TIP CLRP air quality conformity document

Cost Estimation

The staff has gathered cost information from the various agencies and cost figures are in today's dollars. The TERMs project cost is expressed in terms of TIP cost and cost per year. The total cost of project thus includes capital cost, operating cost and maintenance cost. The TIP cost consists of capital cost, and three year of operating cost and maintenance cost. For the cost effectiveness annualized cost has been used. The annualized cost is total cost per year. The following formula shows the procedure.

Annualized cost = capital cost / life span + operating & maintenance cost per year

Cost effectiveness = Annualized cost / annual emissions

The following table shows life span for the for annualized cost estimate following t

Table 8- Life span of Various Facilities

Facility	Life Span (years)
Park and ride lot land (right-of-way)	100
Roadways	20
Bridges	30
Roadway signal systems	12
Rail signalization	20
Structures (i.e., garages)	35
Buses	12
Railcars	35
Locomotives	30
Sidewalks	10
Fueling station	30

Cost Effectiveness

Cost effectiveness of a Transportation Emission Reduction Measure (TERM) is an attribute that is widely used for selecting measures for NOx and VOC mitigation. The calculation of cost effectiveness ($/ton) in the simplest form is the cost per day divided by the emissions reduced in tons per day. The effectiveness in terms of $ per ton of NOx and VOC and PM2.5 have been estimated and shown in the analysis.

Summary Results

The summary results of potential TERMs analyzed are shown in summary form in Table 9 & 10. The list includes some technology measures that have not been evaluated by EPA and their emissions reductions potential have not been certified.

TRAVEL DEMAND AND EMISSIONS REDUCTION FROM POTENTIAL TERMS UNDER CONSIDERATION FOR CONFORMITY OF THE 2006 CLRP & FY 2007-2012 TIP

Table - 9

Ozone Precursor NOx and VOC Emissions Estimate

Potential TERMs	VT (2010)	VMT (2010)	NOx (2010)	VOC (2010)	Cost Effectiveness		Project Category
			tons/day	tons/day	NOx ($/t)	VOC ($/t)	Category *
M-07A Voluntary Employer Parking Cash-Out Subsidy	16662	258261	0.1192	0.0741	5,379	8,655	C
M-24 Speed Limit Adherence (accelerated)		-	0.9167	-	26,618	-	TR
M-47c Employer Outreach for Private Sector Employers (expanded)	1323	20507	0.0095	0.0059	359,330	578,172	C
M-93 Improve Pedestrian Facilities Near Rail Stations	1428	22134	0.0102	0.0063	556,154	894,866	C
M-103 150 Taxicab Replacement Program - CNG (expanded)			0.2030	0.1307	14,300	22,210	SP
M-103a 150 Taxicab Replacement Program - conventional vehicles		-	0.1750	1,136	13,300	20,450	SP
M-110 10 Transit Stores in Maryland	2091	64989	0.0286	0.0151	17,320	32,850	C
M-111 Replace Traffic Signals with Lesser Controls		-	-	-	-	-	TR
M-113 6 Kiosks in Maryland	11	300	0.0001	0.0001	4,448,676	8,224,907	C
M-123 Employer Outreach for Public Sector Employers	10920	169260	0.0781	0.0485	41,827	67,301	C
M-132 Vanpool Incentive Program (expanded M-77b)	1785	111027	0.0478	0.0228	154,175	323,230	C
M-133 Metrorail Feeder Bus Service	0	6050	0.0025	0.0011	535,107	1,261,158	C
M-134 Implement Neighborhood Circulator Buses (10)	3000	46500	0.0215	0.0133	209,733	337,465	C
M-135 Construction of 1000 Parking Spaces at Metrorail Stations	0	20677	0.0087	0.0037	613,732	1,445,350	C
M-142E 100 CNG Buses in place of Old Diesel Buses	-	-	0.1720	0.0326	77,631	41,0051	SP
M-142F 100 Hybrid Buses in place of Old Diesel Buses	-	-	0.2095	0.0576	53,550	194,730	SP
M-142G 100 New Diesel Buses in place of Old Diesel Buses	-	-	0.1696	0.0556	40,250	122,900	SP
M-143 Real Time Bus Schedule Information	1232	19096	0.0088	0.0055	55,371	89,093	C
M-146 Purchase 185 WMATA buses (ridership growth)	18870	292485	0.1350	0.0839	108,400	174,400	C
M-148 WMATA Bus Information Displays with Maps (2000 cases)	2210	34255	0.0158	0.0098	25,348	40,785	C
M-150 Enhanced Commuter Services- (HOV Facilities)	0	51716	0.0217	0.0092	392,867	925,922	C
M-151 Enhanced Commuter Services-US 1 (Reverse Commute)	1916	29693	0.0137	0.0085	588,810	947,409	C
M-152 Enhanced Commuter Services- (Rail Relief)	0	73082	0.0307	0.0130	839,359	1,978,230	C
M-155 Expand Carsharing Program	290	4495	0.0021	0.0013	270,433	435,134	C
M-156 Free bus-to-rail/ rail-to-bus transfers (Similar to NYC pricing structure)	5100	79050	0.0365	0.0227	3,235,093	5,205,344	C
M-158 Free Bus Service Off-Peak (10:00 AM to 2:00 PM Mid-Day and Weekends)	4284	66402	0.0306	0.0190	2,282,683	3,672,893	C
M-159 W15-590 - Diesel Fuel Additive #	-	-	0.1330	-	2,700	-	H
M-160 Bose Automobile Anti-Air Pollutant and Energy Conservation System #	-	-	0.6100	-	1,000	-	H
M-161 Diesel Emulsion Fuel Additive (Non-road or Highway) **	-	-	0.1800	-	12,000	-	H
M-162 Early Engine Retirement (Pre-88) **	-	-	0.9000	-	2,200	-	H
M-163 Truck Idling (Truck Stops and Auxiliary Power Unit) **	-	-	0.4000	-	4,600	-	H
M-164 International Green Diesel Retrofit #	-	-	0.1400	-	141,000	-	H
M-165 Bike Stations at Rail Station	105	1628	0.0008	0.0005	905,260	1,456,714	C
M-144 Parking Impact Fees [1]	121836	1888453	0.8714	0.5415	1,818,865	2,926,599	C

Project Category: TR - Traffic Stream, C - Commute, H - Heavy Duty Vehicles (Engine Technology), SP- Specific Vehicle Type

** EPA Certified Technology available † Emission estimation under revision # No EPA certification Available [1] *This is a revenue generating TERM*

Table - 10

PM2.5 and Precursor NOx Emissions Estimate (2010)

Potential TERMs	Pre NOx (t/y)	PM2.5 (t/y)	Cost Effectiveness		Project Category
	tons/year	tons/year	Pre NOx ($/t)	PM2.5 ($/t)	Category *
M-07A Voluntary Employer Parking Cash-Out Subsidy	30.0385	0.8327	6,658	240,182	C
M-24 Speed Limit Adherence (accelerated)	-	-	-	-	TR
M-47c Employer Outreach for Private Sector Employers (expanded)	2.3851	0.0661	356,375	12,855,749	C
M-93 Improve Pedestrian Facilities Near Rail Stations	2.5744	0.0714	551,580	19,897,500	C
M-103 150 Taxicab Replacement Program - CNG (expanded)	-	0.6614	-	1,360,778	SP
M-103a 150 Taxicab Replacement Program - conventional vehicles	-	0.6614	-	1,096,182	SP
M-110 10 Transit Stores in Maryland	7.2037	0.2095	20,314	698,382	C
M-111 Replace Traffic Signals with Lesser Controls	-	-	-	-	TR
M-113 6 Kiosks in Maryland	0.0335	0.0010	4,420,368	153,006,701	C
M-123 Employer Outreach for Public Sector Employers	19.6867	0.5457	41,483	1,496,443	C
M-132 Vanpool Incentive Program (expanded M-77b)	12.0048	0.3580	153,422	5,144,982	C
M-133 Metrorail Feeder Bus Service	0.6377	0.0195	533,148	17,429,845	C
M-134 Implement Neighborhood Circulator Buses (10)	5.4084	0.1499	208,008	7,503,598	C
M-135 Construction of 1000 Parking Spaces at Metrorail Stations	2.1795	0.0667	610,200	19,950,000	C
M-142E 100 CNG Buses in place of Old Diesel Buses	-	1.9842	-	2,096,605	SP
M-142F 100 Hybrid Buses in place of Old Diesel Buses	-	1.9842	-	1,763,971	SP
M-142G 100 New Diesel Buses in place of Old Diesel Buses	-	1.8960	-	1,123,433	SP
M-143 Real Time Bus Schedule Information	2.2211	0.0616	1,028,018	37,084,341	C
M-146 Purchase 185 WMATA buses (ridership growth)	34.0191	0.9430	970,042	34,992,932	C
M-148 WMATA Bus Information Displays with Maps (2000 cases)	3.9842	0.1104	31,374	1,131,764	C
M-150 Enhanced Commuter Services- (HOV Facilities)	5.4513	0.1667	488,504	15,970,309	C
M-151 Enhanced Commuter Services-US 1 (Reverse Commute)	3.4537	0.0957	728,791	26,290,137	C
M-152 Enhanced Commuter Services- (Rail Relief)	7.7035	0.2356	1,043,686	34,120,518	C
M-155 Expand Carsharing Program	0.5228	0.0145	334,725	12,074,755	C
M-156 Free bus-to-rail/ rail-to-bus transfers (Similar to NYC pricing structure)	9.1944	0.2549	4,004,194	144,445,733	C
M-158 Free Bus Service Off-Peak (10:00 AM to 2:00 PM Mid-Day and Weekends)	7.7233	0.2141	2,825,360	101,920,954	C
M-159 W15-590 - Diesel Fuel Additive	-	-	-	-	H
M-160 Bose Automobile Anti-Air Pollutant and Energy Conservation System	-	-	-	-	H
M-161 Diesel Emulsion Fuel Additive (Non-road or Highway)	-	-	-	-	H
M-162 Early Engine Retirement (Pre-88)	-	9.342	-	126,310	H
M-163 Truck Idling (Truck Stops and Auxiliary Power Unit)	-	29.845	-	19,266	H
M-164 International Green Diesel Retrofit	-	-	-	-	H
M-165 Bike Stations at Rail Station	0.1893	0.0052	897,816	32,386,537	C
New TERMs (revenue generating)					
M-144 Parking Impact Fees [1]	219.6472	6.0889	(1,803,907)	(65,073,456)	C

** Project Category: TR - Traffic Stream, C - Commute, H - Heavy Duty Vehicles (Engine Technology), SP- Specific Vehicle Type*

M – 07A Voluntary Employer Parking Cash-Out Subsidy

Description:
Many employers in the region choose to subsidize automobile parking for their employees. These subsidies are executed through payment of parking fees, or the provision of parking space leased or owned by the employer. This TERM would create a program for giving equal compensation "cash-out" to employees who choose not to use the free parking provided by the employer and use alternative modes of travel such as walk, bicycle, transit, rideshare, etc.

Assumptions:

- Analysis tool sketch planning, COMSIS TDM Model (1993 analysis studied only the impact of transit and ridership.)
- This TERM will only affect work-related trips.
- The existing parking subsidies offered by each employer can be quantified.
- Participation in this TERM by employers in voluntary. It was assumed that 10% of the regions employers would participate in the program.
- The results are based on a 1993 analysis of mandatory employer parking cash-out subsidy for transit/HOV.
- Trip reduction rate by 2010 - 4.3%;
- Trip reduction rate by 2007 - 1.43%
- 85 percent of new users drive alone prior to using transit
- Average trip length = 15.5 miles

Summary Impact (2010):

Daily VT Reduction:	16662	VT
Daily VMT Reduction:	258261	VMT
Daily NOx Reductions:	0.11917	tons/day
Daily VOC Reductions:	0.07406	tons/day
Cost Effectiveness (NOx)	5,379	$/ton
Cost Effectiveness (VOC)	8,655	$/ton

Emission Analysis:

Base 2010 HBW single occupant trips – 3,875,000
Trip reduction rate – 4.3%
Employee participation rate – 10%
Total VT reduction: 3,875,000 x 4.3% x 10% = 16,662
VMT reduction: 16,662 x 15.5 = 258,261

Daily Emission Reductions:

NOx Estimation

Cold Start	16662	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.01067	tons
Running	258,261	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.10849	tons
					Total		0.11917	tons

VOC Estimation

Cold Start	16662	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.02803	tons
Running	258,261	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.04603	tons
					Total		0.07406	tons

Cost Effectiveness:

The cost of administering the program is estimated at $200,000/year. The employer cost is not estimated.

Cost effectiveness NOx	$200,000 / (312 x 0.11917)	=	5,379	$/ton		
Cost effectiveness VOC	$200,000 / (312 x 0.07406)	=	8,655	$/ton		

M – 24 Speed Limit Adherence

Description:

Increase speed limit adherence on portions of the freeway system in the region where speeding is a problem so that 70% of the vehicles that are traveling above the speed limit will travel at or below the posted speed limit. The regional travel demand model assumes that 85% of the vehicles travel above the speed limit under free flow conditions. By assigning five police officers for every 20 miles of freeway, it is expected that speeding will drop from 85% to 25% of all vehicles. The relationship between speed and NOx running emission factors indicates that emissions increase over 48 mph. By reducing the number of vehicles traveling faster than the 55 mph or 65 mph posted speed limit, emission reductions can be realized.

Assumptions:

- Sketch planning is used as an analysis tool
- Initially the enforcement will be performed by officers, photo radar technology will subsequently be implemented and replace the need for officers.
- New laws or regulations may be required for use of photo radar.

Summary of Impacts (2010):

Daily VT Reduction:	N/A
Daily VMT Reduction:	N/A
Daily NOx Reductions:	0.5364 tons/day
Cost effectiveness:	$26,618/ton

Emission Analysis:

This measure consists of increased enforcement of the existing speed limits on freeways and expressways throughout the region. The TERM is designed to increase the 15% adherence rate to 70%. The impact of the measure on the emissions calculation process is to reassign additional speeding VMT in the 60, and 65 mph bins to the 55 mph conditions when the posted speed limit is 55 mph. Similarly 65 mph bins is assigned to the 60 mph bin when the speed limit is 60 mph. The following table shows the NOx emissions benefit estimation for facilities with the three posted speed limits.

Emissions calculations

No VOC benefits as net gain in VOC after enforcement is negative.

NOx Benefits Due to Speed Limits

Roadways Posed At 55 mph

2010

	Before Enforcement				After Enforcement (55 mph limit)		Net Gain in NOX
	Speed (mph)	VMT with 60 mph	NOx emission Factors	NOx Emissions	Net VMT	NOx Emissions (Tons/day)	Tons/day
1	55	3818543	0.8498	3.5770	6152453	5.7633	-2.1863
2	60	891931	0.9303	0.9147	267579	0.2744	0.6403
3	65	2442226	1.043	2.8079	732668	0.8424	1.9655
				7.2995		**6.8800**	**0.4195**

Roadways Posed At 60 mph

	Before Enforcement				After Enforcement (60 mph limit)		Net Gain in NOX
	Speed (mph)	VMT with 60 mph	NOx emission Factors	NOx Emissions	Net VMT	NOx Emissions (Tons/day)	Tons/day
1	60	169500	0.9303	0.1738	1111071	1.1394	-0.9656
2	65	1345102	1.043	1.5465	403531	0.4639	1.0825
				1.7203		**1.6033**	**0.1170**
						Total NOx Benefit =	**0.5365**

Emissions factors from - 'Call for Projects' document, December 2005 Table 2: Average Emissions Factors for "Traffic Stream" TERMs

Cost Analysis:
438 miles (219 miles one way x 2) of freeway in the above Jurisdictions

Approximately 5 officers to patrol 20 miles of freeway 24 hours a day

438 miles/20 miles = 22 segments

22 segments x 5 officers = 110 officers

Total cost per officer:

One time cost	$33,000 (vehicle, equipment, etc)	
Maintenance Cost	$10,000 (maintenance cost)	
Annual cost	$52,000 (salary, overhead)	
	Total	**$95,000**

Total cost for 110 officers

One time cost	$33,000 x 110 = $3,630,000
Annual cost	$52,800 x 110 = $5,808,000
Maintenance cost	$10,000 x 110 = $1,100,000
Education	$100,000
TIP cost:	$6,908,000 x 3 + $3,630,000 + $100,000 = $24,454,000
Annual cost:	$5,808,000 + $1,100,000 +100,000 + $ 3,630,000/6 yrs = $7,613,000

Cost Effectiveness (2010):

$$\text{NOx} = \frac{\$7,613,000/\text{ year}}{312 \text{ days x } 0.5365 \text{ tons/day}} = \$45,490 / \text{ ton}$$

Table 1: Freeway miles by speed and jurisdiction

Jurisdiction	Route	Freeway Mile			Total Miles
		55 mph	60 mph	65 mph	
Frederick County	I-270, I-70	7.0	0.0	30.4	37.4
Montgomery	I-270, I-495	31.6	0.0	4.7	36.3
PG County	I-495, I-95, US-50, US295	26.9	0.0	7.0	33.9
Fairfax	Dulles Toll Rd., I-66, I-495, I-95	49.1	9.4	0.0	58.5
Prince William	I-66, I-95	0.0	12.9	12.9	25.7
Loudoun	Dulles Rd	2.3	0.0	9.4	11.7
Stafford	I-95	0.0	0.0	15.2	15.2
	Total	**117.0**	**22.2**	**79.6**	**218.8**

M-47c Expanded Employer Outreach for Private Sector Employers

Description

The adopted TERM is expanded under the TERM implemented through private sector employers by marketing and implementing employer based TDM programs.

Assumptions

- Sketch planning is used as an analysis tool
- WMATA staff will service all Metro check accounts and the cost will be $350,000. All other sales and service calls will be handled by local sales representatives and central program staff. Their annual expenses will be $500,000.
- Annual funding will be increased by $850,000 from 2008 to 2010.
- The additional funding will be used to focus on District of Columbia, and Prince George's County.
- The additional funding will increase NOx emission reductions of existing employer outreach program by 40%.
- Average trip length = 15.5 miles

Summary Impact

Daily VT Reduction:	1323	VT
Daily VMT Reduction:	20507	VMT
Daily NOx Reductions:	0.00946	tons/day
Daily VOC Reductions:	0.00588	tons/day
Cost Effectiveness (NOx)	359,330	$/ton
Cost Effectiveness (VOC)	578,172	$/ton

Emission Analysis

Increase Commuter Connections FY 2001 work program goals for 2010 (interpolated from 2002 and 2020 goals) by 40%: (Note: 2005 Goal for VT reduction based on 2005 TERM analysis report is 13100. As there will be hardly any change in emissions with new goal, we kept old VT & VMT)

2010 M-47c goal of trip reduction = 13,223
New 2010 M-47 c goals (10% increase) = 14,545
VT reduced = 14,545 – 13,223 = 1,323
VMT reduced = 1,323 x 15.5 = 20,507

Daily Emission Reductions

Nox Estimation

Cold Start	1323	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00085	tons
Running	20,507	x	0.3811 grams / 1 mile	x	1 ton / 907,185 grams	=	0.00861	tons
					Total		0.00946	tons

VOC Estimation

Cold Start	1323	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00223	tons
Running	20,507	x	0.1617 grams / 1 mile	x	1 ton / 907,185 grams	=	0.00366	tons
					Total		0.00588	tons

Cost Analysis (2010)

Total annual cost = $500,000 + $ 350,000 = $850,000
TIP Cost 2005-2010 = $2,550,000
Cost per year: $850,000

Cost Effectiveness (2010)

Cost effectiveness NOx = $850,000 / (250 x 0.00946) = 359330 $/ton

Cost effectiveness VOC = $850,000 / (250 x 0.00588) = 578172 $/ton

M-93 Improve Pedestrian Facilities Near Rail Stations

Description

This measure assumes improvements to sidewalks, curb ramps, crosswalks, and lighting in order to improve pedestrian access to 11 MARC stations and 12 Metrorail stations in Montgomery County. The current analysis was conducted based on needs shown in a Maryland Department of Transportation/ Mass Transit Administration report published in June, 1997 (*Access 2000 – Bicycle and Pedestrian Access to Rail Transit Stations in Maryland*).

Summary of Impacts (2010)

Daily VT Reduction:	1428	VT
Daily VMT Reduction:	22134	VMT
Daily NOx Reductions:	0.01021	tons/day
Daily VOC Reductions:	0.00635	tons/day
Cost Effectiveness (NOx)	556,154	$/ton
Cost Effectiveness (VOC)	894,870	$/ton

Assumptions

- Sketch planning is used as an analysis tool
- Made all improvements to sidewalks, curb ramps, crosswalks, and lighting at and around (0.6 mile radius from station) Montgomery County rail stations, as needed according to MDOT/MTA's *Access 2000* study.
- Used 2 % growth rate, compounded annually, to grow 1996 average weekday passenger totals to 2005 ridership numbers at each station. 1996 average weekday passenger totals from MDOT/MTA's *Access 2000* study.
- Used 5% increase in passengers for areas that needed improvements at and around (0.6 mile radius) the station, and used 3% increase in passengers for areas that need improvements just around (0.6 mile radius) the station.
- 85 percent of new users drive alone prior to using transit
- Average trip length = 15.5 miles

Emission Analysis (2010)

Increase in pedestrian due to improvements = 84765 - 83925 = 840 (refer table 1)
Increase in trips = 2 x 840 = 1680
Number of SOV trips = 1680 x 0.85 = 1428
VMT: 1428 x 15.5 = 22134

Daily Emissions Reductions

NOx Estimation

Cold Start	1428	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00091	tons
Running	22,134	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.00930	tons
					Total		0.01021	tons

VOC Estimation

Cold Start	1428	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00240	tons
Running	22,134	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.00395	tons
					Total		0.00635	tons

Cost Assumptions

In order to estimate the project cost, staff estimated the miles of sidewalk, and number of intersections requiring curb cuts, wheel chair ramps, crosswalks and signal components at 22 Metro and MARC stations. The cost of the improved pedestrian facilities is estimated at $11.4 million. A contingency cost of $2.8 million, (25% of estimated cost) was added to the estimated cost. The total cost of improved pedestrian facilities including contingency cost is estimated at $14.2 million. The cost of the project will be spread over FY 2003 through FY 2005.

Cost Analysis

Cost of improved pedestrian facilities = $11.4 million
Contingency cost 25% = $2.8 million
Life span: 10 years
Number of days per year = 250
Total TIP Cost = $14.2 million
Annualized cost = $14.2 mill / 10 years =$1.42 mill

Cost Effectiveness

Cost effectiveness NOx	$1.42 mill / (250 x 0.01021)	=	556,154	$/ton		
Cost effectiveness VOC	$1.42 mill / (250 x 0.00635)	=	894,866	$/ton		

Tabel 1: Pedestrian Improvements to Transit

TERM Calculation: Pedestrian Access to Transit

	Station	1996 Avg. Weekday Passengers	Needs improvs. at station?	Grow to 2010 2% comp. Ann.	Increase due to improvement 1% growth
MARC:	Dickerson	12	Y	16	16
	Barnesville	61	Y	80	81
	Boyds	9	Y	12	12
	Germantown	345	Y	455	460
	Metropolitan Grove	152	Y	201	203
	Gaithersburg	279	Y	368	372
	Washington Grove	25	Y	33	33
	Rockville	314	N	414	418
	Garrett Park	32	Y	42	43
	Kensington	111	Y	146	148
	Silver Spring	334	N	441	445
Metrorail:	Shady Grove	8465	N	11169	11281
	Rockville	3255	N	4295	4338
	Twinbrook	3511	N	4633	4679
	White Flint	3425	N	4519	4564
	Grosvenor	3201	N	4224	4266
	Medical Center	3545	N	4678	4724
	Bethesda	7106	N	9376	9470
	Friendship Heights	7790	N	10279	10382
	Glenmont		N	0	0
	Wheaton	5125	N	6762	6830
	Forest Glen	1798	N	2372	2396
	Silver Spring	9908	Y	13073	13204
	Takoma	4802	N	6336	6399
	TOTAL	**63605**		**83925**	**84765**

M – 103 Taxicab Replacement Program in the District of Columbia

Description

The District of Columbia adopted a taxicab replacement program in the 1995 CLRP. The program was to be implemented after year 2015 with emission benefits being realized by 2020. This TERM can be accelerated and expanded in order to achieve benefits by 2010. A similar program called the Advanced Technology Vehicle Program has been operational in the Maryland suburbs and has successfully introduced compressed natural gas (CNG) powered taxicabs, airport shuttles, personnel transit buses, and school buses.

Assumptions

- Sketch planning is used as an analysis tool
- 150 cabs will be replaced (50 per year) with new *Compressed Natural Gas (CNG)* powered vehicles by year 2010.
- Replacement vehicle will meet ULEV standards.
- Cabs to be replaced are at least seven years old with high mileage.
- Mileage accumulation of each vehicle is greater than 50,000 miles per year, which translates to 162 daily VMT per cab.
- Taxicabs will be operational 312 days per year.
- Replacement vehicles will not be used after 6 years.
- CNG replacement vehicles will meet Low Emission Vehicle (LEV) standards.
- New CNG vehicles will cost $25,000 each.
- Agreement between administering agency and cab operator to achieve stated emission benefits.
- Administration of the cab replacement program will cost $200,000 annually.
- The program will fund two additional fueling facilities and refurbishment of existing CNG stations that need upgrading.

Emission Reductions

TERM ID	Replacement Vehicle Type	2010 Emission Reductions (tons / day)	
		VOC	NOx
M-103	CNG	0.1307	0.203

Cost Analysis

CNG Replacement Vehicles

Total Cost of 150 cabs	$25,000 x 150 = $3,750,000
Administrative cost	$200,000/yr for 3 years
Refueling facility cost	$1,000,000
Total TIP cost	$3,750,000 + $1,000,000 + $600,000 = $5,350,000
Annualized Cost:	$3,750,000 /6 + $1,000,000/15 + $200,000 = $891,666

Cost Effectiveness (2010)

NOx = $891,666 / (312 days/year x 0.203 tons NOx/day) = $14,300/ ton

VOC = $891,666 / (312 days/year x 0.1307 tons NOx/day) = $22,210/ ton

M – 103a Taxicab Replacement Program in the District of Columbia
(Conventional vehicle)

Description

The District of Columbia adopted a taxicab replacement program in the 1995 CLRP. The program was to be implemented after year 2015 with emission benefits being realized by 2020. This TERM can be accelerated and expanded in order to achieve benefits by 2010.

Assumptions

- Sketch planning is used as an analysis tool
- 150 cabs will be replaced (50 per year) with new *"conventional"* powered vehicles by year 2005.
- Conventional replacement vehicles will meet Light Duty Gasoline Vehicles (LDGV) standards.
- Cabs to be replaced are at least seven years old with high mileage.
- Mileage accumulation of each vehicle is greater than 50,000 miles per year, which translates to 162 daily VMT per cab.
- Taxicabs will be operational 312 days per year.
- Life span of the new cars- 6 years
- New LDGV vehicles will cost $21,000 each.
- Operation of the cab replacement program will cost $200,000 annually.

Emission Reductions

TERM ID	Replacement Vehicle Type	2010 Emission Reductions (tons / day)	
		VOC	NOx
M-103a	LDGV	0.1136	0.1751

Cost Analysis

LDGV Replacement Vehicles:

Total Cost of 2010 Reductions:

3 years x (50 x $21,000 years + $200,000 / year) = $3,750,000

Annualized Cost:

150 x $21,000 / 6 years + $200,000 / year = $725,000

2010 Cost Effectiveness

NOx: $725,000 / (312 days/year x 0.175 tons /day) = $13,300 / ton
VOC: $725,000 / (312 days/year x 0.1136 tons /day) = $20,450 / ton

M-110 10 Transit Stores in Maryland

Description:
This measure would establish 10 Transit Stores in Maryland, similar to those in Arlington County, Virginia and Silver Spring, Maryland.

Assumptions:

- Sketch planning is used as an analysis tool
- Implementation time for the first transit store is 1 year. The planning costs are estimated to be $27,500 and planning is assumed for 2007.
- Each transit store is assumed to be in operation for one year before any impacts occur. The first transit store is planned for 2006, with first benefits occurring in 2007.
- It is estimated to take 5 years for each transit store to reach full potential.
- Initial set-up costs for each transit store are $6,050 (one-time)
- Annual operating costs for each transit store are $126,500
- Exact locations of the transit stores will be decided by the state agencies and local jurisdictions.
- Ridesharing analysis is based on the Commuter Connections Transportation Demand Management Evaluation Project, January 10, 2000. Transit analysis is based on Arlington county transit store surveys.
- Estimated number of applicants a transit store would serve is 1,200 a month and 14,400 per year. This is based on average monthly visitors to the transit store in Silver Spring (April 2001)
- Average trip length = 15.5 miles

Summary of Impacts (2010)

Daily VT Reduction:	2091	VT
Daily VMT Reduction:	64989	VMT
Daily NOx Reductions:	0.0286	tons/day
Daily VOC Reductions:	0.0151	tons/day
Cost Effectiveness (NOx)	17,320	$/ton
Cost Effectiveness (VOC)	32,850	$/ton

ANALYSIS FOR A SINGLE TRANSIT STORE

Calculation of New Transit Riders

The results of the Arlington transit store survey conclude the following characteristics of those applicants entering the store:

Full-Time Employees (FTE):	70%
First Time Visitors (FTV):	35%
Non-Transit Users (CNUT):	5%
Potential to become Transit Users:	79%

These factors are then multiplied together to factor the total applicants who will be assisted.

Population of store visitors who are full-time employees (FTE):14,400 x 0.7 = 10,080

Population of store visitors who are FTE and first-time visitors (FTV)
= 10,080 x 0.7 x 0.35
=3,528

Population of store visitors who are FTE and FTV, and who are currently not using Transit (CNUT)
= 14,400 x 0.7 x 0.35 x 0.05
= 176

Population of store visitors who are FTE, FTV, and who are likely to use transit
= 42,000 x 0.7 x 0.35 x 0.05 x 0.79
= 139
= 139 x 2 trips = 278 two-way trips

Data from the MWCOG study *1991; Passenger Access to Suburban Metrorail Stations* was used to determine the percent of the new transit riders that will be accessing transit by automobile. In such cases, the VMT from the home site to the transit station will need to be accounted.

Access to Transit

Auto	74%	
Bus	17%	24%
Walk	7%	
Other	3%	

VT and VMT Reduction from New Transit Riders

New Transit Riders	278
Bus & Walk Access	24%
Avg. Vehicle Occupancy	1.1
Walk Access VT Reduction	60

60 (Walk Access VT Red.) x 15..5 miles (avg. trip length) x 2 = **1,860 VMT Reduced**

Although the primary function of the transit stores will be to assist commuters into transit, each store will also be on-line with the Commuter Connections program and be able to assist commuters into pooling arrangement as well.

Calculation of New Poolers

The calculation of new rideshare commuters was based on information derived from the MWCOG study: *1993 Survey and Evaluation of Ride Finders Ridesharing Network*. The number of applicants was based on the total of 5,356 rideshare applications for the Maryland rideshare programs (Montgomery county, Prince George's county and Frederick county). The impacts of the 10 transit stores were assumed to be 20% of the total Maryland ridesharing programs. This calculates to approximately 1,071 new applicants over all ten stores or 107 new applicant at each store each year.

All applicants' placement rates:

Continued placement rate: 10.6%
Temporary placement rate: 4.9%
One-time placement rate: 27.3%

Calculations for VT and VMT

Continued placement 107 x 10.6% = 11.34
Temporary placement 107 x 4.9% = 5.24
One-time placement 107 x 27.3% = 29.21
Total = 45
Daily VT reduction = 45 VT
VMT reduction = 45 x 2 x 15.5 = 1,395 VMT

Ridesharing Attrition

	1st year of operation	2nd year of operation	3rd year of operation
1st year applicants	100.0%	100.0%	50.0%
2nd year applicants		100.0%	100.0%
3rd year applicants			100.0%
TOTAL	100.0%	200.0%	250.0%

Transit Commuter Attrition

	1st year of operation	2nd year of operation	3rd year of operation	4th year of operation	5th year of operation
1st year applicants	100.00%	50.00%	25.00%	12.50%	6.25%
2nd year applicants		100.00%	50.00%	25.00%	12.50%
3rd year applicants			100.00%	50.00%	25.00%
4th year applicants				100.00%	50.00%
5th year applicants					100.00%
TOTAL	100.00%	150.00%	175%	187.50%	193.75%

The following table illustrates the VT and VMT reduction of a single transit store when attrition is accounted.

	1st Year	2nd Year	3rd Year	4th Year	5th Year
CAR/VANPOOL					
attrition rate	(100%)	(200%)	(250%)	(250%)	(250%)
VT Reduction	45	90	112	112	112
VMT Reduction	1395	2790	3488	3488	3488
TRANSIT					
attrition rate	(100.00%)	(150.00%)	(175.00%)	(187.50%)	(193.75%)
VT Reduction	60	90	105	112	116
VMT Reduction	1860	2790	3255	3488	3604
T O T A L					
VT Reduction	105	180	217	224	228
VMT Reduction	3255	5580	6743	6976	7092

2010 Cost Analysis for a SINGLE transit store

The following table illustrates the costs associated with this measure which would occur in the FY 2007-2012 TIP. It is estimated to take approximately five years of operation before the transit store reaches its full potential.

One-Time Costs (Annualized for cost effectiveness calculations)

Planning Costs	$4,580	One-sixth of the actual planning costs of $27,500
Commuter Connections	$366	One-sixth of the computers costs ($2,200)
Pentium PC/ Printer	$640	One-sixth of the software costs ($3,850)
Total One-Time Costs	$5,586	

Annual Operating Costs

Salaries/General Overhead	$126,500	The first 2 stores (Mont. Co.) will assume no cost
Monitoring Costs	$27,500	
Commuter Connections	$3,300	
Total Annual Operating Costs	$157,300	
Total Costs	$162,886	

Daily NOx reduction for a SINGLE Transit Store in 2005 is 0.0085 tons per day. This accounts for attrition as well as a VT growth factor of 1.0175 and a VMT growth factor of 1.0198 between 2000 and 2020.

Daily Emissions Reductions for 10 Transit Store (2010)

Nox Estimation

Cold Start	2091	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00134	tons
Running	64,989	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.02730	tons
					Total		0.02864	tons

VOC Estimation

Cold Start	2091	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00352	tons
Running	64,989	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.01158	tons
					Total		0.01510	tons

Detailed Cost Analysis for the FY 2007-2012 TIP

	FY 2007-12					
One-Time Operating Costs						
First Yr. Planning Costs	$27,500					
Software and Installation	$2,200	$2,200	$2,200	$2,200	$2,200	$2,200
Computer Costs	$3,850	$3,850	$3,850	$3,850	$3,850	$3,850
Total One-Time Costs	$33,550	$6,050	$6,050	$6,050	$6,050	$6,050
Annual Operating Costs						
Salaries/General Overhead	$0	$0	$126,500	$253,000	$379,500	$506,000
Monitoring Costs	$27,500	$55,000	$82,500	$110,000	$137,500	$165,000
Commuter Connections	$3,300	$6,600	$9,900	$13,200	$16,500	$19,800
Total Operating Costs	$30,800	$61,600	$218,900	$376,200	$533,500	$690,800
TOTAL COSTS	$64,350	$67,650	$224,950	$382,250	$539,550	$696,850

TIP Cost: $64,350 + 4 x $30,800 + 3 x $6,050 + 7 x $30,800 + 3 x $6050 = $439,100
Cost per year: $439,100/3 = $146,370

$$\text{Cost effectiveness NOx} = \frac{\$146{,}340}{295 \times 0.02864} = 17320 \text{ \$/ton}$$

$$\text{Cost effectiveness VOC} = \frac{\$146{,}340}{295 \times 0.01510} = 32850 \text{ \$/ton}$$

ANALYSIS FOR 10 TRANSIT STORES

It was estimated that each transit store will need to be in operation for one year to be able to reach the potential VT and VMT reduction, and for approximately 5 years before full potential is reached.
The following table illustrates the anticipated year the transit store will open and the year benefits are expected.

	Funding Available By	Date of Operation	First Benefits
1st Store	2006	2006	2007
2nd Store	2007	2007	2008
3rd Store	2007	2007	2008
4th Store	2007	2007	2008
5th Store	2008	2008	2009
6th Store	2008	2008	2009
7th Store	2008	2008	2009
8th Store	2009	2009	2010
9th Store	2009	2009	2010
10th Store	2009	2009	2010

Sources of information:
Arlington County Commuter Assistance Program, second quarterly report FY 1996.
Transit Store-In Store-Research Study, The Marketing Source, May 10, 1995.
Survey and Evaluation of Ride Finders Ridesharing Network, 1993.

The following tables illustrate the VT and VMT reduction for each TMO as well as all 10 Transit Stores. The VT and VMT shown accounts for ridesharing and pooling attrition, as well as a growth factor.

VT Summary					
					Total VT
	New Stores	New Stores	New Stores	New Stores	
	1	2, 3, 4	5, 6, 7	8, 9, 10	
2006	0				0
2007	105	0			105
2008	180	315			495
2009	217	540	315		1072
2010	224	651	540	315	1730
2011	228	672	651	540	2091

VMT Summary					
	New Stores	New Stores	New Stores	New Stores	Total VMT
	1	2, 3, 4	5, 6, 7	8, 9, 10	
2006	0				0
2007	3255	0			3255
2008	5580	9765			15345
2009	6743	16740	9765		33248
2010	6976	20229	16740	9765	53710
2011	7092	20928	20229	16740	64989

M-111 Replace Traffic Signals with Lesser Controls

Description:
For purposes of this analysis Traffic Signals with Lesser Controls TERM will be limited to modern Roundabouts. Fundamentally, roundabouts are a form of intersection control. This measure will reduce intersection delay time, reduce accidents, render the intersection safer for pedestrians as well as non-motorized traffic, and passively enforce the posted speed limit. A further benefit that has been observed as a result of roundabouts is the resurgence of vehicular traffic through the intersection where the roundabout is installed. This traffic was using residential collector roads to avoid the prolonged delay caused by the signalized intersection.

Analysis Tool: Sketch Planning

Note: Analysis/Methodology for this TERM is under revision.

M-113 6 Kiosks in Maryland

Description:
This measure would establish 6 Transportation Information Kiosks in Maryland similar to those being placed in Virginia and the District of Columbia.

Assumptions:

It should be noted that the placement of the kiosks is of critical importance in achieving the estimated impacts.

- Sketch planning is used as an analysis tool
- Implementation time for the first kiosk is one year. Planning costs are estimated to be $33,000 and planning is assumed for 2006.
- Each kiosk is assumed to be in operation for one year before any impacts occur. The first kiosk is planned for 2006, with first benefits occurring in 2007.
- Hardware & Software costs for each kiosk $55,000 (one-time).
- Annual operating costs for each kiosk is $8,800.
- A one-time marketing expense of $ 22,000/year for two years is assumed for each kiosk.
- Exact locations of the kiosks will be decided during the planning study.
- Each kiosk was assumed to generate 12 applicants/year. Then number of applicants is based on information collected from Commuter Connections data for similar kiosks in Virginia.
- Calculations for placements are based on the January 10, 2001 Commuter Connections Transportation Demand Management Evaluation Project.
- Average trip length = 15.5 miles

Daily VT Reduction:	11	VT
Daily VMT Reduction:	300	VMT
Daily NOx Reductions:	0.00013	tons/day
Daily VOC Reductions:	0.00007	tons/day
Cost Effectiveness (NOx)	4,448,676	$/ton
Cost Effectiveness (VOC)	8,224,907	$/ton

Analysis for a Single kiosk

Each kiosk generates an average of 12 applicants per year.
All applicants' placement rates:

Continued placement rate: 10.6%
Temporary placement rate: 4.9%

One-time placement rate: 27.3%
Calculations for VT and VMT

Continued placement 12 x 10.6% = 1.27
Temporary placement 12 x 4.9% = 0.58
One-time placement 12 x 27.3% = 3.27
Total = 5.12

Total daily VT reduced = 5 VT
VMT reduction = 5 x 2 x 15.5 = 155 VMT

It is assumed that applicants that are placed in a car or vanpool will remain in the pool for approximately 2.5 years on the average. The following table illustrates the ridesharing attrition.

It was assumed that new commuters who shift into transit will remain as transit riders for a maximum of five years. It is estimated that for each of those five years only one-half of the existing transit riders will remain. This is illustrated in the following table.

Attrition Rate

	1st year of operation	2nd year of operation	3rd year of operation	4th year of operation	5th year of operation
1st year applicants	100.00%	50.00%	25.00%	12.50%	6.25%
2nd year applicants		100.00%	50.00%	25.00%	12.50%
3rd year applicants			100.00%	50.00%	25.00%
4th year applicants				100.00%	50.00%
5th year applicants					100.00%
TOTAL	100.00%	150.00%	175.00%	187.50%	193.75%

Total VT and VMT reduction from kiosks, including transit and ridesharing attrition for a Single Kiosk

	Year 1	Year 2	Year 3	Year 4	Year 5
attrition rate	*(100.00%)*	*(150.00%)*	*(175.00%)*	*(187.50%)*	*(193.75%)*
Total VT Reduction	5	8	9	10	11
Total VMT Reduction	155	233	271	290	300

The following table illustrates the costs associated with this measure which would occur in the FY 2007-2012 TIP. It is assumed that a kiosk would be in place each year from 2006 to 2010 (two in the year in the last year).

2005 Cost Analysis for a SINGLE kiosk

One-Time Costs (Annualized for cost effectiveness calculations)		
Planning Costs	$5,500	One-sixth of the actual planning costs of $33,000 [six kiosks]
Computer Costs (Hardware/Software)	$11,000	One-fifth of the computers costs ($55,000) [depreciation]
Marketing Costs	$22,000	One-half of the marketing costs ($44,000) [two year]
Total One-Time Costs	$38,500	
Annual Operating Costs		
Telephone, Electricity, etc.	$8,800	
Rent (when applicable)	$11,000	
Labor	$10,000	
Total Annual Operating Costs	$29,800	
Total Costs	**$68,300**	

Daily Emissions Reductions kiosk by 2010

Six kiosks will be in operational by 2010 corresponding reduction in VT and VMT will be 11 trips and 300 VMT respectively.

Nox Estimation

$$\text{Cold Start}\quad 11 \times \frac{0.5811 \text{ grams}}{1 \text{ trip}} \times \frac{1 \text{ ton}}{907{,}185 \text{ grams}} = 0.00001 \text{ tons}$$

$$\text{Running}\quad 300 \times \frac{0.3811 \text{ grams}}{1 \text{ mile}} \times \frac{1 \text{ ton}}{907185 \text{ grams}} = 0.00013 \text{ tons}$$

Total 0.00013 tons

VOC Estimation

$$\text{Cold Start}\quad 11 \times \frac{1.526 \text{ grams}}{1 \text{ trip}} \times \frac{1 \text{ ton}}{907{,}185 \text{ grams}} = 0.00002 \text{ tons}$$

$$\text{Running}\quad 300 \times \frac{0.1617 \text{ grams}}{1 \text{ mile}} \times \frac{1 \text{ ton}}{907185 \text{ grams}} = 0.00005 \text{ tons}$$

Total 0.00007 tons

Detailed Cost Analysis for the FY 2007-2012 TIP

Number of Kiosks	1	2	3	4	5	6
One-Time Operating Costs						
First Yr. Planning Costs	$33,000					
Hardware & Software	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000
Marketing	$22,000	$44,000	$44,000	$44,000	$44,000	$44,000
Total One-Time Costs	$110,000	$99,000	$99,000	$99,000	$99,000	$99,000
Annual Operating Costs						
Electricity/Telephone	$8,800	$17,600	$26,400	$35,200	$44,000	$52,800
Labor	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Rent	$11,000	$22,000	$33,000	$44,000	$55,000	$66,000
Total Operating Costs	$29,800	$49,600	$69,400	$89,200	$109,000	$128,800
TOTAL COSTS	$128,000	$148,600	$168,400	$188,200	$208,000	$227,800

TIP Cost: $128,000 + $148,000 + $168,000 = $444,000
Cost per year: $444,000/3 = $148,000

Cost Effectiveness

$$\text{Cost effectiveness NOx} = \frac{\$148{,}000}{250 \times 0.00013} = 4448676 \text{ \$/ton}$$

$$\text{Cost effectiveness VOC} = \frac{\$148{,}000}{250 \times 0.00007} = 8224907 \text{ \$/ton}$$

Analysis for 6 Kiosks

It was estimated that each kiosk will need to be in operation for one year to be able to reach the potential VT and VMT reduction, and for approximately 5 years before full potential is reached.
The following table illustrates the anticipated year the TMO will open and the year benefits are expected.

	Funding Available By	Date of Operation	First Benefits
1st kiosk	2006	2007	2008
2nd kiosk	2007	2008	2009
3rd kiosk	2008	2009	2010
4th kiosk	2009	2010	2011
5th kiosk	2010	2010	2012
6th kiosk	2010	2011	2012

M-123 Employer Outreach for Public Sector Agencies

Description:
The region adopted a employer outreach NOx mitigation measure that was based on marketing and implementing employer based TDM programs to the private sector. This measure will implement a similar program aimed at the public sector employers and employees in the region.

Analysis Tool: Sketch Planning

Assumptions:

- Sketch planning is used as an analysis tool
- Number of employees in public sector who are not in alternative commute mode - 273,000
- Baseline participation of employers and employees in TDM programs higher than private sector.
- Same level of effort (as expended with the private sector) required to achieve a 4% reduction in vehicle trips with the public sector.
- Four years to achieve the full 5% reduction.
- VT and VMT estimates were based on the previous employer outreach program.
- If start of program in summer of 2006 the first year of benefits will be 2008.
- All Metrochecks leads will be serviced by WMATA. Their estimated expenses are $350,000/year. All other sales and service calls will be handled by local sales representatives and central staff.. Their annual expenses will be $450,000.
- Average trip length = 15.5 miles

Summary of Impacts (2010)

Daily VT Reduction:	10920	VT
Daily VMT Reduction:	169260	VMT
Daily NOx Reductions:	0.07810	tons/day
Daily VOC Reductions:	0.04854	tons/day
Cost Effectiveness (NOx)	41,827	$/ton
Cost Effectiveness (VOC)	67,301	$/ton

Emission Analysis

Total number of public sector employees who are not in alternative commute mode.

Federal:	323,057 – 137,500 (Metrocheck participants) =	185,557
State:	61,694 – 100 (Metrocheck and vanpool users) =	61,594
Local:	164,177 – 829 (Metrocheck and vanpool participants) =	163,348
Carpool/Vanpool Participants:		-137,500
Total:		**273,000**

Current travel mode based on state of commute survey.

Mode	Regional	Average	Rideshare Survey
Drive Alone	65%	51%	37%
Transit	15%	20%	24%
Carpool	15%	25%	34%
Other	5%	4%	5%

SOV commuters who will switch mode due to the program = 273,000 x 0.04 = 10920
SOV commuters who will switch mode by 2010 due to the program = 10920/2 = 5460
VT reduced = 5460 x 2 trips/day = 10920
VMT reduced = 10920 x 15.5 = 169260

Daily Emissions Reductions (2010)

NOx Estimation

Cold Start	10920	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00699	tons
Running	169,260	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.07110	tons
					Total		0.07810	tons

VOC Estimation

Cold Start	10920	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.01837	tons
Running	169,260	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.03017	tons
					Total		0.04854	tons

Cost Assumptions

Annual recurring administrative cost	$450,000 + $350,000 = $800,000
Planning cost	$50,000 one-time cost
Assumed days per year	250 days
Annual Cost	$800,000 + $50,000/3 = $816,666
Total 2007-12 TIP Cost	$816,666 x 3 = $2,430,000

Cost Effectiveness (2010)

Cost effectiveness NOx	$\frac{\$816{,}666}{250 \times 0.07810}$	=	41827	$/ton
Cost effectiveness VOC	$\frac{\$816{,}666}{250 \times 0.04854}$	=	67301	$/ton

M-132 MD/DC Vanpool Incentive Program

Description:
This measure is a package of programs and incentives designed to increase the number of vanpools in the region. The program would work as an extension of the Virginia Vanpool Incentive Program.

Analysis Tool: Sketch Planning

Assumptions

- This program is similar to the program, which is about to be operational in Virginia. Vanpools will be provided a monthly lump sum subsidy for reporting information regarding service provided (number of passenger, miles of travel). Existing vanpools and older vehicles will be provided a reduced subsidy in exchange for reporting data.
- Maryland program would generate 25% o the Virginia impact

Summary of Impacts (2010)

Daily VT Reduction:	1785	VT
Daily VMT Reduction:	111027	VMT
Daily NOx Reductions:	0.0478	tons/day
Daily VOC Reductions:	0.0228	tons/day
Cost Effectiveness (NOx)	154,175	$/ton
Cost Effectiveness (VOC)	323,230	$/ton

Emissions Analysis (2010)

From M-77b Incentive Vanpool in Virginia

Regional VT savings: 7,143 trips

It is assumed that 56% of the vanpools in the region originate in Virginia (1998, COG Beltway Cordon Count).

New Vans – Region	371	New Vans MD/DC	163
Used Vans – Region	978	Used Vans MD/DC	430
Total Vans – Region	1,349	Total Vans MD/DC	593

Funding available by FY	2006
Vanpool by summer	2007
First benefits	2008

Average Trip Distance = 31.1 miles (from: Commuter Connections Transportation Demand Management Evaluation Project. LDA Consulting. January 10, 2000)

VT (2010) = 7143 x 25% = 1785
VMT = 1785 x 31.1 x 2 = 111027 miles

Daily emission reductions (2010)
:

Nox Estimation

Cold Start	1785	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00114	tons
Running	111027	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.04664	tons
					Total		0.04778	tons

VOC Estimation

Cold Start	1785	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00300	tons
Running	111027	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.01979	tons
					Total		0.02279	tons

Cost Analysis

New Van subsidy (based on VA TERM)

$$\frac{\$1563 \text{ (subsidy) x } 1{,}000}{250 \text{ days x } 208 \text{ (Vans in VA)}} = \$\ 30.05 \text{ day/van}$$

Cost of subsidy for newer Vans (MD) = $30.05 x 163 vans x 250 days = $1,224,537

Old van subsidy (based on VA TERM)

$$\frac{\$360 \text{ (subsidy) x } 1{,}000}{250 \text{ days x } 137 \text{ (Vans in VA)}} = \$\ 10.51 \text{ day/van}$$

25% of MD older vans are 5 years old or newer and are eligible for subsidy:
Cost of subsidy for older vans in MD
430 Vans x 0.25 = 107 Vans
107 Vans x $ 10.51 x 250 days = $281,142 (Annual)

Project Cost:

Administration:		$105,000
Marketing:		$120,000
Insurance:	($400 x 270 Vans)	$108,000
Postage:		$3,000
New Vans	(163 x $30.05 x 250)	$1,224,600
Older Vans		$281,200
Total :		**$1,841,800**

Cost Effectiveness

$$\text{Cost effectiveness NOx} = \frac{\$1{,}841{,}800}{250 \times 0.04778} = 154175 \ \$/\text{ton}$$

$$\text{Cost effectiveness VOC} = \frac{\$1{,}841{,}800}{250 \times 0.02279} = 323230 \ \$/\text{ton}$$

M-133 Metrorail Feeder Bus Service

Description
Improve Metrorail feeder bus service at two underutilized park and ride lots and implement a fare buydown program.

Analysis Tool: Sketch Planning

Assumptions

- Sketch planning is used as an analysis tool
- This measure is anticipated to attract 175 new transit riders daily, thereby reducing vehicle trips. Total annual cost of this measure is $445,000.00
- Average trip length = 15.5 miles

New Carrolton Station

- Bowie Park and Ride lot
- 650 spaces, approximately 300 unutilized on a daily basis
- Improve frequency and span of service to the lot (Metrobus routes affected B21, B22, C28). Headways will be reduced from 15 minutes to 10 minutes.
- Combine timetables (service to lot currently listed on three timetables) .
- Implement AM fare buydown to $0.50 (offered at lot only, not entire route).
- Investigate use of shoulders of John Hanson Highway
- Improve signage to lot on Northview Drive.
- Implement targeted marketing effort.
- Purchase one bus on each route: Cost per bus $350,000.
- Total Annual Operating Cost: $200,000/bus
- New ridership: 100 new riders.

Summary of Impacts (2010)

Daily VT Reduction:	0	VT
Daily VMT Reduction:	6050	VMT
Daily NOx Reductions:	0.00254	tons/day
Daily VOC Reductions:	0.00108	tons/day
Cost Effectiveness (NOx)	535,107	$/ton
Cost Effectiveness (VOC)	1,261,158	$/ton

Emission Analysis

New Carrolton Station

Trip length: 19 mi o/w * 2 = 38 mi round trip
VT adjustment: 100 x 0.983 = 98

VMT : 100 * 38 new riders = 3,800 VMT

No VT savings

Daily NOx emission reductions:

$$\text{Running:} \quad 3{,}800 \times \frac{0.3811 \text{ grams}}{1 \text{ mile}} \times \frac{1 \text{ ton}}{907{,}185 \text{ grams}} = 0.0016 \text{ tons}$$

Daily VOC emission reductions

$$\text{Running} \quad 3{,}800 \times \frac{0.1617 \text{ grams}}{1 \text{ mile}} \times \frac{1 \text{ ton}}{907{,}185 \text{ grams}} = 0.00068 \text{ tons}$$

Glenmont Station

- Norbeck Road Park-and-ride lot
- 250 spaces, approximately 225 unutilized on a daily basis.

75 new riders

Trip length: 15 mi o/w * 2 = 30 mi round trip

VMT reduction: 75 * 30 = 2,250 VMT

No VT savings

Daily NOx emissions reductions

$$\text{Running} \quad 2{,}250 \times \frac{0.3811 \text{ grams}}{1 \text{ mile}} \times \frac{1 \text{ ton}}{907{,}185 \text{ grams}} = 0.00095 \text{ tons}$$

Daily VOC emissions reductions

$$\text{Running} \quad 2{,}250 \times \frac{0.1617 \text{ grams}}{1 \text{ mile}} \times \frac{1 \text{ ton}}{907{,}185 \text{ grams}} = 0.00040 \text{ tons}$$

Total NOx:

New Carrolton	0.00160 tons
Glenmont	0.00095 tons
Total	0.00255 tons

Total VOC:

New Carrolton	0.00068 tons
Glenmont	0.00040 tons
Total	0.00108 tons

Benefits:

Year				
New Carrolton		50 riders	100 riders	100 riders
Glenmont		37 riders	75 riders	75 riders

Costs:

Capital cost: $350,000 x 2 = $700,000
Annual Operating cost: 200,000
Annualized capital cost: 700,000/5 = 140,000
Total annualized cost: 340,000
TIP Cost: $700,000 + $10,000,000 = $1,070,000

<u>Cost Effectiveness</u>

$$\text{Cost effectiveness NOx} \quad \frac{\$340{,}000}{250 \times 0.00254} = 535107 \ \$/\text{ton}$$

$$\text{Cost effectiveness VOC} \quad \frac{\$340{,}000}{250 \times 0.00108} = 1261158 \ \$/\text{ton}$$

M –134 Implement 10 Neighborhood Circulator Bus Service to Metrorail

Description:
The circulator bus service would operate over an expanded period from 5:30 am to 10:00 am and from 3:00 pm to 8:00 pm on weekdays.

Analysis Tool: Sketch Planning

Assumptions:

- Sketch planning is used as an analysis tool
- Two buses per neighborhood will be required at a cost of $150,000 per bus, with a useful life of 12 years.
- Anticipated ridership is 150 riders per day per circulator, for a total of 1500 additional transit riders per day.
- Average trip length = 15.5 miles
- The stations where circulator service could be implemented include:

  - ✓ Cheverly station
  - ✓ Deanwood station
  - ✓ Minnesota Ave. station
  - ✓ Vienna/Fairfax – GMU station
  - ✓ Dunn Loring – Merrifield station
  - ✓ Greenbel station
  - ✓ Van Dorn Street station
  - ✓ Addison Road station
  - ✓ Glenmont station
  - ✓ Rhode Island Ave. station
  - ✓ New Carrolton

Summary of Impacts (2010)

Daily VT Reduction:	3000	VT
Daily VMT Reduction:	46500	VMT
Daily NOx Reductions:	0.02146	tons/day
Daily VOC Reductions:	0.01333	tons/day
Cost Effectiveness (NOx)	209,733	$/ton
Cost Effectiveness (VOC)	337,465	$/ton

<u>Emission Analyis (2010)</u>

Anticipated ridership = 150 riders/day/circulator

150 * 10 = 1500 additional riders
1 rider = 2 trips
1,500 * 2 = 3000 VT
VMT: 3000 x 15.5 = 46500 VMT

Daily Emissions Reduction

Nox Estimation

Cold Start	3000	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00192	tons
Running	46,500	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.01953	tons
					Total		0.02146	tons

VOC Estimation

Cold Start	3000	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00505	tons
Running	46,500	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.00829	tons
					Total		0.01333	tons

Cost Analysis:

Annual Operating Costs ($100,000/bus): $1,000,000
Capital Costs: $150,000/bus x 10 = $ 1,500,000
Annualized cost: $1,000,000 + $1,500,000/12 = $1,125,000
TIP Cost (2006-2011): $1,000,000 x 5 + $1,500,000 = $6,500,000

Cost Effectiveness (2010):

Cost effectiveness NOx	$1,125,000 / 250 x 0.02146	=	209733	$/ton
Cost effectiveness VOC	$1,125,000 / 250 x 0.01333	=	337465	$/ton

M –135 Construction of 1000 Additional Parking at WMATA Metrorail Stations

Description: WMATA will add a total of 1000 parking spaces at different Metrorail Stations

Assumptions

- Sketch planning is used as an analysis tool
- Average trip length = 15.5 miles

Emissions Impact (2010)

Daily VT Reduction:	0	VT
Daily VMT Reduction:	20677	VMT
Daily NOx Reductions:	0.0087	tons/day
Daily VOC Reductions:	0.0037	tons/day
Cost Effectiveness (NOx)	613,730	$/ton
Cost Effectiveness (VOC)	1,445,350	$/ton

Emission Analysis:

1000 additional spaces

Trip length: 15.5 mi o/w * 2 = 31 mi round trip

2/3 new trips = 667 trips

667 trips x 31 miles = 20,677 VMT

Daily Emissions Reduction

Cold Start	0	x	$\frac{0.5811 \text{ grams}}{1 \text{ trip}}$	x	$\frac{1 \text{ ton}}{907{,}185 \text{ grams}}$	=	0.00000	tons
Running	20677	x	$\frac{0.3811 \text{ grams}}{1 \text{ mile}}$	x	$\frac{1 \text{ ton}}{907185 \text{ grams}}$	=	0.00869	tons
					Total		0.00869	tons

Revised VOC Estimation

Cold Start	0	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00000	tons
Running	20677	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.00369	tons
					Total		0.00369	tons

Cost Estimation:

Approximate cost per space - $25,000 / space
Capital cost: $25,000 x 1000 spaces = $25 mill
Operating cost per space - $500/space/year
Annual maintenance and operating cost - $500/space/year x 1000 = $0.5 mill
Life of garage: 30 years
Total TIP cost (2007-2012): $25 mill + $0.5 mill x 3 year = $26.5 mill
Annualized cost = $25 mill/30 years + $0.5 mill = $1.33 million

Cost Effectiveness (2010):

Cost effectiveness NOx	$1.33 mill / (250 x 0.00869)	=	613,732	$/ton
Cost effectiveness VOC	$1.33 mill / (250 x 0.00369)	=	1,445,347	$/ton

M-142E 100 CNG Buses in place of Old Diesel Buses

Description:
Under this program the 100 oldest remaining buses in the fleet will be replaced in 2010 with CNG buses.

Assumptions:

- Sketch planning is used as an analysis tool
- Replace 100 old diesel buses with heavy duty CNG buses.
- Fuelling facility needed
- 40,000 miles per year. (128 miles/day)
- 312 days/year operation

Summary of Impacts (2010)

Daily NOx Reductions:	0.1720	tons/day
Daily VOC Reductions:	0.0326	tons/day
Cost Effectiveness (NOx)	77,631	$/ton
Cost Effectiveness (VOC)	410,051	$/ton

Emission Analysis (2010)

NOx Reduction

$$\text{Diesel} \quad \frac{19.87 \text{ grams/mi}}{907185 \text{ grams/ton}} \times 128 \text{ miles/day} \times 100 \text{ buses} = 0.2804 \text{ tons/day}$$

$$\text{CNG} \quad \frac{1.908 \text{ grams/mi}}{907185 \text{ grams/ton}} \times 128 \text{ miles/day} \times 100 \text{ buses} = 0.1084 \text{ tons/day}$$

Diesel	-	CNG			
0.28036	-	0.1084	=	0.1720	tons/day

VOC Reduction

$$\text{Diesel} \quad \frac{4.26 \text{ grams/mi}}{907185 \text{ grams/ton}} \times 128 \text{ miles/day} \times 100 \text{ buses} = 0.0601 \text{ tons/day}$$

$$\text{CNG} \quad \frac{0.485 \text{ grams/mi}}{907185 \text{ grams/ton}} \times 128 \text{ miles/day} \times 100 \text{ buses} = 0.0275 \text{ tons/day}$$

Diesel	-	CNG			
0.06011	-	0.0275	=	0.0326	tons/day

Cost Analysis

Capital cost

100 buses need full funding: $ 370,000 x 100 = $37,000,000
Capital cost for buses: $37,000,000
Capital cost for 1 fuelling facilities and garage retrofit: $15 mill
Operating cost of 100 buses: $12,000/bus/year x 100 buses = $1,200,000
Life of buses: 15 years
Life of fuelling facilities: 30 years
Total TIP cost (2007-2012): $37 mill + $15 mill + $1.2 mill = $53.2 mill
Annualized cost = $ 37 mill/15 + $15 mill/30 + $1.2 mill = $4.166 million

Cost Effectiveness (2010)

$$\text{Cost effectiveness NOx} = \frac{\$4{,}166{,}000}{312 \times 0.17200} = 77631 \text{ \$/ton}$$

$$\text{Cost effectiveness VOC} = \frac{\$4{,}166{,}000}{312 \times 0.03256} = 410051 \text{ \$/ton}$$

M-142F 100 Hybrid Buses in place of Old Diesel Buses

Description
Under this program the 100 old diesel buses in the fleet will be replaced in 2010 with Hybrid buses.

Assumptions

- Sketch planning is used as an analysis tool
- Replace 100 old diesel buses with hybrid buses
- 40,000 miles per year (128 miles/day)
- 312 days/year operation

Summary of Impacts (2010)

Daily NOx Reductions:	0.2095	tons/day
Daily VOC Reductions:	0.0576	tons/day
Cost Effectiveness (NOx)	53,551	$/ton
Cost Effectiveness (VOC)	194,729	$/ton

Emission Analysis (2010)

NOx Reduction

$$\text{Diesel}\quad \frac{19.87 \text{ grams/mi}}{907185 \text{ grams/ton}} \times 128 \text{ miles/day} \times 100 \text{ buses} = 0.28036 \text{ tons/day}$$

$$\text{New Diesel}\quad \frac{1.95 \text{ grams/mi}}{907185 \text{ grams/ton}} \times 128 \text{ miles/day} \times 100 \text{ buses} = 0.11074 \text{ tons/day}$$

NOx Benefit for Hybrid buses are 36% higher than New diesel Buses

$$\text{Diesel} - \text{Hybrid}$$
$$0.28036 - (0.11 \times 0.64) = 0.2095$$

VOC Reduction

$$\text{Diesel}\quad \frac{4.26 \text{ grams/mi}}{907185 \text{ grams/ton}} \times 128 \text{ miles/day} \times 100 \text{ buses} = 0.06011 \text{ tons/day}$$

$$\text{New Diesel} \quad \frac{1.95 \text{ grams/mi}}{907185 \text{ grams/ton}} \times 128 \text{ miles/day} \times 100 \text{ buses} = 0.00454 \text{ tons/day}$$

NOx Benefit for Hybrid buses are 45% higher than New diesel Buses

Diesel	-	Hybrid		
0.06011	-	(0.11 x 0.55)	=	0.0576

Cost Analysis

Capital cost

100 buses need full funding: $ 525,000 x 100 = $52,500,000
Capital cost for buses: $52,500,000
Life of buses: 15 years
Total TIP cost (2002-2005): $52.5 mill = $52.5 mill
Annualized cost = $ 52.5 mill/15 = $3.5 million

Cost Effectiveness (2010)

$$\text{Cost effectiveness NOx} \quad \frac{\$3{,}500{,}000}{312 \times 0.2095} = 53551 \text{ \$/ton}$$

$$\text{Cost effectiveness VOC} \quad \frac{\$3{,}500{,}000}{312 \times 0.0576} = 194729 \text{ \$/ton}$$

M-142G 100 New Diesel Buses in place of Old Diesel Buses

Description
Under this program the 100 old diesel buses in the fleet will be replaced in 2010 with New Diesel buses.

Assumptions

- Sketch planning is used as an analysis tool
- Replace 100 old diesel buses with new diesel buses
- 40,000 miles per year (128 miles/day)
- 312 days/year operation

Summary of Impacts (2010)

Daily NOx Reductions:	0.1696	tons/day
Daily VOC Reductions:	0.0556	tons/day
Cost Effectiveness (NOx)	40,250	$/ton
Cost Effectiveness (VOC)	122,867	$/ton

Emission Analysis (2010)

NOx Reduction

Diesel	19.87 grams/mi / 907185 grams/ton	x	128 miles/day	x	100 buses	=	0.2804	tons/day
New Diesel	1.95 grams/mi / 907185 grams/ton	x	128 miles/day	x	100 buses	=	0.1107	tons/day
	Diesel	-	New Diesel					
	0.2804	-	0.1107	=	0.1696	tons/day		

VOC Reduction

Diesel	4.26 grams/mi / 907185 grams/ton	x	128 miles/day	x	100 buses	=	0.0601	tons/day

New Diesel	$\frac{1.95 \text{ grams/mi}}{907185 \text{ grams/ton}}$	x	128 miles/day	x	100 buses	=	0.0045	tons/day

Diesel	-	New Diesel	=		
0.0601	-	0.0045	=	0.0556	tons/day

Cost Analysis

Capital cost

100 buses need full funding: $ 320,000 x 100 = $32,000,000
Capital cost for buses: $32,000,000
Life of buses: 15 years
Total TIP cost (2007-2012): $32.0 mill = $32.0 mill
Annualized cost = $ 32 mill/15 = $2.13 million

Cost Effectiveness

Cost effectiveness NOx	$\frac{\$2{,}130{,}000}{312 \text{ x } 0.1696}$				=	40250	$/ton
Cost effectiveness VOC	$\frac{\$2{,}130{,}000}{312 \text{ x } 0.0556}$				=	122867	$/ton

M - 143 Real Time Bus Schedule Information

Description:
This measure would provide real time bus schedule information to the transit riders through internet and at bus shelter display units. Satellite technology would track buses and customers would determine real-time location and arrival time of a specific bus. Local jurisdictions and state transit agencies would create integrated information system covering public transit services in the Washington region.

Assumptions

- Sketch planning is used as an analysis tool
- Cost and technology information obtained from City of Fairfax CUE buses
- Capital cost spread over 3 years from 2007-2012
- Number of buses in the metropolitan region considered in the analysis for use of the Real Time bus information – 596

Alexandria Dash	49
Prince George's county The Bus	55
Montgomery county Ryde On	237
Fairfax Connector	175
PRTC omni link	80
Total	**596 Buses**

Summary of Impacts (2010)

Daily VT Reduction:	1232	VT
Daily VMT Reduction:	19096	VMT
Daily NOx Reductions:	0.0088	tons/day
Daily VOC Reductions:	0.0055	tons/day
Cost Effectiveness (NOx)	55,371	$/ton
Cost Effectiveness (VOC)	89,093	$/ton

Emission Analysis

Average daily trips for the local systems: 128,300

WMATA average weekday bus ridership: 500,000

Average daily regional bus ridership: 500,000 + 128,300 = 628,300

Total daily HBW person trips: 4,985,050 (2005CLRP Exhibit 9A)

Total daily all person trips: 4,985,050 x 4 = 19,940,200 trips / region
(HBW trips are 25% of all trips)

Regional average daily bus ridership percentage

$$\frac{628{,}300}{19{,}940{,}200} = \quad 3.15\ \%$$

Estimated new transit share resulting from decrease in transit and and/or initial wait time (min).
MWCOG's regional travel demand model uses actual headway for each route. Since this analysis is not route specific a 5 minute savings in out of vehicle time was used. This number is also close to estimates made in other demonstration projects.

Assumed benefit from the system = 5 minute decrease in wait time.

3.56 % → 4.66% = 1.13% increase in bus mode share due to decrease in wait time (3.56% from earlier analysis is used instead of 3.15%)

(Source: William Allen, Mode Choice Model Sensitivity Analysis, April 1993)

For 2010 (first benefits)

Trips for 2000 – 31,156,702

Daily increase in trips on the local systems = 1.13% x 128,300 = 1450
VT reduced: 1450 x 0.85 SOV = 1232 VT
VMT reduced = 1232 x 15.5 = 19096 VMT

Daily Emission Savings (2010)

Nox Estimation

Cold Start	1232	x $\frac{0.5811 \text{ grams}}{1 \text{ trip}}$	x	$\frac{1 \text{ ton}}{907{,}185 \text{ grams}}$	=	0.00079	tons
Running	19,096	x $\frac{0.3811 \text{ grams}}{1 \text{ mile}}$	x	$\frac{1 \text{ ton}}{907185 \text{ grams}}$	=	0.00802	tons
				Total		0.00881	tons

VOC Estimation

Cold Start	1232	x $\frac{1.526 \text{ grams}}{1 \text{ trip}}$	x	$\frac{1 \text{ ton}}{907{,}185 \text{ grams}}$	=	0.00207	tons
Running	19,096	x $\frac{0.1617 \text{ grams}}{1 \text{ mile}}$	x	$\frac{1 \text{ ton}}{907185 \text{ grams}}$	=	0.00340	tons
				Total		0.00548	tons

Cost Analysis

From City of Fairfax Real time bus information project.

Cost for Bus

1.	AVL/GPS System/bus	$6,995

Cost for Shelters

1.	Display units at shelters	$3,995
Total		**$10,990**

City of Fairfax purchased 4 display units for their 12 buses. This TERM considers installing 172 display units in Metrorail stations and bus stops.

Cost for 596 buses	$6,550,000 cost spread over 3 years of program implementation.
Planning costs	$100,000
Bus life span	15 years

Cost for 2010= $6,550,000/3 + $100,000 = $2,283,300
TIP Cost = $6,550,000 + $100,000 = $6,650,000

Cost Effectiveness (2010)

$$\text{Cost effectiveness NOx} = \frac{\$2{,}283{,}300}{312 \times 0.00881} = 55371 \text{ \$/ton}$$

$$\text{Cost effectiveness VOC} = \frac{\$2{,}283{,}300}{312 \times 0.00548} = 89093 \text{ \$/ton}$$

Note: As of July, 2001 real time bus information can be obtained through cell phones that have internet access, palm pilot units, and computers with internet access. The cost for obtaining real time bus information to the consumer will be the cost per minute provided by the cell phone connection company

M-146 Purchase of 185 Buses to Accommodate Ridership Growth

Description:
WMATA will purchase 185 new CNG buses in the District of Columbia and deploy them on 36 crowded routes resulting in increased frequency.

Assumptions:

- Sketch planning is used as an analysis tool
- Number of passenger per bus = 30
- Number of trips / bus = 4
- Peak frequency with additional 100 buses – 8 minutes
- 2 trips during peak period
- 85% of the riders were SOV riders before switching to transit
- Average trip length = 15.5 miles

Summary of Impacts (2010)

Daily VT Reduction:	18870	VT
Daily VMT Reduction:	292485	VMT
Daily NOx Reductions:	0.1349	tons/day
Daily VOC Reductions:	0.0839	tons/day
Cost Effectiveness (NOx)	108,400	$/ton
Cost Effectiveness (VOC)	174,400	$/ton

Emission Analysis

Number of passenger / bus = 30
Number of trips / bus = 4
Total number of new passenger = 185 x 30 x 4 = 22200
New transit trips = 22,200
VT = 22200 x 0.85 SOV =18870 VT
VMT = 18870 x 15.5 = 292485 VMT

Daily Emission Savings (2010)

NOx Estimation

Cold Start	18870	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.01209	tons
Running	292,485	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.12287	tons
					Total		0.13496	tons

VOC Estimation

Cold Start	18870	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.03174	tons
Running	292,485	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.05213	tons
					Total		0.08388	tons

Capital cost

100 buses need full funding: $ 370,000 x 185 = $68.45 mill
Capital cost for buses: $68.45 mill
Life of buses: 15 years
Total TIP cost (2007-2012): $68.45 mill
Annualized cost = $68.45 mill /15 = $4,563,333

Cost Effectiveness

Cost effectiveness NOx	$4,563,333 / 312 x 0.13496	=	108375	$/ton		
Cost effectiveness VOC	$4,563,333 / 312 x 0.08388	=	174379	$/ton		

M-148 Bus Information Displays with Maps at Bus Stops

Description:
This measure would provide more information at 2,000 Metrobus locations.
Note: WMATA is implementing this TERM

Assumptions

- Sketch planning is used as an analysis tool
- Decrease in waiting time: 2.5 minutes
- Average daily bus ridership: 500,000
- Average daily local bus ridership: 124,000
- Program would be launched in 2008 and continue through 2009
- Average trip length: 15.5 miles

Summary Impact

Daily VT Reduction:	2210	VT
Daily VMT Reduction:	34255	VMT
Daily NOx Reductions:	0.0158	tons/day
Daily VOC Reductions:	0.0098	tons/day
Cost Effectiveness (NOx)	25,348	$/ton
Cost Effectiveness (VOC)	40,785	$/ton

Emission Analysis

Local bus average daily Ridership 124,000

Average daily WMATA bus ridership 500,000

Average daily regional bus ridership 500,000 + 124,000 = 624,000

Total daily person trips 4,400,000 (conformity) x 0.25 (HBW) = 17,600,000

Regional bus mode share percentage = 624,000/17,600,000 = 3.55 %

Assumed benefit from the system = 2.5 minute decrease in wait time.

3.55 % → 4.07% = 0.52% increase in bus mode share due to decrease in wait time

(Source: William Allen, Mode Choice Model Sensitivity Analysis, April 1993)

WMATA Buses: 500,000 (0.52%) = 2600 new trips
VT reductions: 2600 x 0.85 SOV = 2210
VMT reductions: 2210 x 15.5 miles = 34255

Daily NOx Emission Reductions (2010)

Nox Estimation

Cold Start	2210	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00142	tons
Running	34255	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.01439	tons
					Total		0.01581	tons

VOC Estimation

Cold Start	2210	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00372	tons
Running	34255	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.00611	tons
					Total		0.00982	tons

Cost Analysis

Cost per box = $120.00
Number of boxes = 2000
Cost for 2000 display boxes = $240,000
Capital cost per car – $30,000
Operating Cost for car to change schedule = $40,000
Life of car – 6 years
Annualized cost – $240,000 / 3 years + $30,000/6 years + $40,000 = $125,000
TIP Cost: $240,000 + $30,000 + $40,000 x 2 = $350,000

Cost Effectiveness (2010)

Cost effectiveness NOx	$125,000 / 312 x 0.0158	=	25348	$/ton
Cost effectiveness VOC	$125,000 / 312 x 0.0098	=	40785	$/ton

M-150 Enhanced Commuter Services on Major Corridors in Maryland (HOV Facilities)

Description:
This TERM proposes bus service on corridors with HOV facilities and bus lanes such as US 50, I-270, and US 29. Commuters would be picked up at Metrorail Park & Ride facilities close to Metro stations and transported to major work centers.

Assumptions

- Sketch planning is used as an analysis tool
- **US 50 -** Double existing rush hour service on B21,22; B29; and C28 connecting Bowie Park Park & Ride at MD Route 197 with New Carrollton Station. Establish: 15 minute headway non-stop rush only express route between new Prince George's Stadium Park and Ride on Route 301 and New Carrollton Station.
- **I-270 –** New: 15 minute headway rush only express between Urbana Park and Ride and Shady Grove Station via I-270, MD Route 124 Park & Ride and Sam Eig Highway.
- **US-29 –** New: 10 minute headway rush only express linking Burtonsville, Greencastle , and Briggs Chaney Park & Ride lots with Silver Spring Metrorail station.

Summary of Impacts (2010)

Daily VT Reduction:	0	VT
Daily VMT Reduction:	51716	VMT
Daily NOx Reductions:	0.02173	tons/day
Daily VOC Reductions:	0.00922	tons/day
Cost Effectiveness (NOx)	392,867	$/ton
Cost Effectiveness (VOC)	925,922	$/ton

Analysis

	Annual Passengers	Number of Buses
US 50	313,000	11
I 270	364,000	6
US 29	364,000	8
Total commuters	1,041,000	
Daily commuters	3337	
VMT	51,716	

Daily NOx emission reductions (2010)

For this measure there will be no Cold Start and hot Soak reductions since commuters would continue to drive to Park and Ride parking spaces.

Nox Estimation

Cold Start	0	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00000	tons
Running	51,716	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.02173	tons
					Total		0.02173	tons

VOC Estimation

Cold Start	0	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00000	tons
Running	51,716	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.00922	tons
					Total		0.00922	tons

Cost Analysis

POLLUTION MITIGATION SERVICES					
	Annual Cost	Annual Revenue	Annual Subsidy	Annual Passengers	Number of Buses
US 50	1,068,000	175,000	893,000	313,000	11
I 270	814,000	204,000	610,000	364,000	6
US 29	814,000	204,000	610,000	364,000	8

US-50
Cost per bus: $330,000
Cost of Fleet: $330,000 x 11 buses = $3,630,000
Annual cost: (3,630,000/15 years) + 893,000 (annual subsidy) = $1,135,000

I-270
Cost per bus: $330,000
Cost of fleet: $330,000 x 6 = $1,980,000

Annual cost: ($1,980,000/15 years) + $610,000 (annual subsidy) = $742,000

US-29
Cost per bus: $330,000
Cst of fleet: $330,000 x 8 = $2,640,000
Annual cost: ($2,640,000/15 years) + $610,000 (annual subsidy) =$786,000

Total annual cost for the three routes = $2,663,000

Cost Effectiveness

$$\text{Cost effectiveness NOx} = \frac{\$2{,}663{,}000}{312 \times 0.02173} = 392867 \ \$/\text{ton}$$

$$\text{Cost effectiveness VOC} = \frac{\$2{,}663{,}000}{312 \times 0.00922} = 925922 \ \$/\text{ton}$$

M-151 Enhanced Commuter Services on Major Corridors (Reverse Commute)

Description:
This TERM proposes bus service to Potomac Mills and Arundel Mills shopping centers from Metrorail stations. The service would benefit reverse commuters whose work place is in Prince William and Anne Arundel counties.

Assumptions

- Sketch planning is used as an analysis tool
- **Potomac Mills –** Route: from Huntington station via North Kings highway, Route 1, Telegraph Road, Whernside St., Pohick Rd., Route 1, I-95 (at exit 161), Potomac Mills Road and return.
- **Arundel Mills –** New two-way express between Anacostia Station and Arundel Mills mall via Deanwood Station and Baltimore-Washington Parkway.
- This measure would benefit from Cold Start and Hot Soak emissions since commuters would be traveling on Metrorail and continuing their trip in the bus service to shopping malls.
- Effect of version 2.1C travel demand model and round 6.3 land use forecast on VT: 1.71% reduction in VT
- Average trip length = 15.5 miles

Summary Impacts (2010)

Daily VT Reduction:	1916	VT
Daily VMT Reduction:	29693	VMT
Daily NOx Reductions:	0.01370	tons/day
Daily VOC Reductions:	0.00852	tons/day
Cost Effectiveness (NOx)	588,810	$/ton
Cost Effectiveness (VOC)	947,409	$/ton

Analysis

	Annual Passengers	Number of Buses
Arundel Mills	171,000	4
Potomac Mills	426,700	6
Total commuters	597,700	
Daily commuters	1916	
VMT	29,693	

Daily NOx emission reductions (2010)

NOx Estimation

Cold Start	1916	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00123	tons
Running	29,693	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.01247	tons
					Total		0.01370	tons

VOC Estimation

Cold Start	1916	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00322	tons
Running	29,693	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.00529	tons
					Total		0.00852	tons

Cost Analysis:

POLLUTION MITIGATION SERVICES					
	Annual Cost	Annual Revenue	Annual Subsidy	Annual Passengers	Number of Buses
Arundel Mills	1,160,000	174,000	986,000	171,000	4
Potomac Mills	1,443,000	358,400	1,311,000	426,700	6

Arundel Mills
Cost per bus - $330,000
Cost of Fleet - $330,000 x 4 buses = $1,320,000
Annual cost = (1,320,000/15 years) + 986,000 (annual subsidy)
Total = $1,074,000

Potomac Mills

Cost per bus - $330,000
Cost of fleet - $330,000 x 6 = $1,980,000
Annual cost = ($1,980,000/15 years) + $1,311,000 (annual subsidy)
Total cost = $1,443,000
Total annual cost for the three routes = $2,517,000

Cost Effectiveness (2010)

$$\text{Cost effectiveness NOx} = \frac{\$2{,}517{,}000}{312 \times 0.0137} = 588810 \ \$/\text{ton}$$

$$\text{Cost effectiveness VOC} = \frac{\$2{,}517{,}000}{312 \times 0.0085} = 947409 \ \$/\text{ton}$$

M-152 Enhanced Commuter Services On Major Corridors (Rail Relief)

Description: This TERM proposes express bus service from Reston/Herndon, Centreville, and Springfield to Pentagon and downtown Washington, D.C.

Analysis Tool: Sketch Planning

Summary of Impacts (2010)

Daily VT Reduction:	0	VT
Daily VMT Reduction:	73082	VMT
Daily NOx Reductions:	0.03070	tons/day
Daily VOC Reductions:	0.01303	tons/day
Cost Effectiveness (NOx)	839,359	$/ton
Cost Effectiveness (VOC)	1,978,230	$/ton

Daily NOx emission reductions (2010)

VT reduction: 4715
VMT 4715 x 15.5 = 73082

NOx Estimation

Cold Start	0	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00000	tons
Running	73,082	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.03070	tons
					Total		0.03070	tons

VOC Estimation

Cold Start	0	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00000	tons
Running	73,082	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.01303	tons
					Total		0.01303	tons

Cost Analysis

I-66 Reston/Herndon and Centreville

Annual cost = ($18,600,000/15 years) + 5,700,000 (annual subsidy)
Total = $6,940,000

I-395 Springfield

Annual cost = ($3,000,000/15 years) + $900,000 (annual subsidy)
Total = $1,100,000

Total annual cost for the three routes = $8,040,000

Cost Effectiveness

$$\text{Cost effectiveness NOx} = \frac{\$8{,}040{,}000}{312 \times 0.03070} = 839359 \text{ \$/ton}$$

$$\text{Cost effectiveness VOC} = \frac{\$8{,}040{,}000}{312 \times 0.01303} = 1978230 \text{ \$/ton}$$

M-155 Expansion of Car Sharing Program

Description
This TERM funds incentives for 1000 new car sharing customers. Car sharing customers typically increase their transit ridership and decrease driving.

Assumptions

- Sketch planning is used as an analysis tool
- The program funds 1000 new members
- Approximately 35 members share one car
- Every car generates 5 persons switching to transit.
- For 1000 users the program will need 29 cars
- Average trip length = 15.5 miles

Summary of Impacts (2010)

Daily VT Reduction:	290	VT
Daily VMT Reduction:	4495	VMT
Daily NOx Reductions:	0.0021	tons/day
Daily VOC Reductions:	0.0013	tons/day
Cost Effectiveness (NOx)	270,433	$/ton
Cost Effectiveness (VOC)	435,134	$/ton

Emission Analysis

Every car generates 5 transit trips

1 car = 35 members

1000 users = 29 cars

29 cars x 5 transit trips = 145 transit trips

145 x 2 (round trip) = 290 VT

VMT = 290 x 15.5 miles = 4495

Daily Emission Savings (2010)

NOx Estimation

Cold Start	290	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.0002	tons
Running	4495	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.0019	tons
					Total		0.0021	tons

VOC Estimation

Cold Start	290	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.0005	tons
Running	4495	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.0008	tons
					Total		0.0013	tons

Cost Analysis

Subsidy = $125.00 x 1000 users = $125,000

Administrative cost = $50,000/yr

Annual Cost = $175,000 per year

Total TIP cost (2007-12): ($125 x 1000 + 50,000) x 3 years = $525,000

Cost Effectiveness

Cost effectiveness NOx	$175,000 / 312 x 0.0021	=	270433	$/ton		
Cost effectiveness VOC	$175,000 / 312 x 0.0013	=	435134	$/ton		

M-156 Free Bus-to-Rail/Rail-to Bus Transfer (Similar to NYC Pricing Structure)

This program would institute a free bus to rail transfer similar to the reduced fare rail to bus transfer.

Assumptions

- Sketch planning is used as an analysis tool
- 3% increase in bus/rail ridership based on WMATA planning staff.
- Current bus to rail transfer - 200,000
- Average trip length = 15.5 miles

Summary of Impacts (2010)

Daily VT Reduction:	5100	VT
Daily VMT Reduction:	79050	VMT
Daily NOx Reductions:	0.03647	tons/day
Daily VOC Reductions:	0.02267	tons/day
Cost Effectiveness (NOx)	3,235,093	$/ton
Cost Effectiveness (VOC)	5,205,344	$/ton

Emission Analysis

New ridership	200,000 x 0.03 = 6,000
VT reduced	6000 x 0.85 SOV = 5100
VMT reduced	5100 x 15.5 = 79050

Daily NOx Emissions Reductions

NOx Estimation

Cold Start	5100	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00327	tons
Running	79050	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.03321	tons
					Total		0.03647	tons

VOC Estimation

Cold Start	5100	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00858	tons
Running	79050	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.01409	tons
					Total		0.02267	tons

Cost Analysis

Loss in revenue: $0.59 x 200,000 riders x 312 days = $36.816 millions/yr

Cost Effectiveness

Cost effectiveness NOx	$36,816,000 / 312 x 0.03647	=	3235093	$/ton
Cost effectiveness VOC	$36,816,000 / 312 x 0.02267	=	5205344	$/ton

M -158 Free Bus Service Off-Peak (10:00 AM –2:00 PM Mid-Day and Weekends)

Description:
Free bus service off-peak (10-2 mid-day, weekends): Free service during the mid day and all day on weekends.

Assumptions:

- Sketch planning is used as an analysis tool
- Fare discount - 56 cent
- Total daily weekday ridership in off-peak period is 192,800
- Total weekend ridership - 171,800
- This measure is anticipated to attract 5040 new transit riders daily as estimated by WMATA planning staff.
- Total annual cost of this measure is $21,821,184
- Average trip length = 15.5 miles

Summary of Impacts (2010)

Daily VT Reduction:	4284	VT
Daily VMT Reduction:	66402	VMT
Daily NOx Reductions:	0.03064	tons/day
Daily VOC Reductions:	0.01904	tons/day
Cost Effectiveness (NOx)	2,282,683	$/ton
Cost Effectiveness (VOC)	3,672,893	$/ton

Emission Analysis

Weekend bus ridership – 192,000
Week-end off-peak – 171,800
Average off peak and weekend = 181,900
Average fare discount = 56 cents (27 cents 1980 dollar value)
Net increase in ridership estimated by WMATA = 5040

VT reduced: 5040 x 0.85 = 4,284
VMT reduced: 4284 x 15.5 = 66402

Emission Reductions

Nox Estimation

Cold Start	4284	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00274	tons
Running	66402	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.02789	tons
					Total		0.03064	tons

VOC Estimation

Cold Start	4284	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00721	tons
Running	66402	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.01184	tons
					Total		0.01904	tons

Cost Effectiveness

Cost effectiveness NOx	$21,821,000 / 312 x 0.03064	=	2282683	$/ton		
Cost effectiveness VOC	$21,821,000 / 312 x 0.01904	=	3672893	$/ton		

M- 159 W15-590 - Diesel Fuel Additive

Description: This measure represents the use of a fuel additive, W15-590, in vehicles to reduce NOx . This additive can also be blended with the fuel before delivery from the distribution center. It has shown a 10.81% reduction in NOx in lab tests (NOT been verified by EPA). The company says the results are much higher in a "real world" situation.

Analysis Tool: Sketch Planning

Note: The new Heavy Duty Engine Rule will lower the importance of this TERM

Assumptions

- This additive can also be blended with the fuel before delivery from the distribution center.
- This measure represents the use of a fuel additive, W15-590, in vehicles to reduce NOx .
- 500 buses will participate in the program.
- W15-590 will reduce NOx by 10.81%. (Based on the lab results presented by the manufacturer)
- Average cost of fuel additive: 4 cents/gallon
- Even though manufacturer, Woodrow International Limited claims savings in fuel expenses due to improved fuel economy, this analysis does not account for savings.
- Average age of bus in program will be 7 years.

Summary of Impacts (2010)

Daily NOx reductions (minimum): 0.133 tons/day

Emissions Analysis

Number of buses using W15-590: 500
NOx emissions factor for buses over 7 years: 15.87 gm/mile
Average bus mileage: 140 miles/day/bus
Bus VMT: 140 miles/day x 500= 70,000 miles/day
Reduction in NOx emission (minimum): 10.81% x 15.87 gm/mile = 1.72 gm/mile
NOx reduction for 500 buses per day (minimum): 1.72 gm/mile x 70,000 miles/907185 =0.133 tons/day

Cost Analysis

Bus fuel consumption: 2 miles/gallon
Bus fuel consumption per day: 70 gallons/day/bus
Fuel consumption for 500 buses: 70 gallons/day/bus x 500= 35,000 gallons/day

Cost of W15-590 per treated gallon: 4.5 cents
Fuel expenditure reduction: 6%
Cost of fuel: $.70 per gallon
Cost for 500 buses per day with W15-590: 35,000 x 4.5 cents/gallon = $1,575/day
Fuel expenditure reduction: 35,000 x 6% = 2,100 x $.70= $1,470/day
Net cost for reducing NOx: $1,575 - $1,470 = $105/day
Administrative Costs = $160,000 for FY 2004 and FY 2005
Net Annual Fuel Cost = 32,760
Total TIP Cost = $160,000 + 32,760 = $225,520

Cost Effectiveness

$$\text{NOx} = \frac{\$112{,}760}{312 \text{ days} \times 0.133} = \$2{,}700 \text{ / ton}$$

M-160 Bose Automobile Anti-Air Pollutant and Energy Conservation System

Description: The Bose Automobile Anti- Air Pollutant and Energy Conservation System is a mechanical, gas turbine operated system with no platinum catalysts involved as in catalytic converter systems. This system can be used with all types of fuel. It is expected to achieve 15% fuel economy and reduces NOx emissions by 50% as claimed by the manufacturer (NOT verified by EPA). In this program 500 buses would be retrofitted with the Bose Energy Conversion System.

Analysis Tool: Sketch Planning

Note: The new Heavy Duty Engine Rule will lower the importance of this TERM

Bose Energy Conservation System

The Bose Energy Conservation System is developed for high-speed, centrifugal separation of the lighter pollutant combustible gases in the automobile exhaust gas stream from the heavier non-combustible gases. This system uses a high-speed free spinning turbine attached to the auto exhaust system. By spinning around and creating centrifugal force, the device reduces gaseous emissions and recycles combustible gases to the carburetors, resulting in potential energy saving and reduction in the pollutant emissions. It is a mechanical, gas turbine operated system with no platinum catalysts involved as in catalytic converter systems. The Bose system can be used with all types of fuel namely leaded, unleaded gasoline, diesel or alternate fuel. It is expected to achieve 15 % fuel economy and will cost about $525 per vehicle. The Bose system was tested at the Gulf Research Laboratory in Pittsburgh, PA. The test result at the Gulf Research Laboratory shows lifecycle pollutant emissions as 900,000 grams for the Bose system verses 2,621,488 grams for a typical converter, reducing all pollutants by 66%. For NOx the reduction is 50%.

Assumptions

- 500 buses will participate in the program.
- The Energy Conservation System will reduce NOx by 50%. (As claimed by Bose Research and Development. Inc.)
- Cost of the energy conversion system: $525 per unit
- Average age of bus in the program will be 7 years.

Summary of Impacts (2010)

Daily NOx Reductions: 0.61 tons/day

Emission Analysis:

Number of buses retrofitted with the system: 500
NOx emission factor for buses over 7 years: 15.87 gm/mile
Average bus mileage: 140 miles/day/bus
Total Bus VMT : 140 miles/day x 500 = 70,000 miles/day
Reduction in the NOx emission: 50% x 15.87 gm/mile = 7.9 gm/mile
NOx reduction for 500 buses per day = 7.9 gm/mile x 70,000 miles/ 907,185 = 0.61 tons/day

Cost Analysis

Cost of energy conversion device: $525
Capital Cost of 500 devices to be used in 500 buses: $525 x 500 = $262,500
Life span: 5 years
Number of day's buses operated in a year: 312
Administrative Costs = $160,000 (FY 2004 & 2005)
Maintenance Cost = ($100 per device / year x 500) = $50,000
Total TIP Cost = $472,000

Cost Effectiveness

$$\text{NOx} = \frac{\$182{,}500}{312 \text{ days} \times 0.61 \text{ tons/day}} = \$1{,}000/\text{ton}$$

EPA Candidate Measure # 1
M-161 Diesel Emulsion Fuel Additive (Non-road or Highway)

Description: This program will introduce a fuel additive to diesel to reduce NOx and other pollutants. Both on-road and off-road vehicles would participate in the program.

Analysis Tool: Sketch Planning (By EPA)

Note: The new Heavy Duty Engine Rule will lower the importance of this TERM

Assumptions

- 500 vehicle (on-road and off-road) will participate in the program.
- Cost of fuel additive: $1,200/vehicle per year
- The program will be implemented in FY 2008 and 2009 (250 vehicles/year)
- Administrative expenses = $80,000/year
- No additional details on EPA estimate are available
- EPA's environmental technology verification program (ETV) has identified few products that does reduce NOx
- The program will pay participants two years of fuel additive costs

Summary of Impacts (2010)

Daily NOx Reductions: 0.18 tons/day

Emission Analysis

Daily NOx Reductions: 0.18 tons/day
(As estimated by EPA)

Cost Estimation

Cost of fuel additive: $1,200/vehicle/year
Total fuel additive cost: $1,200 x 500 x 2 = $1,200,000
Administrative cost = $160,000
Total TIP Period Cost = $1,360,000

Cost Effectiveness

Annualized Cost = $680,000

NOx	$\frac{\$680,000}{312 \times 0.18}$	=	$ 12,100 / ton

EPA Candidate Measure # 2
M-162 Early Engine Retirement (Pre-88)

Description: This is a voluntary program designed to install new diesel engines by replacing old high polluting diesel engines in private vehicles (heavy duty vehicles). This is similar to "cash for clunkers" where instead of cash, the operator would get a new diesel engine.

Analysis Tool: Sketch Planning (US EPA)

Assumptions:

- 500 old trucks will be replaced through program
- Average truck operation: 8 hrs/day, 300 days/yr.
- Cost of one engine including installation: $20000
- The program will be implemented over a two year period FY 2008 and 2009
- The program will provide for maintenance at $200 / year / engine for three years (three year warranty)

Summary of Impacts (2010):

Daily NOx Reductions: 0.9 tons/day

Emission Analysis:

Daily NOx Reductions: 0.9 tons/day
(As estimated by EPA)

Cost Estimation:

Cost of one engine: $20,000
Maintenance cost: $200/year/engine
Life span: 10 years
Capital Cost of 500 engines: $ 10 million
Two year administrative costs = $160,000
Maintenance cost per year: $200 x 500 = $100,000
Total TIP Cost = $10,000,000 + $300,000 + $160,000 = $10,460,000
Annualized Cost: $10 million / 10 years + $100,000 + $80,000= $1,180,000

Cost Effectiveness:

$$\text{NOx} = \frac{\$1{,}180{,}000}{300 \text{ days} \times 0.9 \text{ tons/day}} = \$4370/\text{ton}$$

EPA Candidate Measure # 3
M-163 Truck Idling (Truck Stops and Auxiliary Power Unit)

Description: This is a voluntary program designed to install pollution-reduction technology on existing diesel vehicles and equipment. Under this program it is proposed to use a small diesel auxiliary power unit (APU), which will be mounted on the truck chassis to provide heat, air conditioning, or engine heat in lieu of operating the engine. This is expected to reduce the vehicle's NOx idling emission by 90%.

Analysis Tool: Sketch Planning (USEPA)

Assumptions

- Typical truck engine emits 0.3 tons/year of NOx while idling.
- Average truck operation: 8 hrs/day, 312 days/yr.
- Cost of one APU + installation cost: $5,000 + $1,000 = $6,000
- Maintenance cost: $550/year/APU
- Users will pay for operating cost.
- The program will be administrated over a two year period from FY 2008 through FY 2009.
- The program will pay for the maintenance of the system during the first year.

Summary of Impacts (2010)

Daily NOx Reductions: 0.4 tons/day

Emission Analysis

Daily NOx Reductions: 0.4 tons/day
(As estimated by EPA: refer to Document "Voluntary Diesel Retrofit Program")

Cost Estimation

Cost of one engine and Installation: $5,000 + $1,000 = $6,000
Maintenance cost: $550/year/APU
Life span: 10 years
Capital Cost of 500 engines: $3 million
Maintenance cost per year: $550 x 500 = $275,000
Two years administrative cost = 2 x $80,000 = $160,000
Annualized Cost: $3 million / 10 years + $275,000 = $575,000

TIP cost: $3,000,000 + $160,000 + $275,000 = $3,710,000

Cost effectiveness:

$$\text{NOx} = \frac{\$575{,}000}{312 \text{ days} \times 0.4 \text{ tons/day}} = \$4{,}600/\text{ton}$$

EPA Candidate Measure # 4

M-164 International Green Diesel Retrofit

Description: Under this program 500 transit buses would be fitted with a quad catalytic filter and Ultra Low Sulfur Diesel fuel would be used.

Note: The new Heavy Duty Engine Rule will lower the importance of this TERM

Assumptions

- 500 buses will be used in program at 250 per year starting in FY 2008 and completed by FY 2009
- Average bus operation: 8 hrs/day, 312 days/yr
- Cost per filter: $8000
- Maintenance cost: $1,000 /year/engine
- Cost per gallon of Ultra Low Sulfur Diesel fuel: 15 cents
- Administrative costs = $80,000/yr for two years
- There have been maintenance issues with these products

Summary of Impacts (2010)

Daily NOx Reductions: 0.14 tons/day for 500 buses

Daily Emission Savings (2010)

NOx Reductions 0.14 tons/day for 500 buses

Cost Estimation

Cost per filter: $8,000
Administrative costs = $160,000 (FY 2008-2009)
Operating and maintenance cost: $1,000/year
Life span: 15 years
Capital Cost of 500 engines: $ 4 million
Maintenance cost for one year: $1,000 * 500 = $500,000
Cost of fuel per bus per year: 20,000 gallons x 15 cent per gallon = $3,000/bus
Cost of fuel for 500 buses per year: $3,000 x 500 = $1,500,000
Annualized Cost: $4 million / 15 years + $500,000 + $1,500,000 = $2,266,666
Total TIP cost = $4,000,000 + $500,000 + $1,500,000 + $600,000
= $6,160,000

Cost Effectiveness

$$\text{NOx} = \frac{\$6,160,000}{312 \text{ days} \times 0.14 \text{ tons/day}} = \$141,000/\text{ton}$$

M-165 Bike Stations at Rail Station

Description: This measure assumes construction of a Bike Station at the Silver Spring Transit Station. A Bike Station is a full-service bicycle storage and rental facility with guarded valet bicycle parking, bicycle rentals, repairs, and supplies.

Assumptions

- Sketch planning is used as an analysis tool
- Used 2% growth rate, compounded annually, (from 2001 to 2006 transit work trip growth rate in FY2001-2006 TIP / CLRP air quality conformity analysis), to grow new users to 2010 figures.
- Capital cost = $200,000 (will vary by location)
- Operating cost includes two attendants and cost for leasing station space.
- Emissions and cost analysis shown here is for Silver Spring station only.
- 5 additional locations would be selected in consultation with local authorities and rail transit providers.
- 10 year life-span for cost analysis
- 85 percent of new users drive alone prior to using transit.
- Average trip length = 15.5 miles

Summary of Impacts (2010)

Daily VT Reduction:	105	VT
Daily VMT Reduction:	1628	VMT
Daily NOx Reductions:	0.00075	tons/day
Daily VOC Reductions:	0.00047	tons/day
Cost Effectiveness (NOx)	905,260	$/ton
Cost Effectiveness (VOC)	1,456,714	$/ton

Emission Analysis (2010)

Current Silver Spring Metrorail station bike rack users= 30
Number of new users = 58
New users in 2005 = 58 x $(1.02)^4$ = 63
Number of new trips = 63 x 2 = 126
Number of SOV trips = 126 x 0.85 = 105
VMT = 105 x 15.5 = 1628

Daily Emissions Reductions

NOx Estimation

Cold Start	105	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00007	tons
Running	1628	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.00068	tons
					Total		0.00075	tons

VOC Estimation

Cold Start	105	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.00018	tons
Running	1628	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.00029	tons
					Total		0.00047	tons

Cost Analysis

Capital cost: $200,000
Operating cost includes salary for two attendants and cost for leasing station space = $150,000
TIP cost: $200,000 +$150,000 x 3 = $650,000
Annualized cost: $200,000/10 + $150,000 = $170,000

Cost Effectiveness

Cost effectiveness NOx	$170,000 / 250 x 0.00075	=	905260	$/ton
Cost effectiveness VOC	$170,000 / 250 x 0.00047	=	1456714	$/ton

M-144 Parking Impact Fees

Description
This measure would consist of a parking impact fee administered by local governments throughout the region. The fees would allow governments to recoup some of the costs associated with maintaining the roadway infrastructure and mitigating the adverse effects of automobile use. The fees could be charged per parking space to land owners annually or on a one-time basis.

Analysis Tool: Sketch Planning , Mode Choice Model

Assumptions

- Two fee scenarios were evaluated:
    1. $250 annual fee applied to Montgomery County, MD, only.
    2. $250 annual fee applied throughout the metropolitan region.
- It was assumed the landowner would recoup the parking fees directly from the drivers parking on their property.
- The Metropolitan Washington Council of Governments' (MWCOG) regional mode choice model was used to estimate the effects of increased parking fees on trip making behavior. Using factors such as employment density and area type, the model forecasts average daily parking costs for each traffic analysis zone. The proposed parking fees were converted to a daily cost of one dollar and added to the model's forecasted parking cost. The new costs (sum of forecasted costs plus proposed fees) were used to execute the mode choice model a second time. The resulting trip forecasts indicate the effect of the proposed cost on the public's travel mode choices.
- All cost calculations are in 2010 dollars.
- Life cycle of cost analysis is one year.
- Average trip length = 15.5 miles

Summary of Impacts (2010)

Daily VT Reduction:	116266	VT
Daily VMT Reduction:	1802123	VMT
Daily NOx Reductions:	0.8315	tons/day
Daily VOC Reductions:	0.5168	tons/day
Cost Effectiveness (NOx)	1,859,944	$/ton
Cost Effectiveness (VOC)	2,992,696	$/ton

Emission Analysis

2005 Trip Summary

Scenario	Automobile Vehicle Trips			Transit Person Trips		
	Trips	% Increase From Base	Trip Reduction from Base	Trips	% Increase from Base	Transit Trip Increase
Base Forecast	3,615,788	0	0	669,825	0	-
Base plus $250 Annually (Regionally)	3,497,512	-3.27%	118,276	747,007	11.52%	77,182

Notes:

1. The automobile vehicle trips include both single occupancy automobiles and high occupancy automobiles.

3.27% reduction in base auto vehicle trips and 11.52% reduction in transit trips are used to estimate reduction in trips in 2010 for the $250 annual fee scenario. These reduction rates were derived from the mode choice model results for the year 2005. (for details pl. see earlier document and analysis for the year 2005)

Scenario 2010

Scenario	Automobile Vehicle Trips			Transit Person Trips		
	Trips	% Increase From Base	Trip Reduction from Base	Trips	% Increase from Base	Transit Trip Increase
Base Forecast	3,725,861	0	0	740,149	0	-
Base plus $250 Annually (Regionally)	3,604,025	-3.27%	121,836	654,884	11.52%	85,265

Note: Auto vehicle trips and transit person trips are taken from the file *2010ICCSummary.xls*

The automobile vehicle trip (VT) values in the table above can be used to calculate the reduction in vehicle miles of travel (VMT) for each alternative.

$250 Annual fee applied regionally

VT_{REGION} = 121,836
VMT_{REGION} = 121,836 x 15.5 = 1,888,458 VMT

Daily Emission Savings (2010)

NOx Estimation

Cold Start	121836	x	0.5811 grams / 1 trip	x	1 ton / 907,185 grams	=	0.07804	tons
Running	1,888,453	x	0.3811 grams / 1 mile	x	1 ton / 907185 grams	=	0.79332	tons
					Total		0.87136	tons

VOC Estimation

Cold Start	121836	x	1.526 grams / 1 trip	x	1 ton / 907,185 grams	=	0.20494	tons
Running	1,888,453	x	0.1617 grams / 1 mile	x	1 ton / 907185 grams	=	0.33660	tons
					Total		0.54155	tons

Cost Analysis

Revenue from TERM:

The number of parking spaces existing in 2005 was forecasted by assuming 100% of the base parking demand will be provided. Applying the $250 annual fee to the parking spaces results in the revenue from the spaces.

Fees Applied Regionally

(For revenue estimation staff discounted trips that would be reduced by other TERMs already implemented in the region. These estimates were based on off-line analysis and therefore were not part of the travel demand model)

VT reduction from other TERMs funded exclusively for emissions reduction by 2005 = 100,000
VT remaining for revenue estimation = 3,604,025 – 100,000 = 3,504,025

3,504,025 Trips x 1 space / 2 trips x $250 / year = $ 438,003,125 / year

Cost of implementing TERM:

The cost of increased transit service to accommodate the additional transit demand was calculated using generalized cost rates obtained from Washington Metropolitan Area Transit Authority (WMATA)*.

Fees Applied in Regionally

$$85{,}265 \text{ Trips/day} \times \frac{\$0.24 \text{ (capital cost)}}{\text{Trip}} \times \frac{250 \text{ days}}{\text{year}} = \$\ 5{,}115{,}900/\text{ year}$$

$$85{,}265 \text{ Trips/day} \times \frac{\$3.37 \text{ (operating cost)}}{\text{Trip}} \times \frac{250 \text{ days}}{\text{year}} = \$\ 71{,}835{,}763 / \text{ year}$$

$$85{,}265 \text{ Trips/day} \times \frac{-\$1.65 \text{ (fare revenue)}}{\text{Trip}} \times \frac{250 \text{ days}}{\text{year}} = -\$\ 35{,}171{,}813/\text{ year}$$

Total $ 41,779,850 /year

*Note:

1. Transit cost rates obtained in 1993 from Washington Area Metropolitan Transit Authority (WMATA) were adjusted to 2010 dollars

Net Revenue: $438,003,125/year - $ 41,779,850 /year = $396,223,275 /year

3 year revenue: = 3 x $396,223,275 = $ 1.19 billion

<u>Cost Effectiveness (2010)</u>

Revenue/ton

$$\text{Cost effectiveness NOx} = \frac{\$396{,}223{,}275}{250 \times 0.87136} = 1818865 \ \$/\text{ton}$$

$$\text{Cost effectiveness VOC} = \frac{\$396{,}223{,}275}{250 \times 0.54155} = 2926599 \ \$/\text{ton}$$

Addendum

PM2.5 & Precursor NOx Estimates
For
Transportation Emissions Reductions Measures (TERMs) Under Consideration For Conformity Of The 2006 CLRP & FY 2007 – FY 2012 TIP

Measure M-07A: Voluntary Employer Parking Cash-Out Subsidy

Measure Number: M-47A

Measure Name: Voluntary Employer Parking Cash-Out Subsidy

Description:

Many employers in the region choose to subsidize automobile parking for their employees. These subsidies are executed through payment of parking fees, or the provision of parking space leased or owned by the employer. This TERM would create a program for giving equal compensation "cash-out" to employees who choose not to use the free parking provided by the employer and use alternative modes of travel such as walk, bicycle, transit, rideshare, etc.

Precursor NOx

Estimated Cost ($/ton/year)	$ 6,658
Estimated Reductions (tpy)	30.04

PM2.5

Estimated Cost ($/ton/year)	$ 240,182
Estimated Reductions (tpy)	0.8327

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (16662 trips * 0.6132 gms/trip +258261 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 30.04 tpy

Total PM2.5 Reduced= (258261 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.8327 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $200,000 / 30.4 tpy = $ 6,658

PM = $200,000 / 0.8327 tpy = $ 240,182

Measure M-47C: Expanded Employer Outreach for Private Sector Employers

Measure Number: M-47A

Measure Name: Employer Outreach for Private Sector Employers

Description:

The adopted TERM is implemented through private sector employers by marketing and implementing employer based TDM programs.

NOx Precursor

Estimated Cost ($/ton/year)	$ 356,375
Estimated Reductions (tpy)	2.39

PM2.5

Estimated Cost ($/ton/year)	$ 12,855,749
Estimated Reductions (tpy)	0.0661

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (1323 trips * 0.6132 gms/trip + 20507 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOxReduced= 2.39 tpy

Total PM2.5 Reduced= (20507 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.0661 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $850,000 / 2.39 tpy = $ 356,375

PM = $850,000 / 0.0661 tpy = $ 12,855,749

Measure M-93: Improve Pedestrian Facilities Near Rail Stations

Measure Number: M-47A

Measure Name: Improve Pedestrian Facilities Near Rail Stations

Description:

This measure assumes improvements to sidewalks, curb ramps, crosswalks, and lighting in order to improve pedestrian access to 11 MARC stations and 12 Metrorail stations in Montgomery County. The current analysis was conducted based on needs shown in a Maryland Department of Transportation/ Mass Transit Administration report published in June, 1997 (Access 2000 – Bicycle and Pedestrian Access to Rail Transit Stations in Maryland).

Precursor NOx

Estimated Cost ($/ton/year)	$ 551,580
Estimated Reductions (tpy)	2.57

PM2.5

Estimated Cost ($/ton/year)	$ 19,897,496
Estimated Reductions (tpy)	0.0714

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (1428 trips * 0.6132 gms/trip + 22134 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 2.57 tpy

Total PM2.5 Reduced= (22134 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.0714 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $4,733,333 / 2.57 tpy = $ 551,580

PM = $4,733,333 / 0.0714 tpy = $ 19,897,496

M – 103 Taxicab Replacement Program in the District of Columbia

Measure Number: M - 103

Measure Name: Taxicab Replacement Program in the District of Columbia

Description:

The District of Columbia adopted a taxicab replacement program in the 1995 CLRP. The program was to be implemented after year 2015 with emission benefits being realized by 2020. This TERM can be accelerated and expanded in order to achieve benefits by 2010. A similar program called the Advanced Technology Vehicle Program has been operational in the Maryland suburbs and has successfully introduced compressed natural gas (CNG) powered taxicabs, airport shuttles, personnel transit buses, and school buses.

Precursor NOx

Estimated Cost ($/ton/year)	-
Estimated Reductions (tpy)	-

PM2.5

Estimated Cost ($/ton/year)	$ 1,360,778
Estimated Reductions (tpy)	1

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total PM2.5 Reduced= (0.08 gms/mile - 0.00 gms/mile) * 50,000 miles/year * 150 cabs / (907,185 g/ton)

Total PM2.5 Reduced= 0.6614 tpy

Cost Effectiveness

Cost ($) / Emissions (tpy)

PM = $900,000 / 0.0044 tpy = $ 1,360,778

M – 103a Taxicab Replacement Program in the District of Columbia (Conventional vehicle)

Measure Number: M - 103a

Measure Name: Taxicab Replacement Program in the District of Columbia (Conventional vehicle)

Description:

The District of Columbia adopted a taxicab replacement program in the 1995 CLRP. The program was to be implemented after year 2015 with emission benefits being realized by 2020. This TERM can be accelerated and expanded in order to achieve benefits by 2010.

Precursor NOx

Estimated Cost ($/ton/year)	-
Estimated Reductions (tpy)	-

PM2.5

Estimated Cost ($/ton/year)	$ 1,096,182
Estimated Reductions (tpy)	0.6614

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total PM2.5 Reduced= (0.08 gms/mile - 0.00 gms/mile) * 50,000 miles/year * 150 cabs / (907,185 g/ton)

Total PM2.5 Reduced= 0.6614 tpy

Cost Effectiveness

Cost ($) / Emissions (tpy)

PM = $725,000 / 0.0044 tpy = $ 1,096,182

Measure M-110: 10 Transit Stores in Maryland

Measure Number: M-110
Measure Name: 10 Transit Stores in Maryland

Description:
This measure would establish 10 Transit Stores in Maryland, similar to those in Arlington County, Virginia and Silver Spring, Maryland

Precursor NOx

Estimated Cost ($/ton/year)	$ 20,314
Estimated Reductions (tpy)	7.20

PM2.5

Estimated Cost ($/ton/year)	$ 698,382
Estimated Reductions (tpy)	0.2095

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (2091 trips * 0.6132 gms/trip + 64989 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)
Total Precursor NOx Reduced= 7.20 tpy

Total PM2.5 Reduced= (64989 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)
Total PM2.5 Reduced= 0.2095 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $146,340 / 7.2 tpy = $ 20,314
PM = $146,340 / 0.21 tpy = $ 698,382

Measure M-113: 6 Kiosks in Maryland

Measure Number: M-113
Measure Name: 6 Kiosks in Maryland

Description:
This measure would establish 6 Transportation Information Kiosks in Maryland similar to those being placed in Virginia and the District of Columbia.

Precursor NOx

Estimated Cost ($/ton/year)	$ 4,420,368
Estimated Reductions (tpy)	0.03

PM2.5

Estimated Cost ($/ton/year)	$ 153,006,701
Estimated Reductions (tpy)	0.0010

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (11 trips * 0.6132 gms/trip + 300 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)
Total Precursor NOx Reduced= 0.03 tpy

Total PM2.5 Reduced= (300 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)
Total PM2.5 Reduced= 0.0010 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $14806000 / 0.03 tpy = $ 4,420,368
PM = $148,000 / 0.001tpy = $ 153,006,701

Measure M-123: Employer Outreach for Public Sector Agencies

Measure Number: M-123

Measure Name: Employer Outreach for Public Sector Agencies

Description:

The region adopted a employer outreach NOx mitigation measure that was based on marketing and implementing employer based TDM programs to the private sector. This measure will implement a similar program aimed at the public sector employers and employees in the region

Precursor NOx

Estimated Cost ($/ton/year)	$ 41,483
Estimated Reductions (tpy)	19.69

PM2.5

Estimated Cost ($/ton/year)	$ 1,496,443
Estimated Reductions (tpy)	0.5457

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (10920 trips * 0.6132 gms/trip + 169260 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 19.69 tpy

Total PM2.5 Reduced= (169260 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.5457 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $816,666 / 19.69 tpy = $ 41,483

PM = $816,666/ 0.548 tpy = $ 1,496,443

M-132: MD/DC Vanpool Incentive Program

Measure Number: M-132
Measure Name: MD/DC Vanpool Incentive Program

Description:
This measure is a package of programs and incentives designed to increase the number of vanpools in the region. The program would work as an extension of the Virginia Vanpool Incentive Program.

Precursor NOx

Estimated Cost ($/ton/year)	$ 153,422
Estimated Reductions (tpy)	12.00

PM2.5

Estimated Cost ($/ton/year)	$ 5,144,982
Estimated Reductions (tpy)	0.3580

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (1785 trips * 0.6132 gms/trip + 111027 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)
Total Precursor NOx Reduced= 12.00 tpy

Total PM2.5 Reduced= (111027 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)
Total PM2.5 Reduced= 0.3580 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $1,841,800 / 12.00 tpy = $ 153,422
PM = $1,841,800 / 0.3585 tpy = $ 5,144,982

M-133: Metrorail Feeder Bus Service

Measure Number: M-132
Measure Name: Metrorail Feeder Bus Service

Description:
Improve Metrorail feeder bus service at two underutilized park and ride lots and implement a fare buydown program.

Precursor NOx

Estimated Cost ($/ton/year)	$ 533,148
Estimated Reductions (tpy)	0.64

PM2.5

Estimated Cost ($/ton/year)	$ 17,429,845
Estimated Reductions (tpy)	0.0195

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (0 trips * 0.6132 gms/trip + 6050 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)
Total Precursor NOx Reduced= 0.64 tpy

Total PM2.5 Reduced= (6050 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)
Total PM2.5 Reduced= 0.0195 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $340,000 / 0.64 tpy = $ 533,148
PM = $340,000 / 0.02 tpy = $ 17,429,845

M –134 Implement 10 Neighborhood Circulator Bus Service to Metrorail

Measure Number: M-134

Measure Name: Implement 10 Neighborhood Circulator Bus Service to Metrorail

Description:

The circulator bus service would operate over an expanded period from 5:30 am to 10:00 am and from 3:00 pm to 8:00 pm on weekdays.

Precursor NOx

Estimated Cost ($/ton/year)	$ 208,008
Estimated Reductions (tpy)	5.41

PM2.5

Estimated Cost ($/ton/year)	$ 7,503,598
Estimated Reductions (tpy)	0.1499

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (3000 trips * 0.6132 gms/trip +46500 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 5.41 tpy

Total PM2.5 Reduced= (46500 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.1499 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $1,125,000 / 5.41 tpy = $ 208,008

PM = $1,125,000 / 0.15 tpy = $ 7,503,598

M –135 Construction of 1000 Additional Parking at WMATA Metrorail Stations

Measure Number: M-135

Measure Name: Construction of 1000 Additional Parking at WMATA Metrorail Stations

Description:

WMATA will add a total of 1000 parking spaces at different Metrorail Stations

Precursor NOx

Estimated Cost ($/ton/year)	$ 610,223
Estimated Reductions (tpy)	2.18

PM2.5

Estimated Cost ($/ton/year)	$ 19,949,596
Estimated Reductions (tpy)	0.0667

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (0 trips * 0.6132 gms/trip +20677 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 2.18 tpy

Total PM2.5 Reduced= (20677 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.0667 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $1.33 mill / 2.18 tpy = $ 610,223

PM = $1.33 mill / 0.068 tpy = $ 19,949,596

M-142E 100 CNG Buses in place of Old Diesel Buses

Measure Number: M - 142e

Measure Name: 100 CNG Buses in place of Old Diesel Buses

Description:

Under this program the 100 oldest remaining buses in the fleet will be replaced in 2010 with CNG buses.

Precursor NOx

Estimated Cost ($/ton/year)	-
Estimated Reductions (tpy)	-

PM2.5

Estimated Cost ($/ton/year)	$ 2,096,605
Estimated Reductions (tpy)	1.9842

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total PM2.5 Reduced= (0.50 gms/mile - 0.05 gms/mile) * 50,000 miles/year / (907,185 g/ton)

Total PM2.5 Reduced= 1.9842 tpy

Cost Effectiveness

Cost ($) / Emissions (tpy)

PM = $4.16 mill / 0.0044 tpy = $ 2,096,605

M-142F 100 Hybrid Buses in place of Old Diesel Buses

Measure Number: M - 142f

Measure Name: 100 Hybrid Buses in place of Old Diesel Buses

Description:

Under this program the 100 old diesel buses in the fleet will be replaced in 2010 with Hybrid buses.

Precursor NOx

Estimated Cost ($/ton/year)	-
Estimated Reductions (tpy)	-

PM2.5

Estimated Cost ($/ton/year)	$ 1,763,971
Estimated Reductions (tpy)	1.9842

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total PM2.5 Reduced= (0.50 gms/mile - 0.05 gms/mile) * 50,000 miles/year / (907,185 g/ton)

Total PM2.5 Reduced= 1.9842 tpy

Cost Effectiveness

Cost ($) / Emissions (tpy)

PM = $3.5 mill / 0.0044 tpy = $ 1,763,971

M-142G 100 New Diesel Buses in place of Old Diesel Buses

Measure Number:	M - 142g	**Description:**
Measure Name:	100 New Diesel Buses in place of Old Diesel Buses	Under this program the 100 old diesel buses in the fleet will be replaced in 2010 with new diesel buses.

Precursor NOx

Estimated Cost ($/ton/year)	-
Estimated Reductions (tpy)	-

PM2.5

Estimated Cost ($/ton/year)	$ 1,123,433
Estimated Reductions (tpy)	1.8960

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total PM2.5 Reduced= (0.50 gms/mile - 0.07 gms/mile) * 50,000 miles/year / (907,185 g/ton)

Total PM2.5 Reduced= 1.8960 tpy

Cost Effectiveness

Cost ($) / Emissions (tpy)

PM = $2.13 mill / 0.0044 tpy = $ 1,123,433

M - 143 Real Time Bus Schedule Information

Measure Number: M - 143

Measure Name: Real Time Bus Schedule Information

Description:

This measure would provide real time bus schedule information to the transit riders through internet and at bus shelter display units. Satellite technology would track buses and customers would determine real-time location and arrival time of a specific bus. Local jurisdictions and state transit agencies would create integrated information system covering public transit services in the Washington region

Precursor NOx

Estimated Cost ($/ton/year)	$ 1,028,018
Estimated Reductions (tpy)	2.22

PM2.5

Estimated Cost ($/ton/year)	$ 37,084,341
Estimated Reductions (tpy)	0.0616

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (1232 trips * 0.6132 gms/trip +19096 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 2.22 tpy

Total PM2.5 Reduced= (19096 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.0616 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $2,283,300 / 2.22 tpy = $ 1,028,018

PM = $2,283,300 / 0.062 tpy = $ 37,084,341

M-146 Purchase of 185 Buses to Accommodate Ridership Growth

Measure Number: M - 146

Measure Name: Purchase of 185 Buses to Accommodate Ridership Growth

Description:

WMATA will purchase 185 new CNG buses in the District of Columbia and deploy them on 36 crowded routes resulting in increased frequency

Precursor NOx

Estimated Cost ($/ton/year)	$ 134,140
Estimated Reductions (tpy)	34.02

PM2.5

Estimated Cost ($/ton/year)	$ 4,838,921
Estimated Reductions (tpy)	0.9430

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (18870 trips * 0.6132 gms/trip +292485 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 34.02 tpy

Total PM2.5 Reduced= (292485 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.9430 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $4,563,333 / 34.02 tpy = $ 134,140

PM = $4,563,333 / 0.943 tpy = $ 4,838,921

M-148 Bus Information Displays with Maps at Bus Stops

Measure Number: M - 148

Measure Name: Bus Information Displays with Maps at Bus Stops

Description:

This measure would provide more information at 2,000 Metrobus locations

Precursor NOx

Estimated Cost ($/ton/year)	$	31,374
Estimated Reductions (tpy)		3.98

PM2.5

Estimated Cost ($/ton/year)	$	1,131,764
Estimated Reductions (tpy)		0.1104

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (2210 trips * 0.6132 gms/trip +34255 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 3.98 tpy

Total PM2.5 Reduced= (34255 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.1104 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $125,000 / 3.98 tpy = $ 31,374

PM = $125,000 / 0.1104 tpy = $ 1,131,764

M-150 Enhanced Commuter Services on Major Corridors in Maryland (HOV Facilities)

Measure Number: M - 150

Measure Name: Enhanced Commuter Services on Major Corridors in Maryland (HOV Facilities)

Description:

This TERM proposes bus service on corridors with HOV facilities and bus lanes such as US 50, I-270, and US 29. Commuters would be picked up at Metrorail Park & Ride facilities close to Metro stations and transported to major work centers.

Precursor NOx

Estimated Cost ($/ton/year)	$ 488,504
Estimated Reductions (tpy)	5.45

PM2.5

Estimated Cost ($/ton/year)	$ 15,970,309
Estimated Reductions (tpy)	0.1667

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (0 trips * 0.6132 gms/trip +51716 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 5.45 tpy

Total PM2.5 Reduced= (51716 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.1667 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $2,663,300 / 5.54 tpy = $ 488,504

PM = $2,663,300 / 0.062 tpy = $ 15,970,309

M-151 Enhanced Commuter Services on Major Corridors (Reverse Commute)

Measure Number: M - 143

Measure Name: Enhanced Commuter Services on Major Corridors (Reverse Commute)

Description:

This TERM proposes bus service to Potomac Mills and Arundel Mills shopping centers from Metrorail stations. The service would benefit reverse commuters whose work place is in Prince William and Anne Arundel counties.

Precursor NOx

Estimated Cost ($/ton/year)	$ 728,791
Estimated Reductions (tpy)	3.45

PM2.5

Estimated Cost ($/ton/year)	$ 26,290,137
Estimated Reductions (tpy)	0.0957

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (1232 trips * 0.6132 gms/trip +19096 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 3.45 tpy

Total PM2.5 Reduced= (19096 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.0957 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $2,517,000 / 3.54 tpy = $ 728,791

PM = $2,517,000 / 0.096 tpy = $ 26,290,137

M-152 Enhanced Commuter Services On Major Corridors (Rail Relief)

Measure Number: M - 152

Measure Name: Enhanced Commuter Services On Major Corridors (Rail Relief)

Description:

This TERM proposes express bus service from Reston/Herndon, Centreville, and Springfield to Pentagon and downtown Washington, D.C.

Precursor NOx

Estimated Cost ($/ton/year)	$ 1,043,686
Estimated Reductions (tpy)	7.70

PM2.5

Estimated Cost ($/ton/year)	$ 34,120,518
Estimated Reductions (tpy)	0.2356

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (0 trips * 0.6132 gms/trip +73082 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 7.70 tpy

Total PM2.5 Reduced= (73082 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.2356 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $8,040,000 / 7.70 tpy = $ 1,043,686

PM = $8,040,000 / 0.236 tpy = $ 34,120,518

M-155 Expansion of Car Sharing Program

Measure Number: M - 155

Measure Name: M-155 Expansion of Car Sharing Program

Description:

This TERM funds incentives for 1000 new car sharing customers. Car sharing customers typically increase their transit ridership and decrease driving.

Precursor NOx

Estimated Cost ($/ton/year)	$ 334,725
Estimated Reductions (tpy)	0.52

PM2.5

Estimated Cost ($/ton/year)	$ 12,074,755
Estimated Reductions (tpy)	0.0145

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (290 trips * 0.6132 gms/trip +4495 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 0.52 tpy

Total PM2.5 Reduced= (4495 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.0145 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $175,000 / 0.52 tpy = $ 334,725

PM = $175,000 / 0.015 tpy = $ 12,074,755

M-156 Free Bus-to-Rail/Rail-to Bus Transfer (Similar to NYC Pricing Structure)

Measure Number: M - 156

Measure Name: Free Bus-to-Rail/Rail-to Bus Transfer (Similar to NYC Pricing Structure)

Description:

This program would institute a free bus to rail transfer similar to the reduced fare rail to bus transfer.

Precursor NOx

Estimated Cost ($/ton/year)	$ 4,004,194
Estimated Reductions (tpy)	9.19

PM2.5

Estimated Cost ($/ton/year)	$ 144,445,733
Estimated Reductions (tpy)	0.2549

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (5100 trips * 0.6132 gms/trip +79050 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 9.19 tpy

Total PM2.5 Reduced= (79050 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.2549 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $36,816,000 / 9.19 tpy = $ 4,004,194

PM = $36,816,000 / 0.255 tpy = $ 144,445,733

M -158 Free Bus Service Off-Peak (10:00 AM –2:00 PM Mid-Day and Weekends)

Measure Number: M - 158

Measure Name: Free Bus Service Off-Peak (10:00 AM –2:00 PM Mid-Day and Weekends)

Description:

Free bus service off-peak (10-2 mid-day, weekends): Free service during the mid day and all day on weekends.

Precursor NOx

Estimated Cost ($/ton/year)	$ 2,825,360
Estimated Reductions (tpy)	7.72

PM2.5

Estimated Cost ($/ton/year)	$ 101,920,954
Estimated Reductions (tpy)	0.2141

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (2484 trips * 0.6132 gms/trip +66402 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)

Total Precursor NOx Reduced= 7.72 tpy

Total PM2.5 Reduced= (66402 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)

Total PM2.5 Reduced= 0.2141 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $21,821,300 / 7.72 tpy = $ 2,825,360

PM = $21,821,300 / 0.214 tpy = $ 101,920,954

M-162 Early Engine Retirement (Pre-88)

Measure Number: M - 162

Measure Name: M-162 Early Engine Retirement (Pre-88)

Description:

This is a voluntary program designed to install new diesel engines by replacing old high polluting diesel engines in private vehicles (heavy duty vehicles). This is similar to “cash for clunkers” where instead of cash, the operator would get a new diesel engine.

Precursor NOx

Estimated Cost ($/ton/year)	-
Estimated Reductions (tpy)	-

PM2.5

Estimated Cost ($/ton/year)	$ 126,310
Estimated Reductions (tpy)	9.3421

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total PM2.5 Reduced= (1.2 gms/mile - 0.05 gms/mile) * 15,000 miles/year / (907,185 g/ton)

Total PM2.5 Reduced= 9.3421 tpy

Cost Effectiveness

Cost ($) / Emissions (tpy)

PM = $1.18 mill / 0.0044 tpy = $ 126,310

M-163 Truck Idling (Truck Stops and Auxiliary Power Unit)

Measure Number: M - 163

Measure Name: Truck Idling (Truck Stops and Auxiliary Power Unit)

Description:

This is a voluntary program designed to install pollution-reduction technology on existing diesel vehicles and equipment. Under this program it is proposed to use a small diesel auxiliary power unit (APU), which will be mounted on the truck chassis to provide heat, air conditioning, or engine heat in lieu of operating the engine. This is expected to reduce the vehicle's NOx idling emission by 90%.

Precursor NOx

Estimated Cost ($/ton/year)	-
Estimated Reductions (tpy)	-

PM2.5

Estimated Cost ($/ton/year)	$ 19,266
Estimated Reductions (tpy)	29.8451

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total PM2.5 Reduced= (1.2 gms/mile - 0.05 gms/mile) * 15,000 miles/year / (907,185 g/ton)

Total PM2.5 Reduced= 29.8451 tpy

Cost Effectiveness

Cost ($) / Emissions (tpy)

PM = $575,000 mill / 0.0044 tpy = $ 19,266

M-165 Bike Stations at Rail Station

Measure Number: M - 165
Measure Name: Bike Stations at Rail Station

Description:
This measure assumes construction of a Bike Station at the Silver Spring Transit Station. A Bike Station is a full-service bicycle storage and rental facility with guarded valet bicycle parking, bicycle rentals, repairs, and supplies.

Precursor NOx

Estimated Cost ($/ton/year)	$ 897,816
Estimated Reductions (tpy)	0.19

PM2.5

Estimated Cost ($/ton/year)	$ 32,386,537
Estimated Reductions (tpy)	0.0052

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (105 trips * 0.6132 gms/trip +1628 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)
Total Precursor NOx Reduced= 0.19 tpy

Total PM2.5 Reduced= (1628 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)
Total PM2.5 Reduced= 0.0052 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $170,000 / 0.19 tpy = $ 897,816
PM = $170,000 / 0.005 tpy = $ 32,386,537

M-144 Parking Impact Fees

Measure Number: M - 144
Measure Name: Parking Impact Fees

Description:
This measure would consist of a parking impact fee administered by local governments throughout the region. The fees would allow governments to recoup some of the costs associated with maintaining the roadway infrastructure and mitigating the adverse effects of automobile use. The fees could be charged per parking space to land owners annually or on a one-time basis.

Precursor NOx

Estimated Cost ($/ton/year)	$ 1,803,907
Estimated Reductions (tpy)	219.65

PM2.5

Estimated Cost ($/ton/year)	$ 65,073,456
Estimated Reductions (tpy)	6.0889

Assumptions

Please see the appropriate page in the main report

Emission Reductions

Total Precursor NOx Reduced= (121836 trips * 0.6132 gms/trip +1888453 VMT * 0.3825 gms/mile) * 250 days/year / (907,185 g/ton)
Total Precursor NOx Reduced= 219.65 tpy

Total PM2.5 Reduced= (1888453 VMT * 0.0117 gms/mile) *250 days/year / (907,185 g/ton)
Total PM2.5 Reduced= 6.0889 tpy

Cost Effectiveness

Annualized Cost ($) / Emissions (tpy)

Pre. NOx = $396 mill / 219 tpy = $ 1,803,907 (This is a revenue generating TERM)
PM = $396 mill / 6.09 tpy = $ 65,073,456